INTEGRATED SCIENCE

TUTOR’S GUIDE

FOR TTC

YEAR 1

OPTION:

Science and Mathematics Education (SME)

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FOREWORD

Dear tutor,

Rwanda Basic Education Board is honoured to present tutor's guide for Integrated Science Year One of TTC SME option which serves as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of Integrated Science subject. The Rwandan educational philosophy is to ensure that learners achieve full potential at every level of education which will prepare them to be well integrated in society and exploit employment opportunities.

In line with efforts to improve the quality of education, the government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate their learning process. Many factors influence what they learn, how well they learn and the competences they acquire. Those factors include the relevance of the specific content, the quality of tutor' pedagogical approaches, the assessment strategies and the instructional materials available. We paid special attention to the activities that facilitate the learning process in which student-teachers can develop ideas and make new discoveries during concrete activities carried out individually or with peers. With the help of the tutor, student-teachers will gain appropriate skills and be able to apply what they have learnt in real life situations. Hence, they will be able to develop certain values and attitudes allowing them to make a difference not only to their own life but also to the nation.

This is in contrast to traditional learning theories which view learning mainly as a process of acquiring knowledge from the more knowledgeable who is mostly the teacher. In competence-based curriculum, learning is considered as a process of active building and developing of knowledge and understanding, skills and values and attitude by the learner where concepts are mainly introduced by an activity, situation or scenario that helps the learner to construct knowledge, develop skills and acquire positive attitudes and values.

In addition, such active learning engages learners in doing things and thinking about the things they are doing and they are encouraged to bring their own real experiences and knowledge into the learning processes. In view of this, your role is to:

- Plan your lessons and prepare appropriate teaching and learning materials.

- Organize group discussions for student-teachers considering the importance of social constructivism suggesting that learning occurs more effectively when the learner works collaboratively with more knowledgeable and experienced people.
- Engage student-teachers through active learning methods such as inquiry methods, group discussions, research, investigative activities and group and individual work activities.
- Provide supervised opportunities for student-teachers to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Support and facilitate the learning process by valuing student-teachers' contributions in the class activities.
- Guide student-teachers towards the harmonization of their findings.
- Encourage individual, peer and group evaluation of the work done in the classroom and use appropriate competence-based assessment approaches and methods.

To facilitate you in your teaching activities, the content of this tutor's guide is self-explanatory so that you can easily use it. It is divided in 3 parts:

The part 1: Explains the structure of this tutor's guide and gives you the methodological guidance;

The part 2: Gives the sample lesson plans as reference for your lesson planning process;

The part 3: Provides the teaching guidance for each concept given in the student book.

Even though this tutor's guide contains the Answers to all activities given in the student-teacher's book, you are requested to work through each question and activity before judging student-teacher's findings.

I wish to sincerely appreciate all people who contributed towards the development of this tutor's guide, particularly REB staff who organized the whole process from its inception. Special gratitude goes to teachers, illustrators and designers who diligently worked to successful completion of this tutor's guide. Any comment or contribution would be welcome for the improvement of this tutor's guide for the next edition.

Dr. MBARUSHIMANA Nelson

Director General, REB

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I wish to express my appreciation to all the people who played a major role in development of this Integrated Science Tutor's Guide for Year One of TTC SME option. It would not have been successful without active participation of different education stakeholders.

I owe gratitude to different Universities and schools in Rwanda that allowed their staff to work with REB in the in-house textbooks production project. I wish to extend my sincere gratitude to lecturers, teachers and all other individuals whose efforts in one way or the other contributed to the success of writing of this tutor's guide. Special acknowlegment goes to teachers, tutors, illustrators and designers who participated in production of this tutor's guide.

Finally, my word of gratitude goes to the Rwanda Basic Education Board staff particularly those from the Curriculum, Teaching and Learning Resources Department who were involved in the whole process of in-house textbook writing.

Joan MURUNGI

Head of Curriculum, Teaching and Learning Resources Department

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PART I. GENERAL INTRODUCTION

1.0. About the tutor's guide

This book is a tutor's guide for Integrated Science subject, Year one in option of SME of TTC. It is designed to accompany student teacher's book and intends to help tutors in the implementation of competence based curriculum specifically Integrated science syllabus.

As the name says, it is a guide that tutors can refer to when preparing their lessons. Tutors may prefer to adopt the guidance provided but they are also expected to be more creative and consider their specific classes' contexts and prepare accordingly.

1.1. The structure of the guide

This section presents the overall structure, the unit and sub-heading structure to help tutors to understand the different sections of this guide and what they will find in each section.

Overall structure

The whole guide has three main parts as follows:

- **Part I: General Introduction.**

This part provides general guidance on how to develop the generic competences, how to integrate cross cutting issues, how to cater for student-teachers with special educational needs, active methods and techniques of teaching Integrated science and guidance on assessment.

- **Part II: Sample lesson plan**

This part provides a sample lesson plan, developed and designed to help the tutor develop their own lesson plans.

- **Part III: Unit development**

This is the core part of the guide. Each unit is developed following the structure below. The guide ends with references.

Each unit is made of the following sections:

- **Unit title:** from the syllabus
- **Key unit competence:** from the syllabus
- **Prerequisites** (knowledge, skills, attitudes and values)

This section indicates knowledge, skills and attitudes required for the success of the unit. The competence-based approach calls for connections between units/topics within a subject and interconnections between different subjects. The tutor will find an indication of those prerequisites and guidance on how to establish connections.

- **Cross-cutting issues to be addressed**

This section suggests cross cutting issues that can be integrated depending on the unit content. It provides guidance on how to come up with the integration of the issue. Note that the issue indicated is a suggestion; tutors are free to take another cross-cutting issue taking into consideration the learning environment.

- **Guidance on the introductory activity**

Each unit starts with an introductory activity in the student-teacher's book. This section of the tutor's guide provides guidance on how to conduct this activity and related answers. Note that student-teachers may not be able to find the right solution but they are invited to predict possible solutions or answers. Solutions are provided by student-teachers gradually through discovery activities organized at the beginning of lessons or during the lesson.

- **List of lessons/sub-heading**

This section presents in a table suggestion on the list of lessons, lesson objectives copied or adapted from the syllabus and duration for each lesson. Each lesson /subheading is then developed.

- **End of each unit**

At the end of each unit the tutor's guide provides the following sections:

- Summary of the unit which provides the key points of content developed in the student-teacher's book.
- Additional information which provides additional content compared to the student-teacher's book for the tutor to have a deeper understanding of the topic.
- End unit assessment which provides answers to questions of the end unit assessment in the student-teacher's book and suggests additional questions and related answers to assess the key unit competence.
- Additional activities:(remedial, consolidation and extended activities). The purpose of these activities is to accommodate each student-teacher (slow, average and gifted) based on end unit assessment results.

Structure of each sub heading

Each lesson/sub-heading is made of the following sections:

Lesson /Sub heading title 1: ……………………………..

- **Prerequisites/Revision/Introduction:**

This section gives a clear instruction to tutor on how to start the lesson.

- **Teaching resources**

This section suggests the teaching aids or other resources needed in line with the activities to achieve the learning objectives. Tutors are encouraged to replace the suggested teaching aids by the available ones in their respective schools and based on learning environment.

- **Learning activities**

This section provides a short description of the methodology and any important aspect to consider. It provides also answers to learning activities with cross reference to student-teacher's book.

- **Exercises/application activities**

This provides questions and Answers to exercises/ application activities.

1.2. Methodological guidance

1.2.1. Developing competences

Since 2015 Rwanda shifted from a knowledge based to a competence based curriculum for pre-primary, primary and general secondary education. For TTCs, it is in 2019 that the competence based curriculum was embraced. This called for changing the way of learning by shifting from teacher centered to a learner centered approach. Tutors are not only responsible for knowledge transfer but also for fostering student-teacher's learning achievement, and creating safe and supportive learning environment. It implies also that a student-teacher has to demonstrate what he/she is able to do using the knowledge, skills, values and attitude acquired in a new or different or given situation.

The competence-based curriculum employs an approach of teaching and learning based on discrete skills rather than dwelling on only knowledge or the cognitive domain of learning. It focuses on what learner can do rather than what learners know. Student-teachers develop basic competences through specific subject unit competences with specific learning objectives broken down into knowledge, skills and attitudes.

These competences are developed through learning activities disseminated in learner-centered rather than the traditional didactic approach. The student-teachers is evaluated against set standards to achieve before moving on.

In addition to specific subject competences, student-teachers also develop generic competences which are transferable throughout a range of learning areas and situations in life. Below are examples of how generic competences can be developed in Integrated Science:

Generic competence	**Examples of activities that develop generic competences**
Critical thinking	• Describe the relationship and interdependence of sciences • Observe, record, interpret data recorded during experiments • Identify and use the applications of integrated science concepts to solve problems of life and society
Research and Problem solving	• Research using internet or books from the library • Design a project for making bioplastics • Design a questionnaire for data collection during field visit
Innovation and creativity	• Create an experiment procedure to prove a point • Develop a graph to illustrate information • Design a data collection survey/questionnaire • Conduct experiments with objectives, methodology, observations, results, conclusions • Identify local problems and ways to resolve them
Cooperation, Personal and Interpersonal management and life skills	• Work in Pairs • Small group work • Large group work
Communication	• Organise and present in writing and verbally a complete and clear report of an experiment . • Observe, record, interpret the results of a measurement accurately. • Select and use appropriate formats and presentations, such as tables, graphs and diagrams.

Lifelong learning	• Exploit all opportunities available to improve on knowledge and skills. Reading scientific journals to keep updated.

1.2.2. Addressing cross cutting issues

Among the changes in the competence based curriculum is the integration of cross cutting issues as an integral part of the teaching learning process-as they relate to and must be considered within all subjects to be appropriately addressed. The eight cross cutting issues identified in the national curriculum framework are: genocide studies, environment and sustainability, gender, Comprehensive Sexuality Education (CSE), Peace and Values Education, Financial Education, standardization Culture and Inclusive Education.

Some cross cutting issues may seem specific to particular learning areas or subjects but the tutor needs to address all of them whenever an opportunity arises. In addition, student-teacher should always be given an opportunity during the learning process to address these cross cutting issues both within and out of the classroom so as to progressively develop related attitudes and values.

Below are examples on how crosscutting issues can be addressed in Integrated science:

Cross-cutting issues	Examples on how to integrate the cross-cutting issues
Inclusive education	Involve all student-teachers in all activities without any bias. Eg: Allow a student-teacher with physical disability (using wheelchair) to take notes or lead the team during an experiment.
Gender	Involve both girls and boys in all activities: No activity is reserved only to girls or boys. Tutor should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.
Peace and Values Education	During group activities, debates and presentations, the tutor will encourage student-teachers to help each other and to respect opinions of colleagues.

Standardization culture	• Some lessons involve carrying out experiments. Instruction should be clear for student-teachers to always check if they are not using expired chemicals or defective apparatus. • In addition, when performing experiments student-teachers have to record data accurately. • For tasks involving calculations, they have to always present accurate results.
Environment and sustainability	• In order to avoid the environment pollution, before, during or after experiments student-teachers avoid throwing away chemicals anywhere; special places or appropriate containers should be used. • Student-teachers also have to be aware of the impacts of the use of hydrocarbons as fuels, halogenoalkanes, and plastics on the environment.
Financial Education	When performing experiments, student-teachers are encouraged to avoid wasting chemicals by using the quantities that are just required. They are required to also avoid spoiling equipments and other materials…

1.2.3. Attention to special educational needs specific to each subject

In the classroom, student-teachers learn in different way depending to their learning pace, needs or any other special problem they might have. However, the tutor has the responsibility to know how to adopt his/her methodologies and approaches in order to meet the learning need of each student-teacher in the classroom. Also tutor must understand that student-teachers with special needs need to be taught differently or need some accommodations to enhance the learning environment. This will be done depending on the subject and the nature of the lesson.

In order to create a well-rounded learning atmosphere, tutor needs to:

- Remember that student-teachers learn in different ways so they have to offer a variety of activities (e.g. role-play, music and singing, word games and quizzes, and outdoor activities).
- Maintain an organized classroom and limits distraction. This will help student-teachers with special needs to stay on track during lesson and follow instruction easily.
- Vary the pace of teaching to meet the needs of each student-teacher. Some student-teachers process information and learn more slowly than others.

- Break down instructions into smaller, manageable tasks. student-teachers with special needs often have difficulty understanding long-winded or several instructions at once. It is better to use simple, concrete sentences in order to facilitate them understand what you are asking.
- Use clear consistent language to explain the meaning (and demonstrate or show pictures) if you introduce new words or concepts.
- Make full use of facial expressions, gestures and body language.
- Pair a student-teacher who has a disability with a friend. Let them do things together and learn from each other. Make sure the friend is not over protective and does not do everything for the student-teacher. Both student-teachers will benefit from this strategy
- Use multi-sensory strategies. As all student-teachers learn in different ways, it is important to make every lesson as multi-sensory as possible. Student-teachers with learning disabilities might have difficulty in one area, while they might excel in another. For example, use both visual and auditory cues.

Below are general strategies related to each main category of disabilities and how to deal with every situation that may arise in the classroom. However, the list is not exhaustive because each student-teacher is unique with different needs and that should be handled differently.

Strategy to help student-teachers with developmental impairment:

- Use simple words and sentences when giving instructions.
- Use real objects that the student-teacher can feel and handle, rather than just working abstractly with pen and paper.
- Break a task down into small steps or learning objectives. The student-teacher should start with an activity that s/he can do already before moving on to something that is more difficult.
- Gradually give the student less help.
- Let the student-teacher work in the same group with those without disability.

Strategy to help student-teachers with visual impairment:

- Help student-teachers to use their other senses (hearing, touch, smell and taste) to play and carry out activities that will promote their learning and development.

- Use simple, clear and consistent language.
- Use tactile objects to help explain a concept.
- If the student-teachers has some sight, ask them what they can see. Get information from parents/caregivers on how the student-teacher manages their remaining sight at home.
- Make sure the student-teacher has a group of friends who are helpful and who allow the student-teachers to be as independent as possible.
- Plan activities so that student-teachers work in pairs or groups whenever possible.

Strategy to help student-teachers with hearing impairment:

- Strategies to help student-teachers with hearing disabilities or communication difficulties
- Always get the student-teacher's attention before you begin to speak.
- Encourage the student-teacher to look at your face.
- Use gestures, body language and facial expressions.
- Use pictures and objects as much as possible.
- Ask the parents/caregivers to show you the signs they use at home for communication use the same signs yourself and encourage other student-teachers to also use them.
- Keep background noise to a minimum.

Strategies to help children with physical disabilities or mobility difficulties:

- Adapt activities so that student-teacher who use wheelchairs or other mobility aids, or other student-teachers who have difficulty moving, can participate.
- Ask parents/caregivers to assist with adapting furniture e.g. The height of a table may need to be changed to make it easier for a student-teacher to reach it or fit their legs or wheelchair under.
- Encourage peer support friends can help friends.
- Get advice from parents or a health professional about assistive devices.

1.2.4. Guidance on assessment

Each unit in the tutor's guide provides additional activities to help student-teachers achieve the key unit competence. Results from assessment inform the tutor which student-teacher needs remedial, consolidation or extension activities. These activities are designed to cater for the needs of all categories of learners; slow, average and gifted learners respectively.

Assessment is an integral part of teaching and learning process. The main purpose of assessment is for improvement. Assessment for learning/ **Continuous/ formative assessment** intends to improve student-teachers' learning and tutor's teaching whereas assessment of learning/summative assessment intends to improve the entire school's performance and education system in general.

Continuous/ formative assessment

It is an ongoing process that arises out of interaction during teaching and learning process. It includes lesson evaluation and end of sub unit assessment. This formative assessment plays a big role in teaching and learning process. The tutor should encourage individual, peer and group evaluation of the work done in the classroom and uses appropriate competence-based assessment approaches and methods.

In Year one textbook, formative assessment principle is applied through application activities that are planned in each lesson to ensure that lesson objectives are achieved before moving on. At the end of each unit, the end unit assessment is formative when it is done to give information on the progress of students and from there decide what adjustments need to be done. Assessment standards are taken into consideration when setting tasks.

Summative assessment

The assessment done at the end of the term, end of year, is considered as summative. The tutor, school and parents are informed on the achievement of educational objectives and think of improvement strategies. There is also end of level/ cycle assessment in form of national examinations.

1.2.5. Student teachers' learning styles and strategies to conduct teaching and learning process

There are different teaching styles and techniques that should be catered for. The selection of teaching method should be done with the greatest care and some of the factors to be considered are: the uniqueness of subjects, the type of lessons, the particular learning objectives to be achieved, the allocated time to achieve the objective, instructional available materials, the physical/sitting arrangement of the classroom, individual student teachers' needs, abilities and learning styles.

There are mainly four different learning styles as explained below:

a) Active and reflective learners

Active learners tend to retain and understand information best by doing something active with it, discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.

b) Sensing and intuitive learners

Sensing learners tend to like learning facts while intuitive learners often prefer discovering possibilities and relationships. Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitive learners like innovation and dislike repetition.

c) Visual and verbal learners

Visual learners remember best what they see (pictures, diagrams, flow charts, time lines, films, demonstrations, etc).; verbal learners get more out of words (written and spoken explanations).

d) Sequential and global learners

Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."

1.2.6. Teaching methods and techniques that promote the active learning

The different student-teacher learning styles mentioned above can be catered for, if the tutor uses active learning whereby student-teachers are really engaged in the learning process.

What is Active learning?

Active learning is a pedagogical approach that engages student-teachers in doing things and thinking about the things they are doing.

In active learning, learners are encouraged to bring their own experience and knowledge into the learning process.

The role of the tutor in active learning

- The tutor engages student-teachers through active learning methods such as inquiry methods, group discussions, research, investigative activities and group and individual work activities.
- He/she encourages individual, peer and group evaluation of the work done in the classroom and uses appropriate competence-based assessment approaches and methods.
- He provides supervised opportunities for student-teachers to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Tutor supports and facilitates the learning process by valuing student-teachers' contributions in the class activities.

The role of learners in active learning

Learners are key in the active learning process. They are not empty vessels to fill but people with ideas, capacity and skills to build on for effective learning. A learner engaged in active learning:

- Communicates and shares relevant information with other learners through presentations, discussions, group work and other learner-centred activities (role play, case studies, project work, research and investigation)
- Actively participates and takes responsibility for their own learning
- Develops knowledge and skills in active ways
- Carries out research/investigation by consulting print/online documents and resourceful people, and presents their findings
- Ensures the effective contribution of each group member in assigned tasks through clear explanation and arguments, critical thinking, responsibility and confidence in public speaking
- Draws conclusions based on the findings from the learning activities.

Some active techniques that can be used in Integrated Science

The teaching methods strongly emphasised in the competence Based Curriculum (CBC) are active methods. Below are some active techniques that apply in sciences:

A. Practical work/ experiments:

Many of the activities suggested in the Integrated Science curriculum as well as in the student-teacher's book are practical work or experiments.

Practical work is vital in learning Integrated Science; this method gives the student-teacher the opportunity to implement a series of activities and leads to the development of both cognitive and hands-on skills. The experiments and questions given should target the development of the following skills in student-teachers: observation, recording and report writing, manipulation, measuring, planning and designing.

A practical lesson/Experiment is done in three main stages:

- **Preparation of experiment:** Checking materials to ensure they are available and at good state; try the experiment before the lesson; think of safety rules and give instructions to lab technician if you have any.
- **Performance of experiment:** Sitting or standing arrangement of student-teachers; introduction of the experiment: aims and objectives; setting up the apparatus; performing the experiment; write and record the data.
- **Discussion:** Observations and interpreting data; make generalisations and assignment: writing out the experiment report and further practice and research.

In some cases, demonstration by the tutor is recommended when for example the experiment requires the use of sophisticated materials or very expensive materials or when safety is a major factor like dangerous experiments and it needs specific skills to be learnt first.

In case your school does not have enough laboratory materials and chemicals, experiments can be done in groups but make sure every student-teacher participates. You can also make arrangements with the neighbouring science school and take your student-teachers there for a number of experiments.

B. Research work

Each student-teacher or group of student-teachers is given a research topic. They have to gather information from internet, available books in the library or ask experienced people and then the results are presented in verbal or written form and discussed in class.

C. Project work

Integrated science tutors are encouraged to sample and prepare project works and engage their student-teachers in, as many as possible. Student-teachers in groups or individually, are engaged in a self-directed work for an extended period of time to investigate and respond to a complex question, problem, or challenge. The work can be presented to classmates or other people beyond the school. Projects are based on real-world problems that capture learners' interest. This technique develops higher order thinking as the student-teachers acquire and apply new knowledge in a problem-solving context.

D. Field trip

One of the main aims of teaching Integrated Science in Rwanda is to apply its knowledge for development. To achieve this aim we need to show to students the relationship between classroom science lessons and applied sciences. This helps them see the link between science principles and technological applications.

To be successful, the field visit should be well prepared and well exploited after the visit:

Before the visit, the tutor and student-teachers:

- agree on aims and objectives
- gather relevant information prior to visit
- brainstorm on key questions and share responsibilities
- Discuss materials needed and other logistical and administrative issues
- Discuss and agree on accepted behaviours during the visit
- Visit the area before the trip if possible to familiarise yourself with the place

After the visit

When student-teachers come back from trip, the tutor should plan for follow-up. The follow-up should allow student-teachers to share experiences and relate them to the prior science knowledge. This can be done in several ways; either: Student-teachers write a report individually or in groups and give to the tutor for marking. The tutor then arranges for discussion to explain possible misconceptions and fill gaps. Or student-teachers write reports in groups and display them on the class notice board for everyone to read.

Main steps for a lesson in active learning approach

All the principles and characteristics of the active learning process highlighted above are reflected in steps of a lesson as displayed below. Generally, the lesson is divided into three main parts whereby each one is divided into smaller steps to make sure that student-teachers are involved in the learning process. Below are those main parts and their small steps:

1) Introduction

Introduction is a part where the tutor makes connection between the current and previous lesson through appropriate technique. The tutor opens short discussions to encourage student-teachers to think about the previous learning experience and connect it with the current instructional objective. The tutor reviews the prior knowledge, skills and attitudes which have a link with the new concepts to create good foundation and logical sequencings.

2) Development of the new lesson

The development of a lesson that introduces a new concept will go through the following small steps: discovery activities, presentation of student-teachers' findings, exploitation, synthesis/summary and exercises/ application activities, explained below:

Discovery activity

Step 1

- The tutor discusses convincingly with student-teachers to take responsibility of their learning
- He/she distributes the task/activity and gives instructions related to the tasks (working in groups, pairs, or individual to instigate collaborative learning, to discover knowledge to be learned)

Step 2

- The tutor let the student-teachers work collaboratively on the task.
- During this period the tutor refrains to intervene directly on the knowledge
- He/she then monitors how the student-teachers are progressing towards the knowledge to be learned and boost those who are still behind (but without communicating to them the knowledge).

Presentation of student-teachers' productions

- In this episode, the tutor invites representatives of groups to present the student-teachers' productions/findings.
- After three/four or an acceptable number of presentations, the tutor decides to engage the class into exploitation of the student-teachers' productions.

Exploitation of student-teachers's productions

- The tutor asks the student-teachers to evaluate the productions: which ones are correct, incomplete or false
- Then the tutor judges the logic of the student-teachers' products, corrects those which are false, completes those which are incomplete, and confirms those which correct.

Institutionalization (summary/conclusion/ and examples)

- The tutor summarises the learned knowledge and gives examples which illustrate the learned content.

Exercises/Application activities

- Exercises of applying processes and products/objects related to learned unit/sub-unit
- Exercises in real life contexts
- Tutor guides student-teachers to make the connection of what they learnt to real life situations. At this level, the role of tutor is to monitor the fixation of process and product/object being learned.

3) Assessment

In this step the teacher asks some questions to assess achievement of instructional objective. During assessment activity, student-teachers work individually on the task/activity. The tutor avoids intervening directly. In fact, results from this assessment inform the tutor on next steps for the whole class and individuals. In some cases, the tutor can end with a homework assignment.

PART II. SAMPLE LESSON PLAN

School Name: ________________Teacher's name:___________________

Term	Date	Subject	Class	Unit N°	Lesson N°	Duration	Class size
		Integrated science	Year 1	4	4 of 6	80 min	
Type of Special Educational Needs to be catered for in this lesson and number of learners in each category				....			

Unit title	Solutions and titrations
Key Unit Competence	To be able to prepare standard solutions and use them to determine concentration of other solutions by titration.
Title of the lesson	Titration of sulphuric acid with sodium hydroxide
Instructional Objective	Using proper chemicals and materials, learners, accurately determine the concentration of sulphuric acid by titration.
Plan for this Class (location: in / outside)	Chemistry laboratory
Learning Materials **(for all learners)**	**Chemicals:** Aqueous 0.35M NaOH solution (50mL), Aqueous solution of sulphuric acid, H_2SO_4 (50mL), Methyl orange indicator/ phenolphthalein, Distilled water **Materials:** Retort stand and clamp, Burette, Pipette/ graduated cylinder, Pipette filler, beakers, 1 conical flask, 1 wash bottle
References	REB, Chemistry senior 5; T.G, 2019; AS Chemistry for AQA, John Atkinson and Carol Hibert, 2000; Chemistry, the central science, 10th Ed. Brown & al.

<table>
<tr><th rowspan="3">Timing for each step</th><th colspan="2">Description of teaching and learning activity</th><th rowspan="3">Generic competences and Cross cutting issues to be addressed + a short explanation</th></tr>
<tr><td colspan="2">Through practical group activities, learners accurately determine the concentration of sulphuric acid by titration using a standard solution of sodium hydroxide.</td></tr>
<tr><th>Teacher activities</th><th>Learner activities</th></tr>
<tr><td>Introduction [10min]</td><td>Form groups of two and ask learners to recall the concept and the objective of a titration.</td><td>Learners discuss about the concept and the objective of a titration.
Expected answers:
Titration is a process used in volumetric analysis, in which a solution of one reactant of known concentration, the titrant, is added to a known volume of another reactant until the reaction between the two is complete.
The primary objective of a titration is to obtain experimental data to determine the concentration of a solution.</td><td>Through group discussions, each student develops cooperation and communication skills.</td></tr>
<tr><td>Development of the lesson [50 min]</td><td>• Provide the procedure and clear instructions for the planed experiment.
• Ask learners to use the materials and chemicals provided and titrate a solution of sulphuric acid.
• Let perform the titration experiment.</td><td>Learners use the provided materials and chemicals, follow the given instructions and perform the suggested experiments.
Each group record their findings.
Some group representatives present their findings.
Classmates evaluated results presented by their colleagues.</td><td>Critical thinking when analysing the experiment results.
Peace and values education through respect other's ideas during discussions and presentations.
Promoting gender by allowing all boys and girls to perform experiments.</td></tr>
</table>

Development of the lesson [50 min]	• Ask each group to record in a note book the experimental data. • Ask learners to use experimental data to calculate the concentration of sulphuric acid. • Ask randomly three groups to present their findings to the whole class.	***Expected answers:*** Average volume of sodium hydroxide used: 17.5mL Equation of the reaction: Moles of NaOH = 17.5×10^{-3}L x 0.35molL-1= 0.006125mol Moles of H_2SO_4 = $\frac{0.006125 \text{ mol}}{2} = 0.0030625$ mol Molarity = $\frac{0.0030625 \text{ mol}}{0.01}$ = 0.306M	**Financial education** by using just the required chemicals. **Environment and sustainability** by avoiding throwing chemicals in inappropriate places. **Standardization culture** by avoiding using expired chemicals.
Conclusion [10 min]	From answers suggested by learners, show the detailed calculations for the concentration of sulphuric acid.	Learners write the summary on their notes books.	
Assessment [10min]	Teacher assesses the understanding level of the learners by asking to state at least five applications of the titration in the daily life.	Learners answer the teacher's questions	
Teacher self-evaluation			

UNIT 1

THE CONCEPT OF INTEGRATED SCIENCE AND MEASUREMENTS OF PHYSICAL QUANTITIES

1.1. Key unit competence

Explain the concept of Integrated Science and use accurately different tools to measure physical quantities in science.

1.2. Prerequisite (knowledge, skills, attitudes and values)

- Mathematical operations: Addition, subtraction, division and multiplication.
- Measurement of capacity, area, time, length, mass, density.

1.3. Cross cutting issues to be addressed

- **Standardization culture**: Emphasize the need to use appropriate instruments and correct SI Units when measuring physical quantities for purposes of standards in everyday life.
- **Financial education:** Emphasize the need to compare price against measuring instrument while buying based on its functionality.
- **Environment and sustainability:** Recognize the safety measures taken for the sake of environmental protection.
- **Peace and values education:** Cooperation and teamwork spirit should be encouraged in learning process.

1.4. Guidance on introductory activity

- Ask student-teachers to look at the illustration of the unit and let them discuss what they see.
- Let them brainstorm in five minutes to discover what is taking place in the illustration of the introductory activity.
- What topics do they think this unit will include based on the illustration?
- Give time for some brainstorming and after share the main sub-units.

1.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Introduction to Integrated Science and its relationship with science subjects.	Explain the meaning of integrated Science and its relationship with other subjects.	4
		Point out the principles of integrated science in the learning process.	
		Explain the role of integrated science in their everyday life situations.	
2	Measurement of physical quantities.	Classify physical quantities and assign SI Units to distinguished physical quantities.	5
		Measure accurately physical quantities using appropriate measuring tools.	
3	End unit assessment	Evaluation of the achievement of the objectives.	2

Lesson 1: Introduction to Integrated Science and its relationship with science subjects

a) Learning objectives

- Explain the meaning of integrated Science and its relationship with other subjects.
- Point out the principles of integrated science in the learning process.
- Explain the role of integrated science in their everyday life situations.

b) Teaching resources:

Textbooks, charts

c) Prerequisites/Revision/Introduction

Arithmetic's operations and scientific basics.

d) Activity 1.1:

- **Technical guidance for activity 1.1**
  - This activity introduces the student-teacher to know more about physical quantities and their measurements.

- Divide your class into small groups, and let them read and interpret the activity based on their understanding and corresponding concepts about physical quantities and their measurements.
- Let the student-teachers perform the activity using their prior knowledge about the provided measuring instruments and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in measurement of physical quantities in the student-teacher book and use the information while reviewing the questions together.

Task 1:

a. Integrated science is the course that serves the purpose of a "general science" course covering both the physical and life sciences.

b. It is very important because it helps us to be aware of the global dimension of science, as a universal activity with consequences for our lives and subject to social, economic, political, environmental, and ethical factors.

Here an integrated science course serves the purpose of a general science course covering both the physical and life sciences. For example, in describing the physics of light, we show how this applies to the inner workings of our eyes, which, in turn, are sensitive to visible light in great part because of the chemical composition of our atmosphere.

Task 2:

This activity is done based on the knowledge and skills gained in previous years in science subjects and what is observed during field visit.

e) Application activity 1.1

1.

- **Let take an example of science and language:** Although science is a practical subject, but it is very important for learners to be able to express their views and ideas in clear and attractive form. For this purpose, it is necessary that they should have thorough knowledge of language which they use. Student teacher who does not have good control over the language cannot express his views and various scientific laws and principles in front of others and especially in front of teacher.
- **Let again take an example of science and Mathematics:** A large number of scientific principles and rules are represented in the form of mathematical expressions, for which it is very necessary for the student teacher intending to get advanced study of science subjects to have sound mathematical basis. Without making use of mathematical expressions and rules, it is not possible for any teacher to conduct science teaching in effective manner.
- **We can stress on science and geography:** Results obtained by the science in terms of climate and the manner in which it affect the human beings and earth are being interpreted by subject of Geography. The manner in which it is mentioned by the geography that how soil gets produced through crushing process of rocks, it makes the subject a special branch of science.

2. Science is about observation and experimentation of things in the physical and natural world. Technology is the practical application of scientific knowledge.

Example 1:

Observation: It's cold outside but it's bearable inside our cave. But we need to follow our food (leave the cave).

Application (Technology): Lets build a cave wherever we need! … and shelters were born.

Yes, clothing and shelter is a basic form of technology. As a matter of fact, there are places on Earth where people can only survive because of technology.

Example 2:

In Geography, weather forecast, a geographer uses a barometer, wind gauge, etc. which are instruments developed by a physicist in technological way.

Example 3:

In Agriculture, the water sprinkler, insecticide sprayer, etc. make use of the principles developed by physicists and it requires a technology to produce these products.

Lesson 2: Measurement of physical quantities

a) Learning objective

- Classify physical quantities and assign SI Units to distinguished physical quantities.
- Measure accurately physical quantities using appropriate measuring tools.

b) Teaching resources

- Blank Flipchart papers, Markers of different colors, Scotch/Masking tape; you may need memory stick, computer and projector.

c) Prerequisites/Revision/Introduction

- Mathematical operations: Division and multiplication.
- Physical quantities and their measurement using measuring instruments learnt in s.1 and S.2.
- Measurement of capacity, area, time, length, mass and density learnt in S.1 and S.2 (measurements of physical quantities).

d) Activity 1.2

- **Technical guidance for activity 1.2.**
  - This activity introduces the student-teacher to know more about physical quantities and their measurements.
  - Divide your class into small groups, and let them read and interpret the activity based on their understanding and corresponding concepts about physical quantities and their measurements.
  - Let the student-teachers perform the activity using their prior knowledge about the provided measuring instruments and write the ideas in the notebook.

- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in measurement of physical quantities in the student-teacher book and use the information while reviewing the questions together.

Response to Activity 1.2:

Task1:

(Guidance) The physical quantities and their corresponding S I Units will vary depending on the student-teacher's standardization and choice.

- Volume, area, density and weight, length, mass.
- Using knowledge gained in primary learners explain the mentioned physical quantities.
- The SI units are: m^3, m^2, kg/m^3, N, m, and kg

Task 2:

Size of the body, size of the garden and amount occupied by water in tank, because they can be measured by using some measuring instruments. For the size of body and garden , the physical quantities to be measured is, length and area, weight and mass and for amount occupied by water in tank is volume, amount of a substance, and weight.

Task 3:

i. A physical quantity is any observable property or process in nature with which a number may be associated.

ii. Fundamental and derived quantities.

iii. Fundamental quantities include mass, length, time and current while **derived quantities** include volume, area, density and force. Refer on the task above for definitions of fundamental and derived quantities.

iv. It helps you in classifying different types of measurements done on whatever physical quantity and to know the exact true measured value of the corresponding quantity.

e) Answers to Application activity 1.2

Question 1

a. Tape measures
b. Weighing balance
c. Plastic Tape measures
d. Stopwatch
e. Vernier callipers

Question 2

Provide vernier callipers and any spherical objects to student teacher teachers and asks them to follow the procedures to determine the diameter of the object.

- For the vernier shown in Figure above, the main scale reading (MSR) is 2.6 cm. However, to get the second decimal value, we make use of the vernier scale.
- The vernier scale mark that coincides exactly with a main scale mark gives the vernier coincidence (VC).
- In this case, the 6_{th} division coincides with the main scale division. Therefore, the external diameter of the cylindrical object is

  MSR + (VC × LC) = 2.6 cm + (6 × 0.01) cm = 2.66 cm.

Question 3

Solution

Main scale reading = 5.0 mm 5.00 mm

Head scale coincidence = 19 divisions

Head scale reading = 19 × 0.01 = 0.19 mm

Full reading = 5.0 + 0.19 = 5.19 mm

The diameter of the ball bearing is 5.19 mm

Diameter of the ball bearing is 5.19 mm

Question 4:

1. It is proved that tape measure can give measurements very quick because itself contains 3 m.
2. No. The ones included in fundamental quantities include the following: Mass, length and time only.

Question 5:

Physical quantity	Name of the unit	Symbol of the S I units.
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Volume	Cubed metre	m^3
Area	Squared metre	m^2

Question 6:

The choice of the physical quantities depends on the student teacher teacher

Question 7

a. 250 m = 25000 cm.

b. 320 mg = 0.320 g.

c. 5µg = 0.000005 g.

d. 7200 cm = 72.00 m.

e. 3 kg = 3000 g.

1.6. Summary of the unit

- Science is about observation and experimentation of things in the physical and natural world.
- Integrated science is a subject which incorporates the knowledge base of all the science fields, both physical and life sciences and these science fields are included in one subject as a whole integrated science in that the fields of science are not segmented.
- A quantity is any observable property or process in nature with which a number may be associated.
- A physical quantity is defined as a property of a material that can be quantified by measurement.

- Physical quantities are classified into fundamental and derived quantities.
- Fundamental quantities are 7 physical quantities that cannot be expressed in terms other quantities
- Different selection criteria for measuring tools include and not limited: a**ccuracy, amplification, calibration, t**he size and type of parts to be measured, the environment (temperature, humidity, dust, pressure, and so on) and the skills required by operator, and the cost of equipment.

1.7. Additional information for tutors

- Density is a very important property of every material in our environment just because it is used to compare materials.
- The symbol for density is the Greek letter p read as **Rho**, while mass and volume are abbreviated (m) and (v) respectively. Using these symbols, the formula for density is

$$p = \frac{m}{v}$$

- Experimentally it has been shown that the earth pulls a mass of 1 kg with a force of 9.8 N/kg. However, a convenient rounded up value of 10 N/kg is commonly used.

The following are the processes skills used in using measuring instruments:

a) Observation

Scientists make observations every day, for which they wish to get answers and explanations.

Scientists then ask questions from the observations they make.

The questions may take several forms such as why, how, what and when. A good question that can be answered through scientific investigation should be well defined, testable, measurable and controllable. :

b) Prediction/hypothesis

A hypothesis or prediction is a guessed possible answer to the question. It can come from experience or existing scientific knowledge. It must however be testable in order to approve or disapprove it. The following is an example of a hypothesis:

“Wood floats on paraffin because its density is lower than that of paraffin.

c) Experimentation (Data collection and recording)

This stage involves designing and carrying out an experiment in order to collect and record data. The experiment design outlines the materials to be used, procedures to be followed, precautions to take and the method of recording data.

The scientists carries out data collection and recording procedures and trials carefully in order to get the appropriate and accurate data.

In carrying out the procedures, good scientist observes **health, safety** and **environmental measures**.

d) Data analysis

The raw data collected and recorded need to be analysed in order to give meaningful information. Data analysis may involve:

- Organizing the data and studying the trend to determine how it is varying or it remain constant.
- Drawing graphs and charts to show the trend in the set of data.
- Calculating required values that are representative of the data.
- Identifying sources of error in the experiment.

e) Interpretation of results

This involves deriving meaningful information from the analysed data.

This may include establishing the meaning of data values obtained, trend or the behaviour observed for the object under investigation.

f) Drawing conclusions (decision making)

A conclusion is a summary of what was established through the investigation.

At this stage the scientists also compares the hypothesis with the conclusion, and gives a statement confirming the hypothesis as true or disapproving it all together.

g) Reporting the results of a scientific investigation

In most cases, the findings of a scientific investigation have to be communicated in a formal way to the interested parties. Methods of presenting the findings of a scientific investigation include:

Oral presentation, Power point presentation, Use of posters, Video conferencing, scientific journals and publications, and reports.

Evaluating a scientific investigation

After completing a scientific investigation, the researcher should evaluate the entire process of the investigation against the objectives that were outlined before the commencement of the investigation.

1.8. Answers to end unit assessment

1. Fundamental quantities are those quantities that are not defined in terms of other quantities. Sample example: mass, its SI unit is kilogram (kg)

Whereas **derived quantities** are ones that are defined in terms of the fundamental quantities. Sample example: volume, its SI unit is m^3.

2. It is more helpful in measurement of physical quantities.

3. (a) $2.7m = 2.7 \times 1000mm = 2700mm$
   (b) $26.9cm = 26.9 \times 100 = 2.69mm$
   (c) $356\mu m = 356 \times 0.000001 \times 1000mm = 0.356mm$

4. a. Tapemeter
   b. Balance
   c. Tapemeter
   d. Stopwatch
   e. Micrometer screw gauge

5. Given that Area = 60 cm2 , height = 10 cm ,

New level of water after lowering steel into the can = 7 cm and V = ?

Volume of water before inserting steel, V1 = 60 x 10 m^3, V1= 600 m^3

Volume of water before inserting steel, V2 = 60 x 7 m^3, V2 = 420 m^3

Therefore, volume of steel metal, V=V2-V1, V = 180 m^3

6. The length of the glass rod (L) = 3.3mm

7. a) Observable property
   b) Fundamental and derived physical quantities.
   c) Fundamental physical quantities.
   d) A unit and a number
   e) International system of units

8. •Measure the volume of the liquid displaced when the object is submerged
   - Measure the initial volume of water in a graduated cylinder
   - Submerge the irregular object
   - Measure the final volume of the water
   - The difference between the final volume and the initial volume is the volume of the object.

9. i) Plant, Amount of fertilizer, frequency of fertilizer, Fertilizer brand and growth after month.

ii) Data types was not controlled effectively.

iii) He was not fair in frequency of fertilizer because all types of plant are not treated in the same way.

iv) All types of plants should be treated in the same way.

10. The unit project will be done by student-teacher and get the required observation with tutors guidance.

1.9. Additional activities (Questions and answers)

1.9.1. Remedial activities

1. What are the readings shown by micrometer screw gauge in Fig. (a) and (b)?

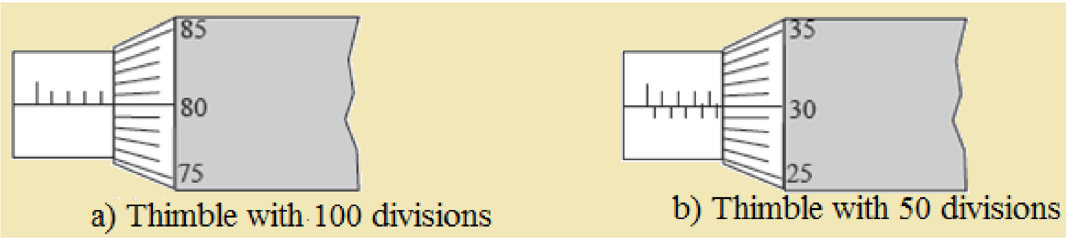


Fig: Thimble divisions.

Response:

In Fig.(a), the least count = 0.01 mm.

The micrometer screw gauge reading

= MSR + (HSC × LC)

= 4.0 m + (80 × 0.01) mm

= 4.80 mm.

In Fig.(b), LC = 0.01 mm.

The micrometer screw gauge reading

$= MSR + (HSC \times LC)$

$= 4.5 + (30 \times 0.01)$ mm

$= 4.80$ mm.

2. What are the readings shown by the vernier callipers in Fig. (a) and (b)?

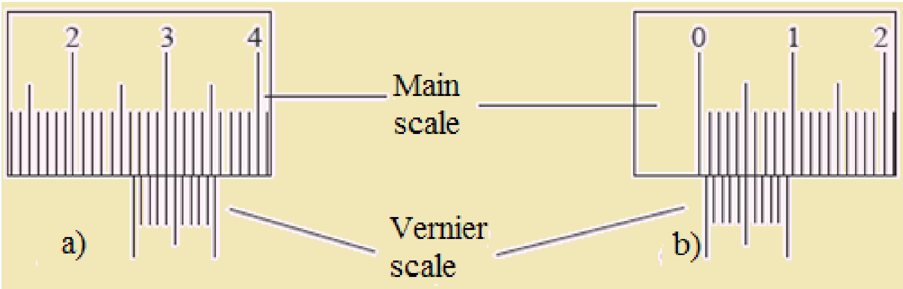


Fig: Vernier caliper readings

Response:

(a) Main scale reading = 2.6 cm

Vernier scale reading = 0.04 cm

Reading = 2.64 cm

(b) Main scale reading = 0.00 cm

Vernier scale reading = 0.05 cm

Reading = 0.05 cm

3. How many seconds are there in 1 week?

Response:

1 week = 7 days

1 day = 24 h

1 h = 60 min

1 min = 60 s

1 week = $7 \times 24 \times 60 \times 60$

= 604 800 s

4. Look at the table below and try to complete it based on the skills gained in the previous concepts done;

Name	Symbol	Factor		Name	Symbol	Factor
deci	………	10^{-1}		deca	da	……
centi	c	…….		hecto	h	……
milli	…….	10^{-3}		…….	k	10^{3}
micro	µ	……..		mega	……	10^{6}
nano	……..	10^{-9}		giga	G	……

Response:

Fill in the blank space using the skills gained in the previous concepts done;

Name	Symbol	Factor		Name	Symbol	Factor
deci	d	10^{-1}		deca	da	10^{1}
centi	c	10^{-2}		hecto	h	10^{2}
milli	milli	10^{-3}		kilo	k	10^{3}
micro	µ	10^{-6}		mega	M	10^{6}
nano	n	10^{-9}		giga	G	10^{3}

1.9.2. Consolidation activities

1. It is possible to measure and record the internal diameter of a test tube using a vernier calliper.

Steps followed to use vernier

1. Insert the inside jaws of a vernier callipers into the test tube.
2. Move the sliding jaws until the jaws just touch the inside walls of the test tube as shown in the figure below.
3. Take and record the readings on the main scale and the vernier scale. Use these readings to determine the internal diameter of the test tube.

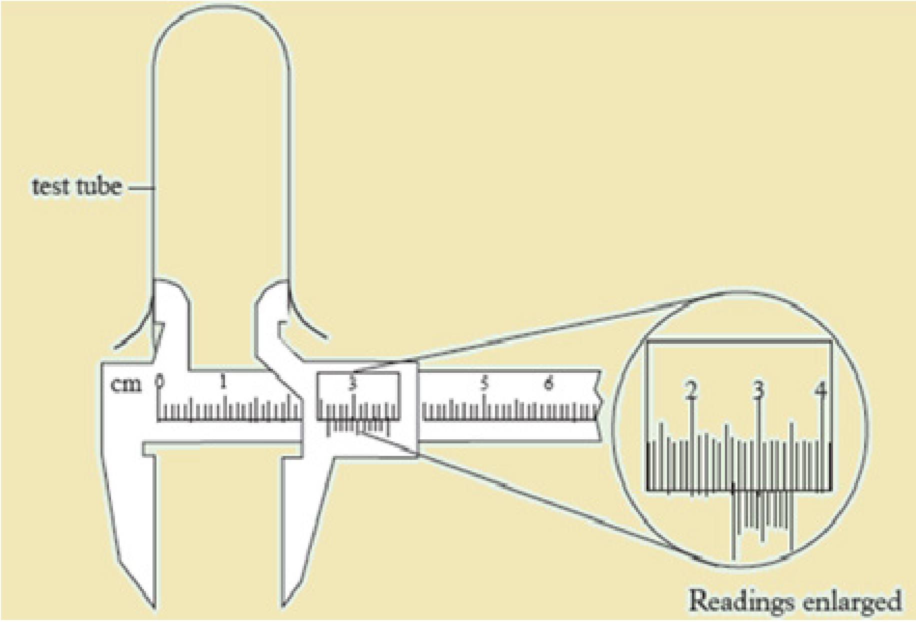


Fig: Measurement of internal diameter using vernier calipers.

Response:

- We can determine the diameter of the test tube shown in figure above as follows: The internal diameter of the test tube is given by

$$MSR + (VC \times LC) = 2.6 \text{ cm} + (2 \times 0.01) \text{ cm}$$
$$= 2.62 \text{ cm}$$

2. Provided different physical quantities such as force, mass, length, time, volume, density, and area.

Questions:

a. Examine the examples of physical quantities given above and then sort them into two categories of physical quantities?

b. Briefly, explain the differences between the two categories of physical quantities used in question (a) above?

c. How can someone obtain the value of a certain physical quantity? Justify your answer with the help of three examples of physical quantities given above.

Response:

a. Fundamental quantities are mass, time and length **whereas derived quantities** are force, volume, density and area.

b. Fundamental quantities are those quantities that are not defined in terms of other quantities whereas **derived quantities** are ones that are defined in terms of the fundamental quantities.

c. It is possible to obtain the value of a given quantity by using an appropriate instrument. Length by metre rule or tape measure, mass by balances and time by watch.

d. No. Just because some of situations require direct decision.

e. It is more supportful in taking conclusions.

1.9.3. Extended activities

1. Do all tests of physical quantities always involve measuring? Explain your reasoning to justify your decision.
2. Explain why it is very important to have quality measurements of physical quantities?

Response:

1. No just because some of the tests will require direct answer by saying yes or no.
2. To increase standardization culture in the society.

UNIT 2

INTRODUCTION TO BIODIVERSITY

2.1. Key Unit competence

Explain how biodiversity is threatened by climate change and human activities

2.2. Prerequisite (knowledge, skills, attitudes and values

The student teachers learnt biodiversity where they studied classification of kingdom Animalia and introduction to environmental Biology in chapter two and three of senior two. From these, they got knowledge, skills, attitudes and values which will help them to study well this unity.

2.3. Cross-cutting issues to be addressed

a) Inclusive education

This unit involves a collection of specimens and activities require observations on figures on the proper use of introduction to biodiversity. These activities require assembling specimens, apparatus and observation of the results. This may be challenging to student teachers with special educational needs especially children with visual impairment. However, the tutor can make some arrangements like:

- Grouping student teachers. Student teachers with special educational needs are group with others and assigned roles basing on individual student's abilities.
- Providing procedure earlier before the experiment so that student teacher gets familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts.
- Every important point is written and spoken. The written points help student teachers with hearing impairment and speaking aloud helps student teachers with visual impairment
- Remember to repeat the main points of the lessons.

b) Gender education

Emphasize to student teachers that anybody irrespective of their gender can present and reports during group activities. Give a role model who are successful in real life without considering their gender, make sure that during experiments both boys and girls shares and participates equally the works.

c) Environment and sustainability

Student teachers get basic knowledge from the natural sciences, so introductory to biodiversity through collections of specimens, student teachers understand and interpret principles of sustainability. They also get skills and attitudes that will enable them in their everyday life to address the environment and climate change issue and to have a sustainable livelihood. Help the student teachers to know maximum skills and attitudes on the environmental sustainability and to be responsible of environmental care.

d) Financial education

In biodiversity, some organisms are beneficial economically as they can be used to generate incomes.

2.4. Guidance on introductory activity 2

The tutor guide student teachers to use text books and work on the introductory activity 2 as written in student teachers, text books.

- Engage student teachers to work collectively on the introductory activity.
- Ask any four student teachers to present their findings while others are following.

Possible answers to the introductory activity:

a. student teachers should list all living organisms they see including plants and animals
b. Answers may vary according to organisms considered. Plants are eaten by animals.
c. Climate factors may affect all organisms. Long dry season may cause plants to dry up and die, and animals will not find the food.

2.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Meaning of key ecological terms and Identification of biodiversity	Define key ecological terms and explain biodiversity Identify the components of biodiversity and evaluate the consequences of its loss Characterise the biotic and abiotic components that define Rwanda's ecosystems (e.g., freshwater, marine, and terrestrial).	2
2	Sampling techniques and methods to determine the distribution and abundance of organisms in area	- Explain the importance of random sampling in determining the biodiversity of an area - Use suitable survey methods to assess the distribution and abundance of organisms in a local area	1
3	Spearman's rank and Pearson's linear correlation and Simpson's Index of Diversity (D)	- Use Spearman's rank correlation and Pearson's linear correlation to analyse the relationships between the distribution and abundance of species and abiotic or biotic factors. - Apply Simpson's Index in measuring the diversity of an area - Evaluate the effects of human population size, resource use, and technology on environmental quality.	2
4	End unit assessment 2		1

Lesson 1: Meaning of key ecological terms and identification of biodiversity

a) Learning objective

- Define key ecological terms and explain biodiversity
- Identify the components of biodiversity and evaluate the consequences of its loss

- Characterise the biotic and abiotic components that define Rwanda's ecosystems (e.g., freshwater, marine, and terrestrial).

b) Teaching resources

Different student teachers' books, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

The student teachers have a notion on biodiversity from ordinary level where they studied kingdoms of different living organisms. From there, they got knowledge, skills and attitudes and values which can conduct them to study well this lesson.

d) Learning activity

The tutor guides student teachers to use text books and work on the activity 2.1 which involves to explain the meaning of some ecological terms: (Species, Ecosystem, Niche, population, community and biodiversity) as written in student teachers' text books.

- Engage student teachers to work collectively on the activity.
- Ask any four student teachers to present their findings while others are following.
- The meaning of these ecological terms are found in content summary of the lesson 2.1.

Answers to learning activity 2.1

- **Species** is a group of closely related organisms which are capable of interbreeding to produce fertile offspring
- An **ecosystem** is a collection of all the organisms that live together in a particular place, together with their nonliving, or physical environment.
- An **ecological niche** is the status or the role of an organism in its habitat or the mode of life of an organism within its habitats.
- An **ecological population** is a group of individuals of the same species which live in a particular area at any given time.
- An **ecological community** consists of populations of different species which live in the same place at the same time, and interact with each other.

- **Biodiversity** is defined as the full range of variety and variability within and among living organisms and the ecological complexes in which they occur

Application activity 2.1

a. **Genetic diversity:** the combination of different genes found within a population of a single species, and the patterns of variation found within different populations of the same species. These variations are caused by the gene mutations or chromosomal mutations which create differences in individuals of the same species.

b. **Species diversity:** this is concerned with variation in number of species and their relative abundance in an area in which they inhabit. All species are different from each other. These could be structural differences, such as the difference between a mango tree and a cow. They could also be functional differences, such as the differences between bacteria that cause decay and those that help us to digest food.

c. **Ecosystem diversity:** this is concerned with variations in ecosystems or habitats that occur within a region. Environmental factors like climate change may cause diversity of habitats or systems within a region.

Lesson 2: Sampling techniques and methods to determine the distribution and abundance of organisms in area

a) Learning objective

- Explain the importance of sampling techniques in determining the biodiversity of an area
- Use suitable survey methods to assess the distribution and abundance of organisms in a local area

b) Teaching resources

Different student teacher's books, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

The student teachers have a notion on biodiversity from ordinary level where they studied kingdoms of different living organisms. They also learned the meaning of ecological terms types of biodiversity in previous lesson. From there, they got knowledge, skills and attitudes and values which can conduct them to study well this lesson.

d) Learning activity

The tutor guides student teacher's to use text books and work on the activity 2.2 which involves to discuss sampling techniques, and methods to determine distribution and abundance of organism in an area as written in student teacher's text books.

- Engage student teachers to work collectively on the activity.
- Ask any four students teachers to present their findings while others are following.
- The sampling techniques, and methods to determine distribution and abundance of organisms in an area are discussed in content of the lesson 2.2.

Expected Answers to activity 2.2 are:

- Figure a) represent netting methods of sampling
- Figure b) represent line transect sampling method
- The methods to determine distribution and abundance of organism in an area are listed in student teachers book. Unit 2.

e) Answers to application activity 2.2

1. Simple random sampling is as simple and accurate. This gives it a strong advantage when conducting research on a larger population.
2. You provide the square quadrats $1m^2$, long wire to each group of student teachers and conduct them in school garden. Remember to tell them to avoid dangerous insects. Allow students teachers to work themselves and present their products. The formula used is $D = 1 - \sum(n/N)^2$
3. Expected answers are:

The benefits of using the following sampling techniques:

i. Quadrats:

- These techniques are simple.
- These techniques can be easily ample many different times
- These are good for the ground that is flat

ii. Transect:

- This is simple technique.
- It may be applied to sample different areas of ecosystem

- This technique indicates change in land as well as organism abundance.

iii. Mark and recapture

- This technique can be applied for first mobile animals

4. Expected answers:

- Quadrats are used when the organisms to be sampled are immobile.
- Transect technique is used when change over time of topography from the air under the see is measured.
- Mark and recapture technique is used when to count first moving animas difficult to see

Lesson 3: Spearman's rank and Pearson's linear correlation

a) Learning objective

Sampling techniques and methods to determine the distribution and abundance of organisms in area.

b) Teaching resources

Different student teachers books, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

The student teachers have a notion on biodiversity from ordinary level where they studied kingdoms of different living organisms. They learned the meaning of ecological terms types of biodiversity in previous lesson. They also studied sampling techniques and methods to determine the distribution and abundance of organisms in area. From there, they got knowledge, skills and attitudes and values which can conduct them to study well this lesson.

d) Learning activities

The tutor guides student teachers to use text books and work on the Activity 2.3.1 and activity 2.3.2 which involves to explain the process of Spearman's ranking and Pearson's linear correlation and to explain the purpose of calculating the Simpson diversity index, and how to calculate Simpson index D, Simpson index of diversity and Simpson reciprocal index as written in student teachers' text books.

- Engage student teachers to work collectively on the activity.
- Ask any four students to present their findings while others are following.
- Information about how to explain the process of Spearman's ranking and Pearson's linear correlation and to explain the purpose of calculating the Simpson diversity index, and how to calculate Simpson index D, Simpson index of diversity and Simpson reciprocal index are discussed in content summary of the **unit 2.lesson 2.3.**

e) Application activities 2.3

1. To decide if there is an association between collected data, a correlation coefficient is calculated and plot scatter graph drawn in order to make a judgment. The strongest correlation is present for studied items when all the points lie on a straight line. In this case, there is **linear correlation**, and the **correlation coefficient equals 1**.
   a. If a given variable X increases so does another variable Y, the relationship is **a positive correlation**.
   b. If a variable X increases while the variable Y decreases, then the relationship is **a negative correlation**.
   c. **A correlation coefficient of 0** means that there is no correlation at all.
2. The species richness is the number of species in an area, while the species evenness is a measure of how many individuals of each species are present.
3. Ensure you sample at different depths in water. Ensure you sample the mud. Ensure you sample at different distances from the bank. Ensure you have adequate footwear, and don't fall in.
4. In a habitat with high diversity, there is a complex feeding structure and any one species relies on many others. If one food species disappear, predators can feed on others. In a simple, low-diversity habitat, one species may rely entirely upon another. If the food species disappear, the predators will have no food and also disappear.
5. a.

Species	Number (n)	n/N	$(n/N)^2$
A	56	0.448	0.200
B	48	0.384	0.147
C	12	0.096	0.009
D	6	0.048	0.002

E	3	0.024	0.0003
Sum of $(n/N)^2$			0.358
$D = 1 - \sum (n/N)^2$			0.641
1-D			0.359

b. The Simpson diversity index is used to measure diversity of area surveyed.

c. The area surveyed is less diverse as the value of the Simpson diversity index is low (0.359).

6. The vegetation in an open area inhabited by grasslands with 0.8 is more diverse, while the vegetation beneath some conifer trees with 0.2 is less diverse.

2.6. Summary of the unit

The unit **"introduction to biodiversity"** is divided into three sub-headings: Meaning of key ecological terms and Identification of biodiversity, Sampling techniques and methods to determine the distribution and abundance of organisms in area and Spearman's rank and Pearson's linear correlation and Simpson's Index of Diversity (D)

It deals with:

Defining some ecological terms and Identification of biodiversity. **Species** is a group of closely related organisms which are capable of interbreeding to produce fertile offspring. Occasionally two organisms which are genetically closely related but not of the same species can interbreed to produce infertile offspring. For example, a cross between a **donkey** and a **horse**, produces a **mule**, which is infertile. Hence, a donkey and a horse do not belong in the same species. Another example includes lions and tigers belonging in different species. However, when a male tiger mates with a female lion they can have fertile offspring called **tiglons**, although the offspring of female tigers and male lions called **ligers** are not fertile. Note that normally tigers are forest dwellers and lions are plains dwellers and they are ecologically isolated. Breeding has only been observed in captivity.

Sampling techniques and methods to determine the distribution and abundance of organisms in area and Spearman's rank. **Random sampling method**

A random sampling method is a sampling method where samples are taken from different positions within a habitat and those positions are chosen randomly. Random sampling in important to avoid the bias.

Quadrat sampling method

A quadrat is a square area that is marked using a pre-made square of plastic, or stakes and string and it can range in size. Different species and their numbers within the quadrat are counted. Counting is repeated many times in different places in the habitat to get an accurate representation of biodiversity.

Pearson's linear correlation and Simpson's Index of Diversity (D). Simpson index D can be expressed in two ways and takes into consideration the total number of organisms of a particular species and the total number of organisms of all species. It is calculated as follows: D =1-$\sum$ (n/N)^2 or $\mathbf{D = 1 - \frac{\sum n(n-1)}{N(N-1)}}$, with **n**: the total number of organisms of a particular species and **N**: the total number of organisms of all species. When the index equals or is nearby 0 there is an infinite diversity of considered species. When it equals or is nearby 1, this means that there is no diversity. The bigger the value of D, the lower the diversity and small is D, bigger is the diversity.

2.7. Additional information for tutors

The biodiversity in ecosystems may be composed of different living organisms, which are grouped into three domain (Eukarya, Archaebacteria, and Eubacteria)

2.8. Answers to the end unit assessment 2

1. A habitat is a specific area or place in which an individual organism lives.
2. Answers can vary. Some can be: Homes for humans, trees for birds and insects, hollows in soil for snakes woods and stones for lichens water dams for algae.
3. We share so many of our genes with plants simple because all living organisms risen from the same ancestor cell.
4. Some living organisms like: cows and sorghum have big value in cultural traditions in Rwanda.
5. Expected answers are:
   a. Water pollution is the contamination of water bodies
   b. Sedimentation, pollution, climate change, deforestation, landscape changes, and urban growth industrialization...

c. It would be a death of aquatic animals. It means that the main problem caused by water pollution is that it kills organisms that depend on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat.

6. Desertification is thought by scientists to be a consequence of climate change, has been considered to be related to deforestation. Disrupting water cycles and soil structure results into less rainfall in an area.

7. Biodiversity contributes to ecosystem goods and services. The ecosystem goods and services include:

   - **Provisioning services** (provision of food, air, fire wood, medicines, energy, fresh water),
   - **Regulating services** (climate regulation, water purification, waste treatment, natural hazard),
   - **Supporting services** (nutrient cycling, primary production) and
   - **Cultural or aesthetic services** (recreation, ecotourism).

8. a. **Population** is a group of Individuals of the same species while **Community** is a group of populations of different species which live in the same place at the same time, and interact with each other

b.

Ecological niche	Habitat
Is the status or role of an organism in its habitat or the mode of life of an organism within its habitats	Is a specific area or place in which an individual organism lives

9. The two main component of ecosystem are biotic factors and abiotic factors. Biotic factors, these include all of the living organisms in an ecosystem and the interactions among themselves. Their interactions involve; producers, consumers and decomposers. Abiotic components, also called abiotic factors which are the non-living physical aspects of the environment such as the sunlight, soil, temperature, wind, water, and air.

10.

Species	N	n/N	$(n/N)^2$
Potato	2	0.133	0.018
Maize	8	0.533	0.284

Mango tree	1	0.060	0.004
Banana	1	0.060	0.004
Beans	3	0.2	0.04
			0.35
D= sum $(n/N)^2$			0.65
1-D			0.35

The area surveyed is less diverse as the value of the Simpson diversity index is low (0.35).

2.9. Additional activities

2.9.1. Remedial activities

1. What do you understand by the term biodiversity?
2. What do you think would happen to plants if there were no insects?
3. What do you think is importance of biodiversity?

Answers to the remedial activities

1. **Biodiversity** is defined as the full range of variety and variability within and among living organisms and the ecological complexes in which they occur Plants will not reproduce properly due to lack of pollination, and it will end by the plant extinction.
2. Biodiversity contributes to ecosystem goods and services. The ecosystem goods and services include:
   - **Provisioning** services (provision of food, air, fire wood, medicines, energy, fresh water),
   - **Regulating** services (climate regulation, water purification, waste treatment, natural hazard),
   - **Supporting** services (nutrient cycling, primary production) and
   - C**ultural** or **aesthetic** services (recreation, ecotourism).

2.9.2. Consolidation activities

1. Suggest different ways to conserve our forests.
2. Discuss the major factors leading to the degradation of ecosystems in Rwanda.
3. What would happen if biodiversity is completely lost?

Answers to the consolidation activities

1. Cutting of forest should be regulated by adopting methods like Clear cutting, Selective cutting, and Shelter wood cutting.
    - To avoid forest fire
    - Reafforestation and afforestation
    - Proper usage of forest products and forests.
2. Major factors leading to the degradation of ecosystems in Rwanda.
    - Habitat loss and the degradation of the environment
    - Introduction of invasive alien species and genetically modified organisms
    - Pollution
    - Climate change
    - Overexploitation of natural resources
3. Consequences of biodiversity loss:
    - They are various consequences of biodiversity loss. At the frontline, there is a change in ecosystem goods and services.
    - These changes lead to different natural dieters including droughts and floods associated to the decrease in food production, and high spread of diseases.

2.9.3. Extended activities

1. Describe how diversity is threatened by climate change and human activities.
2. Explain how forests contributes to the availability of clean water?
3. Distinguish between Ecological niche and habitat.
4. What will happen to living organisms if they have the same ecological niche?
5. Describe the effect of climate change on biodiversity loss

Answers to the extended activities

1. The climate change in the pattern of weather, related changes in oceans, land surfaces and ice sheets due to global warming resulting from man's activities. Increasing global temperatures have resulted into melting of icebergs raising sea levels and so flooding coastal areas eventually affecting the niche, and these may take the lives on many living things.

2. Forests on earth filter the usable water again and again, constantly recycling the water we use for drinking.

3. Difference between ecological niche and habitat

Ecological niche	Habitat
Is the status or role of an organism in its habitat or the mode of life of an organism within its habitats	is a specific area or place in which an individual organism lives

4. There will be competition and it will end by the extinction of some species.

5. Increased heat of the Earth's surface affects biodiversity. It leads to the death of various microorganisms, animal and plant species which failed to adapt to the new conditions. The following are some of the likely impacts of climate change on biodiversity:

   - The climate change will have differential effects on species. Some species will migrate through fragmented landscapes whilst others may not be able to do so.
   - Many species that are already vulnerable are likely to become extinct.
   - Changes in the frequency, intensity, extent, and locations of climatically and no climatically induced disturbances will affect how and at what rate the existing ecosystems will be replaced by new plant and animal assemblages.
   - Loss or fragmentation of forest habitat due to climate change is a major threat to biodiversity.
   - Climate change negatively affects crop production and cause vulnerable people to depend mostly on ecosystem services.
   - Climate change negatively impacts water bodies by increasing or dropping water levels.

UNIT 3

INTRODUCTION TO CLASSIFICATION

3.1. Key Unit competence

Apply the basic knowledge of classification to group living organisms into the three domains.

3.2. Prerequisite (knowledge, skills, attitudes and values

Students teachers have knowledge, skills, attitudes and values about biodiversity learnt in the previous unit "introduction to biodiversity". This will help them to learn well this unit.

3.3. Cross cutting issues to be addressed

a) Environment and sustainability

Guide Students teachers while collecting specimens and prevent them from cutting down plants and unnecessary killing of animals. Learners must recognise the significance of plants and animals in environmental protection. Students teachers also need to understand their positive roles in environment and sustainability.

b) Gender

In all lessons of this unit, this cross cutting issue can be integrated. As a teacher your role is to ensure gender equality in activities you conduct inside and outside the classroom. Gender can be integrated, for example by mix boys and girls in group work, while setting tasks and when presenting.

c) Comprehensive sexuality education (HIV/AIDS, STI, Family planning, Gender equality and reproductive health)

When facilitating a lesson of common bacterial diseases, learners need to be aware that syphilis and gonorrhoea are STIs and at the same time caused by bacteria.

Lesson of the structure and classification of viruses, integrate in this cross cutting issue. Link the cause of AIDS which is HIV to this issue and emphasise on preventative measures. Learners are required to put into practice the preventative measures of HIV/AIDS and STIs.

d) Peace and Values Education

The role of a teacher is to create and promote peace in a learning environment. Guide learners to ensure that all living organisms co – exist in harmony. This cross cutting issue can be integrated at any time in classroom, outside classroom, in school environment and anywhere in life. Teacher should not be a source of conflicts. Learners need to appreciate peace and values and advocate for positive behaviour among them.

3.4. Guidance on introductory activity 3

Guide student teachers to use their text books and work on the introductory activity 3, and request 2 students to present their findings. The factors conserved to make these groups may be the physical appearance of the organisms.

The seven groups formed may be:

Group	Organisms
1	Mosquito and house fly
2	Lizard and snake
3	Mango plant and citrus plant
4	Beans plant and soya beans
5	Maize plant and sorghum plant
6	Hen and duck
7	Chimpanzee and gorilla

3.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Taxonomic hierarchy and Three domains of life: Archaea, Bacteria and Eukarya	-Describe the classification of species into the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species. -Outline the characteristic features of the three domains (Archaea, Bacteria and Eukarya).	6

2	Kingdoms of organisms: Monera, Protoctista, Fungi, Plantae, Animalia.	-Outline the characteristic features of the kingdoms monera, Protoctista, Fungi, Plantae and Animalia. -Identify common bacterial diseases in plants and animals and demonstrate methods of preventing them -Discussing economic importance of bacteria.	5
3	Classification, Characteristics and economic importance of viruses	Describe and classify different viruses	4
4	Dichotomous keys for identification of organism	Design and apply a dichotomous key for a group of organisms.	4
5	End unit assessment		2

Lesson 1: Taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya

a) Learning objective

- Describe the classification of species into the taxonomic hierarchy: domain, kingdom, phylum, class, order, family, genus and species.
- Outline the characteristic features of the three domains (Archaea, Bacteria and Eukarya).

b) Teaching resources and aids may be:

Text books and internet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about biodiversity learnt in the previous unit. This will help them to learn well this lesson.

d) Learning activities 3.1.1

Activity 3.1.1:

Provide student teachers with papers and request them to make small parts of papers in form of cards on which they write a list of words such as continent, district, country, cell, province, sector, village and house family.

- Guide student teachers to arrange the small papers in increasing order of the size of the words written on them.
- Student teachers should say that the people of the same family have more similarities than those in the whole country.
- A good comparison should indicate that arrangement of the cards in increasing or decreasing order is similar to the increasing order of 8 groups of the biological taxonomic hierarchy.

The arrangement may be:

The largest	Continent	Domain
	Country	Kingdom
	Province	Phylum
	District	Class
	Sector	Order
	Cell	Family
	Village	Genus
The smallest	House family	Species

Application activity 3.1.1

For the answer refer to notes under 3.1.1.

Activity 3.1.2:

Guide student teachers to use their text books, or if in computer laboratory, guide them to use internet and work on the activity 3.1.2. So, they have to identify the characteristics of each of the three biological domains: archaea, bacteria and eukarya as they are discussed in the content summary of the sub heading 3.2: Three domains: archaea, bacteria and eukarya (main characteristics, types and economic importance).

Answers to application activity 3.1.2

1. The six kingdoms are: archaebacteria, eubacteria, Protista, fungi, plantae and Animalia.

2. Eukarya, Archaea and Bacteria.
3. Archaebacteria, eubacteria include only prokaryotes. Fungi and Animalia include only heterotrophs.
4. A domain is bigger than a kingdom, a domain is composed of many kingdoms.
5. This organism would be placed in in the kingdom protista, because it is unicellular, has a nuclear membrane, and contains chloroplasts.
6. This is true mainly about archaeabacteria that live in hot and acidic springs where temperatures exceed 100 and the pH may be as low as 2. These are termed as thermo acidophilic bacteria. e.g Nymphaea thermarum. However, some can inhabit in anaerobic habitats and give off methane as a product of their metabolism. They live in guts of cattle and are responsible for intestinal gases. These are referred to as methanogenic Archaeabacteria. Some are halophilic archaeabacteria and they live in very salty conditions such salt flats. They can grow in salt concentrations approaching saturation. Because they tolerate extreme conditions similar to those that are thought to have existed at the dawn of life, Archaea are believed to have been the first forms of life on earth.

Lesson 2: Characteristic features of the kingdoms: Protoctista, Fungi, Plantae, Monera and Animalia

a) Learning objective

- Outline the characteristic features of the kingdoms monera, Protoctista, Fungi, Plantae and Animalia.
- Identify common bacterial diseases in plants and animals and demonstrate methods of preventing them.
- Discussing economic importance of bacteria.

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about biodiversity learnt in the previous unit. They also learnt the taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya. This will help them to learn well this lesson.

d) Learning activities

Guide student teachers to use textbooks to discuss characteristic features of kingdoms: protoctista, fungi, plantae, monera and Animalia as indicated by the activity 3.1.2 from the student teachers' text books. They should discuss characteristic features as they are written in the content summary of the lesson 3.2. They also have to work on the activity 3.2.1, activity 3.2.3, activity 3.2.6, activity 3.2. 7 and give answers which should be related to the information given in the lesson 3.2

Application activity 3.2

1. The characteristics for each among the five kingdoms are discussed in the content summary of the lesson 3.2.
2. Protists have a wide range of feeding methods. They obtain food in the following ways:
   - Autotrophic nutrition in a process of photosynthesis for example in algae
   - Phagocytosis by engulfing food particles such as amoeba
   - Endocytosis; in ciliates such as paramecium that use oral groove
   - Others are parasitic like plasmodia that cause malaria.
3. Characteristics of protists are;
   - Eukaryotic organisms.
   - Mostly single-celled, or exist as groups of similar cells
   - Some have animal-like cells (no cell wall) and are sometimes known as protozoa
   - They feed by both autotrophic nutrition like algae and heterotrophic nutrition such as protozoa.
4. a) Classification of organisms into respective Kingdoms

Name of organism	Kingdom
Housefly	Animalia
Maize	Plantae
Frog	Animalia
Bat	Animalia
Eagle	Animalia

   b) Maize and frog because maize has chlorophyll and cell wall while in a frog they are absent

5. Plants have cells with chloroplasts that contain chlorophyll thus are autotrophs while members of fungi do not have chloroplasts and they feed heterotrophically ie are saprophytes.

Lesson 3. Classification, characteristics and economic importance of viruses

a) Learning objective

Describe and classify different viruses

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Students have knowledge, skills, attitudes and values about biodiversity learnt in the previous unit. They also learnt the taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya**.** This will help them to learn well this lesson.

d) Learning activity 3.3

Guide student teachers to use textbooks to classify viruses, explain the economic importances of viruses and discuss economic importance of viruses as indicated in the activity 3.3. They should give answers which are related to the information given in the lesson 3.3

Answers to application activity 3. 3

1. A virus is a particle of nucleic acid, proteins and in some cases lipids which can reproduce only by infecting living cells.
2. A typical virus is composed of core of DNA or RNA surrounded by a protein coat, which is called a capsid.
3. The virus enters a cell, makes copies of itself, and causes cell to burst. In another way, the virus embeds its DNA into the DNA of the host cell and replicates.
4. Bacteriophage is a virus that infects bacteria while a retrovirus is a virus that contains RNA.
5. Most biologists and students argue that viruses should not be considered as a form of life because they don't show all characteristics of living organisms hence exist between the border line of living things and non-living things

Lesson 4. Dichotomous keys for identification of organism

a) Learning objective

Design and apply a dichotomous key for a group of organisms.

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about biodiversity learnt in the previous unit. They also learnt the taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya. This will help them to learn well this lesson.

d) Learning activity 3.4

Guide Student teachers to use textbooks to classify these plants based on the external structure of the leaves as indicated in the activity 3.4. They should give answers which are related to the information given in the lesson 3.4

Answers to application activity 3.4

1. Phylum Arthropoda: because all organisms shown, have jointed appendages or legs and all possess exoskeleton.
2. The characteristic feature used to classify different insects is the presence or absence of wings, or the number of pairs of legs.
3. The spider has four pairs of legs while the mosquito has three pairs of the legs.
4. A millipede has a cylindrical body shape, while a centipede has a flattened body shape.
5. The characteristics like: **size** and **color** are often less considered to classify organisms because both can be influenced by the environment, the season, the age or state of the organism at the time of identification.

3.6. Summary of the unit

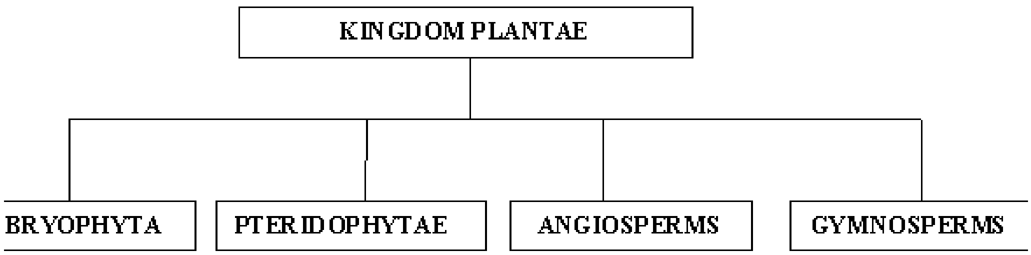
The unit "introduction to classification" is divided into four sub-headings: Taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya; Characteristic features of the kingdoms: Protoctista, Fungi, Plantae, Monera and Animalia; Classification, Characteristics and economic importance of viruses; and Dichotomous keys for identification of organism.

It deals with:

- Explaining the Taxonomic hierarchy and three domains of life: Archaea, Bacteria and Eukarya.
- Discussing the Characteristic features of the kingdoms: Protoctista, Fungi, Plantae, Monera and Animalia.
- Describing Classification, Characteristics and economic importance of viruses,
- Explaining the Dichotomous keys for identification of organism.

3.7. Additional information for tutors

The content in this unit is not enough to address all the necessary information especially the details of every kingdom. You need to know other information about the classification of living organisms. An example is summary of division of kingdom plantae as follows:



Division bryophyte: examples are Mosses, Liverworts and Hornworts.

- They are non-vascular land plants, which do not contain any conducting tissues and are often referred to as bryophytes.
- These plants are small, grow close to the ground and include mosses and liverworts.
- They are very small in structure and are considered as important members of our ecosystem.
- The reproduction process is carried in their spores. They are non-flowering plant and are found mainly growing on the ground, on other plants and on rocks.
- They play a vital role in preventing soil erosion

Division pteridophytae: examples are horsetails, ferns and club mosses.

- They are seedless vascular plants, which contain vascular tissues but do not produce seeds.
- They are involved in transportation of fluids.
- The reproduction process is carried by spores.

Division angiosperm: examples are trees, shrubs vines and all flowering plants

- Angiosperms are flowering plants, which develops the seeds within a protective structure.
- The reproduction process is carried by Angiosperm.
- They develop their seeds within an ovary, which itself is embedded in a flower. After the stage of fertilization, the flower falls and the ovary become a fruit.
- Angiosperms in the class Dicotyledonae grows into two seed-leaves (cotyledons).
- An angiosperms leaf consists of a single, branched, main vein, which originates from the base of the leaf blade. In few plants, it may also consist of four or more main veins diverging from the same base

Division Gymnosperm: examples are palms

- Gymnosperms are non-flowering plants with undeveloped seeds, which are present in an enclosed structure.
- Monocot begins with a single seed-leaf. The main veins of their leaves are usually parallel and unbranched.
- Monocot plays an important role in providing us with our primary sources of nutrition, which includes grains and fruits

3.8. Answers to the End unit assessment 3

1. b
2. a
3. c
4. a
5. a
6. c
7. d
8. c
9. c
10. c

11. The answers are given in the following table:

Structures	Organisms
Antennae	Fungus
Flagella	Snail
Spores	Housefly
Coiled shell	Euglena
Pseudopodia	Amoeba
Cilia	Paramecium

12. The following are the answers:
   a. X Protoctista and Y Monera
   b. The following are the answers:
      i. The answers are:
      - Both protoctista and monera exhibit autotrophic and heterotrophic nutrition.
      - Both x and y are unicellular organisms except few members of x such as algae.
      - Both have members with flagella.

      ii. Both x and fungi undergo parasitic mode of feeding.
      iii. Some members of protoctista such as algae and plantae both carry out photosynthesis.
      iv. Most members of x locomote like animals
13. Significance of classification;
   - To identify living organisms and place them into their correct groups basing on their observable characteristics.
   - To understand the evolutionary relationship between different organisms.
   - To arrange information about living organisms in order, for easy study purposes.
   - To enable biologists to identify characteristics of organisms.
   - To put organisms into small manageable groups basing on their similarities for easy study purpose

3.9. Additional activities

3.9.1 Remedial activities

1. The following is a list of organisms belonging to various kingdoms: housefly

(*Musca domestica*), maize (*Zea mays*), Frog (*Rana spp*), Bat and Eagle. Classify these organisms into their kingdoms.

Answer: Housefly, frog, bat, eagle belong to kingdom Animalia. Maize in kingdom plantae.

2. Describe the three main cell shapes of prokaryotes.

Answer: Rod-shaped bacilli, spherical-shaped cocci and corkscrew-shaped spirilli.

3. What is the role of certain bacteria in changing atmospheric Nitrogen in a form usable by plants?

Answer: Plants cannot use Nitrogen gas directly. Certain bacteria that have symbiotic relationships with plants carry out nitrogen fixation, which is the process of converting Nitrogen into a form plants can use.

3.9.2. Consolidation activities

1. Study the descriptions of the following organisms, and place them in the correct kingdom.

Organism A: Multicellular, photoautotrophic, with cell walls that contain cellulose.

Organism B: their cell walls lack peptidoglycan, and their cell membranes contain certain lipids that are not found in any other organism. Many live in of the most extreme environment, and can survive only in absence of Oxygen.

Organism C: Unicellular, eukaryotic organisms that have chloroplasts.

Answer:

Organism A: belongs in kingdom plantae.

Organism B: belongs in kingdom Archaebacteria.

Organism C: belongs in kingdom protoctist.

2. What is the best way to protect humans against most viral diseases?

Answer: The best way to protect humans against most viral diseases is prevention. Once a viral disease has been contracted, it might be too late to control the disease.

3. Suppose that bacteria lost the ability to fixe nitrogen in the soil. How would this affect the other organisms?

Answer: Because other organisms depend on bacteria for converting nitrogen gas into nitrogen compound, this organisms might die if bacteria loss their ability to fix nitrogen.

4. Does taxonomic classification place emphasis on the similarities between organisms, the differences between organisms or both? Explain your reasoning.

Answer: Taxonomic classification emphasizes both. Similarities place organisms together in large groups, and differences separate organisms into small groups.

3.9.3. Extended activities

1. Describe the two ways that viruses cause infection.

Answer: In lytic infection, a virus enters a cell, makes copies of itself, and causes cell to burst. In a lysogenic infection, the virus embeds its DNA into the DNA of the host cell and replicates.

2. Do you think viruses should be considered as a form of life? Give reasons for your answer.

Answer: Most biologists and students argue that viruses should not be considered as a form of life because they don't show all characteristics of living organisms hence exist between the border line of living things and non-living things. They are not classified in any of the five kingdoms because**:**

- Viruses are acellular – they do not have a cellular structure like bacteria and protists.
- They crystallize in isolation
- They do not reproduce, respire and feed outside the living cells. (Do not show the characteristics of a living cell).
- Viruses have none of the features that we traditionally use for classification.

3. The scientific name of blue monkey is ***Cercopithecus mitis*,** complete Kingdom, Phylum, class, genus and species of blue monkey.

Answer: Classification of a blue monkey.

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primate
Family	Cercopithidae
Genus	Cercopithecus
Species	mitis

Scientific name is ***Cercopithecus mitis***.

4. Both snakes and warms are tube-shaped, with no legs. How could you determine whether the similarity in shape means that they share a recent common ancestor?

Answer: Answers to student teachers should indicate that the internal structures would have to be examined for similarities and that the organisms would have to be examined genetic similarities and differences.

UNIT 4

SOLUTIONS AND TITRATION

4.1. Key Unit competence

Prepare standard solutions and use them to determine concentration of other solutions by titration.

4.2. Prerequisite (knowledge, skills, attitudes and values

Student-teachers will learn better solutions and titration if they have understanding on: The symbols of elements and their valences, unit 5, senior 1, concept of acids and bases, unit 11 senior 1concepts of mole and molecular mass, unit 7 Senior 2. The teacher will help learners to recap the concepts above.

4.3. Cross cutting issues to be addressed

a) Inclusive education:

This unit involves a number of formulae of substances, the writing of formulae and chemical reactions. This may be challenging to students with special educational needs especially students with visual impairment or visual difficulties.

However, the teacher can make some arrangements like the following:

- Grouping students
  - Students with special educational needs are grouped with others and assigned roles basing on individual student's abilities.
  - If a teacher has students with visual difficulties, when writing on the blackboard, write in large, clear writing, especially when it comes to formulae and chemical reactions. Read out what you are writing, for the benefit of those who are not able to see the blackboard clearly.
  - If learners are sharing textbooks, try to arrange for those with visual difficulties to have their own copies, as far as this is possible.
  - Give extra time for them to write summary notes or write down observations after experiments.

- Every important point is written and spoken.
- Remember to repeat the main points of the lessons.
- For students with visual impairment teacher can write of them a summary using the braille alphabet if possible.
- For learners with **hearing difficulties**, the teacher has to encourage them to sit closer to the front of the classroom. Stop every so often while teaching to ask learners whether they have understood, or if they need you to repeat a point. Encourage learners not to be afraid to ask questions.
- When teaching, speak clearly and ensure that all the learners can hear your voice. Avoid speaking hurriedly as this will make it difficult for learners with hearing difficulties to make sense of what you are saying.

▪ **Learners with mobility difficulties:**
  - These include learners in crutches, wheelchairs, or with walking difficulties.
  - Encourage other learners to look out for and help their classmates. Ask their follow learners to help them with their notes, if their conditions hinder them from writing well.

▪ **Learners with reading difficulties:**
  - Learners with this kind of difficulties struggle to make sense of words or understand written work and take longer to read than other learners.
  - Encourage them to pay careful attention during class time and participate for example by asking questions, answering questions, so that they can make the most of what they hear and observe. Instead of repeating word for word what is in the textbook, simplify the concepts to ease their understanding, so that when they have already understood.

b) Gender

During group activities try to form heterogeneous groups (with boys and girls) or when students start to present their findings encourage both (boys and girls) to present.

c) Financial education

As the unit deals with the importance of preparing solutions in modern life, the teacher will draw the learners' attention on the economic impact of preparing some solutions especially standard solutions and the importance of using just require chemicals.

d) Peace and values education

During group activities, the teacher will encourage learners to help each others and to respect opinions of colleagues.

e) Environment and sustainability

The attention of the students is drawn on the necessity of to not throw chemicals anywhere but rather to put them in appropriate containers.

4.4. Guidance on introductory activity 4

For this activity, the teacher forms groups of five students that are as heterogeneous as possible.

The teacher makes sure that each student from each group performs an activity.

The teacher provides a clear sheet for reporting. On this, there is among others the title of experiment, the observations and deductions.

The teacher asks randomly representative of two or three groups to present their findings.

After presentation, the teacher decides to engage the class into exploitation of the students' findings.

After presentation the teacher asks the students to judge findings from different groups and harmonise their work.

The teacher summarises their findings and introduce the new unit.

Answers to introductory activity

1. a) - 5% is the amount of ethanol that is in Beer 1, meaning that in 100Cl of Beer 1, there are 5cl of ethanol.

   - 5.5% is the amount of ethanol in Beer 2, meaning that in 100cl of Beer 2, there is 5.5cl of ethanol

   b) The total volume of alcohol(ethanol) in a bottle of 72cl of Beer 1 is 5*72/100 =3.6 cl

   c) The total volume of alcohol in a bottle of 65 of Beer 2 is 5.5*65/100 = 3.57 cl

2. Dilution 1: 5 is a dilution factor. This means that from one bottle of Fruit juice, you can make 5 bottles by diluting it with drinking water.

4.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Standard and primary standard solutions	Define the terms standard solution and primary standard solution.	3
2	Properties of a standard and primary standard primary solution	Explain the properties of a standard primary solution.	2
3	Preparation of standard solutions	Prepare solutions with different concentrations and interpret the titration results	2
4	Titration process focusing on precise measurements	Explain the titration process, emphasising the need for precise measurements. Carry out titrations, interpret resulting data and do calculations involved.	6
5	End unit assessment		2

Lesson 1. Standard and primary standard solutions

a) Learning objective

Define the terms standard solution and primary standard solution.

This is the first lesson of unit 4 and is a double lesson. That is to say it has two periods

(120 minutes). The first lesson also covers the introduction of the whole unit.

b) Teaching resources

Chalks, manila paper and flip charts

c) Prerequisites/Revision/Introduction (10minutes)

Students will learn better the definition of standard solutions and primary standard

solutions if they have understanding on: concepts of mole and molecular mass, unit 7 Senior 2, The concept of pure substances and mixtures, Senior 1, Unit 4, Concentration of solutions, senior 3, Unit 7.

d) Learning activities

Before introducing the lesson, the tutor has to introduce the whole unit. Let then learners

attempt activity 4.1 which leads students to the first lesson of the unit.

As a facilitator, you are expected to guide learners through the following steps:

- Ask students carefully to attempt the questions.
- Each student records his or her answers.
- Select some learners (2-4) to share their findings to the whole class
- Allow the rest of the class evaluate the findings of the presenters.
- Based on the student-teachers' finding write a summary about solutions and standard solutions.

Answers to activity 4.1

1. a) Solution is homogeneous mixture formed by dissolving one or more substances. The dissolving substance is called solvent and the dissolved substance(s) is (are) called solute(s). It may be liquid, gaseous or solid.

   b) Concentration is the amount of solute in a solution.

2. Perform a titration of the basic solution, NaOH (aq), using a solution of an acid such as hydrochloric acid with known concentration.

   Make a summary of the lesson (short notes: 10minutes) and assess the learners' understanding by letting them do the application activity 4.1.

e) Answers to application activity 4. 1

A standard solution is a solution whose concentration is known and therefore can be used as a secondary standard whereas a primary standard solution is a solution of a substance chemically stable that can be used to determine the concentrations of other solutions to an extremely high accuracy.

Lesson 2. Properties of a primary standard solution

a) Learning objective

Explain the properties of primary a standard solution.

b) Teaching resources

Manilla paper flip charts or chalkboard

c) Prerequisites/Revision/Introduction

Student-teahers will learn better the properties of primary of standard solutions if they have

understanding on: Mole concept (chemistry S2unit 7) and the concept of primary standard, TTc year 1 unit 4, Lesson 1.

d) Learning activities

- Before introducing the lesson, let learners therefore attempt activity 4.2 which leads students to the second lesson of the unit
- As facilitator you are expected to guide learners through the following steps:
- form groups of four and let the learners perform the activity 4.2
- Let some groups present their work to the class and allow the rest of the class to evaluate the work of their colleagues
- Comment on students' responses written in their note books, and give them the summary of expected feedback based on their findings.

Answers to activity 4.2:

See student teacher's book, unit 4 Lesson 2. Properties of a primary standard solution

- Assess the lesson by letting student-teachers do the application activity 4.2

e) Answers to application activity 4. 2:

See student teacher's book lesson 2: Properties of a primary standard solution

Lesson 3. Preparation of standard solutions

a) Learning objective

Prepare solutions with different concentrations and interpret the titration results

b) Teaching resources

Volumetric flasks, beakers, spatulas, electronic balance, funnels, stoppers, sodium peroxide, **glass rods and distilled water**

c) Prerequisites/Revision/Introduction

Students will learn better the preparation of standard solutions if they have understanding on: concepts of mole and gas laws, unit 7 Senior 2, Concentration of solutions, senior 3, Unit 7.

d) Learning activities

The activity 4.3.1., The activity 4.3.2 and The activity 4.3.3 are facilitated in the same way. The tutor forms groups, and let student-teachers do the concerned activity using their prior knowledge about mole concept and expressions of concentration by using calculations involved.

Expected Answers to activity 4.3.1., activity 4.3.2 and activity 4.3.3: Refer to content in student teacher book under those activities respectively.

e) Application activities

The tutor assesses the skills of the student-teachers by letting them doing the application activity 4.3.1., activity 4.3.2 and activity 4.3.3

The tutor asks 3 groups to present their work.

Allow the rest of the class to evaluate their colleagues.

Based on learners' production, the tutor summarizes the student-teachers' ideas.

Answers to application activity 4.3.1

Preparation of 1L 0.02M $KMnO_4$

a. Calculations involved

(i) **Number of moles of $KMnO_4$ in 1L of a 0.02M solution**
$M = n/V$ or $n = M \times V$
$n = 0.01mol/L \times 1L = 0.01mol$

(ii) **Mass of $KMnO_4$needed:**
Molar mass of $KMnO_4$= 158g/mol
$n = \frac{m}{Mm}$ or $m = n \times Mm$
Mass of $KMnO_4$= 0.01mol x 158g/mol = 1.58g

b. Procedure

i. Using a balance weigh 1.58g of $KMnO_4$;

ii. Carefully transfer into a 1L volumetric flask containing approximately 700mL of distilled water, using a funnel and a wash bottle;

iii. Stopper the flask and gently shake the mixture until there is complete dissolution;

iv. Add more water until the level is about 1cm below the mark of the flask;

v. Using a dropper, add the rest of distilled water, drop by drop, until the graduation mark is reached;

vi. Stopper the volumetric flask and gently shake again for homogenisation of the solution.

The solution prepared is 1L of 0,01M $KMnO_4$.

vii. Label the solution.

Preparation of 250mL of a 5g/L

a. Calculations involved

Mass of oxalic in 250mL = (5g x250)/ 1000 = 2.5g$\frac{m}{Mm}$

Mass of oxalic acid needed = 2.5g

b. Procedure

i. Using a balance weigh 2.5g of oxalic acid;

ii. Carefully transfer into a 250mL volumetric flask containing approximately 100mL of distilled water, using a funnel and a wash bottle;

iii. Stopper the flask and gently shake the mixture until there is complete dissolution;

iv. Add more water until the level is about 1cm below the mark of the flask;

v. Using a dropper, add the rest of distilled water, drop by drop, until the graduation mark is reached;

vi. Stopper the volumetric flask and gently shake again.

The solution prepared is 10g/L oxalic acid.

Answers to application activity 4.3.2

a. Calculations involved

(i) Mass of HCl contained in one litre = 1.18g/mLx1000mL = 1180g

(ii) Mass of 36% HCl in one litre = $1180\text{g}\times\frac{36}{100}$ = 424.8g

(iii) Number of moles of HCl in one litre = $\frac{424.8g}{36.5g/mol}$ = 11.64mol

The molar concentration of 36% HCl is 11.64M

(iv) Number of moles of 0.5M needed in 500mL (0.500L) = $\frac{0.5mol}{L}$ x 0.500L=0.25mol

(v) Volume of 36% HCl needed to prepare 500mL of 0.3M HCl = $\frac{0.25mol}{11.64mol/L}$ = 0.02148L

In general: molarity of the stock solution = $\frac{\mathbf{D \times 10 \times P}}{\mathbf{M_m}}$

a. Procedure

i. Using a graduated pipette or a burette, measure 21.48mL of concentrated HCl;

ii. Using a funnel, carefully transfer the concentrated acid into a 500mL volumetric flask containing about 300mL of distilled water;

iii. Put a stopper and gently shake the mixture;

iv. Using a wash bottle, add more distilled water until the level is 1cm below the mark;

v. Using a dropper pipette, make up to 500mL dropwise;

vi. Stopper the volumetric flask and gently shake.

The solution prepared is 0.5M HCl.

vii. Label the solution.

Lesson 4. Titration process focusing on precise measurements

Sub lesson 4.4.1. Simple acid-base titrations

a) Learning objectives

Explain the titration process, emphasising the need for precise measurements.

Carry out titrations, interpret resulting data and do calculations involved.

b) Teaching resources

Requirements

- Retort stand
- Clamp
- Burette
- Pipette
- Conical flask
- Beaker
- Wash bottle
- Glass rod

- Acid solutions such as HCl(aq), H_2SO_4(aq)
- Basic solutions such as NaOH(aq), KOH(aq)
- Phenolphthalein or methyl orange
- Distilled water

c) Prerequisites/Revision/Introduction

Students will learn better the preparation of standard solutions if they have understanding on: concepts of mole and gas laws, unit 7 Senior 2, Concentration of solutions, senior 3, unit 7.

d) Learning activities

Guidance

Before the practical

- Try to copy this activity on a worksheet and make copies equal to the number of groups that you will form according to your class size.
- Try to make the required materials available before your students enter (go) in the laboratory.
- Fill burettes with titrant solution for each group.
- Prepare all chemicals needed to perform this practical activity.
- Make sure you understand well the content (theory) about the practical to be performed so as to help students link it with their observations

During practicals

- Form groups of 3/4.
- Give them worksheet and ask them to read instructions.
- Ask them to read the procedure written on the worksheet and verify if all chemicals and apparatus are available and well prepared.
- Provide each group with a reporting sheet.
- Let learners perform the experiment as described in the procedure.

- Move around to ensure that all learners are actively engaged.
- Every group records their observations and make an interpretation.
- Call upon randomly four groups to share their results
- Let the class evaluate the findings of their colleagues and point out the key ideas about the hydration titration.
- Write a short summary about the titration.

Answers to activity 4.4.1

See student teacher's book, lesson 4: Titration process focusing on precise measurements

e) Answers to Application activity 4.4.1

1. Balanced equation for the reaction between $Ba(OH)_2$ and HCl:

   $Ba(OH)_2(aq) + HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

   Number of moles of HCl that reacted = MxV = 0.008mol

   From the equation, the mole ratio for $Ba(OH)_2$: HCl =1:2

   Hence 0.008mole of HCl reacts with 0.004mol of $Ba(OH)_2$

   Remember, Molarity = nxv

   So, Molarity of $Ba(OH)_2$ = 0.1M.

2. Equation of the reaction:

   $NaOH(aq) + HCl(aq)\ NaCl(aq) + H_2O(l)$

   Moles of HCl that reacted =MxV = 0.25moldm-3 x 0.015dm^3 = 3.75x10^{-3} mol

   Moles of NaOH neutralized =moles of HCl, since the mole ratio of

   NaOH:HCl is 1:1 = 3.75x10^{-3}mol.

   Molarity of NaOH solution =0.15M.

3. For this question, student-teachers are supposed to perform this practical activity and then use results to answer the questions asked.

Sub lesson 4.4.2. Determination of atomic masses by titration

a) Learning objectives

Explain the titration process, emphasising the need for precise measurements.

Carry out titrations, interpret resulting data and do calculations involved.

b) Teaching resources

Textbooks, internet connection, manila paper/ chalk board

c) Prerequisites/Revision/Introduction

Student teachers will learn better the preparation of standard solutions if they have understanding on: concepts of mole and gas laws, unit 7 Senior 2, Concentration of solutions, senior 3, unit 7.

d) Learning activities

Before introducing the lesson, let learners therefore attempt activity 4.4.1 which leads students to the second lesson of the unit.

As facilitator you are expected to guide learners through the following steps:

- form groups of four and let the learners perform the activity 4.2
- Let some groups present their work to the class and allow the rest of the class to evaluate the work of their colleagues
- Comment on students' responses written in their note books, and give them the summary of expected feedback based on their findings.

Expected answers to activity 4.4.2

See student teacher's book sub lesson 4.4.2

e) Expected Answers to application activity 4.4.2

Number of moles of the acid = 0.0037 x0.11 = 0.0037mol

0.037mol of the acid weigh 0.4955g

1mole of the acid weighs 0.4955g: 0.0037mol = 133.92g/mol ≈134g/mol

The molar mass of the acid is 134g/mol.

Sub lesson 4.4.3. Determination of number of moles of water of crystallisation

a) Learning objectives

Explain the titration process, emphasising the need for precise measurements.

Carry out titrations, interpret resulting data and do calculations involved.

b) Teaching resources

- Internet
- Books
- Manila paper or chalk board

c) Prerequisites/Revision/Introduction

Students will learn better the preparation of standard solutions if they have understanding on: concepts of mole and gas laws, unit 7 Senior 2, Concentration of solutions, senior 3, unit 7.

d) Learning activities

As facilitator you are expected to guide learners through the following steps:

- Form groups of four and let the learners perform the activity 4.4.3
- Let some groups present their work to the class and allow the rest of the class to evaluate the work of their colleagues
- Comment on students' responses written in their note books, and give them the summary of expected feedback based on their findings.

Expected answers to activity 4.4.3

See student teacher's book sub lesson 4.4.3

e) Expected Answers to application activity 4.4.3

Number of moles of NaOH used = $\frac{15.9mL}{1000mL}$ x 0.50mol = 0.00795mol
Since the equation of the reaction is:

$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(l)$,

The number of moles of $H_2C_2O_4$ is 0.00795mol/2 = 0.003975mol
Number of moles of $H_2C_2O_4$ in 1000mL = $\frac{0.003975mol}{0.025L}$ = 0.159moles
The molarity of $H_2C_2O_4$ is 0.159M
250mL of the solution contain 5.00g of $H_2C_2O_4$
1000mL of the solution contain $\frac{5.00g \text{ x } 1000mL}{250mL}$ = 20g of $H_2C_2O_4$
That is, mass concentration of $H_2C_2O_4$ = 20g/L
Molarity = $\frac{mass\ concentration}{Molar\ mass}$
Or molar mass = $\frac{mass\ concentration}{Molarity}$
Molar mass = $\frac{20g/L}{0.159mol/L}$ = 126g/mol
One mole of $H_2C_2O_4.xH_2O$ weighs 126g
That is 2 + (2 x 12) + (4 x 16) +(x x 18) = 126
90 + 18x = 126; x = 2
Formula of the compound: **$H_2C_2O_4.2H_2O$**

4.6. Summary of the unit

Standard solutions are those with known concentration. Primary standard solutions are used to standardise other solutions. The main characteristics of a primary standard are: high percentage purity and molecular weight, stability and non toxic. a standard solution is a solution containing a precisely known concentration of an element or a substance and used to determine the unknown

concentration of other solution. Standard solutions can be prepared by dissolution of solids or by diluting stock solutions.

In analytical chemistry, the titration is the controlled addition and measurement of the amount of a solution of known concentration required to react completely with a measured amount of a solution of unknown concentration. The point at which the two solutions used in a titration are present in chemically equivalent amount is the equivalence point.

There are many types of titrations: acid-base titrations, redox titrations, complexiometric titrations, and so on.

In this unit we have dealt with acid-base titrations with two their applications namely the determination of the number of moles of water of crystallisation and determination of relative atomic mass.

4.7. Additional information for tutors

The following substances cannot be used as primary standards:

1) Sodium hydroxide (NaOH) because:

i. It is deliquescent i.e. during weighing it absorbs water vapour from air, eventually forming a concentrated solution of the solid.

   $NaOH(s) + aq \rightarrow NaOH\ (aq)$

ii. It absorbs carbon dioxide from the air forming a solution of Na_2CO_3.

   $2NaOH\ (aq) + CO_2\ (g) \rightarrow Na_2CO_3\ (aq) + H_2O\ (l)$

   When excess carbon dioxide gas comes into contact with NaOH a white powder of sodium hydrogen carbonate is precipitated. This occurs when NaOH is either in solid pellet form or in a concentrated solution i.e.

   $NaOH\ (s) + CO_2\ (g) \rightarrow NaHCO_3\ (S)$

   $NaOH\ (aq) + CO_2\ (g) \rightarrow NaHCO_3\ (s)$
   (white powder)

2) Potassium permanganate ($KMnO_4$) because:

It is contaminated by MnO2 thus its solution should be filtered first before use.

In the presence of strongly alkaline solution, permanganate ion (MnO_4^-) are reduced to dark brown or gray-black MnO_2 i.e.

$$MnO_4^-(aq) + 2H_2O\ (l) + 3e^- \rightarrow MnO_2(s) + 4OH^-(aq)$$

(Deep purple) (Dark-brown)

It is slowly reduced by ordinary distilled water to manganese (IV) oxide, MnO_2 especially in the presence of acid or strong light i.e.

$$MnO_4^-(aq) + 4H^+(aq) \rightarrow 3O_2(g) + 2H_2O(l) + 4MnO_2(s)$$

MnO_4^- a very powerful oxidising agent cannot be acidified using hydrochloric acid. Only sulphuric acid can be used. MnO_4^- ions oxidizes the Cl^- ions to chlorine thus affecting the end-point i.e.

$$2MnO_4^-(aq) + 10Cl^-(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5Cl_2(g)$$

Note: $KMnO_4$ can be standardized using arsenic (III) oxide or sodium oxalate as primary standard.

3) Sodium thiosulphate ($Na_2S_2O_3$) because:

It has variable water content. When left exposed to air, its solution readily absorbs carbon dioxide from air, which forms carbonic acid. $S_2O_3^{2-}$ ions being very sensitive to acidic media (weak or strong) gets decomposed to SO_2(g) and sulphur which initially appears as a cloudy white precipitate suspended in solution which later settles down as a yellow solid as shown in the disproportionation reaction below:

$$S_2O_3^{2-}\ (aq) + 2H^+\ (aq) \rightarrow SO_2\ (g) + H_2O\ (l) + S\ (s)\ \text{(yellow)}$$

Other compounds which cannot be used as primary standards include:

4) Ammonium iron (II) sulphate because has variable composition.

5) Slaked lime, Ca $(OH)_2$ because is not readily soluble in water and it also reacts with carbon dioxide in air.

6) Conc.H_2SO_4 and CaO are hygroscopic.

7) Conc.HNO_3 is highly oxidizing.

8) Absolute ethanol has variable concentration and is volatile.

4.8. End unit assessment (answers)

Standard of performance: Correctly prepare standard solutions and use them to determine the concentration of other solutions by titration.

1. a) A standard solution is one whose concentration is known.

b) A primary standard is a compound of known concentration, which is used for preparing a standard solution.

2. Characteristics of a good primary standard are the following:

i. Must always be available pure form

ii. Must be stable in air

iii. Must be readily soluble in a given solvent

iv. Must have a high molecular weight and

v. Must give consistent titre values.

3. Equation for the reaction: $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Number of moles of HCl = $0.102 moldm^{-3} \times 0.030 dm^3 = 0.00306 mol$

Moles of NaOH in $25 cm^3$ = 0.00306mol (since the mole ratio is 1:1)

Moles of NaOH in $1.00 dm^3 = \frac{0.00306 mol \times 1}{0.025} = 0.1224 mol$

Mass of NaOH in the impure sample = 0.1224mol x 40g/mol = 4.896g

% purity of NaOH = $\frac{Mass\ of\ NaOH \times 100}{Mass\ of\ impure\ NaOH} = \frac{4.896 \times 100}{5} = 97.92\%$

4. Equation of the reaction:

$Na_2CO_3 (aq) + 2HNO_3 (aq) \rightarrow 2NaNO_3 (aq) + CO_2 (g) + H_2O (l)$

Number of moles of HNO_3 = 1x0.05 = 0.05mol

Molar ratio HNO_3: Na_2CO_3 =2 :1

5. Number of moles of NaOH used = $\frac{15.9 mL}{1000 mL} \times 0.50 mol = 0.00795 mol$

Since the equation of the reaction is:

$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(l)$,

The number of moles of $H_2C_2O_4$ is 0.00795mol/2 = 0.003975mol

Number of moles of $H_2C_2O_4$ in 1000mL = $\frac{0.003975mol}{0.025L}$ = 0.159moles

The molarity of $H_2C_2O_4$ is 0.159M

250mL of the solution contain 5.00g of $H_2C_2O_4$

1000mL of the solution contain $\frac{5.00g \times 1000mL}{250mL}$ = 20g of $H_2C_2O_4$

That is, mass concentration of $H_2C_2O_4$ = 20g/L

Molarity = $\frac{mass\ concentration}{Molar\ mass}$

Or molar mass = $\frac{mass\ concentration}{Molarity}$

Molar mass = $\frac{20g/L}{0.159mol/L}$ = 126g/mol

One mole of $H_2C_2O_4.xH_2O$ weighs 126g

That is 2 + (2 x 12) + (4 x 16) +(x x 18) = 126

90 + 18x = 126;   x = 2

Formula of the compound: **$H_2C_2O_4.2H_2O$**

6. a) **Phenolphtalein**

b) Calculate the necessary mass of ethanedioic to be dissolved in $250cm^3$according to the required concentration.

- Weigh the required mass of ethanedioic acid using an electronic balance and carefully transfer in a beaker containing 150mL of distilled water.
- Stir using a glass rod until complete dissolution.
- Using a filter funnel, transfer the solution and the washings, in a 250 mL volumetric flask.
- Using a wash bottle, add more distilled water up to about 1cm of the graduation mark.
- Using a dropper pipette, complete the volume the graduation mark.
- Stopper the flask and shake to homogeneous.
- Label the solution.

c) Moles of NaOH = 23.5×10^{-3} dm^3x 0.1 $moldm^{-3}$= 2.35×10^{-3}mol

d) (i) Moles of $(COOH)_2$ in $25cm^3 = 2.35x10^{-3}mol/2 = 1.175\ x10^{-3}mol$

(ii) Moles of $(COOH)_2$ in $250cm^3 = 1.175\ x10^{-3}mol\ x\ 10 = 1.175x10^{-2}mol$

e) (i) $1.175x10^{-3}mol$ of $(COOH)_2$ weighs 1.48 g.

1mol of $(COOH)_2$ weighs $1.48\ g/1.175x10^{-3}mol = 125.76g/mol \approx 126g/mol$

(ii) $90 + 18x = 126 \quad x = 2$

f) Wear gloves and a mask.

4.9. Additional activities (Questions and answers)

4.9.1 Remedial activities

1. Describe the procedure, including required calculations, for the preparation of 250ml of a 2.00M NaCl solution

a. Calculations involved

(i) Number of moles of NaCl in 250mL (or 0.250L) of a 0.4M solution

$M = n/V$ or $n = M\ x\ V$

$n = \frac{0.4mol}{L}\ x\ 0.250L = 0.1mol$

(ii) Mass of NaCl needed:

Molar mass of NaCl = 58.5g

$n = \frac{m}{Mm}$ or $m = n\ x\ Mm$

Mass of NaCl = 0.1mol x 58.5g/mol = 5.85g/mol

b. Procedure

i. Using an electronic balance weigh 5.85g g of NaCl;

ii. Carefully transfer into a 250ml volumetric flask containing approximately 100mL of distilled water, using a funnel and a wash bottle;

iii. Stopper the flask and gently shake the mixture until there is complete dissolution;

iv. Add more water until the level is about 1cm below the mark of the flask;

v. Using a dropper, add the rest of distilled water, drop by drop, until the graduation mark is reached;

vi. Stopper the volumetric flask and gently shake again.

The solution prepared is 250ml of 0,4M NaCl.

vii. Label the solution.

2. What is the molarity of a hydrochloric acid solution if 36.7mL of the HCl are neutralized by 43.2mL of 0.236M sodium hydroxide solution?

Answer:

a) Number of moles of NaOH used, $n_{NaOH} = M_{NaOH} \times V_{NaOH}$

b) Number of moles of HCl $= \frac{0.236mol}{L} \times 0.0432L = 0.0102mol$

c) The balanced equation of the reaction: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$, shows that one mole of HCl reacts with one mole of NaOH.

Thus, number of moles of HCl in 36.7mL is $n_{HCL} = 0.0102mol$

d) Molarity of HCl

Number of moles of HCl in one litre is: $n_{HCl} = \frac{0.0102mol \times 1000mL}{36.7mL} =$ 0.278mol

Thus molarity of HCl is 0.278M

Or molarity $= \frac{0.0102mol}{0.0367L} = 0.278M$

4.9.1. Consolidation activities

1. Give a description, including calculations involved, for the preparation of 0.5 litre of 1M HNO_3 from 70% concentrated nitric acid with density of $1.42g/cm^3$.

a. Preliminary calculations

$$M = \frac{D \times 10 \times P}{M_m} = \frac{1.42 \times 10 \times 70}{63} = 15.78$$

$$\mathbf{M_i \times V_i = M_f \times V_f}$$

$$V_i = \frac{1 \times 0.5}{15.78} = 0.03168L = 31.68mL$$

b. Procedure

i. Using a graduated pipette or a burette, measure 31.68mL of concentrated HNO_3;

ii. Using a funnel, carefully transfer the concentrated acid into a 500mL volumetric flask containing about 300mL of distilled water;

iii. Put a stopper and gently shake the mixture;

iv. Using a wash bottle, add more distilled water until the level is 1cm below the mark;

v. Using a dropper pipette, make up to 500mL;

vi. Stopper the volumetric flask and gently shake.

The solution prepared is 1M HNO_3.

vii. Label the solution.

2. 5.125g of washing soda crystals are dissolved and made up to 250cm^3 of solution.

   A 25.0cm^3 portion of the solution requires 35.8cm^3 of 0.0500M sulphuric acid for neutralisation. Calculate the percentage of sodium carbonate in the crystals.

Answer:

a) Write equation:

Na_2CO_3 (aq) + H_2SO_4 (aq) → Na_2SO_4 (aq) + CO_2 (g) +H_2O (l)

1mole of Na_2CO_3 neutralises 1 mole of H_2SO_4.

b) Calculate the amount, in moles, of the standard reagent.

Amount (mol) of H_2SO_4= $35.8 \times 10^{-3}dm^3 \times 0.05moldm^{-3} = 1.79 \times 10^{-3}mol$

Amount (mol) of Na_2CO_3 = $1.79 \times 10^{-3}mol$

But: Amount of Na_2CO_3 = $25.0 \times 10^{-3}dm^3 \times C$

Equate these two values: $1.79 \times 10^{-3}mol = 25.0 \times 10^{-3}dm^3 \times C$

$C=\frac{0.00179mol}{0.00025dm3} = 0.0716\ moldm^{-3}$

Amount (mol) of Na_2CO_3 in whole solution = volume x concentration

=250x10-3dm3 x 0.0716M =0.0179 mol

Mass of Na_2CO_3 = 0.0179mol x 106g mol^{-1} =1.90g

% of Na_2CO_3 $=\frac{1.90gX100}{5.125g}$ =37.1%

Washing soda crystals are 37.1% sodium carbonate.

4.9.3. Extended activities

1. Aim: To determine the atomic mass of the element X in the acid XCH_2COOH

Procedure:

The following solutions are provided. Solution FA1 made by dissolving 2.3625g of the acid to make 250cm^3 of solution. Solution FA2 was made by dissolving 4g of sodium hydroxide pellets to make 1000cm^3 of solution.

Results: 25cm^3 portion of FA_1 was titrated with 25.10cm^3 FA_2 using methyl orange indicator.

a. Calculate the molecular mass of the acid XCH_2COOH

b. Hence calculate the atomic weight of the element whose symbol is X.

Theory: The acid XCH_2COOH reacts with sodium hydroxide in a neutralization reaction by the equation.

$XCH_2COOH + NaOH \rightarrow XCH_2COONa + H_2O$

Answer:

a. Molarity of FA_2 (Sodium hydroxide) $=\frac{4}{40}=0.1M$

Therefore, 1000cm^3 of sodium hydroxide solution has 0.1mol

Therefore, 25.1cm^3 of sodium hydroxide solution has $=\frac{0.1x25.1}{1000}=0.00251$ mol

The number of moles of FA_2 which reacted = 0.00251mol, and since the mole ratio of reaction is 1:1, the number of moles of the acid reacted = 0.00251 mol.

25cm^3 of FA_1 pipetted contain 0.00251moles

1000cm^3 of FA1 would contain $\frac{0.00251x1000}{25}=0.1004$mol

Therefore Molarity of the acid solution = 0.1004mol

Since Molarity $=\frac{concentration\ in\ grams\ per\ litre\ of\ the\ acid}{Relative\ molecular\ mass\ of\ the\ acid}$

Relative molecular mass $=\frac{Concentration\ in\ grams\ per\ litre}{Molarity}$

The concentration in g/l of acid = 2.3625x4 = 9.45

Therefore Relative molecular mass $=\frac{9.45}{0.1004}=94$

b. Calculate the mass of X

$X + 24 + 32 + 3= 94$

$X = 94 – 59=35$

X is chlorine

Therefore, the acid is chloroethanoic acid: ClCH2COOH

UNIT 5

THIN LENSES

5.1. Key Unit competence

Interpret and solve problems on thin lenses and glass prism

5.2. Prerequisite (knowledge, skills, attitudes and values)

The student teacher will learn better this unit if he/she has the Knowledge, skills, values and attitudes related nature of light, reflection of light, refraction of light for Ordinary level and able to use ICT tools like computer, XO laptop.

5.3. Cross cutting issues to be addressed

Gender: Let the student teacher carry out activities in student teacher's book (if it is a mixed school, the number of boys and girls in each group should be balanced).

Inclusive education:

- All differentiation should be taken into consideration in solving different activities in this unit.
- Help them in selecting their group leaders. Identify student teacher with special needs in group making. -Encourage them to actively participate in their respective groups.

Peace and value:

- When student teachers are working activities, tell them that they can respect each other's opinion (don't blame someone, respect his/her ideas).
- Put learners in groups (select any number of learners depending on the size of the class) make sure that they work in harmony.

5.4. Guidance on introductory activity

- Invite student teachers to perform what is provided in introductory activity
- Request student teachers to answer questions asked and brainstorm

- Encourage student teachers to think in critical and innovative way
- Keep in mind that student teachers may not be able to find the right answers. You must guide them and orient their answers.
- Let student observe the images and think critically where are used in our daily life activities

5.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Types of lenses and their characteristics	- Outline types of lenses and their properties. - Differentiate between lenses and curved mirrors	2
2	Refraction of light through lenses	Explain the phenomenon of refraction of light by lenses	3
3	The thin lens equations	Derive and use the thin lens equations	2
4	Defects of lenses, their corrections and applications of lenses	- Outline defects of lenses and their corrections. - Describe the daily applications of lenses - Appreciate applications of lenses in real life situations	3
5	Refraction through prisms and related calculations.	- Observe and describe the shape of a prism - Derive expressions for deviation of light rays, minimum deviation, and angle of dispersion and refractive index of glass prism. - Predict and calculate the refraction of rays through prisms - Explain deviation by prism - Solve problems related to deviation by prism - Calculate the refractive index of a prism	8

		- Discuss the total internal reflection of light by prism - Solve problems related to thin lenses and glass prism.	6
6	End unit assessment		2

Lesson 1: Types of lenses and their characteristics

a) Learning objective

- Outline types of lenses and their properties.
- Differentiate between lenses and curved mirrors

b) Teaching resources

Concave and convex lenses, bi-convex lens, plano-convex lens, bi- concave lens, plano-concave, Lasers, candles, optical bench, screen microscope lens, and some eye glasses.

c) Prerequisites/Revision/Introduction

The student teachers will learn better this lesson if the tutor introduce it using the above teaching and learning resources.

d) Learning activity 5.1.

Guidance

- Provide the learners with the lenses and eye glasses and let the learners examine the physical features of the lenses.
- Let the learners touch and feel the lenses.
- With the use of guided questions lead the learners to discuss that lenses are pieces of glasses with curved surfaces.
- Take the learners into a dark room.
- Divide them in groups of four and provide each group with a convex lens, a concave lens and a torch.
- Let the learners shine light on each mounted lens and observe the emergent rays.
- Using leading and guided questions help the learners develop the concept of a converging lens and a diverging lens from their observation.

Answers to activity 5.1

a. In addition to crown glass and flint glass, modern day lens makers use quartz crystals and acrylic plastic. These materials may be used in combination.

b. Differ from their shapes and focal lengths

c. They are classified as concave and convex depending to their shapes

e) Application activity 5.1

Answer:

1. Refer to the summary of the activity 5.1

2. Make sure that the network is available in smart classroom

- Invite your student teacher to go in smart classroom to make a research on where the types of lenses are used in our daily life activities
- Tell them to bring report on what they find out.
- Comment on their reports

Lesson 2: Refraction of light through lenses

a) Learning objective

Explain the phenomenon of refraction of light by lenses

b) Teaching resources

Light box or flashlight, index cards or poster board (for image cutout) meter sticks, clean convex lens, clean concave lens, black poster board (for image screen), worksheet per student scissors, markers, tape, clamps, etc..

Student teacher may want to use various object around the classroom to help stabilize the upright position of the screen, lens, and image source

c) Prerequisites/Revision/Introduction

Student teacher will review on the types of lenses and its characteristics

d) Learning activity 5.2

Guidance

- Help student teacher to work the experiment provided in activity **5.2**

- Guide the experiment and distribute the TLMs according to the group formed
- Tell them to write the observation of their practices
- Pick some five learners at random to present to class their observations. Discuss the relevance of their experiment
- By use of challenging and thought provoking questions guide the learners to conclude the experiment
- Invite your student teacher to continue make a deep research on their practices

Answers to activity 5.2

- Guide the practices of the provided experiment
- Together with student teacher, make the conclusion of the experiment based on that:

Rays come from all points on the objects. Where these rays meet or appear to meet after refraction by the lens is the position of the image.

i. objects outside are inverted or reversed

ii. the objects are magnified

iii. Image is formed on the paper, if the paper is moved away the image becomes blurred

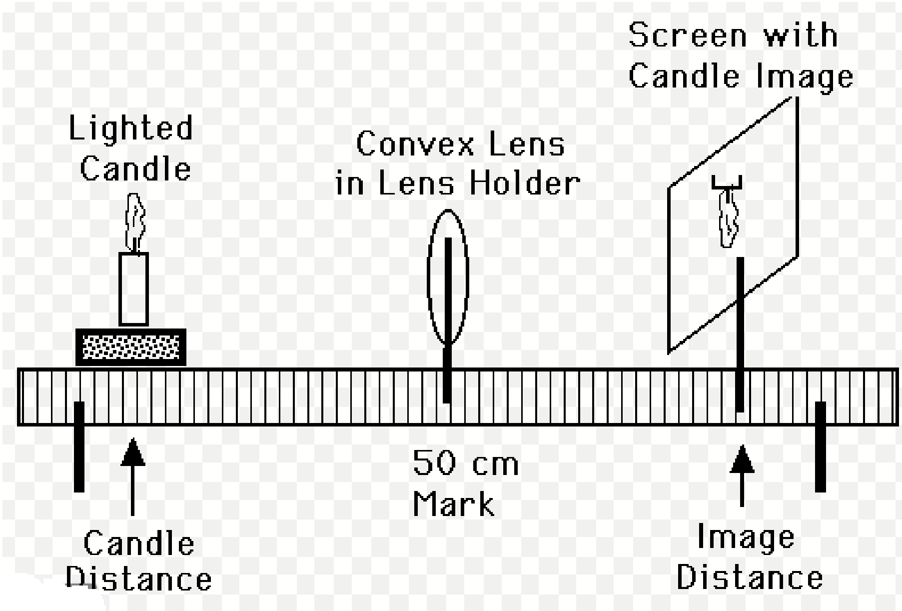
iv. Rays come from all points on the objects. Where these rays meet or appear to meet after refraction by the lens is the position of the image.

e) Application activity 5.2

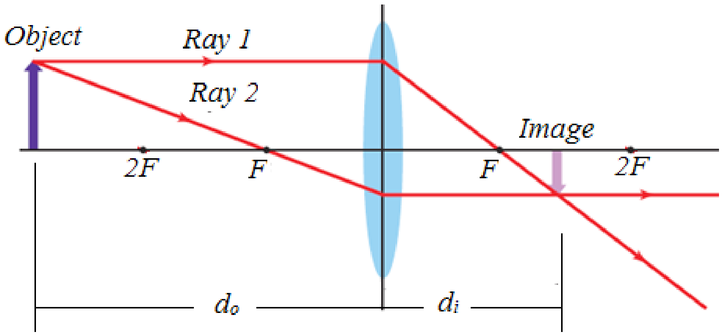
Answers:

1. Refer to the summary of the activity 5.2 in student teacher text book

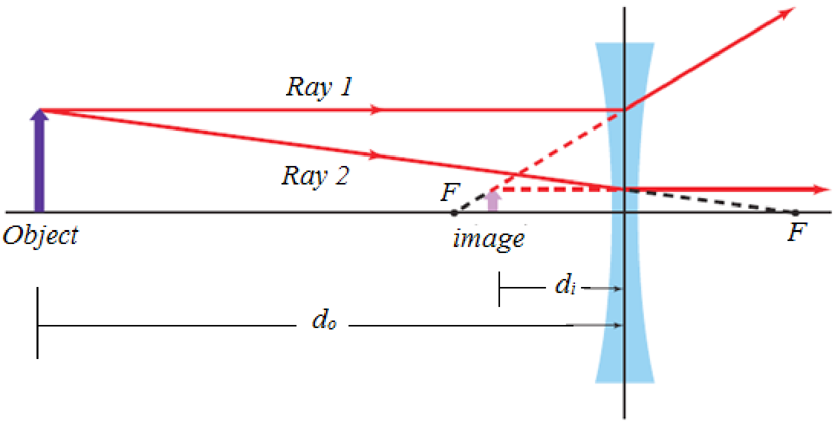
- Guide student teacher to perform the experiment, remember to change focal length
- Tell student teacher to write their observation



2. a. Converging or convex



b. Diverging or concave



Lesson 3: The thin lens equations

a) Learning objective

Derive and use the thin lens equations

b) Teaching resources

Concave and convex lenses, computer, projector

c) Prerequisites/Revision/Introduction

The student teacher will revise on calculation of focal length for diverging and converging lenses, review on graphical construction of images by diverging and converging lens

d) Learning activity 5.3

Guidance

- Guide the learners and use ray diagrams for several positions of the object, to derive the lens formula stating clearly all the assumptions made.
- Assumptions are: the lenses are thin and rays of light fall on a lens at points close to the principal axis.
- Using ray diagrams for several positions of the object, guide the learners to develop the lens' equation for concave lenses.
- Show the learners that for both cases of lenses, the lens formula holds.

Answers to activity: 5.3

Task 1:

Facilitate student teachers to do the experiment provided in the **activity 5.3.**

Remember to bring all required teaching and learning materials for helping student teacher to do the experiment.

Develop the concept that distances of real objects and real images are positive, and distances of virtual objects and images are negative.

Similarly, guide the learners to discover that the focal lens of a convex lens is positive and that of a concave lens is negative since their principal foci are real and virtual respectively.

Task 2:

Refer to the summary for activity 5.3

e) Application activity 5.3 Response

1. From u+v =10.0 and v=4u, we find u=2.0m and v=8.0m. Then

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}=\frac{1}{2.0m}+\frac{1}{8.0m}=\frac{5}{8.0m}\ or\ f=\frac{8.0m}{5}=+1.6m$$

2. Notice that $r_1>0$ and $r_2>0$ because both surfaces have their centers of curvature to the right. Consequently,

$$\frac{1}{f}=(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)=(1.54-1)\left(\frac{1}{20cm}-\frac{1}{40cm}\right)=\frac{0.54}{40cm}\ or\ f=+74cm$$

Since f turns out to be positive, the lens is converging.

Lesson 4: Defects of lenses, their corrections and applications of lenses

a) Learning objective

- Outline defects of lenses and their corrections.
- Describe the daily applications of lenses
- Appreciate applications of lenses in real life situations

b) Teaching resources

Glasses, flip chart, manila paper computer, projector, concave and convex lenses

c) Prerequisites/Revision/Introduction

The student teacher will have the prerequisite on image formation of different types of lenses, calculation of focal length of lenses, types of lenses and their characteristics.

d) Learning activity 5.4

Guidance

- Provide the student teachers with a ruler and a white sheet of papers.
- Instruct the student teachers to do activity 5.4 in the student teacher's books

- Provide the student teachers with a convex lens, let them repeat the same experiment with a convex lens.
- Using ray diagrams, describe how the defects can be minimized.
- Explain to the student teachers that if they had an achromatic doublet, they could do the experiment about minimizing chromatic aberration.

Answers to activity 5.4

Refer to the summary of the activity 5.4 in student teacher textbook

Explain to the student teachers that what they have observed using a ruler can also be observed when the lens is used but because the lens converges light rays, the rays come closer to each other and the colours of the image overlap and are not clearly seen.

Talk about the two types of defects; the spherical and chromatic aberration.

e) Application activity 5.4

i. Answer: Refer to the summary of the activity 5.4

- Spherical aberration can be reduced using lenses of large focal lengths and plano-convex lenses
- Chromatic aberration can be reduced using achromatic doublet (or achromat)

ii. If a plano-convex lens is used as objective lens in a telescope, convex surface should face the parallel rays.

Lesson 5: Refraction through prisms and related calculations

a) Learning objective

- Observe and describe the shape of a prism
- Derive expressions for deviation of light rays, minimum deviation, and angle of dispersion and refractive index of glass prism.
- Predict and calculate the refraction of rays through prisms
- Explain deviation by prism
- Solve problems related to deviation by prism
- Calculate the refractive index of a prism
- Discuss the total internal reflection of light by prism

b) Teaching resources

Prisms, protractor, computer, projector, white sheet of paper,Glass prism, optical pins, white sheet of paper, soft board and fixing pins

c) Prerequisites/Revision/Introduction

- The student teacher will revise on reflection and refraction rays diagram, refraction of light
- The student teachers revise on refraction through prisms and related calculations

d) Learning activity 5.5.1

Guidance

- Ask student teacher if they have ever seen a glass prism.
- Facilitate the student teacher in group formation
- Guide them in their discussions about the **activity 5.5** .1in student teacher textbook
- Provide the student teacher with an equilateral glass prism
- Let student manipulate the glass prism for identifying the properties of it
- From the observation of the angle of prism A, angle of incidence, angles of refraction on the two faces of the prism guide student teacher to explain the process of those different rays in glass prism using the flip chart of images on computer projected in front of all students.

Answers to activity 5.5.1

In optics, a prism is transparent material like glass or plastic that refracts light. At least two of the flat surfaces must have an angle less than 90^o between them. The exact angle between the surfaces depends on the application

Answers to Application activity 5.5.1

1. When a polychromatic light is incident on the first surface of the prism, each constituent colour gets refracted through a different angle. When these colours are incident on the second surface of the prism they are again refracted further. (Dispersion of light by a prism)

2. Invite student teacher to go in smart classroom and make research on provided activity.

- Make sure that the network is available
- Tell the student teacher to bring to you what they find out from their research
- Provide them a time for making comments of their findings.

Learning activity 5.5.2

Guidance

- Guide the student teachers to discover that the graph of a plot of ***sin i*** against, ***sin r*** is a straight line graph and the gradient represents the mean value of the refractive index of the prism material.
- Provide the student teachers with a glass prism of refracting angle 60^o, four optical pins, a white sheet of paper, a soft board and fixing pins
- Instruct the student teachers to work through **activity 5.5.2** in student teacher's book

Answers to activity 5.5.2

1. Guide the student teachers to conclude that the total deviation of a ray by the prism is due to refraction at both faces of the prism and is the sum of the deviation of the ray due to refraction at the first surface and its deviation at the second surface.

   Derive together with the student teachers an expression for deviation of light by the prism;

   $\mathbf{D = (i_1 + i_2) - A}$ by use of figure 5.17 in the student teacher's book.

Answers to application activity 5.5.2

1. A ray of light is refracted through 60^0 prism of ordinary glass. It is already known that the refractive index of ordinary glass is n=1.52 ….. (1)

Measure of angle of incidence $(i_1)=35^0$

By Snell's law in prism,

$\text{Sin } i_1 = n\sin r_1$

$\text{Sin } (35^0) = 1.52\sin r_1$

$$Sinr_1 = \frac{0.57}{1.52}$$

$r_1 = 23^0 \ldots.(2)$

Apex angle (A) of a 60^0 prism = 60^0

Also relation between apex angle and angle of reflection is

$A = r_1 + r_2$

$r_2 = 60-23 = 37^0$ ….(3)

Applying Snell's law for emergent ray (i_2) in prism,

$\text{Sin } i_2 = n\sin r_2$

$\text{Sin } i_2 = 1.52 \times \sin 37^0$

$i_2 = 66^0$ …..(4)

Angle of deviation (D) is given by:

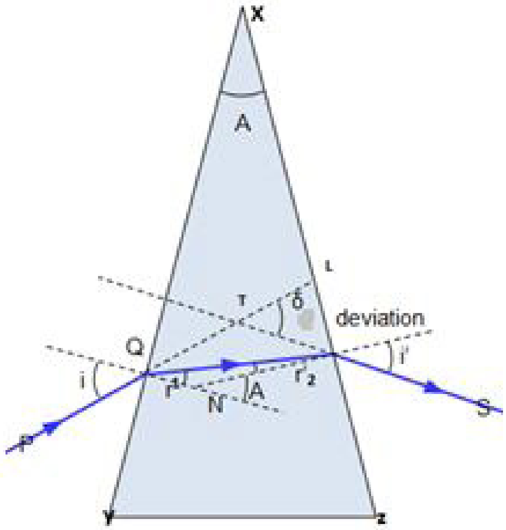
$D = i_1 + i_2 - A$

$D = 35+66-60 = 41^0$

2. When prism is symmetrical with respect to incident ray and emergent ray, i.e. when refracted ray from first face is parallel to base of the equilateral prism, angle of deviation becomes minimum.

   When, Incident ray = emergent ray, $r_1 = r_2$, then, Angle of deviation becomes minimum.

3. Consider a prism ABC of small angle A about 10 – 12 degree as shown in the figure



When a ray of light PQ making angle of incidence I incident on face AB, it is refraction in first face, r_2 is angle of incidence on RS. Here **e** is angle of emergence, r_1 is angle of refraction in first face, r_2 is angle of incidence on second face and D is the angle of deviation. The angle of deviation of the ray of PQ is given by

$$D = (i - r_1) + (e - r_2)$$

$$= (i + e) - (r_1 + r_2) \quad \ldots..(1)$$

At face AB,

$$n = \frac{\sin i}{\sin r_1} \ldots..(2)$$

Since angle of incident is small then,

Equation 2 become

$$n = \frac{i}{r_1}$$

Or , $i = nr_1$

Similarly at face AC,

$e = nr_2$

Substituting value of I and e in 1 we get

$= (n-1)(r_1+r_2)$

$= (n-1)(A)$ where $r_1 + r_2 = A$

$D= (n-1)(A)$

That is angle of deviation of a ray is independent with angle of incidence in a small angled prism

5.6. Summary of the unit

A **lens** is a transmissive optical device that focuses or disperses a light beam by means of refraction. A simple lens consists of a single piece of transparent material, while a compound lens consists of several simple lenses (*elements*), usually arranged along a common axis. Lenses are made from materials such as glass or plastic, and are ground and polished or molded to a desired shape. A lens can focus light to form an image, unlike a prism, which refracts light without focusing. Devices that similarly focus or disperse waves and radiation other than visible light are also called lenses, such as microwave lenses, electron lenses, acoustic lenses, or explosive lenses.

Thin Lens Equation

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

The thicker a lens gets, the less accurate the equation becomes.

In this equation, *u* is the object distance, or the distance of the object from the center of the lens. v is the image distance, or the distance to the image that the lens produces, again from the center of the lens. And *f* is the **focal length**, which is just a number that represents how strongly a particular lens converges or diverges light; it's a property of the lens itself. With lenses, distances are always measured along a central axis from the very center of a lens.

Lens maker's equation

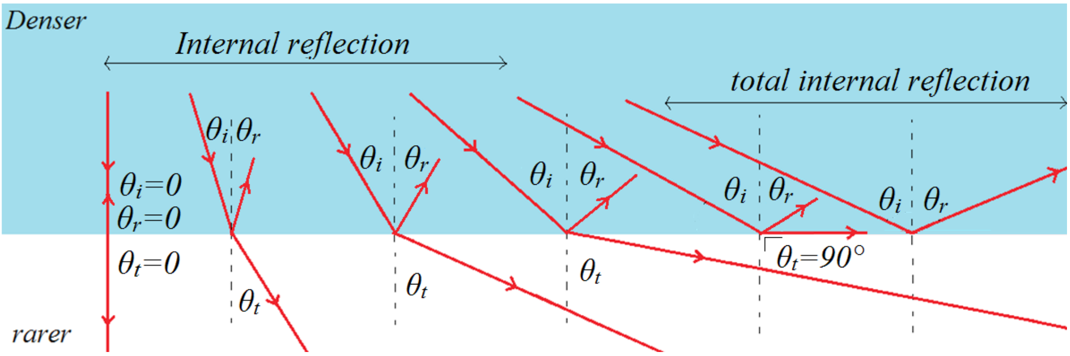
$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

5.7. Additional information for tutors

1. Internal reflection

Description

When light refracts into a medium whose index of refraction is smaller than the index of the previous medium, one part of the light refracts away from the normal while the other reflects back in the medium. Such reflection is commonly called **"internal reflection"**.



The angle of refraction may reach or approach 90° for some incident angle θ_c which is called **"critical angle"**. For incident angles greater than the critical angle there will be **"total internal reflection"** to mean that no part of light refracts. The critical angle can be calculated from Snell's law by setting the refraction angle equal to 90°

$$n_i \sin\theta_i = n_r \sin\theta_r$$

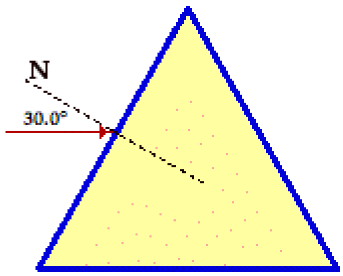
$$n_1 \sin\theta_c = n_2 \sin 90$$

$$n_1 \sin\theta_c = n_2 \times 1$$

$$\sin\theta c = \frac{n_2}{n_1}$$

$$\theta c = Sin^{-1}\left(\frac{n_2}{n_1}\right)$$

e.g: The triangular prism at the right is made of strontium titanate. A ray of light in air approaches the boundary at an angle of incidence of 30.0°. The ray strikes at the midpoint of one of the faces of the triangle.



a. Determine the angle of refraction upon entering into the prism.

b. Use geometric principles to determine the angle of incidence at the opposite side of the triangle.

c. Will the light ray refract out of the prism at this opposite face or will it undergo total internal reflection? Do the calculation and explain the answer.

Answer:

a. 12.0°

b. 48.0°

c. The critical angle is 24.5°. This light ray will not refract; it will undergo total internal reflection since the angle of incidence is greater than the critical angle.

5.8. Answers to end unit assessment 5

1. Convex lenses are thicker at the middle. Rays of light that pass through the lens are brought closer together (they converge). A convex lens is a converging lens. When parallel rays of light pass through a convex lens the refracted rays converge at one point called the principal focus.

2. When a ray of light passes from a less dense material (eg air) into a denser material (eg glass or water) it is bent away from the surface between the two materials. This means that in this situation the angle of refraction is always less than the angle of incidence.

3. If the 90^0 is in the glass, there is no solution. It's impossible! If it's in air then the refracted angle in the glass is about 45^0. A ray of light in the air enters a prism having 60° from one surface and emerges into the air from the other surface.

4. The factors responsible for the angle of deviation through prism are angle of incidence of incident ray and refractive index of the material.

5. Concave→Virtual→Upright→Smaller

   Convex→Virtual→Upright→Larger

   Convex→Real→Inverted→Smaller

6. The answer is found in **5.4** in student-teacher's book

7. Answer

$$\frac{1}{f}=\frac{1}{d_i}+\frac{1}{d_0}\rightarrow\frac{1}{d_0}=\frac{1}{f}-\frac{1}{d_i}=\frac{1}{65\ mm}-\frac{1}{78\ mm}$$
$$d_0=390\ mm$$

8. Answer

$$\frac{1}{f}=\frac{1}{d_i}+\frac{1}{d_0}\rightarrow\frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_0}=\frac{1}{15cm}-\frac{1}{10\ cm}$$
$$d_i=-30\ cm$$

The image is 30 cm in front of the lens

9. Answer

$$\frac{1}{d_i}=-\frac{1}{f}-\frac{1}{d_0}=-\frac{1}{10cm}-\frac{1}{50cm}$$
$$d_i=-8.33\ cm$$

The image is located at 8.33 cm in front of the lens.

10. Answer

(a)

$$\frac{1}{f}=\frac{1}{d_i}+\frac{1}{d_0}=\frac{1}{32\ cm}+\frac{1}{8\ cm}$$
$$f=6.4\ cm$$

(b)

$$m=-\frac{d_i}{d_0}=-\frac{8\ cm}{32.0cm}=-0.25$$

The lens is converging

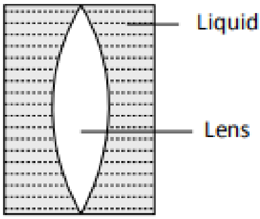
(c) Power of the lens is

$$P=\frac{1}{f}=\frac{1}{6.4\times10^{-2}}=15.625\ dioptres$$

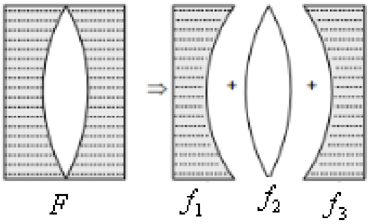
5.9. Additional activities

5.9.1. Consolidation activities

1. Shown in figure here is a convergent lens placed inside a cell filled with a liquid. The lens has focal length +20 cm when in air and its material has refractive index 1.50. If the liquid has refractive index 1.60, the focal length of the system is (a) + 80 cm (b) 80 cm (c) – 24 cm (d) – 100 cm



Solution: (d)



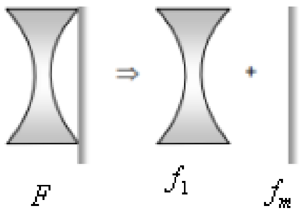
here $\frac{1}{f_1}=(1.6-1)\left(\frac{1}{\infty}-\frac{1}{20}\right)=\frac{-3}{100}$....(i) $\frac{1}{f_2}=(1.5-1)\left(\frac{1}{20}-\frac{1}{-20}\right)=\frac{1}{20}$....(ii)

$\frac{1}{f_3}=(1.6-1)\left(\frac{1}{-20}-\frac{1}{\infty}\right)=\frac{-3}{100}$....(iii)

By using $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}\Rightarrow\frac{1}{F}=\frac{-3}{100}+\frac{1}{20}-\frac{3}{100}\Rightarrow F=-100cm$

1. A concave lens of focal length 20 cm placed in contact with a plane mirror acts as a (a) Convex mirror of focal length 10 cm (b) Concave mirror of focal length 40 cm (c) Concave mirror of focal length 60 cm (d) Concave mirror of focal length 10 cm.

Solution: (a)



By using $\frac{1}{F}=\frac{2}{f_1}+\frac{1}{f_m}, f_m=\infty \Rightarrow F=\frac{f_1}{2}=\frac{20}{2}=10cm$

5.9.3. Extended activities

1. A convex lens forms a real image of an object for its two different positions on a screen. If height of the image in both the cases be 8 cm and 2 cm, then height of the object is (a) 16 cm (b) 8 cm (c) 4 cm (d) 2 cm

   Solution: (c) By using $o=\sqrt{I_1 I_2} \Rightarrow 0=\sqrt{8\times 2}=4cm$

2. A thin double convex lens has radii of curvature each of magnitude 40 cm and is made of glass with refractive index 1.65. Its focal length is nearly (a) 20 cm (b) 31 cm (c) 35 cm (d) 50 cm

   Solution: (b) By using $f=\frac{R}{2(n-1)}=\frac{40}{2(1.65-1)}=30.7cm$

3. (a) State the properties of a concave mirror which makes it possible to be used as a dentist mirror.

   (b) An object of 20cm of length is placed perpendicular to the principal axis of a convex mirror of 15cm of focal length.

   i. Calculate its position and the position of image if the length of image is equal to $3/4$ of object.

   ii. What are properties of image produced?

Answer

a. The properties of a concave mirror to be used as dentist mirror are:

- The object must be between focal point and pole
- The image is behind mirror
- Image is virtual
- Image is upright (erect)
- Image is magnified.

b. i. For a convex mirror

$$m = \frac{h_i}{h_0} = -\frac{d_i}{d_0} = \frac{3}{4} \rightarrow d_i = -\frac{3d_0}{4}$$

From the mirror formula: $\frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{f}$ we get

$$\frac{1}{d_0} + \frac{1}{-\frac{3d_0}{4}} = \frac{1}{-15\ cm} \rightarrow \frac{1}{d_0} - \frac{4}{3d_0} = \frac{1}{-15\ cm} \rightarrow \frac{3-4}{3d_0} = -\frac{1}{15\ cm}$$

$$d_0 = \frac{15\ cm}{3} = 5\ cm$$

$$d_i = -\frac{3d_0}{4} = d_i = -\frac{3(5\ cm)}{4} = -3.75\ cm$$

ii. The properties of the image:

- Image is virtual
- Image is upright
- Image is diminished

UNIT 6

SIMPLE AND COMPOUND OPTICAL INSTRUMENTS

6.1. Key unit competence

Describe and use effectively simple and compound optical instruments

6.2. Prerequisite (knowledge, skills, attitudes and values)

The student teacher will learn better this unit if he/she has the Knowledge, skills, values and attitudes related nature of light, reflection of light, refraction of light for Ordinary level and able to use ICT tools like computer, XO laptop.

6.3. Cross cutting issues to be addressed

Gender: Let the student teacher carry out activities in student teacher's book (if it is a mixed school, the number of boys and girls in each group should be balanced).

Inclusive education:

- All differentiation should be taken into consideration in solving different activities in this unit.
- Help them in selecting their group leaders. Identify student teacher with special needs in group making. Encourage them to actively participate in their respective groups.

Peace and value:

- When student teachers are working activities, tell them that they can respect each other's opinion (don't blame someone, respect his/her ideas).
- Put learners in groups (select any number of learners depending on the size of the class) make sure that they work in harmony.

6.4. Guidance on introductory activity

- Invite student teachers to perform what is provided in introductory activity
- Request student teachers to answer questions asked and brainstorm

- Encourage student teachers to think in critically and innovative way
- Keep in mind that student teachers may not be able to find the right answers. You must guide them and orient their answers.
- Let student observe the images and think critically where are used in our daily life activities
- Help the student teacher to link those instruments with their career of teaching

6.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Introduction to optical instruments and their images formation	- Explain an optical instrument - Identify the physical features of a camera and simple and compound microscope and their difference - Explain the operation of a lens camera, simple and compound microscope and their applications. - Construct diagrams of simple and compound microscope. - Carry out an investigation on how optical instruments form images - Design compound microscope	5
2	Magnifying power of optical instruments and its calculation	Determine the magnifying power of optical instruments	3
3	Astronomical Telescope	- List different types of telescopes and describe the physical features of a telescope. - Demonstrate the operation of telescopes.	3
4	Human eye as single lens system	- Explain the physical features of a human eye. - Describe the image formation by the eye.	2

5	Visual angle and accommodation of the eye	- Explain the visual angle of a normal eye - Explain the far and near point of the eye	1
6	Defects of vision and their correction	Detect the defects of vision and administer their corrections	3
7	End unit assessment		1

Lesson 1. Introduction to optical instruments and their images formation

a) Learning objective

- Explain an optical instrument
- Identify the physical features of a camera and simple and compound microscope and their difference
- Explain the operation of a lens camera, simple and compound microscope and their applications.
- Construct diagrams of simple and compound microscope.
- Carry out an investigation on how optical instruments form images
- Design compound microscope

b) Teaching resources

Converging lens, diverging lens, Microscope, Camera, simple telescopes binoculars, Jar of pond water, Slide, Cover slip, etc

c) Prerequisites/Revision/Introduction

The student teacher should have the prerequisite on where the optical instruments are found in our daily life activities.

d) Learning activity 6.1.

Guidance

On the Task 1,

- Instruct learners to look around class and view the various objects in the class room.
- Let each learner write down what he/she has seen

- Take the learners outside class and instruct them to observe distant objects around the school and let each learner write down what he/she has seen.
- Pick some five learners at random to present to class their observations. Discuss the relevance of their observations.
- By use of challenging and thought provoking questions guide the learners to conclude that any device used to aid vision is called an optical instrument.
- Invite your student teacher to continue make a deep research on the instrument used at night to observe galaxy
- Let them go in smart classroom for making their own research and make sure that the network is available

On the Task 2,

- Guide the student teacher to explain that a magnifying glass consists of a thin converging lens

On the Task 3,

- Ask the student teacher to describe, each in his/her own words, a compound microscope.
- Provide the student teacher with two lenses of focal lengths 5cm and 10cm together with a half metre ruler and some plasticine.
- Using guided and thought provoking questions lead the student teacher to discover that by arranging the lenses, they have actually made a compound microscope.
- Using a ray diagram, guide the student teacher to discover how the microscope forms an image.

Answers to activity 6.1

Task 1

i-ii-iii) Give time and space to students and they should tell you about findings from (i) and (ii) and brainstorm (iii)

iv) use camera and lenses but telescopes and the binocular fields glasses should be the best choice and allow the student-teacher tell you what they think.

Task 2:

When you move the hand lens away slowly from the word the size of the word decreases

Task 3:

a. A compound microscope is used to view very small organisms that cannot be seen using our naked eyes for example micro organisms.

b. In laboratories, in medicine

c. The image is colored differently

e) Application activity 6.1

1. Differences and similarities between the lens camera and the human eye

- **Similarities between the lens camera and the human eye.**
  - A diaphragm to control the amount of light that gets through to the lens. This is the shutter in a camera, and the pupil, at the center of the iris, in the human eye.
  - A lens to focus the light and create an image. The image is real and inverted.
  - A method of sensing the image. In a camera, film is used to record the image; in the eye, the image is focused on the retina, and a system of rods and cones is the front end of an image-processing system that converts the image to electrical impulses and sends the information along the optic nerve to the brain
- **Differences between the lens camera and the human eye.**
  - With a camera, the lens has a fixed focal length. If the object distance is changed, the image distance (the distance between the lens and the film) is adjusted by moving the lens. This can't be done with the human eye: the image distance, the distance between the lens and the retina, is fixed. If the object distance is changed (i.e., the eye is trying to focus objects that are at different distances), then the focal length of the eye is adjusted to create a sharp image. This is done by changing the shape of the lens; a muscle known as the ciliary muscle does this job.
  - A camera's lens is analogous to the human cornea; photographic film or light sensors can be compared to the retina. Both systems can adjust the amount of light they allow in, by means of the iris in a human eye or the aperture control in a camera.

2. **Step i):** Provide the student teacher with a manila paper and wax paper.

   - Guide the student teacher to do activity 6.1(2) in student teacher's book pages
   - Ask the student teacher to describe in their own words the image they have observed? Is it upside down or right side up. Is it smaller or larger than the actual object? What type of image is it?
   - Using thought provoking questions guide the student teachers to discover that the device they have made is actually a pinhole camera.

   Step ii): Ask the student teachers which instrument was used by person who took their photos as they were to register for the national examination.

   Ask the student teachers what they nowadays use to take photographs.

   Guide the student teachers, with the help of leading questions, to conclude that they actually use a lens camera to take pictures.

   Step iii) : Try to get a camera and bring to the student teacher to see and touch. You may even take their photos.

   Explain to the student teacher its mode of operation. Talk about the functions of the parts; The diaphragm, shutter, film, and the lens.

   Step iv): Provide the student teacher with a convex lens. Ask the student teacher to explain and in their own words the type of angle formed. The image formed is inverted, smaller than the object and coloured if the object is coloured.

3. **Step i:** Provide the student teachers with a hand lens and instruct them to do application activities 6.1(3) in the student teacher's book **page**

   Guide the student teachers to explain that a magnifying glass consists of a thin converging lens and it is used to view very small organisms or parts of organisms which cannot be easily seen by the naked eye.

   It forms a virtual, upright, magnified image of an object placed between the lens and its principal focus.

   Step ii: Guide the student teachers to draw a ray diagram depicting the formation of an image by a simple microscope

Simple microscope in normal adjustment:

- Using guided questions lead the student teachers to explain when the microscope can be in normal adjustment.
- In normal adjustment, the final image is at the near point while when it is not in normal adjustment, the final image is at infinity.

4. Let's student teacher go and search other information on formation of images for other optical instrument seen.

- Make sure that the network in smart classroom is available.
- Ask them to submit what they find out through their research
- Together with student teacher make a comment for all.

Lesson 2. Magnifying power of optical instruments and its calculation

a) Learning objective

Determine the magnifying power of optical instruments

b) Teaching resources

Camera, projector, microscope, telescope, binocular, computer, Flip chart, manila paper

c) Prerequisites/Revision/Introduction

Student teacher review on optical instrument (Camera, microscope and telescope)

d) Learning activities

Guidance

- Guide the student teacher to explain the concept of magnifying power of an optical instrument using the visual angles, Magnifying power.
- Using leading questions, guide the student teacher to explain how the instruments use visual angles to view objects in a detailed manner.

Answers to activity 6.2

1. Optical magnification is the ratio between the apparent size of an object (or its size in an image) and its true size, and thus it is a dimensionless number.
2. Make sure that the network is available in your smart classroom
   - Tell your student teacher to write a summary for what their find out through their research
   - Provide the time for your student teacher of making comments for all

e) Application activities 6.2

Solution:

1) Let the power of the convex lens be

$P1=\frac{100}{40}$

$=2.5D$

Let the power of the concave lens be

$P2=\frac{100}{25}$

$=-4D$

$P=P1+P2$

$=2.5-4.0$

$=-1.5D$

2) **Solution:**

given d=25m; m=10

angular magnification m=df

$f=dm=\frac{25}{100}$

$=2.5cm$

$p=100f=\frac{100}{2.5}$

$=40D$

3) **Solution**

Known :

The focal length of the objective lens (f_{ob}) = 0.9 cm

The focal length of the ocular lens (f_{ok}) = 2,5 cm

The overall magnification (M) = 90 times

The near point of a normal eye (N) = 25 cm

Wanted: The distance between the object and the objective lens (s_{ob})

The equation of the total angular magnification when the accommodation is minimum :

$$M = (m_{ob})(M_{ok}) = \left(\frac{1 - f_{ok}}{S_{ob}}\right)\left(\frac{N}{f_{ok}}\right)$$

$$M = \left(\frac{S_{ob'}}{S_{ob}}\right)\left(\frac{N}{f_{ok}}\right)$$

$$90 = \left(\frac{S_{ob'}}{S_{ob}}\right)\left(\frac{25}{2.5}\right)$$

$$90 = \left(\frac{S_{ob'}}{S_{ob}}\right)(10)$$

$$9 = \left(\frac{S_{ob'}}{S_{ob}}\right)$$

$$S_{ob'} = 9S_{ob}$$

Lesson 3. Astronomical Telescope

a) Learning objective

- List different types of telescopes and describe the physical features of a telescope.
- Demonstrate the operation of telescopes.

b) Teaching resources

Telescope, computer, projector

c) Prerequisites/Revision/Introduction

Student teacher will review on image formation on microscope, calculation of angular magnification on microscope.

d) Learning activity 6.3

Guidance

Task 1

- Ask student teacher why they are not able to see the planets during the night.
- Ask them if they have ever heard of an instrument called a telescope.
- Guide the student teacher to explain why our eyes cannot be able to see distant objects such as planets.
- Task 2
- Group the student teachers and provide each group with three convex lenses of focal lengths 5cm, 10cm and 20cm.
- By the use of thought provoking and guided questions lead the student teachers to discover that what they have made is a terrestrial telescope.

Answers to activity 6.3

Task 1

- They an instrument called Telescopes which is used to view distant objects such as stars and other objects.
- Our eyes have vision limitation so that they cannot see distant objects.

Task 2

An astronomical telescope produces an inverted image, so it is not suitable for viewing objects on the earth. It is suitable for viewing stars and other heavenly bodies. A terrestrial telescope provides an erect image and this makes it suitable to view objectives on the earth.

The third lens between the objective and eyepiece is the erecting lens. The angular magnification of the telescope is similar to that of the astronomical telescope.

e) Application activity 6.3

1. Here, magnifying power, m=5

   f_o =Focal length of the objective

   f_e = Focal length of the eye-piece

$f_o + f_e = 120cm$ (given)

$$m = \frac{f_o}{f_e} = 5$$

Or, $f_o = 5\ f_e$

$5f_e + f_e = 120$

$6\ f_e = 120$

Or, $f_e = \frac{120}{6} = 20m$

And, $f_o = 100cm$

2. i) Magnification

ii) Separation = fo+fe =120+5 =125cm

Lesson 4. Human eye as single lens system

a) Learning objective

- Explain the physical features of a human eye.
- Describe the image formation by the eye.

b) Teaching resources

Manilla paper, flip chart of human eye, computer, projector

c) Prerequisites/Revision/Introduction

The student teacher review on image formation through lenses, have also prerequisite on the parts of human eye

d) Learning activity 6.4

Guidance

- Group the student teacher in groups of two and guide them to do activity **6.4** in the student teacher's book.
- By use of thought provoking and challenging questions, guide student teachers to answer the asked questions as described in their book.
- Facilitate student teacher in analyzing their observations about the external parts of human eye and how images are formed in their eyes **refer to activity 6.4**

Answers to activity 6.4

Task 1:

- The forest appears to have the same height because all the trees subtend the same angle to the eye and hence their apparent sizes on the retina are the same.

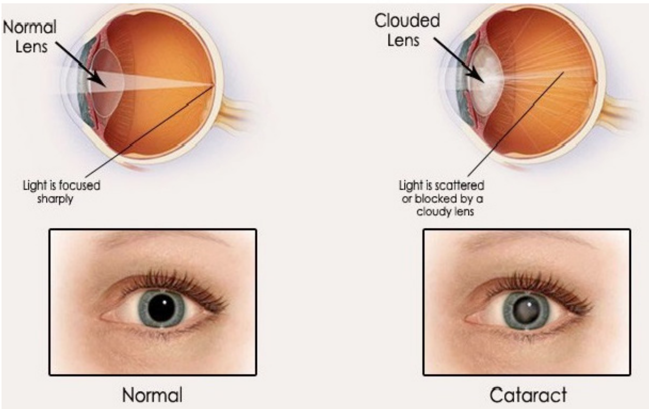
Task 2:

- Through the use of guided questions lead the learners to discover that people with normal vision can focus both near and distant objects.
- Lead them to conclude that this ability of the eye to see near and distant objects is called accommodation of the eye.
- The near point of the eye is the nearest point that can be focused by the unaided eye. It is a closest distance that the 'normal' human eye can observe clearly; without any strain to the eye. It is called the least distance of distinct vision. The near point of a normal eye is 25cm.
- The distance from a distant object to the eye is the far point of the eye. The far point of the eye is infinity.
- Guide the learners to conclude that people with normal vision can clearly see near and distant objects. Those who clearly see near objects but cannot see distant objects are said to be short sighted.
- Those who see only distant objects are said to be long sighted.

e) Answers to application activity 6.4

1. The central field of vision for most people covers an angle of between 50° and 60°. Within this angle, both eyes observe an object simultaneously. This creates a central field of greater magnitude than that possible by each eye separately. The vertical range of the visual field in humans is around 150 degrees. It varies Person to person and with age.
2. With a healthy and normal eye, you should be able to see approximately 95 degrees temporally (towards your ear) and approximately 60 degrees nasally (towards your nose) from the center
3. The image distance is the distance between eye-lens and retina in the eye which is naturally fixed and it can't be changed. Therefore, after increasing the distance of an object from an eye, there will be no change in the image distance inside the eye.

4. The medical condition in which the lens of the eye of a person becomes progressively cloudy resulting in blurred vision. It can also lead to total loss of vision of the eye. This type of defect of an eye cannot be corrected by using any type of spectacle lenses. It can only be corrected by surgery. With the help of surgical operation the opaque lens is removed from the eye of the person and a new artificial lens is inserted in its place.



5. Make sure that the internet network is available
   - Let student teacher make their own research and ask them to write a summary on what their find out through their research
   - Together with student teacher make comments on what they got.
6. These specialized cells are called photoreceptors. There are 2 types of photoreceptors in the retina: rods and cones. However, cones are most sensitive to one of three different colors (green, red or blue). Signals from the cones are sent to the brain which then translates these messages into the perception of color.
7. Behind the cornea is a colored, ring-shaped membrane called the iris. The iris has an adjustable circular opening called the pupil, which can expand or contract to control the amount of light entering the eye.

Lesson 5. Defects of vision and their correction

a) Learning objective

Detect the defects of vision and administer their corrections

b) Teaching resources

Flip charts, Manila paper, lenses, computer, projector

c) Prerequisites/Revision/Introduction

Review on formation of images on lenses, the parts of human eye

d) Learning activity 6.5

Guidance

- Ask learners why some people wear eye glasses.
- Set the learners to discuss this question in groups of three.
- Guide the learners to conclude that those people who put on different glasses have eye defects.
- Request each learner to hold a book at an arm's length and move the book towards one's face up to a point where the prints are read without the eye getting strained.
- Ask them try to read the words on a chalkboard a distance far away from the classroom.
- Find out from them if they are able to see clearly both near and distant objects?
- Using ray diagrams, guide the learners to discuss the different types of defects; short sightedness, long sightedness, astigmatism and Presbyopia.
- Provide learners with lens spectacles; ones that are convex and the others concave.
- Allow the learners touch the different spectacles and feel the difference.
- Using guided questions lead the learners to discover which kind of defects the spectacles are used to correct.
- Guide the learners to draw ray diagrams for the formation of images by the spectacles.

Answers to activity 6.5: Refer to the content under activity 6.5

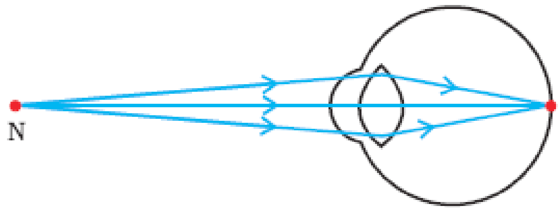
Guide the learners to conclude that people with normal vision can clearly see near and distant objects. Those who clearly see near objects but cannot see distant objects are said to be short sighted. Those who see only distant objects are said to be long sighted.

e) Answers to application activity 6.5

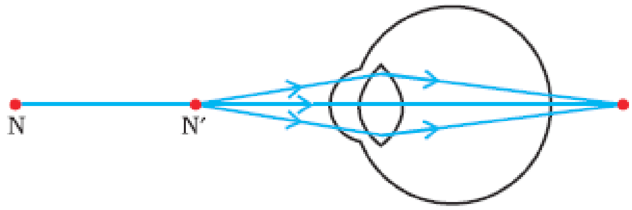
1. a) Name of the defect is Hypermetropia which is also known as far-sightedness. A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly. The near point, for the person, is farther away from the normal near point (25 cm).

Such a person has to keep a reading material much beyond 25 cm from the eye for comfortable reading. This is because the light rays from a close by object are focused at a point behind the retina as shown in Fig. (b). this defect arises either because

(i) the focal length of the eye lens is too long, or (ii) the eyeball has become too small.



(a) Near point of a Hypermetropic eye



(b) Hypermetropic eye

Above fig(a) and fig(b) shows the ray diagram of Hypermetropic eye. The point N is far beyond the normal near point 25 cm.

If N ' is the normal near point, then due to this defect image is formed very much behind retina as shown in fig.(b) Correction of the defect is done by using convex lens of appropriate power.

2. a) Astigmatism usually causes vision to be blurred or distorted to some degree at all distances. Some of its symptoms are eye strain, headaches, squinting and eye irritation.

   Astigmatism is a common vision problem caused by an error in the shape of the cornea. With astigmatism, the lens of the eye or the cornea, which is the front surface of the eye, has an irregular curve. This can change the way light passes, or refracts, to your retina. This causes blurry, fuzzy, or distorted vision.

   b) Eyeglasses are the simplest and safest way to correct astigmatism.

   - Contact Lenses work by becoming the first refractive surface for light rays entering the eye, causing a more precise refraction or focus.

- Refractive Surgery aims to change the shape of the cornea permanently

c) Astigmatism symptoms can include: Blurry vision, Distorted vision, Discomfort with reading on a computer or in print, Eye strain or headaches.

3. a. Presbyopia is a common age-related condition that occurs when the natural lenses of your eyes lose their flexibility as you reach middle age. This condition affects your close-range visual acuity.

   b) The symptom of presbyopia is difficulty seeing objects up close. This is why many middle-aged adults prefer holding their reading materials at an arm's length rather than right in front of them. You may experience headaches or eyestrain while trying to accomplish close-range tasks. If you experience any of these symptoms, visit your trusted eye doctor as soon as possible for a comprehensive eye exam.

4. This is because the ciliary muscles of eyes are unable to contract beyond a certain limit. If the object is placed at a distance less than 25cm from the eye, then the object appears blurred because light rays coming from the object meet beyond the retina.

6.6. Summary of the unit

1. **Chromatic aberration**: an optical aberration, in which an image has colored fringes, caused by differential refraction of light of different wavelengths

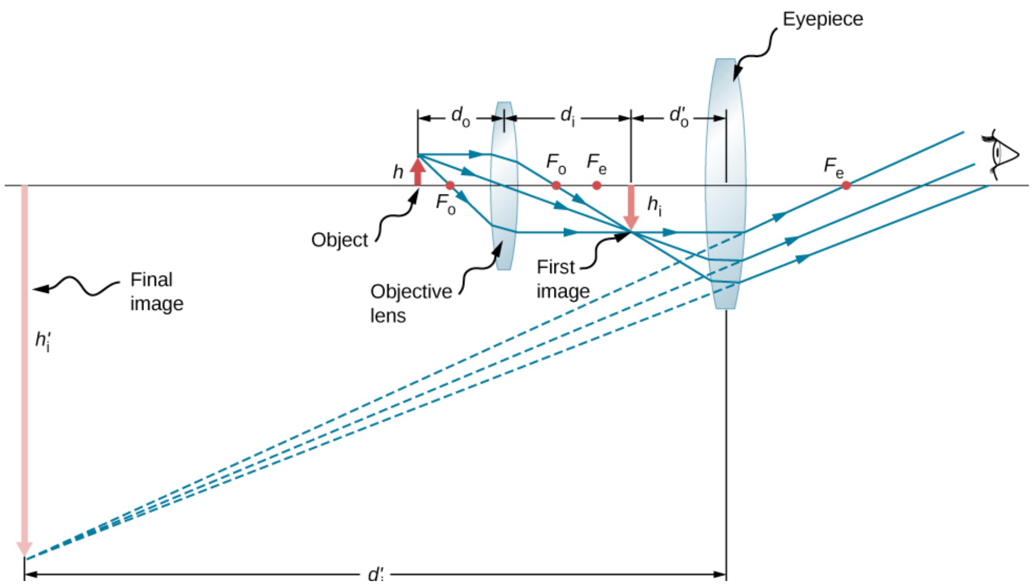
2. **Spherical aberration**: a type of lens aberration that causes blurriness, particularly away from the center of the lens

3. **Achromatic**: free from color; transmitting light without color-related distortion

Image formation for compound microscope and Telescope

1. Compound microscope

A compound microscope is composed of two lenses: an objective and an eyepiece. The objective forms the first image, which is larger than the object. This first image is inside the focal length of the eyepiece and serves as the object for the eyepiece. The eyepiece forms final image that is further magnified.



2. Telescopes

Telescopes are meant for viewing distant objects and produce an image that is larger than the image produced in the unaided eye. Telescopes gather far more light than the eye, allowing dim objects to be observed with greater magnification and better resolution. Telescopes were invented around 1600, and Galileo was the first to use them to study the heavens, with monumental consequences. He observed the moons of Jupiter, the craters and mountains on the moon, the details of sunspots, and the fact that the Milky Way is composed of a vast number of individual stars.

6.7. Additional information for tutors

Resolving power

If two distant objects are close together, it may not be possible to see separate images through a telescope even through the lenses are perfect and produce high magnifying power. This is due to the phenomenon of diffraction . Here we can state that the smallest angle θ subtended at a telescope by two distant objects which can just be seen separated is given approximately by:

$$\theta = \frac{1.22\lambda}{D}$$

Where λ is the mean wavelength of the light from the distant objects and D is the diameter of the objective lens.

Θ is called the resolving power of the telescope. The smaller the value of θ, the greater is the resolving power because two distant objects which are closer together can then be seen separated through the telescope. Note that the formula for θ only depends on the diameter of the objective and not on its focal lengths and that it does not concern the eyepiece. As we have seen, the focal lengths of the objective and eyepiece affect the angular magnification of a telescope but high angular magnification does not produce high resolving power. Higher resolving power is obtained by using an objective lens of greater diameter.

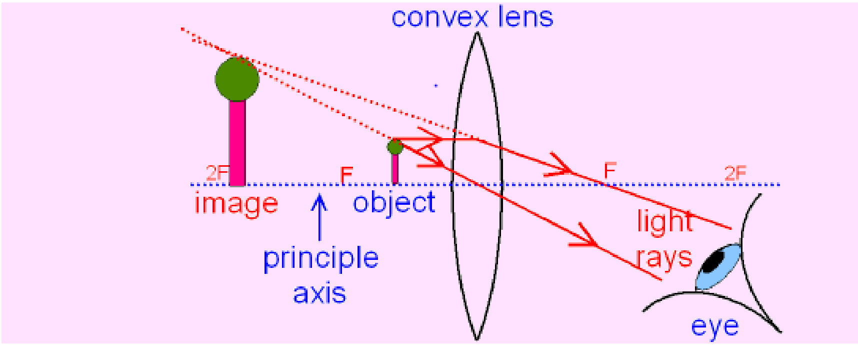
Example: the objective of a telescope has a diameter of 200mm (0.2m), and the mean wavelength of the light from distant stars is $6x10^{-7}$m, the resolving power:

$$\theta = \frac{1.22X6X10^{-7}}{0.200} = 4X10^{-6} \text{ rad (approx.)}$$

This means that two stars which subtend this angle at the telescope objective can just be seen separated or resolved.

6.8. End unit assessment 6 (answers)

1. A magnifying glass uses a convex lens, which is a converging lens to produce an image. The image produced is upright, magnified and virtual as long as the object is at or within the focal length of the lens. Look at a small object or fine print through the magnifying glass.



2. a) A telescope has objective lenses producing long focal lengths, while a microscope has objective lenses producing short focal lengths. On the other hand, microscopes view very small objects, and its objective lens produces a larger version of the actual image. The focal lengths of both instruments make this possible.

   b) and c) : **Refer to activity 6.2 and 6.3**

3. a) The telescope is adjusted so that the final image is at infinity so that the eye is completely relaxed when viewing it. This is called normal adjustment

b) **Exit pupil (eye ring):** If the rays leaving all the points of an object are traced, it is found that all rays after passing through the eyepiece pass through a small circular area. This is called the exit pupil or eye ring. This is the best position where the eye should be placed to collect as much light that passes through the objective as possible.

c)

Microscope	**Telescope**
It is used to see very small objects	It is used to see large and distant objects
In microscope focal length of eye piece lens is greater than the focal length of the objective lens	In telescope focal length of objective is greater than eye piece
The aperture of objective is small	The aperture of objective is large
For higher magnification focal length of object should be small	For higher magnification focal length of objective should be large.

4. a) $M = \frac{f_1}{f_2} = \frac{120}{5} = 24$

b) Separation = $f_1 + f_2$ = 120+5 =125cm

5. Answer:

Magnifying power is given by:

f_e =5cm and f_o =200cm

$$M = -\frac{f_o}{f_e}\left(1+\frac{f_e}{d}\right)$$

Least distance of distinct vision, d = 25cm

$$M = -\frac{200}{5}\left(1+\frac{5}{25}\right)$$

$$= -40\left(1+\frac{1}{5}\right)$$

$$= -40\left(\frac{6}{5}\right) = -48cm$$

6. a) A diverging lens of focal length 1m is needed.

b) Using the lens, rays from a book at the near point must be refracted by the lens as if they come from a point 25cm away after refraction. In this case, object distance = new near point distance =u

image distance v =-25cm because the image is virtual in diverging lens

focal length = -1m = -100cm, as the lens is diverging.

From $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{(-25)}+\frac{1}{u}=\frac{1}{-100}$$

$$\frac{1}{(u)}=\frac{-1}{100}+\frac{1}{25}=\frac{3}{100}$$

So u $=\frac{100}{3}=33.3cm=new\ near\ point\ distance.$

7. u =object distance = +25cm

   V = image distance =-30cm (virtual image at N)

From $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{-30}+\frac{1}{25}=\frac{1}{f}=\frac{1}{150}$$

So f = +150cm (converging lens) and power = $\frac{1}{1.5m}=0.67$

8. Given, power of lens for distant vision (p) = -5.5D

   Power of lens for near vision (P) =+1.5D

   i. Focal length for distant vision

   we know that power of lens $P=\frac{1}{f}$

   Where P is power of lens and f is the focal length

$$-5.5D\ =\frac{1}{f}$$

$$f=\frac{1}{-5.5}=-0.18m$$

   Thus, focal length of the lens for distant vision = -0.18m or -18cm

   ii. Focal length for near vision

   we know that power of lens $P=\frac{1}{f}$

$$1.5 = \frac{1}{f}$$

$$f = \frac{1}{1.5} = 0.66m = 66cm$$

Focal length of lens for near vision =0.66m or 66cm

6.9. Additional activities

6.9.1 Remedial activities

1. How does microscope magnification work?

Solution

The eyepiece lens (the one closest to your eye) magnifies the image from the objective lens, rather like a magnifying glass. On some microscopes, you can move the eyepiece up and down by turning a wheel. This gives you fine control or "fine tuning" of the focus.

2. What are the parts of a compound microscope?

Solution

The three basic, structural components of a compound microscope are the head, base and arm.

- Head/Body houses the optical parts in the upper part of the microscope.
- Base of the microscope supports the microscope and houses the illuminator.
- Arm connects to the base and supports the microscope head.

3. A small telescope has an objective lens of focal length 140 cm and eyepiece of focal length 5.0 cm. What is the magnifying power of telescope for viewing distant objects when the telescope is in normal adjustment (i.e When the final image is at infinity) What is the seperation between the objective lens and eyepiece ?

Solution:

In normal adjustment separation separation between the objective and the eyepiece =fo+fe

=140+5

=145cm

4. What kind of object is used in a reflecting telescope to magnify the image?

Answer: A refracting telescope uses a concave mirror, a plane mirror, and a convex lens to magnify images.

6.9.1. Consolidation activities

1. What is the maximum magnification of a compound light microscope?

Solution

With 10x objective piece, the overall magnification is: With 40x objective piece, the overall magnification is: With 100x objective piece, the overall magnification is: Hence, the highest magnification that can be obtained with a compound microscope is 1000x.

2. The focal length of the objective lens is 1.8 cm and the focal length of the ocular lens is 6 cm. The microscope is used by a normal eye without accommodation, the distance between the objective lens and the ocular lens is 24 cm. Determine the object distance from the objective lens.

Solution

Known :

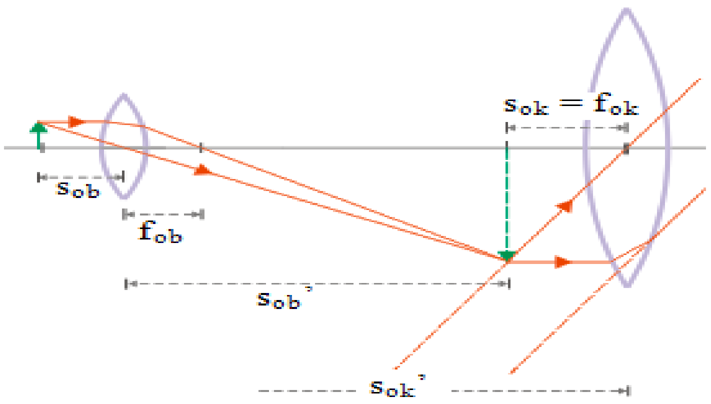
The focal length of the objective lens (f_{ob}) = 1.8 cm

The focal length of the ocular lens (f_{ok}) = 6 cm

The distance between the objective lens and the ocular lens = the length of the microscope (l) = 24 cm

Wanted: Distance between the object and the objective lens (s_{ob})

When the accommodation is minimum, the distance between the final image and the ocular lens is infinity, as shown in the figure below.



The distance between the objective lens and the ocular lens (l) = the focal length of the ocular lens (f_{ok}) + the distance between the image and the objective lens (s_{ob}').

$s_{ob}' = l - f_{ok}$ = 24 cm – 6 cm = 18 cm

Calculate the distance between the object and the objective lens (s_{ob}) using the equation of relation between the focal length of the objective lens (f_{ob}), the distance between the object and the objective lens (s_{ob}) and the distance between the image and the objective lens (s_{ob}') :

$$\frac{1}{f_{ob}} = \frac{1}{S_{ob}} + \frac{1}{S_{ob'}}$$

$$\frac{1}{S_{ob}} = \frac{1}{f_{ob}} - \frac{1}{S_{ob'}}$$

$$\frac{1}{S_{ob}} = \frac{1}{1.8} - \frac{1}{18} = \frac{10}{18} - \frac{1}{8} = \frac{9}{18}$$

$$S_{ob} = \frac{18}{9} = 2$$

The distance between the object and the objective lens is 2 cm.

3. What happens to eye lens of people suffering from both hypermetropia and myopia? how is it corrected by bifocal and progressive?

Answer:

This is due to gradual weakening of ciliary muscles and reducing flexibility of the eye lens. It is corrected using a bifocal lens or a progressive lens.

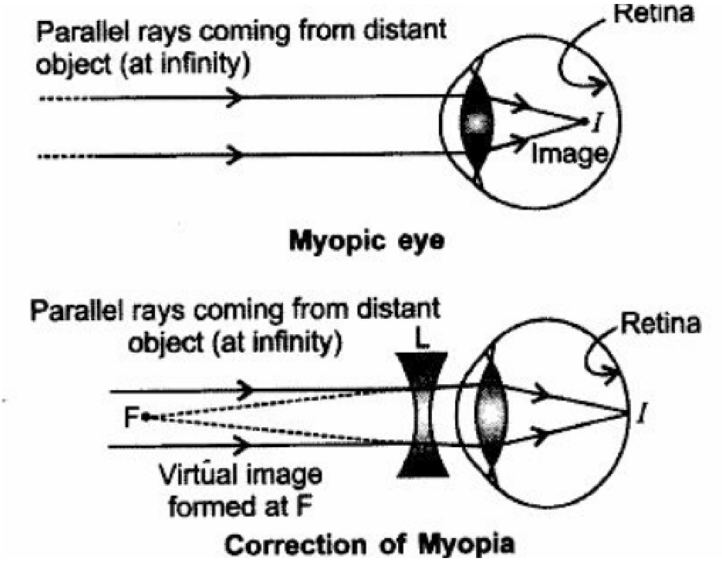
A bifocal lens consists of both- concave and convex lenses. The upper portion consists of a concave lens which corrects myopia. The lower portion consists of a convex lens which corrects the hypermetropia.

4. a) What is myopia (near-sightedness)? Draw a ray diagram to show how it can be corrected using a lens.

Answer:

Myopia is the inability of an eye in viewing long distant objects. The image in this case is formed before the retina. For every myopic eye, there exists a far point beyond which clear image cannot be seen.

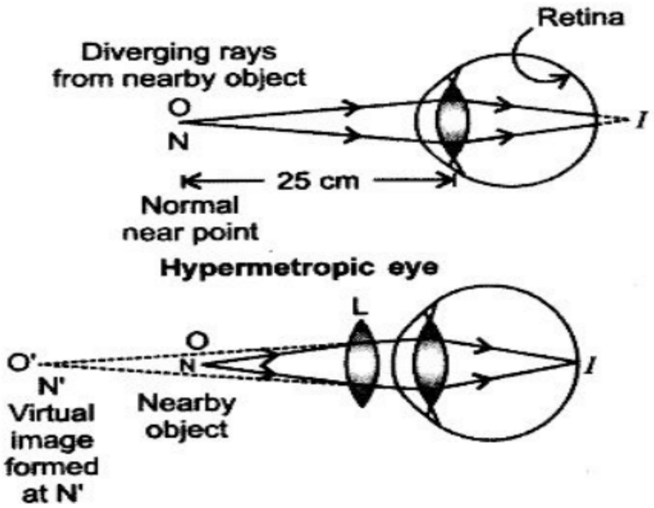
The short-sightedness is corrected by using a concave lens which diverges and shifts the image to the retina.



b. What is hypermetropia (far-sightedness)? Draw a ray diagram to show how this defect can be corrected using a lens.

Answer:

Hypermetropia is the inability of an eye in viewing the nearby objects. The image in this case is formed beyond the retina. For a hypermetropic eye, there exists a near point. It is corrected by using a convex lens, which converges and shifts the image to the retina.



6.9.3. Extended activities

1. A microscope consists of a 5X objective and a 20X ocular. The distance between the lenses is 15 cm. (a) Determine the overall magnification if the eye is relaxed (b) determine the focal length of the ocular lens (c) the focal length of the objective lens.

Solution

The magnification of the objective lens (m_{ob}) = 5X

The magnification of ocular lens (M_{oc}) = 20X

Near point (N) = 25 cm

The distance between the lenses (l) = 15 cm

(a) The overall magnification (M)

$M = m_{ob} M_{oc}$

$M = (5)(20) = 100X$

(b) The focal length of the ocular lens (f_{oc})

The formula of angular magnification of ocular lens (M_{oc}) when the eye is relaxed :

$M_{oc} = N / f_{oc}$

The focal length of the ocular lens :

$f_{oc} = N / M_{oc} = 25 \text{ cm} / 20 = 1.25 \text{ cm}$

(c) the focal length of the objective lens (f_{ob})

The formula of the magnification of the objective lens when the eye is relaxed :

$$m_{ob} = \frac{d_{ob}}{d_{ob}} = \frac{1 - f_{ob}}{d_{ob}}$$

The distance of the real image from the objective lens (d_{ob}') :

$d_{ob}' = l - f_{oc} = 15 \text{ cm} - 1.25 \text{ cm} = 13.75 \text{ cm}$

The object distance from the objective lens (d_{ob}) :

$$d_{ob} = \frac{d_{ob'}}{m_{ob}} = \frac{13.75cm}{5} = 2.75cm$$

The focal length of the objective lens (f_{ob}) :

$$\frac{1}{f_{ob}} = \frac{1}{d_{ob}} + \frac{1}{d_{ob'}} = \frac{1}{2.75} + \frac{1}{13.75}$$

$$\frac{1}{f_{ob}} = \frac{13.75}{(2.75)(13.75)} + \frac{2.75}{(2.75)(13.75)} = \frac{16.5}{37.8}$$

$$f_{ob} = \frac{37.8}{16.5} = 2.29\ cm$$

2. A telescope has an objective of focal length 50 cm and eyepiece of focal length 5 cm. The least distant of distinct vision is 25 cm. The telescope is focused for distinct vision on a scale 200 cm away from the object. Calculate:

   (a)the separation between the objective and eyepiece
   (b) the magnification produced?

Answer:

Let AB be the position of the object and given focal length of telescope f_1 = 50 cm

focal length of eyepiece f_2 = 5 cm

object distance u = 200 cm

least distance of distinct vision = 25 cm

Now calculating for image distance v formed by the objective (A^1B^1),

Applying lens formula,

v = (uf)/(u - f) = (200 × 50)/(200 - 50)

v = 200/3 cm

Now the distance between A^1B^1 and the eye piece is

u^1 = I - 200/3 -------(1) ; here I = separation distances between the lenses.

Now the least distance of distinct vision = image distance from the eye piece and eye piece focal length = 25 cm

Thus,

$u^1 = v^1f^1/v^1-f^1$ = (-25× 5)/(-25 -5) = -125/-30

$u^1 = 25/6$ cm

Now reducing the above found values in 1 we get,

$I = 25/6 + 200/3 = 425/6$

$I = 70.83$ cm

Hence the total magnification produced = $m_0 \times m_1$

where m_1 = magnification of eye piece

Total magnification $m_2 = (200/3)\times(1/200)\times25\times(6/25) = 2$

UNIT 7

PROPAGATION OF MECHANICAL WAVES

7.1. Key Unit competence

Evaluate the propagation of mechanical waves.

7.2. Prerequisite (knowledge, skills, attitudes and values)

- Reflection and refraction of light in ordinary level
- Pythagoras theorem in mathematics covered in ordinary level.
- Basic trigonometric functions covered in Mathematics subject

7.3. Cross cutting issues to be addressed

- **Standardization culture**: Emphasize the need to use appropriate instruments.
- **Financial education:** Emphasize the need to compare price against measuring instrument while selecting instrument to use.
- **Environment and sustainability:** Recognize the safety measures taken for the sake of environmental protection.
- **Peace and values education:** Cooperation and teamwork spirit should be encouraged in learning process.

7.4. Guidance on introductory activity 7

- Ask student-teachers to look at the illustration of the unit and let them discuss what they see.
- Let them brain in five minutes to discover what is observed in the illustration of the unit.
- Let sample student-teacher expose their ideas in five minutes to discover more details in the illustration of the unit.
- Ask them to suggest what topics do they think this unit will focus on based on the illustration?
- Give time for some brainstorming and try to introduce the unit based on the discussion done.

7.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Introduction to waves.	Define waves and related terms.	2
2	Properties of waves.	Describe properties of waves.	2
3	Progressive waves and its mathematical treatment.	Interpret progressive waves and solve problems related to it.	4
4	Young's double slit experiment and its mathematical treatment.	Interpret Young's double experiment and solve problems related to it.	6
5	Stationary waves	Interpret the phenomena of stationary waves and explain how it occurs in strings.	6
6	End unit assessment.	Evaluate the achievement of the objectives.	2

Lesson 1. Introduction to waves

a) Learning objective

Define waves and related terms.

b) Teaching resources

Bucket, ropes or springs, fixed end such as trees.

c) Prerequisites/Revision/Introduction

Reflection, refraction of light energy through different media.

Trigonometric ratios especially sine and cosine ratio.

d) Learning activity 7.1

Technical guidance

- This activity leads to explanations of wave concepts such as amplitude, frequency displacement, wavelength and wave phase.

- Try this activity and let students explain the terms transverse and longitudinal waves.
- Divide your class into small groups, and let them read and interpret the activity based on their understanding.
- Let the student-teachers perform the activity using their prior knowledge about the provided resources and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts.

Answers to activity 7.1

- When the water is disturbed there is a formation of circular disturbance
- Yes, wave oscillates per to the direction of motion. Transverse wave.
- Yes, wave oscillates per to the direction of motion. Longitudinal wave.

e) Application activity 7.1

1. As the propagation has same direction to motion of energy then it is (b) longitudinal.
2. It is transverse
3. Definition and diagram refer to the diagram under 7.6 in student teacher's book

Lesson 2. Properties of waves

a) Learning objective

Describe properties of waves.

b) Teaching resources

Springs, water ripple tank or basin, stones,

c) **Prerequisites/Revision/Introduction**

- Wave description and types
- Snell's law for light and other forms/types of energy.

d) **Learning activities**

Technical guidance in activity 7.2

- This activity leads to an explanation of reflection, refraction, diffraction and interference of waves.
- Divide your class into small groups, and let student teachers appreciate applications of wave in life.
- Let the student-teachers perform the activity using their prior knowledge but don't forget to guide them.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts.

Answers to Activity 7.2:

Task1:

a. When the pulse reaches at the rigid wall is turns back. The phenomenon is called reflection
b. When the pulse reaches the boundary of the springs a part reflects and another part move forward with increasing speed. The phenomena are partially reflection and partially refraction.

Task2:

a. When the water moves through finger it moves in circular path. This is diffraction
b. The disturbances overlap. This is interference

e) Application activity 7.2

1. It reflects or refracts
2. The frequency is constant because the frequency is due to disturbance of source not the medium of propagation.
3. Reflected pulse will be inverted, a crest will reflect as a trough.
4. Interference is a phenomenon in which two waves superpose to form a resultant wave of greater, lower, or the same amplitude. Constructive and destructive interference result from the interaction of waves that are correlated or coherent with each other, either because they come from the same source or because they have the same or nearly the same frequency. Interference effects can be observed with all types of waves, for example, light, radio, acoustic, surface water waves, gravity waves, or matter waves.

Lesson 3. Progressive waves and its mathematical treatment

a) Learning objective

Interpret progressive waves and solve problems related to it.

b) Teaching resources

Flipchart papers, videos, computer and projector,

c) Prerequisites/Revision/Introduction

Trigonometric equations and waves properties

d) Learning activity 7.3

Technical guidance

- This activity leads to applying the equation of two superimposed progressive waves
- Divide your class into small groups, and let them read and interpret the activity based on their understanding and corresponding concepts such as superposition.
- Let the student-teachers perform the activity using their prior knowledge about the provided task and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.

- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts the student-teacher book and use the information while reviewing the questions together.

Answer for activity 7.3:

Check the availability of internet and guide student teachers to conduct an internet research on progressive waves, its wave function and where they are applied in everyday life and report. Remember that young people may not look for correct information and try to be present. Ask them to make a presentation of results and together you discuss main points.

e) Application activity 7.3

a.

$$k = \frac{2\pi}{\lambda} = \frac{2\pi rad}{40.0cm} = 0.157 rad/cm$$
;

$$\omega = 2\pi f = 2\pi(8.00s^{-1}) = 50.3 rad/s, T = \frac{1}{f} = \frac{1}{8} = 0.125s$$

$$v = \lambda f = (40.0cm)(8.00s^{-1}) = 320 cm/s$$

b. Solution: Because A = 15.0 cm and y = 15.0 cm at x = 0 and t = 0,

15.0 = (15.0) sin φ or sin φ = 1 the value φ = π/2 rad (or 90°).

The wave function is of the form

$$y = A\sin(kx - \omega t + \frac{\pi}{2}) = A\cos(kx - \omega)$$

Substituting the values for A, k, and ω into this expression, we obtain
$y = (15.0cm)\cos(0.157x - 50.3t)$

Lesson 4. Young's double slit experiment and its mathematical treatment

a) Learning objective

Interpret Young's double experiment and solve related problems

b) Teaching resources

Lamps, slits, monochromatic source of lights, screens

c) Prerequisites/Revision/Introduction

Waves’ properties, Pythagorean theory and motions

d) Learning activity 7.4

Technical guidance

- This activity describes interference fringes (constructive interference and destructive interference)
- Divide your class into small groups, and let them read and interpret the activity based on their understanding and corresponding concepts about waves.
- Let the student-teachers perform the activity using their prior knowledge.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers’ comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers’ work and provided concepts.
- Comment on student-teachers’ discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts.

Answers to activity 7.4

This activity requires no material other than owner fingers. Let student teachers hold their index and middle fingers close to each other, leaving a small slit between them about 1 mm in width.

Let them look through the slit into a source of light such as the window or a lamp. You will need to look with one eye up close to the slit. Student teachers should be able to see a number of vertical dark lines between the fingers.

Warning: Do not let them look directly at the sun.

e) Answers to Application Activity 7.4

1. They would not. The filament of a headlight is a centimeter or so across, not a point source. You need point sources to form interference. Even if it were a point source, head lights fling waves off in every possible wavelength. You wouldn't see the interference because it would be evenly scattered throughout the range of light, and equal out of destructive and constructive interference at any given point. Referring to figure 7.2 let student teachers understand that monochromatic point source is one of key elements of interference.

2. Referring to text below 7.4 and example there let student teachers understand that fringes alter by bright and dark according to type of color emitted by the source example if it is red the fringes will be alterations of red and dark, angle by angle.

3. Yes, it is possible to create a situation where there is only destructive interference. If the light wave passed through the two slit in double slit experiment which are exactly out of phase to each other when both reach screen and this happens to be the case for every point on the screen.

Lesson 5. Stationary waves

a) Learning objective

- Interpret the phenomena of stationary waves and explain how it occurs in strings.

b) Teaching resources

- rope or coiled spring, strings or chordophones such as electric bass, violin, viola, cello, double bass, banjo, mandolin, ukulele, and harp, computer and projectors.

c) Prerequisites/Revision/Introduction

Waves' properties, wave's equation

d) Learning activity 7.5

Technical guidance

- This activity leads to a deep understanding of wave equation and wave properties through creation of non progressive wave i.e stationary waves' characteristics.
- Let student teachers vibrate strings and observe the results.
- Let the student-teachers perform the activity using their prior knowledge and write the ideas in the notebook.

- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts.

Answers toActivity 7.5

- Inverted, and returns to your hand.
- Then, the displacement given by your hand to the rope each time will add to the displacement of the reflected wave.
- As a result, the oscillation of the rope in one segment will be much greater than the motion of your hand.
- Yes, the points are called nodes and antinodes.

e) Answers to Application activity 7.5

1. A simple kind of wave called a "pulse" is created. String waves are an example of transverse waves because the string moves up and down at right angles to the horizontal motion of the wave or pulses.
2. To use a slinky to create a longitudinal wave, pull a few coils back and release. Yes, For a transverse wave, jostle the end coil side to side.
3. Since wave speed $u = \sqrt{[T/\mu]}$, T would have to be quadrupled to double u.
4. No, a pulse inverts upon reflection only if the end is fixed.
5. The vertical velocity depends on the amplitude and the frequency. Since the frequency and wavelength are interdependent, we can say it depends on the wavelength. For a fixed wavelength, we could say it depends on the speed, and the speed depends on the tension, mass, and length of the string.
6. If you shake one end of a taut rope steadily three times each second, the period of the sinusoidal wave set up in the rope will be 1/3 seconds.

7.6. Summary of the unit

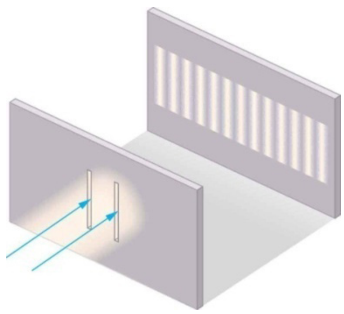
- **Waves** can be defined as a disturbance in a material medium that transfers energy from one place to another.
- The time **period (T)** of the wave is the time it takes for one complete vibration of the wave.

- The **frequency f** is the number of wavelengths that pass a point in space in one second.
- The **wavelength** l is the horizontal distance in space between two nearest points that are oscillating in phase.
- The **wave speed v** is the speed at which the wave advances.
- **Phase difference** (phase angle) is the angular difference between two points on the wave or between two waves.
- The **wave number** also called the propagation number k is the spatial frequency of a wave.
- The **Intensity** of a wave or the power radiated by a source are proportional to the square of the amplitude.
- **Wavefront** is a line or surface in the path of the wave motion on which the disturbance at every point have the same phase.
- **Mechanical waves** are waves produced by the disturbance in a material medium.
- A **progressive wave** consists of a disturbance moving from one point to another.
- **Longitudinal wave** propagates through some medium with vibrations in the direction of propagation of the disturbance.
- In **Transverse waves,** the direction of vibrations is perpendicular to the direction of propagation of the wave.
- **Equation of a progressive wave** is given by: $y_p = A\sin 2\pi\left(\omega t - \frac{2\pi x}{\lambda}\right)$
- **Principle of superposition** states that the resultant displacement at any time is the vector sum of the individual displacements.
- **Stationary waves** are waves which seem to be at rest.
- The positions of nodes are $\chi = \frac{M\lambda}{4}$ where m = 1, 3, 5, 7, 9, ...
- The positions of antinodes are $\chi = \frac{\eta\lambda}{2}$ where n = 0, 1, 2, 3, 4, 5, 6, ..
- **Electromagnetic waves** are disturbances in form of varying electric and magnetic fields.
- All kinds of waves reflect, refract, interfere and also spread around the obstacle.

- Other than the superposition of waves meeting at a point, other **conditions for interference** are:
  - The sources of the waves must be coherent, which means they emit identical waves with a constant phase difference.
  - The waves should be monochromatic - they should be of a single wavelength.
- Young's double slit experiment gave definitive proof of the wave character of light.
- An interference pattern is obtained by the superposition of light from two slits.
- There is constructive interference when $d\sin\theta = m\lambda$ (for $m = 0,\ 1,\ -1,\ 2,\ -2,\ \ldots$, where d is the distance between the slits,θ is the angle relative to the incident direction, and m is the order of the interference.
- There is destructive interference
  when $d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$ (for $m = 0,\ 1,\ -1,\ 2,\ -2,\ \ldots.$

7.7. Additional Information for tutors

Young's double slit experiment. Here pure-wavelength light sent through a pair of vertical slits is diffracted into a pattern on the screen of numerous vertical lines spread out horizontally. Without diffraction and interference, the light would simply make two lines on the screen.



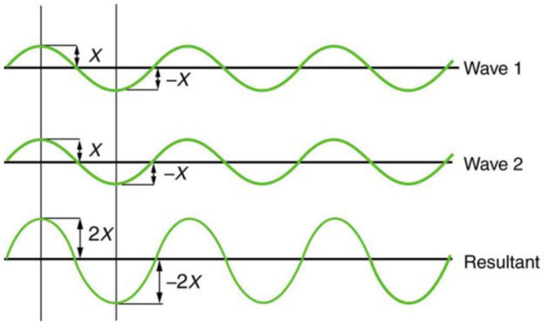
It is not ordinarily possible to observe wave behavior for light, such as observed in Young's double slit experiment. First, light must interact with something small, such as the closely spaced slits used by Young, to show pronounced wave effects. Furthermore, Young first passed light from a single source (the Sun) through a single slit to make the light somewhat coherent.

By **coherent**, we mean waves are in phase or have a definite phase relationship. **Incoherent** means the waves have random phase relationships.

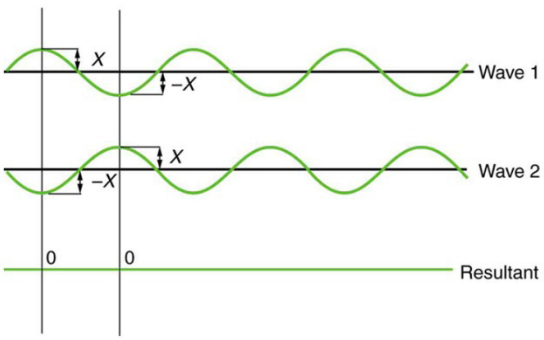
Why did Young then pass the light through a double slit? The answer to this question is that two slits provide two coherent light sources that then interfere constructively or destructively.

Young used sunlight, where each wavelength forms its own pattern, making the effect more difficult to see. We illustrate the double slit experiment with monochromatic (single λ) light to clarify the effect.

The amplitudes of waves add. (a) Pure constructive interference is obtained when identical waves are in phase. (b) Pure destructive interference occurs when identical waves are exactly out of phase, or shifted by half a wavelength.



(a)



(b)

7.8. End unit assessment 7 (answers)

1. Answer: 657 nm

First, identify known values in terms of their corresponding variable symbol:

L = 10.2 m = 1020 cm	y = 22.5 cm
m = 10	d = 0.298 mm = 0.0298 cm

(Note: m was chosen as 10 since the y distance corresponds to the distance from the 5th bright band on one side of the central band and the 5th bright band on the other side of the central band.)

Then convert all known values to an identical unit. In this case, cm has been chosen as the unit to use. The converted values are listed in the table above.

Substitute all values into Young's equation and perform calculation of the wavelength. The unit of wavelength is cm.

$\lambda = y \cdot d / (m \cdot L)$

$\lambda = (22.5 \text{ cm}) \cdot (0.0298 \text{ cm}) / [(10) \cdot (1020 \text{ cm})]$

$\lambda = 6.57 \times 10^{-5}$ cm

Finally convert to nanometers using a conversion factor. If there are 10^9 nm in 1 meter, then there must be 10^7 nm in the smaller centimeter.

$\lambda = (6.57 \times 10^{-5} \text{ cm}) \cdot (10^7 \text{ nm} / 1 \text{ cm}) =$ **657 nm**

2. Answer: 524 nm

First, identify known values in terms of their corresponding variable symbol:

L = 5.87 m = 587 cm	y = 8.21 cm
m = 4	d = 0.150 mm = 0.0150 cm

Then convert all known values to an identical unit. In this case, cm has been chosen as the unit to use. The converted values are listed in the table above.

Substitute all values into Young's equation and perform calculation of the wavelength. The unit of wavelength is cm.

$\lambda = y \cdot d / (m \cdot L)$
$\lambda = (8.21 \text{ cm}) \cdot (0.0150 \text{ cm}) / [(4) \cdot (587 \text{ cm})]$
$\lambda = 5.24 \times 10^{-5}$ cm

Finally convert to nanometers using a conversion factor. If there are 10^9 nm in 1 meter, then there must be 10^7 nm in the smaller centimeter.

$\lambda = (5.24 \times 10^{-5} \text{ cm}) \cdot (10^7 \text{ nm} / 1 \text{ cm}) =$ **524 nm**

3. a. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 12.8 cm	d = 0.250 mm	m = 4.5	L = 8.2 meters
Converted values:			
y = 12.8 cm	d = 0.0250 cm	m = 4.5	L = 820 cm

(Note that m = 4.5 represents the fifth nodal position or dark band from the central bright band. Also note that the given values have been converted to cm.)

b. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 32.9 cm	d = 50.0 μm	m = 6	L = 7.65 m
Converted values:			
y = 32.9 cm	d = 0.00500 cm	m = 6	L = 765 cm

(Note that m = 6 corresponds to six spacings. There are three spacings between the central antinode and the third antinode. The stated distance is twice as far so the m value must be doubled. Also note that the given values have been converted to cm. There are 106 μm in one meter; so there are 104 μm in one centimeter.)

c. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 8.4 cm	d = 0.25 mm	m = 2.5	L = 235 cm
Converted values:			
y = 8.4 cm	d = 0.025 cm	m = 2.5	L = 235 cm

(Note that the fourth nodal line is assigned the order value of 3.5. Also note that the given values have been converted to cm.)

d. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 98 mm	d = 0.500 mm	m = 3	L = 525 cm
Converted values:			
y = 9.8 cm	d = 0.0500 cm	m = 3	L = 525 cm

(Note that there are three spacings between the second and the fifth bright bands. Since all spacings are the same distance apart, the distance between the second and the fifth bright bands would be the same as the distance between the central and the third bright bands. Thus, m = 3. Also note that the given values have been converted to cm.)

e. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 0.1 • L	d = 0.200 mm	m = 10	L - not stated
Converted values:			
y = 0.1 • L	d = 0.200 mm	m = 10	L - not stated

(Note that there are 10 spacings between the central anti-node and the tenth bright band or tenth anti-node. And observe that they do not state the actual values of L and y; the value of y is expressed in terms of L.)

f. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 32.1 cm	d = 25.0 µm	m = 6.5	L = 6.5 m
Converted values:			
y = 32.1 cm	d = 0.00250 cm	m = 6.5	L = 650 cm

(Note that there are five spacings between the central anti-node and the fifth anti-node. And there are 1.5 spacings from the central anti-node in the opposite direction out to the second nodal line. Thus, m = 6.5. Also note that the given values have been converted to cm. There are 10^6 µm in one meter; so there are 10^4 µm in one centimeter.)

g.This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 1 cm	d = 0.100 mm	m = 0.5	L = 300 mm
Converted values:			
y = 1 cm	d = 0.0100 cm	m = 0.5	L = 30.0 cm

(Note that a the first-order minimum is a point of minimum brightness or a nodal position. The first-order minimum is the first nodal position and is thus the m = 0.5 node. Also note that the given values have been converted to cm.)

h. This question simply asks to equate the stated information with the variables of Young's equation and to perform conversions such that all information is in the same unit.

y = 3.5 cm	d = 0.050 mm	m = 1	L = 10.0 m
Converted values:			
y = 3.5 cm	d = 0.0050 cm	m = 1	L = 1000 cm

(Note that the spacing between adjacent bands is given. This distance is equivalent with the distance from the central bright band to the first antinode. Thus, m = 1. Also note that the given values have been converted to cm.)

4. The amplitude will be changed by a factor of $\sqrt{2}$. The wave speed does not because it doesn't depend on power.

5. The speed of the wave is along the propagation of the wave and is constant, but the speed of the rope segment is along y-axis (up and down) in a fixed position and may vary depending on the tension applied.

6. The waves do not ascend at constant speed because the speed of the wave depends on the tension of the rope which varies along the rope.

7. $v = f\lambda = 4.00Hz \times 60.0 \times 10^{-2} m = 2.4 m/s$

8. $A = 2.00cm$

$$\lambda = \frac{2\pi}{k} = \frac{2\pi}{2.11} = 2.976m$$

$$f = \frac{\omega}{2\pi} = \frac{3.62\, rad/s}{6.28 rad} = 0.576Hz$$

$$v = \lambda f = \frac{2\pi}{2.11} \times \frac{3.62}{2\pi} = 1.72\, m/s$$

7.9. Additional activities

7.9.1 Remedial activities

1. How do transverse waves differ from longitudinal waves?

Response Differences:

- Movement: The movement of the medium is different. In the longitudinal wave, the medium moves left to right, while in thee transverse wave, the medium moves vertically up and down.
- Longitudinal waves have a compression and rarefaction, while the transverse wave has a crest and a trough.
- Longitudinal waves have a pressure variation, transverse waves don't.

- Longitudinal waves can be propagated in solids, liquids and gases, transverse waves can only be propagated in solids and on the surfaces of liquids.
- Longitudinal waves have a change in density throughout the medium, transverse waves don't.

2. When all the strings on a guitar are stretched to the same tension, will the speed of a wave along the most massive bass string be faster, slower, or the same as the speed of a wave on the lighter strings?

   Response: Since wave speed u = $\sqrt{[T/\mu]}$ most massive bass string be slower.

3. If one end of a heavy rope is attached to one end of a lightweight rope, a wave can move from the heavy rope into the lighter one.
   a. What happens to the speed of the wave?
   b. What happens to the frequency?
   c. What happens to the wavelength?

Response: Since u = $\sqrt{[T/\mu]}$ (a) the speed will increase. The frequency should stay the same because the waves in the light rope are caused by the waves in the heavy rope. The point where the ropes attach will oscillate with a common frequency. So, for (b), the frequency would be the same. For (c), use the equation v=fλ. You already correctly determined that the velocity increases; so, if the frequency stays the same, the wavelength must increase.

7.9.1. Consolidation activities

1. In a double slit interference experiment, the distance between the slits is 0.0005m and the screen is 2 meters from the slits. Yellow light from a sodium lamp is used and it has a wavelength of 5.89 x 10^{-7} m. Show that the distance between the first and second fringes on the screen is 0.00233 m. (Fringe is another word for bright spot).

$d=5.0x10^{-4}m$	λ =5.89 x 10^{-7} m

$$d\sin\theta = m\lambda \Rightarrow \sin\theta = m\lambda/d \Rightarrow \theta = \sin^{-1}(m\lambda/d)$$

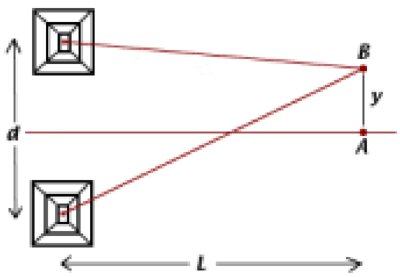
m=1, θ_1= 0.675°	m=2. θ_2= 0.135 °

$$\tan\theta = h/l \qquad y_1 = h \qquad \tan\theta = y_1/l \Rightarrow y_1 = l\tan\theta = 2\times\tan(0.675)$$

y_1(Height of lower fringe) = 0.0236m	y_2(Height of upper fringe) = 0.0472m

$$\Delta y = 0.0236m$$

2. Two radio towers are broadcasting on the same frequency. The signal is strong at A, and B is the first signal minimum. If d = 6.8 km, L = 11.2 km, and y = 1.73 km, what is the wavelength of the radio waves to the nearest meter?



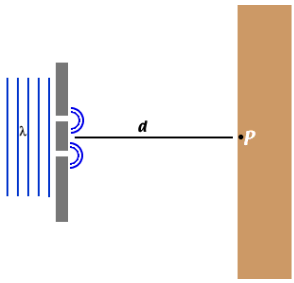
First find the angle:

$$\tan\theta = y/L \Rightarrow \theta = \tan^{-1}(y/L) = \tan^{-1}(1.73/11.2) = 8.78°$$

Find the wavelength

$$d\sin\theta = m\lambda \Rightarrow \lambda = d\sin\theta/m = 6.8\times\sin(8.78°)/1 = 1.04km$$

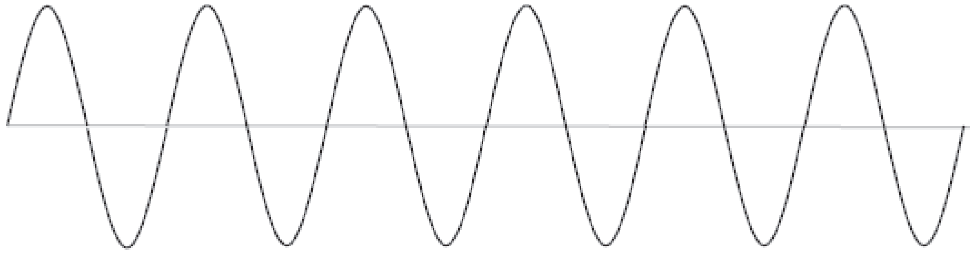
3. Water waves of wavelength of 5.44 meters are incident upon a breakwater with two narrow openings separated by a distance 247 meters. To the nearest thousandth of a degree what is angle corresponding to the first wave fringe maximum?



$$d = 247m$$
$$\lambda = 5.44m$$
$$m\lambda = d\sin\theta \Rightarrow \sin\theta = m\lambda/d \Rightarrow \theta = \sin^{-1}(m\lambda/d)$$
$$\theta = \sin^{-1}(1\times 5.44/247) = 1.262°$$

7.9.3. Extended activities

a. If this entire wave train is 30 meters long what is the wavelength of this wave?



Response: 5 meters

b. Challenge Problems: (Show equation, work, final answer with correct units.)

1. What is the wavelength of a sound wave with a frequency of 50 Hz? (Speed of sound is 342 m/s)
2. A sound wave in a steel rail has a frequency of 620 Hz and a wavelength of 10.5 m. What is the speed of sound in steel?
3. Determine the frequency of a microwave 6.0 cm in length. (A microwave is an electromagnetic wave. It travels through space at a speed of 3.0 x 10 ^8 m/s)
4. What is the period of the microwave in problem 3?

Response to question B:

This activity aims to the use of both mechanical and electromagnetic waves to let student teachers know other types of waves rather than mechanical waves only.

1. Since $\lambda = \frac{v}{f}, \lambda = \frac{342}{50}m = \frac{171}{25}m$
2. Since $v = \lambda f, v = 620*10.5m/s = 6510m/s$
3. $f = \frac{v}{\lambda} = \frac{30,000,000,000}{6}Hz = 5,000,000,000Hz$
4. $T = \frac{1}{f} = \frac{1}{5,000,000,000}s = 2\times10^{-10}s = 0.2ns$

UNIT 8

COMMON DISEASES AND HYGIENE

8.1. Key Unit competence

Implement ways of preventing and controlling common diseases and hygiene related issues.

8.2. Prerequisite (knowledge, skills, attitudes and values)

In order to succeed well this unit, student-teachers should possess knowledge and understanding, skills and attitudes that are related to classification of diseases in unit 11 and unit 12 of senior 1 and 2 respectively. They should be also able to do observation, analysis, interpretation of the pictures and then capable to present and or communicate the results.

8.3. Cross cutting issues to be addressed

The cross-cutting issues to be addressed by this unit include inclusive and gender education, and standardized culture.

a) Inclusive education

This unit involves a number of activities on research from different sources and experiments that require the listening and vision. This may be challenging to student-teachers with special educational needs especially children with visual impairment. However, the teacher can do the following:

- Grouping student-teachers with special educational needs with others and assigned roles basing on individual student-teacher's abilities.
- Providing procedure earlier before the experiment so that student-teachers get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts.
- Every important point is written and spoken. The written points help student-teachers with hearing impairment. Speaking aloud helps student-teachers with visual impairment
- Remember to repeat the main points of the lessons.

b) Gender education

- Involve both girls and boys in all activities: No activity is reserved only to girls or boys.
- Teachers should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.

c) Standardization culture

- Some lessons involve carrying out experiments about diseases. Student-teachers will understand the causes of diseases and also the drugs used to treat them. Through questions they can develop awareness of the standardized culture whereby the misuse use of some drugs as well as their state could not treat diseases. Thus, student- teachers have to always check if they are not using expired chemicals or defective apparatus.

8.4. Guidance on introductory activity 8

The introductory activity helps you to engage student-teachers in the classification and patterns of disease and invite the student-teachers to follow the next lessons.

As facilitator help the student-teacher teachers to develop competences in the following:

- Ask student-teachers to observe the figure, read and discuss the given questions.
- Engage student-teachers in working collectively the activity.
- Help student-teachers with different problems.
- Ask any four student-teachers to present their findings while others are following
- Help the student-teacher-teachers to make summary of the group discussions.

The expected answers

Issues caused by eating without washing hands include diseases such as cholera, typhoid, amoebic dysentery, etc. They can be prevented by washing hands before eating, using toilets, not eating food which is not cleaned.

8.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	**Common diseases** (Infectious diseases, STDs, deficiency diseases, and worm diseases)	- Explain the symptoms, mode of prevention of infectious diseases. - Describe the types of infectious and deficiency diseases and worm diseases - Describe the challenges encountered to eradicate some common infectious diseases - Describe the worm diseases	4
2	Importance and Hygiene practices	- Outline the importance of hygiene and related issues. - Analyze the importance of hygiene and related issues - Create a health and hygiene community of practice in the society to apply the hygiene practices to avoid diseases	1
3	Human immune system: Immunity, structure and role of antibodies	- Describe the human immune system and ways to keep it healthy - Explain the Immunity, structure and role of antibodies in human immune system.	2
4	Common addictive substances and their effects	- Discuss the most common addictive substances and their effects on the society. - Describe the common addictive substances and prevent their effects	2
5	Balanced diet	- Explain how to prepare a balanced diet - Prepare a balanced diet -Acknowledge the importance of having a balanced diet and its relation to age and gender. -Appreciate the need for a specific diet for individuals who carry out strenuous activities like sports and manual labour.	2
	End unit assessment		1

Lesson 1. Common diseases

a) Learning objective

By the end of this lesson, student teacher should be able to:

- Explain the symptoms, mode of prevention of infectious diseases.
- Describe the types of infectious and deficiency diseases and worm diseases
- Describe the challenges encountered to eradicate some common infectious diseases
- Describe the worm diseases

b) Teaching resources

Different student- teacher's books, graph charts illustrating different diseases sufferers, foods and drinks, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the first lesson of the 8^{th} unit. In this lesson you will be dealing with different infectious diseases, their mode of transmission and symptoms, modes of prevention and treatment, effects of tobacco smoking, alcohol, and drug abuse, as well as importance and practices of hygiene. The first thing to do before starting teaching is to remind student-teachers that they have learnt about infectious diseases in senior two, and ask them to list some infectious diseases and their causal agents they know, so that they can prepare themselves for this lesson.

d) Learning activity 8.1

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 8.1 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.

- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 8.1

1.

a. A person is suffering from HIV/AIDS

b. Its causative agent is HIV

c. It is transmitted through the following ways

- **Intimate sexual contact**. The most frequent mode of transmission of HIV is through sexual contact with an infected person.
- **Infected blood entering bloodstream:** by means of unsterilized needles and syringes. Unfortunately, the disease can be contracted after being given blood or blood products already infected with HIV. Close contact between infected and non-infected people through cuts and open wounds has also been known to pass on the virus.
- **From mother to baby:** An infected pregnant woman can pass on the virus to her baby through the placenta, at birth or through breast milk during suckling. The chances of infection being transmitted from the mother to her baby are currently estimated to be 25-50%.

2. The infectious diseases are: Cholera, typhoid, tetanus, tuberculosis, polio, measles, Ebola, malaria, sleeping sickness, trichomoniasis, candidiasis, athlete's foot, ring worms, elephantiasis, bilharzias, syphilis, gonorrhea.

   The above diseases are infectious ones because:

   - They are caused by germs
   - They are transmitted from one person to another

e) Answers to application activity 8.1

For Answers to this activity of filling the provided table, refer to notes in Student-teacher's book, under subheading 8.1.

Lesson 2. Hygiene practices and their importance

a) Learning objective

By the end of this lesson, I should be able to:

- Explain what is meant by hygiene
- Identify the importance of promoting hygiene in community
- Describe the practices of hygiene.
- Discuss how poor hygiene and sanitation leads to different health problems.

b) Teaching resources

Different student- teacher's books, graph charts illustrating different mode of promoting hygiene, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the second lesson of the 2^{th} unit.

To understand well this lesson it is better if student-teacher know the following:

- Sources of waste materials that can bring out health problems
- Some diseases caused by poor hygiene
- Due to knowledge they have, you will ask them to share experiences so that they can prepare themselves for this lesson.

d) Learning activity 8.2

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 8.2 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.

- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to Activity 8.2

To answer the asked question, student-teachers will use different ideas depending on life status in their families. It is your turn to compile ideas from them and harmonize and give short summary.

e) Answers to application activity 8.2

1. Care of eyes, nose and feet

Care of the eyes

- Wash eyes with clean water.
- Protect your eyes from foreign objects and dusts.
- Protect your eyes from too much or too low light. You always read under adequate light.

Care for the nose

- Never insert hard objects in the nose.
- Keep the nose clean by blowing it regularly.
- Avoid being hit in the nose.

Care for feet

- Washing the feet regularly with water and soap.
- Keeping the feet dry to avoid fungi or foot rot and bad smell.
- Wearing clean socks.
- Avoid sharing socks.
- Keep nails short and clean.
- Airing your feet daily.
- Apply some oil like Vaseline to keep the feet smooth.

2. The general human hygiene may be described by:

- Washing the body regularly with clean water and soap.
- Wearing clean clothes.
- Living in clean environment with adequate fresh air.
- Eating adequate balanced diet. Young children should be fed between 5 to 6 times per day. Their diet should be rich in proteins.
- Having regular exercises.

General importance of human hygiene are:

- It insure proper growth and development of children.
- It helps to prevent diseases especially hygiene related diseases.
- It prevent bad smell it helps to keep the environment clean, tidy and beautiful.
- It makes the environment appealing and attractive.

Lesson 3. Human immune system: Immunity, structure and role of antibodies

a) Learning objective

By the end of this lesson, student teacher should be able to:

- Describe the human immune system and ways to keep it healthy
- Explain the Immunity, structure and role of antibodies in human immune system.

b) Teaching resources

Different student- teacher's books, graph charts, models, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the third lesson of the 8^{th} unit. In this lesson you will be dealing with how the human body defense mechanism. The first thing is to remind student-teacher that they used to study the human immune system in senior two, unit 13. Due to the background they have, they can prepare themselves for this lesson.

d) **Learning activity 8.3**

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 8.3 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 8.3

Yes, it is possible that the human body can resist an infection from environment full of pathogens due to its lines of defense such as:

a. **Body's first line of defense** which line of defense prevents harmful micro-organisms from entering the body. It is the external defense system of the body.

Example of the body defense mechanism include:

i. **The skin** creates a physical barrier that protects the cells inside the body against the entrance of pathogens.

ii. **The nose** and passages leading to the lungs are lined with cells that produce sticky fluid called mucus that traps invading microbes and dust.

iii. **The stomach** that produces hydrochloric acid which destroys many of the microbes that enter the body in food and drinks we take.

iv. **Tears act as a barrier to pathogens**. Tears contain a powerful enzyme that can digest and breakdown harmless substances.

v. **Clotting of blood** occurs when an open cut or wound exposes blood to air. Such a cut causes a break in the skin exposing the body to harmful micro-organisms.

b. **Body's second line of defense**: This is the body defense mechanism that fights the pathogens already entered the body. It uses white blood cells to destroy pathogens

e) Answers to Application activity 8.3

I. Multiple choice questions:

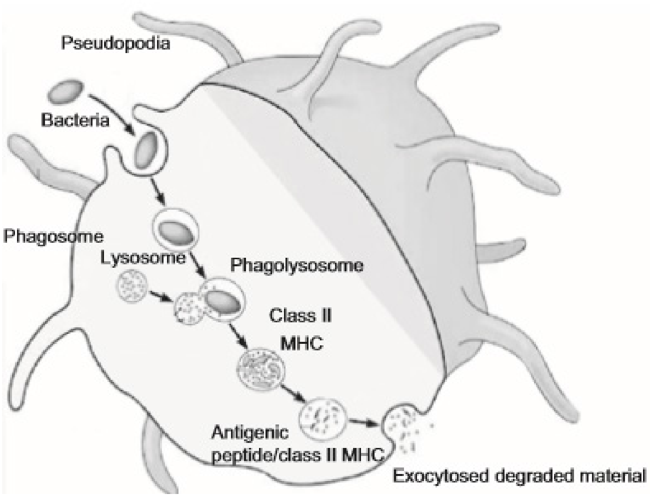
1. (d); recognition of antigen by receptors on B-lymphocytes.
2. (b); as IgG type of antibodies can cross placenta
3. (a); as B-lymphocytes grow in size, acquire Golgi apparatus and transform into actively secreting plasma cells.
4. (c); as histamine causes decrease in blood pressure and respiratory problem due to constriction of bronchioles
5. (b); as tetracycline binds to 30S ribosomal sub-unit preventing bacterial protein synthesis
6. (b); is correct as in the absence of thymus, mature T cells don't form
7. (b); as Rheumatoid arthritis is an auto-immune disease
8. (c); as live attenuated pathogens by changing to virulent form can actually cause disease.
9. (b); it is the reaction of the cells and fluids of the body to the presence of a substance.
10. (c); as by employing various strategies bacteria have evolved resistance to a number of antibiotics leaving many diseases untreatable.

III. Long answer type questions:

1. When a blood smear is prepared, two types of cells can be identified: small, very numerous, without nucleus called red blood cells (RBC) because they contain red pigment, haemoglobin for oxygen transport and large, less numerous, with darkly staining nucleus called white blood cells (WBC), because they do not contain red pigment. Among the WBCs, different cell types can be distinguished:

(i) Phagocytes, which include neutrophils (having single, multi-lobed, nucleus) and monocytes (having kidney-shaped nucleus) with a moderate amount of cytoplasm, and

(ii) Lymphocytes, with a very large, darkly staining nucleus occupying the entire volume of the cell, with very little cytoplasm. Phagocytes, which include both neutrophils and macrophages, play an important role in innate immunity. They can identify foreign invading pathogens, discriminate them from cells of the body, and internalize them by throwing pseudopodia around them. Once within the phagocytes, pathogens are digested by a number of hydrolytic enzymes, thus freeing the body of disease-causing germs. Phagocytes also help in removing old, dead cells as well as cancerous cells.



Lesson 4. Common addictive substances and their effects

a) Learning objective

- Discuss the most common addictive substances and their effects on the society.
- Describe the common addictive substances and prevent their effects

b) Teaching resources

Different student- teacher's books, chemical, different types of drugs, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the fourth lesson of the 8th unit. In this lesson you will be dealing with **common addictive substances and their effects.** The first thing is to ask student-teachers what they know about tobacco, alcohol, marijuana. From what they know, they can prepare themselves for this lesson.

d) Learning activity 8.4

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 8.4 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any two student-teachers to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 8.4

1. Student teachers will answer according to what they use. But in human life most of people use substances like tobacco, Bier, water. Other ones are used in illegal ways. Even if tobacco and bier are used they also have serious negative effects.
2. All except water
3. Confer to student-teacher book on Unit 8, 8.4 common addictive substances and their effect

e) Application activity 8.4

Expected answers:

I.

1. False	4. True
2. True	5. True
3. True	6. False

7. True 9. True
8. False 10.True

II. Nicotine and Tar

III. Alcohol is depressant, it causes a disease called ALCOHOLISM, it can develop different diseases like cirrhosis of the liver, for heavy drinkers it can cause death.

Lesson 5. Balanced diet

a) Learning objective

- Explain how to prepare a balanced diet
- Prepare a balanced diet
- Acknowledge the importance of having a balanced diet and its relation to age and gender.
- Appreciate the need for a specific diet for individuals who carry out strenuous activities like sports and manual labor.

b) Teaching resources

Different student- teacher's books, different food categories, graph charts illustrating different food types, models, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the fifth lesson of the 8th unit. In this lesson you will be dealing with how to prepare the balanced diet, importance of having a balanced diet and its relation to age and gender. The first thing is to remind student-teachers that they used to study the balanced diet in senior one, unit 7. Due to the background they have, they can prepare themselves for this lesson.

d) Learning activity 8.5

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in individually an activity 8.5 in their student-teacher books
- Provide the necessary materials.

- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 8.5

1.

a. The main nutrients in A are: carbohydrates, lipids, proteins, vitamins, salts.

b. The balanced one is A because it contains all necessary nutrients required

2. Risk of deficiency diseases

3. A good healthy family eating plan should emphasize on all groups of food containing necessarily vegetables, fruits, whole grains, fat free or low fat dairy products. I should also have lean meat, poultry, fish, eggs, and nuts taken alternatively. This plan should limit the saturated fats, sodium and sugar. To make the eating plan do not forget to control the portion size.

Lesson 6: Basic food service technics

Answers to Learning activity 8.6

Answers to this activity are under 8.6 in the student book.

Answers to Application activity 8.6

The expected answers are:

1. The principle sources of food nutrients are any balanced foods and complete foods containing all food groups.

2. Eating a variety of foods promotes good health and can help reduce the risk of disease

8.6. Summary of the unit

In this unit, I have learned that:

- Infectious diseases are caused by microorganisms known as pathogens which may include viruses, bacteria, fungi and protozoa.
- *Vibrio cholerae* are pathogens of cholera which multiply in the intestine, releasing a powerful toxin which results in violent inflammation of the intestine and production of the watery diarrhea.
- Human malaria is caused by infections from four species of plasmodium: *Plasmodium falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*, each responsible for a different form of the disease.
- AIDS (**Acquired Immune Deficiency Syndrome)** is a disorder which damages the human body's immune system. It is caused by the HIV virus (Human Immunodeficiency Virus).
- Sexually transmitted diseases (STDs) are transmitted by infected persons to healthy persons during sexual intercourse. Examples of these diseases are **chlamdia, gonorrhoea, syphillis and, HIV and AIDS.**
- The examples of common deficiency diseases are Kwashiorkor, Marasmus, Vitamin deficiencies.
- Worms causing infection in people are parasites that live and breed mostly in the intestine. Infection is caused by worms such as roundworms, hookworms and tapeworms.
- **Immunity** is a process by which the body of a living organism defends itself against pathogens.
- **The immune system** is a protective system that is made of a series of defenses that fight against diseases by: recognizing, attacking, destroying and remembering each type of pathogen that enters the body. It does this by producing specialized cells which inactivate pathogens.
- An antibody is shaped like the letter **Y**, and has two identical **antigen-binding sites**. The shape of the binding site allows the antibody to recognize a specific antigen with a complementary shape.
- Immune system has the capacity to kill cells, it is very important for it to make a distinction between self and non-self.

- Whenever there is a failure in distinguishing self from non-self, auto-immune diseases develop such as multiple sclerosis, rheumatoid arthritis.
- Mounting of a successful immune response depends on a number of cells and chemical mediators, defect in any component can lead to immunodeficiency state such as absence of mature T lymphocytes in Di George syndrome.
- Immune system has two main parts, innate and adaptive.
- Two branches of the immune system collaborate with each other to make a highly effective immune response.
- Innate system is present at birth, comes into operation immediately upon infection, relies on barriers such as skin and mucous membranes, phagocytes and NK cells, and lacks memory.
- Tobacco, Alcohol and drugs are **common addictive substances**
- The signs and symptoms of drug addiction drug vary according to the individual and the substances he or she uses.
- The main food nutrients are carbohydrates (sugars and starches), proteins, lipids (fats and oils), vitamins, mineral salts and water.
- A balanced diet contains all the food nutrients that a person needs in the right quantities. Different people need different diets depending on their age, gender, level of activity and whether or not they are ill.
- A nutritional disorder occurs when a person does not have enough food or when their diet is lacking certain vitamins or minerals.
- Scurvy, rickets, anaemia, starvation and obesity are examples of nutritional disorders.

8.7. Additional information for tutors

On infectious diseases you have to know different kind of infection such as :

Measles is a contagious acute viral disease with symptoms that include a bright red rash of small spots that spread to cover the whole body. Small white spots, known as Koplik's spots, appear in the mouth on the inside of the cheeks a few days before the rash appears and can be used in diagnosis.

Typhoid caused by ***Salmonella typhus***, a Gramnegative bacterium

Typhoid is waterborne disease. The bacteria are derived from the feces of a patient. It has high infectivity as low dosage of organisms is only needed for typhoid to spread. Common sources of typhoid infection are contaminated water, milk and food.

Smallpox caused by ***Variola virus (DNA virus),* a pox virus**. It was a highly infectious disease transmitted by direct contact and it affects the respiratory passage.

Tinea which is a skin infection due to a fungus; often, there are several patches of ringworm on the skin at once. Tinea is also known as Ringworm and it is caused by a tiny fungus known as dermatophyte.

Malaria Rapid Test Background Information

Malaria is a serious parasitic disease characterized by fever, chills, and anemia and is caused by a parasite that is transmitted from one human to another by the bite of infected Anopheles mosquitoes. There are four kinds of malaria that can infect humans: Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, and Plasmodium malariae. In humans, the parasites (called sporozoites) migrate to the liver where they mature and release another form, the merozoites. The disease now occurs in more than 90 countries worldwide, and it is estimated that there are over 500 million clinical cases and 2.7 million malaria-caused deaths per year. At the present, malaria is diagnosed by looking for the parasites in a drop of blood. Blood will be put onto a microscope slide and stained so that the parasites will be visible under a microscope.

This test is an aid in the diagnosis of Malaria infection. The disease now occurs in more than 90 countries worldwide, and it is estimated that there are over 500 million clinical cases and 2.7 million malaria-caused deaths per year.

Guidance on Skills lab 8

This activity can be better carried if student-teachers are allowed to visit the nearest medical clinic.

The school administration can recommend them to visit the nearest clinic where they will learn from medical personnel how the test for malaria is conducted nowadays. If possible, the school should provide them with the kit so that, once back, they can also conduct the malaria test at school level.

8.8. End unit assessment 8 (answers)

i. Choose whether the given statements are True (T) or False (F):

1. **True**; innate immunity is present at birth.
2. **False**; as breast milk contains IgA type of antibodies.
3. **True**; as antibodies can tag the microbial agents and bind to phagocytes.
4. **False**; as antibiotics cure the disease by either killing or slowing the growth of bacteria.
5. **True**; as initially this disease was curable, but gradually the bacterium acquired resistance to a number of antibiotics.
6. **False**; as hay fever is a localized allergic reaction involving upper respiratory tract.
7. **True**; as memory cells are already primed and upon second exposure to the same antigen grow bigger in size and start secreting antibody.
8. **True**; as preformed antibodies are administered to neutralize the toxin with no stimulation of immune system.
9. **False**; Immune system has two main parts, innate and adaptive.
10. **True**; as intact cell wall is important for survival of bacteria.

ii. Long answers

1. Antibodies are immunoglobulins, designated as Ig. Different types of antibodies, secreted by B-lymphocytes are written as IgM, IgG, IgA, IgE and IgD. These antibodies are capable of recognising over a million different antigens and confer protection in a number of ways. Functions performed by antibodies are:

   i. Antibodies bind to toxins produced by bacteria that cause infection like diphtheria or tetanus, effectively nullifying them.

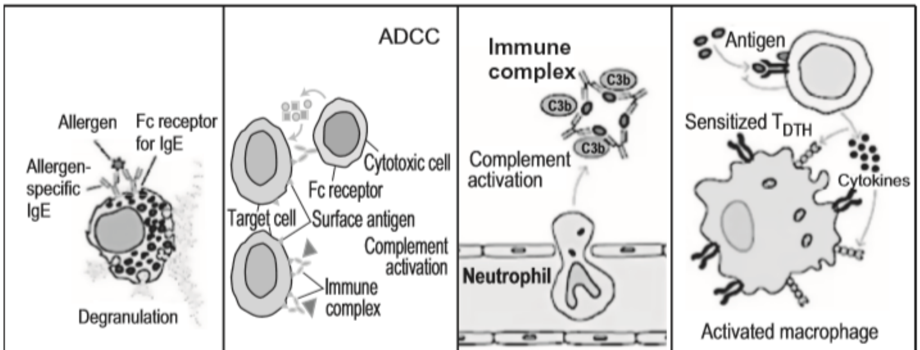
   ii. By attaching to microbial pathogens, antibodies promote their clearance by phagocytes manifold.

   iii. Antibodies form a covering on bacteria and viruses, not allowing them to gain entry into tissues. Bacteria and viruses, thus having being coated, are eliminated by beating of cilia present on the epithelial cells in the respiratory tract or by peristalsis of the gastrointestinal tract.

iv. Antibody, esp. of the IgG type, is highly mobile, capable of leaving circulation and reaching skin where it can neutralize surface bacteria. This antibody can also pass through the placenta reaching the developing foetus, providing it some protection against infections.

v. Antibody, esp. of the IgA type, is found in large amounts in mother's milk, and helps protect the newborn against infections during the first months of life when infant's immune system is not fully functional.

vi. Antibody of the IgE type, plays an important role against parasitic infections, though it is also responsible for the allergic reactions to various allergens in the environment and will be described later in detail.



Type I	Type II	Type III	Type IV
IgE mediated Hypersensitivity	IgG mediated Cytotoxic Hypersensitivity	Immune Complex Mediated Hypersensitivity	Cell Mediated Hypersensitivity
Ag induces crosslinking of IgE bound to mass cells and basophils with release of vasoactive mediators	Ab directed against cell surface antigens meditates cell destruction via complement activation or ADCC	Ag-Ab complexes deposited in various tissues induce complement activation and an ensuing inflammatory response mediated by massive infilatration of neutrophils	Sensitized T_H1 cells release cytokines that activate macrophages or TC cells which mediate direct cellular damage
Typical manifestations include systemic anaphylaxis and localized anaphylaxis such as hay fever, asthma, hives, food allergies, and eczema	Typical manifestations include blood transfusion reactions, erythroblastosis fetalis, and autoimmune hemolytic anaemia	Typical manifestations include localized Arthus reaction and generalized reactions such as serum sickness, necrotizing vasculitis, glomerulnephritis, rheumatoid arthritis, and systemic lumpus erthyematosus	Typical manifestations include contact dermatitis, tubercular lesions and graft rejection

Types of Hypersensitive responses

2. **(a) Phagocytes**, which include both neutrophils and macrophages, play an important role in innate immunity. They can identify foreign invading pathogens, discriminate them from cells of the body, and internalize them by throwing pseudopodia around them. Once within the phagocytes, pathogens are digested by a number of hydrolytic enzymes, thus freeing the body of disease-causing germs. Phagocytes also help in removing old, dead cells as well as cancerous cells.

(b) Lymphocytes, with a very large, darkly staining nucleus occupying the entire volume of the cell, with very little cytoplasm. Generation of memory cells upon first exposure to infectious agent is seen in primary response. Primary response leads to the generation of activated lymphocytes of the B- or T- type as well as memory cells. This response is not only weak in intensity but also takes a long time to initiate.

(c) Immune response is a response produced by the body upon invasion of a foreign substance, especially infectious microbes and toxins produced by them and is protective in nature.

3. Differences between active and passive immunity

Active Immunity

i. It Is produced due to contact with pathogen or its antigen.

ii. Immunity is not immediate. A time lapse occurs for its development.

iii. It lasts for sufficiently long period, may be lifelong.

iv. Antibodies are produced by the body in response to pathogen or antigen.

v. Side effects are very few.

Passive Immunity

i. It Is produced due to antibodies obtained from outside

ii. Immunity develops immediately

iii. It lasts for a few days

iv. Antibodies are obtained from outside

v. At times the body reacts to the introduction of antisera. It is called serum sickness.

4. Though smallpox has been successfully eradicated, eradication of other diseases such as measles, tuberculosis, cholera and malaria has not been so successful. Success of smallpox vaccine was due mainly to the fact that pox virus did not mutate and the same vaccine could be used everywhere and the vaccine was highly effective. On the other hand, though measles vaccination has decreased death rates drastically, its total eradication has not been achieved so far due to several reasons. The disease is highly infectious, and spreads very fast. As long as it is present in one area, unvaccinated children in any country are at risk.

For measles, boosters are required, difficult to achieve in poor countries, parents' decision not to vaccinate their children due to fear or other misconceived notions has also made the vaccination program less effective.

Effective vaccine against cholera has not been available for two major reasons:

(a) Immunity conferred by the vaccine is not long lasting;

(b) Cholera is a toxin mediated disease while protective immune mechanism is antibacterial rather than antitoxic.

Oral cholera vaccines have become available recently. Tuberculosis is a major killer, causing 2 to 3 million deaths annually. According to WHO reports, nearly one-third of the world's population is currently infected with TB.

Today, the only approved tuberculosis vaccine is bacilli Calmette Guerin (BCG) which was started in 1921.

Though it is quite effective in infants and young children, in adults, its efficacy is variable. Many boosters are also being developed, MVA85A, being the most advanced boost available. BCG vaccine has not been modified since 1921 and that may also be one reason why it is not so effective. That bacteria may have changed through evolution is suggested by their evolution of resistance to a number of known antibiotics.

A lot of effort is being devoted, but proving difficult as the bacterium lives within the cells and lack of suitable animal model for developing and testing human tuberculosis vaccine is posing a big challenge. In Africa, coinfections of human immunodeficiency virus and TB have led to increases in the incidence rate of TB.

5.

	Name
Cause malaria	Plasmodium
Transmits malaria	Female anopheles mosquito
Cause influenza	Influenza virus
Causes Ancylostomiasis	Ancylostoma duodenale
Provide penicillin	Penicilium notatum

Elephantiasis	Wuchereria bancrofti
Transmits venereal disease	HIV, Chlamydia trachomatis, Treponema paridum,……..
Scurvy	lack of vitamin C
Causes body's bad smell	Poor hygiene and sanitation
Creates feeling of pleasure and satisfaction	Cocaine abuse

8.9. Additional activities (Questions and answers)

8.9.1 Remedial activities

1. Diseases are broadly divided into two categories. What are they?
2. What do you think is a causal agent of cholera?
3. State the functions of having a balanced diet

Expected answers:

1. Two categories of diseases are
    - Infectious diseases
    - Non-infectious diseases
2. Vibrio cholerae.
3. A balanced diet helps to:
    - Make you strong
    - Provide better health
    - Make you more productive
    - Ensure strong immune system

8.9.1. Consolidation activities

1. Differentiate Antibody from Antigen.
2. State any two diseases caused by: a. Bacteria b. Protozoa c. Microscopic fungi
3. Explain what is meant by ring vaccination.

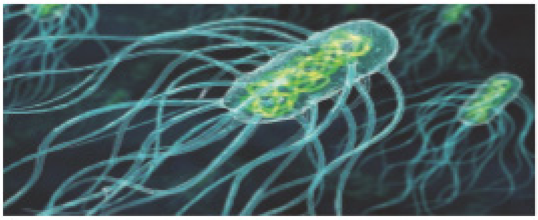
Expected answers:

1. Antibody: is a protein produced by the body's immune system when it detects harmful substances called antigen while Antigen is any substance that causes your immune system to produce antibodies against it.
2. Any two diseases caused by:
   a. Bacteria: Cholera, typhoid, tetanus, tuberculosis, etc.
   b. Protozoa: Malaria, sleeping sickness, trichomoniasis, etc.
   c. Microscopic fungi: Candidiasis, athlete's foot, ring worms, etc.
3. Ring vaccination is a vaccination of everyone within a certain place of the outbreak of the disease.

8.9.3. Extended activities

1. Work on the following question

Observe the figure and answer to the question below.



   a. What is this figure presenting?
   b. Give the effect of living organism in figure to human body life?

2. What do you think are factors that cause the failure to eradicate tuberculosis?
3. 3.(i) .... leads to production of long lived memory cells.

   (ii) Cholera is a .... mediated disease.

   (iii) .... decreases blood pressure and contraction of muscles of bronchioles.

   (iv) .... occurs upon inhaling certain allergens in the air leading to sneezing and coughing. (v) Penicillin is produced by ....

Expected answers

1. a) The figure is presenting Salmonella typhus

b). The effect of Salmonella typhus to human body life is that it causes the disease Typhoid

2. Factors that cause the failure to eradicate tuberculosis?

   - Patients can carry pathogen and infection without showing symptoms. Therefore, they are difficult to identify due to a long period of incubation
   - Germs of tuberculosis can survive longer in the house dust
   - The disease is related to poverty where many people share the same room and have malnutrition.
   - The disease is associated with AIDS that reduced the body immunity
   - Long period of treatment (6-8 moths), hence patients give up when not yet fully healed. The pathogens then form endospores that resists to medicines.
   - The disease is also spread through milk from infected animals. Tuberculosis is an airborne disease i.e. spread in air

3. (i) Vaccination (ii) Toxin (iii) Generalized allergic reaction
   (iv) Hay fever (v) Penicillium notatum

UNIT 9

MICROSCOPE AND CELL STRUCTURE

9.1. Key Unit competence

Describe the structure and function of cells in an organism.

9.2. Prerequisite (knowledge, skills, attitudes and values)

Student teachers have some knowledge, skills, attitudes and values about the manipulation of microscope, and about the structure of the cell as the have studied these in senior one ordinary level. This will facilitate them to study well this unit.

9.3. Cross cutting issues to be addressed

a) Peace and value

It should be integrated in sub-heading called: cell organelles. When teaching that a cell has many organelles with different functions but that all are important and work together for the survival of the cell. Tell Student teachers that, in the same way: in human society, we are many but we can work together in peace and harmony despite of the difference of our abilities, disabilities or physical appearance.

b) Financial education

This cross-cutting issue should be integrated in the sub-heading called: "**ultrastructure of the cell".** When guiding Student teachers on how to manipulate the microscope, you should give a caution of handling them carefully as they are very expensive, and that the country spends a lot of money to buy them.

c) Gender education

This cross-cutting issue should be integrated in all sub-headings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities, and when cleaning materials used during practical activities: both boys and girls should participate equally.

d) Inclusive education.

This cross-cutting issue should be integrated in all sub-headings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: Student teachers with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, Student teachers without arms and legs; you the tutor and other Student teachers should help them to achieve the competences as required in all teaching-learning activities.

e) Standardisation culture

Student-teachers should realise that the quality of medical conclusion depends on the standard of the equipment they use. The advanced microscopes give most accurate result when testing for e carcinogen cells, normal sperm cells, intestinal parasites, etc.

9.4. Guidance on introductory activity

- In groups or pairs, help learners to choose group representatives.
- Help Student teachers to text books and work on the introductory activity 3.1.
- Supervise the work on how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask Student teachers to present what they have done
- Help Student teachers to summarize what they have learnt.

9.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Cell theory and microscopes	- Describe the main features and functions of the components of a compound light microscope. - Manipulate a compound light microscope to observe prepared slides. - Compare light and electron microscopes - Prepare temporary slides for observation under light microscopes using different objective lenses.	5
2	Eukaryotic and prokaryotic cell	State differences between eukaryotic and prokaryotic cells	4

3	The components of both Plant and animal cell	-Describe the cell structure -Explain the difference between animal cell and plant cell, -Compare the animal cell and plant cell	4
4	Specialized cells	- Explain and interpret cell specialization and functions of specialized cells - Appreciate the importance of cell specialization in multicellular organisms.	3
5	End unit assessment		2

Lesson 1. Cell theory and microscopes

a) Learning objective

- Describe the main features and functions of the components of a compound light microscope.
- Manipulate a compound light microscope to observe prepared slides.
- Compare light and electron microscopes
- Prepare temporary slides for observation under light microscopes using different objective lenses.
- Explain the cell theory

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have some knowledge, skills, attitudes and values about the manipulation of microscope, and about the structure of the cell as they have studied these in senior one/ordinary level. This will facilitate them to study well this unit. Guide them in answering questions of introductory activity 9.

d) Learning activity 9.1

Guide student teachers to use internet and textbooks and work on the activity 9.1.

e) Application activity 9.1

1. Advantages of the electron microscope over light microscope:

Light microscope has a higher resolution and is therefore able of a higher magnification estimated at up to 2 million times compared to the light microscope which can show a useful magnification only up to 1000-2000 times. These differences are due to a physical limit imposed by the wavelengths of the light. Electron microscopes therefore allow for the visualization of structures that would normally be not visible by optical microscopy.

Depending on the type of electron microscope different observation can be processed. For example, for a transmission electron microscopy (TEM) a beam of electrons is transmitted through a specimen to form an image of the specimen which is most often an ultrathin section less than 100nm thick or a suspension on a grid, while the scanning electron microscope (SEM) produces images of a sample by scanning the surface with a focused bean of electrons. The SEM has a resolution power of about 5 nm higher than that of a light microscope but lower than that of a TEM.

2. An **electron microscope** uses a beam of **electrons** to magnify an object. The lensing system employs electric and magnetic fields and is specialized for applications requiring much higher magnification while **light microscopes** employ **light** and an array of glass lenses to magnify an object.

3. Magnification= size of the image / size of object

   The size of the image should be converted to μm: Size of image =50mm=50000μm

   Therefore, magnification =50000 /5=10000

   Conversely, if the magnification is 50000 times, and the size of the image is 5mm (5000 μm), the actual size of the object is: size of image/ magnification=5000/50000=0.1 μm.

4. 100/10000=0.01 mm (observed size divided by magnification)

   This can be converted to μm by multiplying by 1000

   0.01mm=10 μm, or it can be calculated as 100mm x1000 μm

   Actual size =100 000/10 000 μm=10 μm

5. Complete the table below:

Parts of microscope	Functions
Base	supports and stabilizes the microscope
Revolving nosepiece	rotates to allow use of different power objectives
Coarse focus adjustment	moves stage up and down a large amount for coarse focus
Objective lenses	focuses and magnifies light coming through the slide
Eye piece / ocular lens:	magnifies image produced by objective lens

6. The light microscope is important because they allow scientists to study microorganisms, cells, (and their contents), genes, crystalline structures and molecular structures. Microscopes are one of the most important diagnostic tools when doctors examine tissue samples.

7. Help and follow how the learner apply microscope technique rules.

   - Carry the microscope with both hands, one hand under the base, and the other on the arm. When getting ready to put the microscope away, always return it to the low power or scanning power setting.
   - When setting the microscope on a table, always keep it away from the edge.
   - It is generally best to clear your lab table of items that are not being used.
   - The lenses of the microscope cost almost as much as all of the other parts together. Never clean them with anything other than lens paper. Paper towels and other paper tissues will scratch the lens.
   - Please inform the instructor or the biology lab technician of any microscope damage or irregularity in its operation as soon as possible. Do not return a faulty microscope without first informing the instructor or lab tech.
   - You are responsible for the microscope while using it— treat it with care!

8. Electron microscopes are very important in medicine and biology research because they are used to investigate the ultra-structures of a wide range of biological and inorganic specimens including viruses, microorganisms, cells, large molecules, biopsy (examination of tissue removed from a living body to discover the presence, cause, or extent disease) samples, metals, and crystals.

It is not possible to view any living material by using electron microscope due to vacuum inside electron microscope and living specimens cannot be viewed because electron microscopes require a vacuum in the tube - otherwise the electrons would be absorbed by air molecules

9. Comparative study between light and electron microscope focussing on the advantages of each type of microscope.

   - Both light and electron microscopes form larger (magnified) and more detailed (highly resolved) images of small objects or small areas of larger objects
   - Both light and electron microscopes are used in study and research in biology and medical sciences particularly histology, material sciences such as metallurgy and other aspects of science.
   - Specimens must be carefully prepared using techniques appropriate for both the equipment and the sample including slicing, staining, and mounting.

Lesson 2. Eukaryotic and prokaryotic cell

a) Learning objective

- State differences between eukaryotic and prokaryotic cells

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Students have some knowledge, skills, attitudes and values about the manipulation of microscope, and about the structure of the cell as the have studied these in senior one ordinary level. They have also studied the Cell theory in previous lesson. This will facilitate them to study well this unit.

d) Learning activity 9.2

Guide students to manipulate the microscopes and work on the activity 9.2. The probable answers should be correlated with information discussed in the content summary of the lesson 9.2.

e) Application activity 9.2

1. **Prokaryotes** are organisms having cells with no true nuclear envelope. Prokaryotic cells do not contain a nucleus or any other membrane-bound organelle. **Eukaryotes** are organisms having cells with true nucleus i.e. with a nucleus enclosed in a nuclear envelope.

2. Refer to the content summary of lesson 9.2

Lesson 3. Plant and animal cells

a) Learning objective

- Describe the cell structure
- Explain the difference between animal cell and plant cell,
- Compare the animal cell and plant cell

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation, electron micrographs.

c) Prerequisites/Revision/Introduction

Student teachers have some knowledge, skills, attitudes and values about the manipulation of microscope, and about the structure of the cell as the have studied these in senior one ordinary level. They have also studied the Cell theory in previous lesson. This will facilitate them to study well this unit.

d) Learning activity 9.3

Provide clearer electronic micrographs to students, and guide them to work on the learning activity 9.3. Probable answers should be correlated with the information discussed in the content summary of the lesson 9.3 from the students' text books.

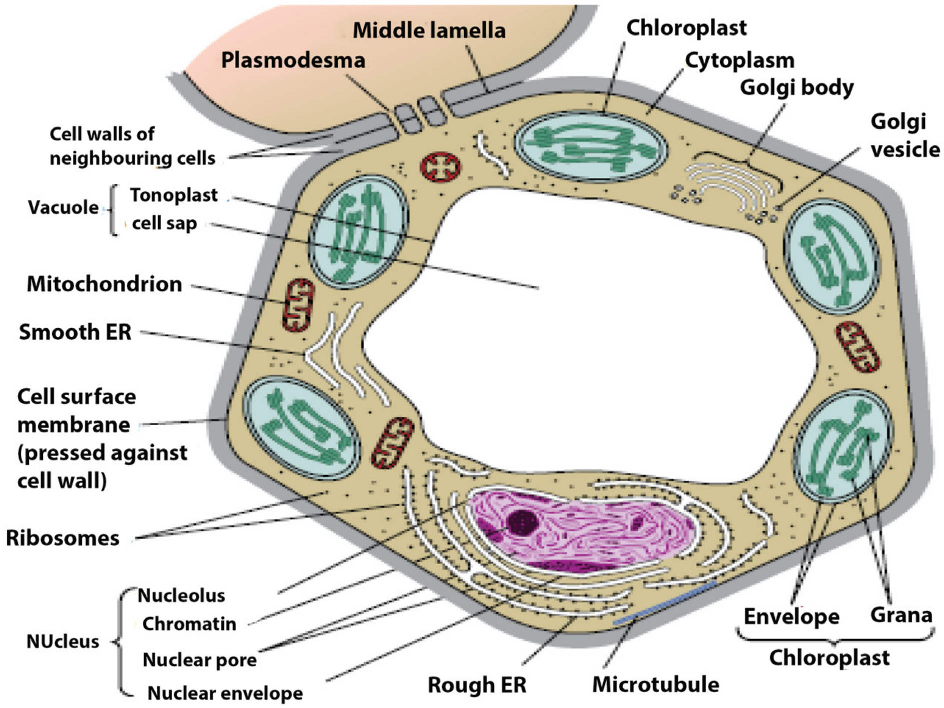
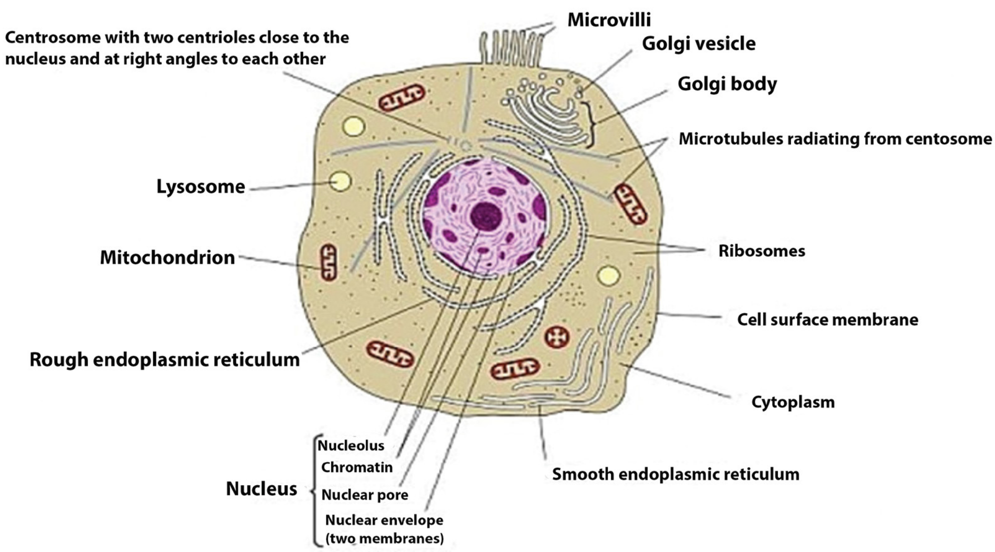


Figure for the Structure of a plant cell



The figure for the structure of a plant cell

e) Application activity 9.3

1. The structures of both animal cell and plant cell are described in the content summary of the lesson 9.3.

Lesson 4: Organelles and their functions

Answers to learning activity 9.4. Refer to content under activity 9.4 in student book

Application activity 9.4

1. The term **fluid mosaic** is used to describe the molecular arrangements in membranes. It consists of: A bilayer of phospholipid molecules forming the basic structure, many protein molecules floating in the phospholipid bilayer. Some are free; others are bound to other components or to structures within the cell and some extrinsic proteins are partially embedded in the bilayer on the inside or the outside face while other intrinsic proteins are completely spanning the bilayer.
2. The basic structure of phospholipids has two parts: **hydrophilic part** which means water loving and which consists of the phosphate head**,** and **hydrophobic part** which means water hating and which consist of fatty acids. If phospholipid molecules are completely surrounded by water, a bilayer can form phosphate heads on each side of the bilayer stick into water, while the hydrophobic fatty acid tails point towards each other.
3. The types of proteins in cell membrane are:
   - **Carrier proteins** which fix or attach molecules and facilitate them to cross through the cell membrane by active transport
   - **Channel proteins** which pump substances and allow facilitated diffusion. They act as pores.
   - **Receptors** of enzymes and neurotransmitters
   - **Glycoproteins** act as receptor proteins which recognise the substance to pass through the membrane
   - **Integrated proteins** define the shape of the cell
   - **Immune proteins** (antigens) found in the membrane on the red blood cell, recognise the antibodies.
4. Partially permeable membrane mean that cell membranes are permeable to water and some solutes.

5. As mitochondria are the site for energy production, muscle cells which are more active should contain a lot of mitochondria and fat storage cells which are relatively less active contain few mitochondria.

6. Chromosomes contain genetic information which is transmitted from one generation to another.

7. The cell came from a plant.

8. a)

Part	Name	Function
A	Chloroplast	Site for photosynthesis
B	Vacuole	Storage of substances
C	Nucleus	Controls all activities of the cell
D	Mitochondrion	Site for cell respiration/ energy production
E	Golgi apparatus	It receives proteins from the ER and modify them, add sugar molecules to them, packages the modified substances into vesicles that can be transported to their final destinations throughout the cell or outside of the cell.
F	Cytoplasm	Contains all organelles/ site for chemical reactions
G	Cell wall	Protection of internal cellular parts
H	Endoplasmic reticulum	Site for lipids synthesis

b) Cytoskeleton is a network of protein filaments that helps the cell to maintain its shape an it is also involved in in movement.

9. Similarities between animal cell and plant cell

- Both animal and plant cells have a cell membrane, a cytoplasm and a nucleus.
- Both animal and plant cells have a true nucleus bounded by an envelope.
- Both animal and plant cells have mitochondria, Golgi apparatus, Reticulum endoplasmic, lysosome, big ribosomes (80S), peroxisome, microtubules.
- The protoplasm is enveloped by a bounding cell membrane called **plasmalemma.**
- The protoplasm is composed of a dense round structure called nucleus which is surrounded by a less dense jelly-like cytoplasm.

- The cytoplasm contains numerous organelles such as mitochondria, Golgi bodies, secretory vacuoles, endoplasmic reticulum.
- Mitochondria appear as very small darkly staining, rod-like structures.
- Golgi bodies are semi-transparent irregular, and membrane bound structures.
- Vacuoles contain secretions, food- particles, or decomposing organic substances.

10. a) False b) False c) False

Lesson 5. Specialized cells

a) Learning objective

- Explain and interpret cell specialization and functions of specialized cells
- Appreciate the importance of cell specialization in multicellular organisms.

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have some knowledge, skills, attitudes and values about the manipulation of microscope, and about the structure of the cell as the have studied these in senior one ordinary level. They have also studied the Cell theory in previous lesson. This will facilitate them to study well this unit.

d) Learning activity 9.5

Guide Student teachers to observe the figure in the Student teachers text books and guide them to work on the activity 9.4. They should give answers which appreciate the role of cell specialization for the cells observed in the figure. They are differentiated to perform a specific function in the body.

e) Answers to application activity 9.5

1. Because their nucleus is lost, Erythrocytes are specialized by have a **biconcave** shape which enable them to carry out their function (to transport Oxygen) sufficiently.

2. Cell division, protein synthesis, aerobic respiration.

3. Expected answers:

   a. Neutrophils contain many lysosomes that have digestive enzymes to digest pathogens.

   b. Sperm cells have the tail which helps them to move, they have many mitochondria which produce APT that provides energy for movement, and they have also enzymes in their acrosome which digest the walls of the egg during fertilization.

   c. Root hair cells have thin wall, are numerous to provide large surface area for absorption of water and minerals.

4. Photosynthesis is carried out in palisade mesophyll more than in spongy mesophyll because palisade mesophyll contains many chloroplasts compared to spongy mesophyll.

5. It is multicellular organisms where cell specialization is a characteristic?

6. Mitochondria would be most common in muscle cells.

7. Differentiation refers to the changes occurring in cells of a multicellular organism so that each different type of cell becomes specialized to perform a specific function.

9.6. Summary of the unit

The unit **"Microscope and cell structure"** is divided into four sub-headings: Cell theory and microscopes, Eukaryotic and prokaryotic cell, the components of both Plant and animal cell, specialized cells. It deals with: Explaining the cell theory, working of a microscope; comparing eukaryote from a prokaryote; describing the structure of the cell, and specialisation of the cells.

Eukaryotic cells contain membrane-bound organelles, including a true nucleus enclosed in a nuclear envelope. They include cells of: plants, animals, fungi and protoctista. **Prokaryotes** are organisms having cells with no true nuclear envelope. Prokaryotic cells do not contain a nucleus or any other membrane-bound organelle. Prokaryotes include bacteria and blue-green algae. They make up the **monera** kingdom.

Ultrastructure of a plant cell contains different parts like:

Cell wall, cell membrane, cytoplasm with organelles. Organelles found in the cytoplasm of a plant cell include: chloroplast, mitochondria, Golgi apparatus, endoplasmic reticulum, ribosomes, big central vacuole, and the nucleus which contains chromosomes. The plant cell also has a regular shape, with a relatively bigger size than animal cell. Differentiation refers to the changes occurring in cells of a multicellular organism so that each different type of cell becomes specialised to perform a specific function.

9.7. Additional information for tutors

Our body is made up by many cells. A group of many cells having similar function is called a tissue. A group of many tissues having similar function make an organ. A group of many organs makes a system/organ system. Many systems working together make an organism. Below is a list of lifespan of some cells:

Life spans of various human cells

Cell type	Lifespan	Cell division
Lining of oesophagus	2-3 days	Can divide
Lining of small intestine	1-2 days	Can divide
Lining of large intestine	6 days	Can divide
Red blood cells	About 120 days	Do not divide
White blood cells	10 hours to decade	Many do not divide
Smooth muscles	Long-lived	Can divide
Cardiac (hear) muscles	Long-lived	Cannot divide
Skeletal muscle	Long-lived	Cannot divide
Neurone (nerve cell)	Ong-lived	Most do not divide

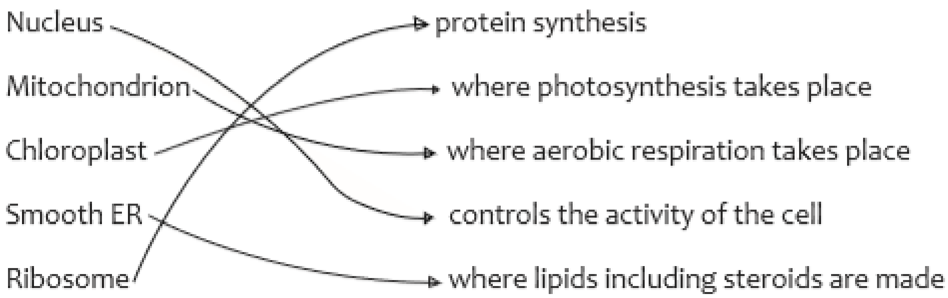
9.8. End unit assessment 9

Answers to the End unit assessment 9

Section A: Multiple choice questions

1. d
2. c
3. a
4. b
5. b

6. Match each part of the cell to its correct statement:



Section B: Questions with short answers

1. A **cell membrane** is directly in contact with the plasma (cytoplasm) and is found in all cell, while a cell wall surrounds the cell membrane and is not found in animal cells.
2. The structures that animal and plant cells have in common are: nucleus, cytoplasm, cell membrane, mitochondria and ribosomes. Those found only in plant cells are: cell wall, permanent vacuole and chloroplasts, and those found only in animal cells are: lysosomes and centromere.
3. List:
   a. Centrosomes, centrioles, nucleolus, ribosomes, cytoskeleton, and flagella.
   b. Lysosomes, ER, Golgi bodies.
   c. Chloroplast, mitochondrion and nucleus.
4. Identify an organelle from its description below.
   a. • Golgi apparatus manufactures lysosomes.
      • Nucleolus within nucleus manufactures ribosomes.
   b. Ribosome
   c. Endoplasmic reticulum.
   d. Rough ER can transport newly synthesized protein round the cell.
   e. Mitochondria
   f. Nucleus
   g. Chloroplast
   h. Centriole
   i. Nucleus.
   j. Plasma membrane.

k. Ribosome.

l. Chloroplast and mitochondrion.

Section C. Essay questions

1. The structure and function of the cell membrane consists of a phospholipid bilayer containing proteins. Its functions include: controlling what enters and leaves the cell, protection of internal structures. The cell wall is made of cellulose and proteins. It is porous (has pores) enough to allow water, oxygen, carbon dioxide and other substances to pass through easily. Its functions are: protection and support of the cell.

2. The basic structure of the cell membrane is made by a phospholipid bilayer, containing intrinsic and extrinsic proteins. The basic structure of phospholipids has two parts: hydrophilic part (water loving), which consists of the phosphate head, and hydrophobic part (water hating), which consist of fatty acids. If phospholipid molecules are completely surrounded by water, a bilayer can form. Phosphate heads on each side of the bilayer stick into water, while the hydrophobic fatty acids tails point towards each other.

3. Chloroplasts use energy from sunlight to make energy-rich food molecule. The mitochondria transfer the energy in food molecules to high-energy compounds that the cell can use. Both chloroplast and mitochondria are bounded by double membranes separated by a fluid-filled space. The inner membrane of chloroplast is continuous with thylakoids having the chlorophyll pigment. The inner membrane of mitochondrion is highly folded to form cristae. The central part of the mitochondrion is called the matrix.

4. The following are the answers:

a) A: cell membrane,

B: centriole,

C: cytoplasm, and

D: Rough ER.

b) To calculate the actual length of the mitochondrion, use the formula:

$$A = \frac{I}{M} = \frac{I}{M},$$

A, where: M is magnification, I is image size of mitochondrion (measured on the diagram by using a ruler) and A is actual size.

C) The advantage to have a division of labour between different cells in the body will allow the organism to perform all biological processes to keep it healthy.

5. The expected answers are:

A) a. A: glycolipid, B: Channel protein, C: glycoprotein, D: phospholipid bilayer.

The function of the part B (channel protein) is to help to move materials across the cell membrane.

B) a. The expected answers are • support • protection • movement • sharp e.t.c

6. a) Cell signaling and recognition is done by some hormone receptors which are glycoproteins glycolipids.

   b) Carrier proteins

   c) Enzymes and coenzymes.

7. The expected answers are

   - The rough ER is surrounded with ribosomes and transports proteins made on the attached ribosomes while smooth ER is made of tubular cavities and have no ribosomes
   - The rough ER is involved in protein synthesis while smooth ER is involved in lipid synthesis

8. The expected answers are

   a. Mitochondria

   b. Aerobic respiration

9.9. Additional activities (Questions and answers)

9.9.1 Remedial activities

1. On your choice, list and give the functions of two organelles from animal cell and plant cell.
2. What is the adaptations of chloroplast for its function?
3. State the general function of the glycoproteins and glycolipids.
4. Which among prokaryote and eukaryote is more complex?
5. Explain how a sperm cell is adapted to fertilise the egg.

Answers to Remedial activities:

1. From animal cell: mitochondria: site for energy production; nucleus: it controls all cell activities. From plant cell: chloroplasts: site for photosynthesis, Ribosomes: site for proteins synthesis.
2. Chloroplasts are adapted by: having thylakoids with chlorophyll where light dependent reactions occur, stroma where light-independent reactions occur.
3. Both glycoproteins and glycolipids are involved in the cell protection, the process by which cell adhesions are brought about and also in the uptake and entry of selected substances.
4. Eukaryote is more complex than prokaryote. Eukaryote may be a multicellular organism with many structures that are not found in prokaryote. Also, eukaryotic cells have most of all organelles, but prokaryotic cells lack some organelles like a real nucleus
5. A sperm cell is adapted by having: tail for movement, many mitochondria to produce energy for movement, acrosome with enzymes for digesting the wall of the egg during fertilisation, half number of chromosomes which, when fused with chromosomes from the egg form a diploid zygote.

9.9.2. Consolidation activities

1. Discuss two largest organelles of an animal cell and their functions.
2. A student was telling his colleagues that the lysosome is not important to the cell. Discuss to his idea.
3. Why must cell membrane be partially permeable?
4. Compare a prokaryotic cell to a eukaryotic plant cells considering the presence of the cell wall.
5. What are the adaptations of red blood cell for its function?

Answers to consolidation activities:

1. The nucleus: controls all activities of the cell, and ER: rough ER transports proteins made on attached ribosomes, while smooth ER does not have ribosomes, and it involves in making lipids that the cell needs.
2. His idea is wrong. Lysosomes are very important as they contain powerful digestive enzymes which can break down materials, and destroy invalid microorganisms. In acrosome, lysosomes help the sperm to penetrate the egg by breaking down the material surrounding the egg.

3. A cell membrane should be permeable in order to allow some materials to move through it.

4. Both prokaryotic and eukaryotic plant cell have the cell wall surrounding their plasma membranes.

5. Adaptations of red blood cell for its function are: having Haemoglobin to fixe oxygen, lacking some organelles including the nucleus for providing big space for haemoglobin, having biconcave shape to facilitate diffusion of gases, they are numerous

9.9.3. Extended activities

1. Talk about Robert Hooke contribution on cell discovery.

2. How is a cell like a factory?

3. How the structure of the nuclear membrane enables it to carry out its function controlling what enters and leaves the nucleus?

Answers to extended activities

1. From his experiment on observing slides of cork taken from the bark of an Oak tree under the compound microscope, Robert Hooke decided that the slides were made up of a lot of many small chambers that he called cells. He used the word "cell" in his book Micrographia, published in 1665.

2. Students may give various answers. One response may involve the comparison of ribosomes to machines in the factory. They may also compare other organelles to different parts of the factory.

3. The nuclear membrane contains many pores which enable it to carry out its function controlling what enters and leaves the nucleus?

UNIT 10

CELL AND NUCLEAR DIVISION

10.1. Key Unit competence

Describe the stages of the cell cycle and explain the significance of cell and nuclear division in organisms.

10.2. Prerequisite (knowledge, skills, attitudes and value)

Students have knowledge, skills, attitudes and values about the structure of the cell, manipulation of microscope and importance of nucleus and chromosomes learnt in the previous lesson. This will facilitate them to study well this unity.

10.3. Cross cutting issues to be addressed

a) Peace and value

Tell students in their groups sold know that we are many but we can work together in peace and harmony despite of the difference of our abilities, disabilities or physical appearance.

b) Financial education

This cross-cutting issue should be integrated in the sub-heading called: "**ultrastructure of the cell".** When guiding students on how to manipulate the microscope, you should give a caution of handling them carefully as they are very expensive, and that the country spends a lot of money to buy them.

c) Gender education

This cross-cutting issue should be integrated in all sub-headings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities, and when cleaning materials used during practical activities: both boys and girls should participate equally.

d) Inclusive education.

This cross-cutting issue should be integrated in all sub-headings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: students with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, students without arms and legs; you the teacher and other students should help them to achieve the competences as required in all teaching-learning activities.

10.4. Guidance on introductory activity

Guide students to use the text books and work on the introductory activity 10. Possible answers to the introductory activity may be:

1. It is impossible to build a house by using only one brick.
2. The house grows up and increases in size as a result of building bricks over others.
3. As the house grows up and increases in size as a result of building bricks over others, the human body will also increase in size as a result of cell division which increases the number of cells of the body.
4. An adult body size cannot be made by only one cell.
5. Cells which are used to build the body come from cell division.
6. The cells may divide mitotically, where one cell sprits into two daughter cells.

10.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Cell cycle	-Describe the main stages of the cell cycle	2
2	Mitosis and Meiosis	-Describe the process of mitosis and meiosis. -Compare mitosis and meiosis -Explain and interpret haploid and diploid conditions of the cell cycle	4
3	Mitosis and Meiosis roles in living organisms	-Outline the significance of mitosis in cell replacement and tissue repair by stem cells. -Explain the role of meiosis in gametogenesis in humans and in the formation of pollen grain and embryo sacs in flowering plants	4

		-Show concern to individuals with physical disabilities like Down's syndrome	
4	End unit assessment		2

Lesson 1. Cell cycle

a) Learning objective

Describe the main stages of the cell cycle

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about the structure of the cell, manipulation of microscope and importance of nucleus and chromosomes learnt in the previous lesson. This will facilitate them to study well this unity.

d) Learning activity 10.1

Guide student teachers to use text books and work on the learning activity 10.1 to describe the phases of cell cycle.

The answer: The cell cycle is a series of events of cellular growth and division that has five phases such as:

- The first growth phase (G_1),
- The synthesis phase (S),
- The second growth phase (G_2),
- Mitosis (M),
- Cytokinesis.

e) Application activity 10.1

1. The cell cycle is a series of events of cellular growth and division that has five phases such as:

   The first growth phase (G_1), the synthesis phase (S), the second growth phase (G_2), mitosis (M), and cytokinesis.

2. The answer is found in the content summary of the lesson 10.1.
3. If cytokinesis does not take place in succession of the cell cycle, the two formed nuclei will remain in the same cytoplasm.

Lesson 2. Mitosis and Meiosis: Stages and results

a) Learning objective

- Describe the process of mitosis and meiosis.
- Compare mitosis and meiosis
- Explain and interpret haploid and diploid conditions of the cell cycle

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about the structure of the cell, manipulation of microscope and importance of nucleus and chromosomes learnt in the previous lesson. They learnt the cell cycle in previous lesson. This will facilitate them to study well this unity.

d) Learning activity 10.2

Provide students with manila papers, markers, and other possible resources. Guide them to work on the activity 10.2. Their graphical presentation should be similar to those found in content summary of the lesson 10.2.

e) Application activity 10.2

1. The larger the cell becomes, the more demands the cell places on its DNA and the more trouble the cell has moving enough nutrients and wastes across the cell membrane.
2. The answer is found in the content summary of the lesson 10.2
3. During interphase the cell grows and replicate its DNA. Students should describe what happens during G1, S and G2 phases.
4. Cytokinesis is the division of the cytoplasm in both types of cells. The difference is that in plant cells a cell plate forms midway between the divided nuclei.

5. a) the number is 6. b) in gonads, c) prophase I.

Lesson 3. Mitosis and Meiosis roles in living organisms

a) Learning objective

- Outline the significance of mitosis in cell replacement and tissue repair by stem cells.
- Explain the role of meiosis in gametogenesis in humans and in the formation of pollen grain and embryo sacs in flowering plants
- Compare mitosis and meiosis
- Show concern to individuals with physical disabilities like Down's syndrome

b) Teaching resources

Teaching resources and aids may be: text books and internet, computer animations, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Students teachers have knowledge, skills, attitudes and values about the structure of the cell, manipulation of microscope and importance of nucleus and chromosomes learnt in the previous lesson. They learnt the cell cycle in previous lesson. This will facilitate them to study well this unity.

d) Learning activity 10.3

Guide student teachers to observe the figure and work on the activity 10.3. The answer should be to appreciate mitosis which allows growth (figure A) and tissue repair (figure B).

e) Application activities 10.3

1. Functions of mitosis

   a. **Mitosis allows growth:** A single cell divides repetitively to produce all the cells in an adult organism.

   b. **Mitosis allows to repairing and cell replacement:** by producing new cells to replace ones that have been damaged or worn out.

   c. **Mitosis is involved in asexual reproduction:** a single parent cell divides into two genetically identical offspring.

d. **Mitosis allows genetic stability** by producing two nuclei which have the same number of chromosomes as the parent cell.

e. **Regeneration:** Some animals are able to regenerate whole parts of the body, such as legs in crustacean and arms in starfish. Production of the new cells involves mitosis.

2. The cyclins are proteins which regulate the process of cell cycle.

3. The problem begins when a single cell in a tissue undergoes **transformation**, the process that converts a normal cell to a cancer cell. The body's immune system normally recognizes a transformed cell as an abnormal and destroys it. However, if the cell escapes immune system, it may proliferate to form **a tumour** (a mass of abnormal cells within an otherwise normal tissue).

4. There are three types of tumors: **benign tumors, malignant tumors and metastasis**.

   i. **Benign tumour:** it is a lump of the abnormal cells that remains at the original site**.** Most benign tumors do not cause serious problems and can be removed by surgery.

   ii. **Malignant tumors**: these are cells abnormal cells that have become invasive enough to impair with the functions of one or more organs. An individual with a malignant tumor is said to have **cancer**.

   iii. **Metastasis**: Cancer cells may also separate from the original tumour, enter the blood and lymph vessels, and invade other parts of the body, where they proliferate to form more tumours. This spread of cancer cells beyond their original site is called **metastasis**.

10.6. Summary of the unit

This unit **"Nuclear and cell division"** deals with cell cycle, and different phases which are involved in it like: interphase, mitotic, cytokinesis and meiotic division and their significance to living organisms. The cell cycle consists of a series of events of cellular growth and division that has five phases such as: the first growth phase (G_1), the synthesis phase (S), the second growth phase (G_2), mitosis (M), and cytokinesis.

The mitotic division consists of four phases including: prophase, metaphase, anaphase and telophase. It is a type of nuclear division where a mother nucleus sprint into two daughter nuclei identical between them and between them and their mother cells, with the same number of chromosomes. Cytokinesis is a division of cytoplasm which leads to formation of two daughter cells identical to their mother cell. Meiosis is a type of cell division which is concerned with reproductive cells (gametes). From a diploid cell, meiosis leads to formation of haploid gametes.

10.7. Additional information for tutors

Even if many cell divide, they are other cells which do not divide. These are like red blood cells which lack nuclei. They are produced in bone marrow. The white blood cells: many of them do not divide, neurons: most do not divide, cardiac and skeletal muscle cells do not divide. So they have to be protected from being damaged.

10.8. End unit assessment 10

i.

1) True
2) False
3) True
4) False
5) False
6) True
7) True
8) True
9) False

ii. Multiple Choice Questions

1) b
2) c
3) a
4) a
5) d

iii. Long Answer Type Questions

1) The main stages of cell cycle I are:

- The first growth phase (G_1),
- The synthesis phase (S),
- The second growth phase (G_2),
- Mitosis (M),
- Cytokinesis.

2) Homologous chromosomes are those which are identical and form pairs. These homologous chromosomes line up gene-for-gene down their entire length, allowing the crossing-over to occur. This process permits the exchange of genetic material between maternal and paternal chromosomes. Thus, crossing-over results in genetic recombination by producing a new mixture of genetic material.

3) And 4) see the answers in the content summary of the lesson 10.2.

5) And 6) see the answers in the content summary of the lesson 10.3

7) To maintain the number of chromosomes in species after fertilization of gametes to form a zygote.

8) and 9 and 10) see answers in the content summary of the lesson 10.3

11) Answers are:

a) Anaphase I

b) 1= centriole, 2= centrosome, 3= spindle.

c) Reproductive cells

d) No movement of chromosomes to poles can occur.

12) When someone is infected by HIV it penetrates in the nucleus of the host cell, so that when the host cell divides, at the same time the HIV is multiplied.

10.9. Additional activities

10.9.1 Remedial activities

1. Meiosis starts with diploid cell but ends with .... haploid cells.

   (a) One (b) two (c) three (d) four

2. What do you mean by the terms haploid cell and diploid cell?
3. By using a tabular form, discuss 10 differences between mitosis and meiosis.

Answers:

1. Four
2. A diploid cell abbreviated as 2n contain two sets of chromosomes in their nuclei, while the haploid cells have only one set of chromosomes, abbreviated as n.
3. See the content summary of the lesson 10.3

10.9.2. Consolidation activities

1. Meiosis is done into two divisions: meiosis I and Meiosis II. In which division haploid cells are produced from a diploid cell.
2. Differentiate the haploid cell from a diploid cell.
3. A horse cell contains 64 chromosomes. How many chromosomes are there in a) a horse liver cell. B) a horse sperm cell.

4. What do you understand by:
   - Spindle formation,
   - Synapsis,
   - Bivalents,
   - Chiasma formation
   - Movement of chromosomes.

Answers

1. In meiosis I
2. See answers in the content summary of the lesson 10.2.
   a) 64 chromosomes, b) 32 chromosomes.
3. **Spindle fibers:** are microtubules that move chromosomes during cell division. They are found in eukaryotic cells. Spindle fibers moves chromosomes during mitosis and meiosis to ensure that each daughter cell gets the correct number of chromosomes.

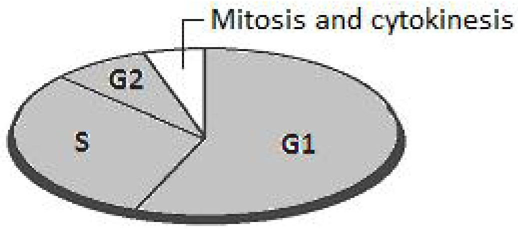
   Bivalents: These are the two homologous chromosomes attached at chiasmata. The homologous chromosomes consist of two sister chromatids each.

   Synapsis: In prophase I, homologous chromosomes become closely associated in **synapsis**. At prophase I of meiosis, after the homologous pair of chromosomes pair up in the process called synapsis, the non-sister chromatids overlap, forming an X-shape. They then exchange their alleles at the point of crossing over.

   Chiasmata: is the region of crossing over between two homologous chromosomes during prophase I of meiosis.

10.9.3. Extended activities

1. Suggest why most plant cells (except meristem cells) are not capable of undergoing mitosis and cytokinesis
2. Some cells have several nuclei within the cytoplasm of a single cell. Considering the events in a typical cell cycle, which phase of the cell cycle is not operating when such cells form?
3. The diagram represents the cell cycle. During which phase does the following take place:



a. DNA replication
b. Energy production
c. Organelle replication?
d. Name the main stages in mitosis.

Answers:

1. The formation of a cell wall in plant cells stops cells being able to divide effectively. Meristematic cells have very thin wall.
2. The presence of many nuclei indicates that mitosis has occurred repeatedly without cytokinesis having occurred, because there is still only one cell.
3. a) S phase. b) G2 phase. c) G2 phase. d) Prophase, metaphase, anaphase and telophase.

UNIT 11

AUTOTROPHIC NUTRITION

11.1. Key Unit competence

Describe the process of photosynthesis and explain the various environmental factors that influence the rate of photosynthesis.

11.2. Prerequisite (knowledge, skills, attitudes and values)

Students have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this unit.

11.3. Cross cutting issues to be addressed

a) Peace and value

Tell student teachers that they can work together in their groups in peace and harmony despite of the difference of our abilities, disabilities or physical appearance.

b) Gender education

This cross-cutting issue should be integrated in all sub-headings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities, and when cleaning materials used during practical activities: both boys and girls should participate equally.

c) Inclusive education.

This cross-cutting issue should be integrated in all sub-headings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: student teachers with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, students without arms and legs; you the tutor and other student teachers should help them to achieve the competences as required in all teaching-learning activities.

d) Environmental sustainability

Phototropism sustain our environment by either producing Oxygen used by living organisms for respiration or by absorbing the CO2 from atmosphere. It produces also the food for living things.

11.4. Guidance on introductory activity 11

Engage student teachers in their groups to use text books and work on the introductory activity 11. After making analysis, students should conclude that:

- They see the bubbles on the leaves of elodea which indicate Oxygen gas that is produced.
- The substance is sugar/ carbohydrates which are not waste but food nutrients to living organisms.
- The organelle is a chloroplast,

11.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Types of autotrophic nutrition	- State and explain the types of autotrophic nutrition.	2
2	Structure of the chloroplast and Adaptations for photosynthesis	- Describe the structure and function of the chloroplast - Describe the role of other chloroplast pigments (chlorophyll a, chlorophyll b, carotene and xanthophyll) in light absorption in the grana. - Explain the adaptations of plants for photosynthesis	3
3	Absorption and action spectra and Other carbon dioxide fixation pathways (C4 CAM)	Interpret absorption and action spectra of chloroplast pigments - Outline the three main stages of the Calvin cycle. - Describe and outline the conversion of the Calvin cycle intermediates to carbohydrates, lipids and amino acids and their uses in the plant cell	5

		- Differentiate C4, CAM and C3 plants in fixation of carbon dioxide	
4	Rate of photosynthesis: limiting factors of photosynthesis	Discuss and investigate factors of photosynthesis	4
5	Importance of autotrophic nutrition and Tests for starch in terrestrial plants and for oxygen in aquatic plants	- Discuss and appreciate the importance of photosynthesis - Identify starch in terrestrial plants and oxygen in aquatic plants	4
6	End unit assessment		2

Lesson 1. Types of autotrophic nutrition

a) Learning objective

State and explain the types of autotrophic nutrition.

b) Teaching resources

Textbooks, internet, computer, projector, manila papers and markers

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this lesson.

d) Learning activity 11.1

Engage student teachers in their groups to use text books or internet in computer lab and work on the learning activity 11.1.

Their answer should be correlated with the types discussed in the summary content of the lesson 11.1.

e) Answers to application activity 11.1

1. Photosynthesis is a process by which, autotrophs make their own food by using inorganic substances in presence of light energy and chlorophyll.

2. a) Living organisms which make their own food are called **autotrophs**, while others, including humans, which cannot make their own food but depend on autotrophs are called **heterotrophs**.

b) Chemoautotrophs are organisms (mainly bacteria) which get energy from oxidation of chemicals, mainly inorganic substances like hydrogen sulphide and ammonia

$H_2S + O_2 \longrightarrow 2H_2O + 2S + E.$

$(NH_4)_2CO_3 + 3O_2 \longrightarrow 2HNO_2 + CO_2 + 3H_2O + E.$

While photoautotrophs are organisms which organisms which get energy from sunlight and convert it into sugars. Green plants and some bacteria like green Sulphur bacteria can make their own food from simple inorganic substances by a process called **photosynthesis.**

3. Yes, animals' life depends on plants. Because plants produce not only Oxygen to use in our respiration, but also organic substances which serve as our food nutrients. Both of these are the main requirements for our life.

Lesson 2. Structure of the chloroplast and Adaptations for photosynthesis

a) Learning objective

- Describe the structure and function of the chloroplast
- Describe the role of other chloroplast pigments (chlorophyll a, chlorophyll b, carotene and xanthophyll) in light absorption in the grana.
- Explain the adaptations of plants for photosynthesis

b) Teaching resources

Textbooks, internet, computer, projector, microscope, manila papers and markers.

c) Prerequisites/Revision/Introduction

Students have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this lesson.

d) Learning activity 11.2

The teacher should

- Provide student-teachers with microscopes and well prepared slides of plant cells which show clearly the structure of chloroplast.
- Engage student-teachers to observe the slides under the compound microscopes, and draw the structure of chloroplast they see
- Search and relate the structure of chloroplast with the process of photosynthesis

The structure of the chloroplast should be similar in structure like the one found in content summary of lesson 11.2. The correlation between the chloroplast structure and the process of photosynthesis is also described in the content summary of the lesson 11.2.

e) Application activity 11.2

1. The structure of chloroplast is well described in the content summary of the lesson 11.2.
2. The thylakoids contain photosynthetic pigments which are used to absorb light energy. The stroma contains different enzymes which are involved in catalyzing light-independent reactions.
3. The correlation between the structure of the leaf and the process of photosynthesis is well described in the content summary of the lesson 11.2.

Lesson 3. Absorption and action spectra and other carbon dioxide fixation pathways (C4 CAM)

a) Learning objective

- Interpret absorption and action spectra of chloroplast pigments
- Describe and outline the conversion of the Calvin cycle intermediates to carbohydrates, lipids and amino acids and their uses in the plant cell
- Differentiate C4, CAM and C3 plants in fixation of carbon dioxide

b) Teaching resources

Textbooks, internet, computer, projector, microscope, manila papers and markers.

c) Prerequisites/Revision/Introduction

Students teachers have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this lesson.

d) Learning activity 11.3

Engage student-teacher to brainstorm photosynthetic pigments which are involved in absorption of light. Student-teacher should discuss photosynthetic pigments as are discussed in the content summary in the lesson 11.3

e) Application activity 11.3

1) The process of photosynthesis require light energy which is also absorbed by the chlorophyll. So, both are conditions of photosynthesis.

2) Plants are green because of green light is reflected by the chlorophyll in leaves.

3) The plants would not grow well because chlorophyll does not absorb much light in the yellow region of visible light.

4) Accessory pigments in leaves are very important in the process of photosynthesis, because they absorb additional light energy to be used in the process of photosynthesis. The more light intensity, the higher rate of photosynthesis.

5, 6, 7, 8 and 9) see answers in the content summary of the lesson 10.3.

10) Photorespiration is a process that occurs in presence of light (photo) and consumes O2 (respiration). However, unlike normal cellular respiration, photorespiration generates no ATP, and unlike photosynthesis, photorespiration generates no food.

Lesson 4. Rate of photosynthesis: limiting factors of photosynthesis

a) Learning objective

Discuss and investigate factors of photosynthesis

b) Teaching resources

Textbooks, internet, computer, projector, microscope, manila papers and markers.

c) Prerequisites/Revision/Introduction

Student teachers have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this lesson.

d) Learning activity 11.4

Engage student teachers to brainstorm limiting factors of photosynthesis. Student-teacher should explain effects of limiting factors of photosynthesis as discussed in the content summary of the lesson 11.4

e) Application activity 11.4

1. See the answer in the content summary found in the lesson 11.4.
2. a) It is true that the rate of photosynthesis is generally lower at 5:30 AM than it is at 12:30 PM, during a sunny day" because: At 5:30 AM, there is lower light intensity, and lower temperature than at 12:30 PM. Know that: the lower temperature and light intensity, the lower rate of photosynthesis.

   b) It is true that: "The rate of photosynthesis is generally higher in Rwanda during the sunny day than in Sahara Desert", because in Rwanda plants absorb much water in the soil compared the plants growing in Sahara Desert where water in soil is too low.

Lesson 5. Importance of autotrophic nutrition and Tests for starch in terrestrial plants and for oxygen in aquatic plants

a) Learning objective

- Discuss and appreciate the importance of photosynthesis
- Identify starch in terrestrial plants and oxygen in aquatic plants

b) Teaching resources

Textbooks, internet, computer, projector, microscope, manila papers and markers.

c) Prerequisites/Revision/Introduction

Student- teachers have knowledge, skills, attitudes and values about the parts of the plants, and some notion on photosynthesis learnt in senior two. This will help them to study this lesson.

d) Learning activity 11.5

Guide students-teachers to form two groups: proposers and opposers. Engage them to debate on the topic. The proposers should provide possible importances of autotrophic nutrition (done in plants but not in animals) as discussed in the content summary found in the lesson 11.5.

e) Application activity 11.5

1. Oxygen
2. The steps to follow during testing for starch in terrestrial plant are well discussed in the content summary of the lesson 11.5
3. This will kill the cells, stop all chemical reactions and allow alcohol and iodine to penetrate the leaf more easily, and will removes the waxy cuticle which prevents entry of iodine/potassium iodide solution, will also denatures enzymes, particularly those which convert starch to glucose e.g. diastase. Boiling arrests all chemical reactions, since enzymes which catalyse the reactions are denatured. Denatured enzymes have altered or destroyed active sites due to heat, pH, and ionic concentration.
4. The summary of testing for oxygen in aquatic plants are well discussed in the content summary of the lesson 11.5
5. This will soften the leaf by replacing water removed by the ethanol.
6. The summary of importances of photosynthesis to the living organisms are well discussed in the content summary of the lesson 11.5

11.6. Summary of the unit

The unit "Autotrophic nutrition" is divided into five lessons such as:

- Types of autotrophic nutrition
- Structure of the chloroplast and Adaptations for photosynthesis
- Absorption and action spectra and other carbon dioxide fixation pathways (C4 CAM)
- Rate of photosynthesis: limiting factors of photosynthesis
- Importance of autotrophic nutrition and Tests for starch in terrestrial plants and for oxygen in aquatic plants.

Autotrophic nutrition is a process by which living organisms make their own food. This process is carried out by photoautotrophs like green plants, green algae and green bacteria; and chemoautotrophs. There are two types of autotrophic nutrition such as chemoautotrophic and photoautotrophic nutrition. **Chemoautotrophic nutrition** is an autotrophic nutrition where organisms (mainly bacteria) get energy from oxidation of chemicals, mainly inorganic substances like hydrogen sulphide and ammonia. **Photoautotrophic nutrition.** It is an autotrophic nutrition where organisms get energy from sunlight and convert it into sugars. Green plants and some bacteria like green Sulphur bacteria can make their own food from simple inorganic substances by a process called **photosynthesis**.

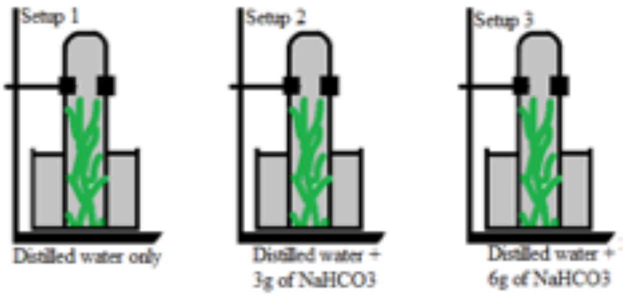
In eukaryotes photosynthesis takes place in chloroplasts. A chloroplast contains many sets of disc like sacs called thylakoids, which are arranged in stacks known as grana. Each granum looks like a stack of coins where each coin being a thylakoid. In the thylakoid, proteins are organized with the chlorophyll and other pigments into clusters known as photosystems. The photosystems are the light-collecting units of the chloroplast. The function of thylakoids is to hold the chlorophyll molecules in a suitable position for trapping the maximum amount of light. The photosynthesis rate varies with the species but also varies within individuals for a same species; this varies under the influence of certain external factors which are: the temperature, CO_2 concentration in the atmosphere, light intensity and soil humidity.

11.7. Additional information for tutors

Heterotrophs depend on autotrophs. Autotrophism results in the production of organic substances which serve as food nutrients. Heterotrophs will then feed on autotrophs to get those food nutrient that they eat and digest to allow them to survive.

Guidance on Skills lab 11

The activity must be done in group. The student-teachers will work in three different conditions: (1) algae in water only (2) Algae in water mixed with 3 g of baking soda and 6 g of baking soda.



The role of baking soda (NaHCO3) is to provide CO2 which is the reactant and limiting factor in the photosynthesis reaction.

Student-teachers should observe that the setup 1releases no or very few bubbles of oxygen gas while the setup 3 with large amount of CO2 will produce more bubbles of oxygen gas.

11.8. Answers to the end unit assessment 11

i.

1) False
2) True
3) False
4) False
5) False

ii.

1) c
2) c
3) c

iii.

1. There are two types of autotrophic nutrition such as chemoautotrophic and photoautotrophic nutrition.
2. See the answer to the content summary of the lesson 11.2
3. Plants absorb the light energy by using molecules called pigments such as: chlorophyll a, chlorophyll b, carotene (orange), xanthophyll (yellow) and phaeophytin (grey) but chlorophyll a is the principle pigment in photosynthesis.
4. Refer to the content summary of the lesson 11.2
5. Refer to the content summary of the lesson 11.3
6. Refer to the content summary of the lesson 11.3
7. Refer to the content summary of the lesson 11.4

8. a) A= Photosystem II, B= photosystem A

   b) Photolysis of water.

   c) ATP, $NADPH_2$ and O_2

9. a) X= Phosphoglyceric acid (PGA).

   Y= Phosphoglyceraldehyde (PGAL).

   Z= Ribulose biphosphate (RuBP)

   b) i) Reduction and regeneration. ii) Light-dependent reactions.

   c) Reduction leads to production of sugars as the food of living things.

   d) The substances may be:

   - Sucrose: when Oxygen combined with fructose. It is a form by which carbohydrates are transported in plants.
   - Polysaccharides like starch for energy storage, and cellulose for structural support.
   - Amino acids when combined with nitrates,
   - Nucleic acids when Oxygen combined with phosphates, and
   - Lipids.

11.9. Additional activities

11.9.1 Remedial activities

1. How do heterotrophs and autotrophs differ in the way they obtain energy?
2. Write a basic words and chemical equations of photosynthesis
3. State any five adaptations of the green leaf for photosynthesis.

Answers

1. Autotrophs are able to obtain energy by making their own food. Heterotrophs obtain their energy by consuming food.
2. Carbon dioxide combines with water in presence of light and chlorophyll to give Glucose and Oxygen.

$$6CO_2 + 6H_2O \xrightarrow{\text{Light and Chlorophyll}} C_6H_{12}O_2 + 6O_2$$ (Green plants).

3. Refer to the content summary of the lesson 11.2

11.9.1. Consolidation activities

1. Explain the involvement of the plant parts bellow in the process of photosynthesis
   a) Stomata, b) Lamina, c) Leaf stalk, d) Leaf cuticle, e) Xylem, f) Phloem.
2. Summarize what happens during the Calvin cycle.
3. Why are light-dependent reactions important to the Calvin cycle?

Answers

1. See answers on the content summary of the lesson 11.2
2. Refer to the content summary of the lesson 11.3
3. The light-dependent reactions provide the Calvin cycle with ATP and NADPH. The Calvin cycle uses energy in ATP and NADPH to produce high-energy sugars.

11.9.3. Extended activities

1. What may happen to the rate of photosynthesis in a photosynthetic cell if the thylakoids in chloroplast are damaged completely?
2. Without autotrophs, the life is impossible on the Earth. By providing possible reasons, defend or disagree with this statement.
3. Some plant leaves contain yellow and red pigments as well as chlorophyll. In the fall, those leaves become red or yellow. Suggest an explanation to that for those color changes.

Answers

1. The rate of photosynthesis in a photosynthetic cell stops.
2. The statement is true, because autotrophs produce food nutrients and Oxygen which are the basic requirement for heterotrophs to survive

UNIT 12

THE CHEMICAL BASIS OF LIFE

12.1. Key Unit competence

Explain the use of biological molecules in living organism.

12.2. Prerequisite (knowledge, skills, attitudes and values)

In order to succeed well this unit, student-teachers should possess knowledge and understanding, skills and attitudes that are related to the food nutrients and diet as well as enzymes in unit 5 and unit 6 of senior 1 and 2 respectively. They should be also be able to do observation, analysis, interpretation of the pictures and then capable to present and or communicate the results.

12.3. Cross cutting issues to be addressed

The cross-cutting issues to be addressed by this unit include inclusive and gender education, and standardized culture.

a) Inclusive education

This unit involves a number of activities on research from different sources and experiments that require the listening and vision. This may be challenging to student-teachers with special educational needs especially children with visual impairment. However, the teacher can do the following:

- Grouping student-teachers with special educational needs with others and assigned roles basing on individual student-teacher's abilities.
- Providing procedure earlier before the experiment so that student-teachers get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts.
- Every important point is written and spoken. The written points help student-teachers with hearing impairment. Speaking aloud helps student-teachers with visual impairment
- Remember to repeat the main points of the lessons.

b) Gender education

- Involve both girls and boys in all activities: No activity is reserved only to girls or boys.
- Teachers should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.

c) Standardization culture

- Some lessons involve carrying out experiments about chemicals of life tests. Student-teachers will understand the importances of testing for food nutrients, enzymes and water in body health. Through questions they can develop awareness of the standardized culture whereby some chemicals may be used in bad way. Thus, student-teachers have to always check if they are not using expired chemicals or defective apparatus.

12.4. Guidance on introductory activity 12

The introductory activity helps you to engage student-teachers in the classification chemical of life/ biological molecules and invite the student-teachers to follow the next lessons.

As facilitator help the student-teachers to develop competences in the following:

a. Ask student-teachers to observe the figure, read and discuss the given questions.
b. Engage student-teachers in working collectively the activity.
c. Help student-teachers with different problems.
d. Ask any four student-teachers to present their findings while others are following
e. Help the student-teachers to make summary of the group discussions.

The expected answers should be relating to chemicals of life obtained from different types of food given in the figure such as carbohydrates, lipids, proteins, mineral salts, vitamins, etc.

12.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	**Biological molecules** (The chemical elements, sub-units, structure, function of carbohydrates, lipids and proteins, molecular structure and functions of polysaccharides and isomerism of monosaccharide and formation of glycosidic bond.)	- State the roles of carbohydrates and lipids. - Explain the proportion of hydrogen in carbohydrates and lipids and relate this to the amount of energy released when oxidized - Describe chemical elements that make up carbohydrates, fats and proteins - Interpret the charts and illustrations of molecular structure and the formation of maltose and triglycerides. -Appreciate the importance of carbohydrates and lipids in organisms. -Describe sub-units that make up biological molecules -Describe the structure of proteins and their function Explain the isomerism of monosaccharide and formation of glycosidic bond -Describe molecular structure and functions of polysaccharides glycogen and cellulose in living organisms	11
2	Test for the presence of different biological molecules in variety of context	- Identify different biological molecules in variety of context - Perform a test for the presence of different biological molecules in variety of context	2
3	The structure of DNA	Describe the structure of DNA	1

4	Water and enzymes	- Explain how hydrogen bonding occurs between water molecules and relate the properties of water to its roles in living organisms. - Discuss the water properties for life and its roles as a solvent in organisms - Explain the criteria of naming enzymes - Describe characteristics of enzymes and their mode of actions - Analyze factors affecting enzyme action - Investigate the effects of temperature, pH, enzyme and substrate concentration, and inhibitors on enzyme activity. - Understand the roles of enzymes in industry and medicine. - Apply enzymes actions in living organisms	5
	End unit assessment		1

Lesson 1. Biological molecules

a) Learning objective

- State the roles of carbohydrates and lipids.
- Explain the proportion of hydrogen in carbohydrates and lipids and relate this to the amount of energy released when oxidized
- Describe chemical elements that make up carbohydrates, fats and proteins
- Interpret the charts and illustrations of molecular structure and the formation of maltose and triglycerides.
- Appreciate the importance of carbohydrates and lipids in organisms.

- Describe sub-units that make up biological molecules
- Describe the structure of proteins and their function
- Explain the isomerism of monosaccharide and formation of glycosidic bond
- Describe molecular structure and functions of polysaccharides glycogen and cellulose in living organisms

b) Teaching resources

Different student- teacher's books, different kinds of foods, laboratory chemicals like enzymes, experimental materials, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

This is the first lesson of the 12th unit. In this lesson you will be dealing with different biological molecules/chemicals of life such as carbohydrates, proteins, lipids, vitamins, mineral salts, enzymes and water. The first thing to do before starting teaching is to remind the student-teachers that they studied chemical of life (food nutrients and diet, unit 7) in senior one, and senior two unit5, Identification of food components and unit 6, Enzymes. Due to the background they have, you will ask them to discuss for revision so that they can prepare themselves for this lesson.

d) Learning activity 12.1

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 12.1 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems
- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.

- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 12.1

All chemicals of life are made up with carbon, hydrogen, oxygen, except proteins that sometimes contain Sulphur, Nitrogen and water which lack carbon

For complete answer, read the student-teacher book.

Answers to activity 12.1.3

1. a)Proteins structure are: Primary, secondary, tertiary and quaternary structure

   b)Protein polymer are formed by condensation process where a molecule of water lost and the resulting bond is called ester link2. The idea behind this scenario it is about the denaturation of protein.

2. The plastic burn and the cords are no longer holding together, this is the same to the protein chain, when exposed to heat the peptide bonds holding the amino acids break and the protein is denatured.

Answers to Activity 12.1.4

1. Monosaccharide means single sugar; because monos: single sacchar: sugar
   Polysaccharide it is a polymer of monosaccharide
2. Answers are:

   a) Monosaccharide

   b) Disaccharide

   c) Polysaccharides
3. Figure of Starch, cellulose, or glycogen

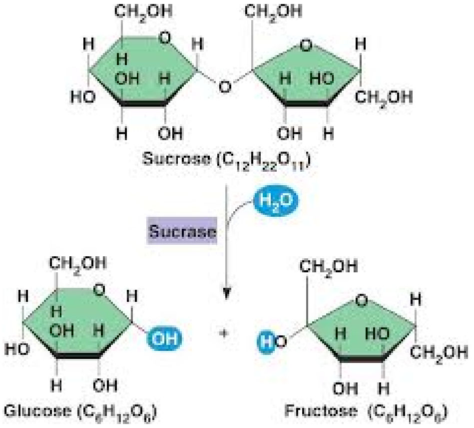
e) Application activities 12.1

1.

Biological molecules	Food sources	Functions
Carbohydrates	They are mainly found in fruits, cassava, potatoes, sugar cane, honey milk.	Provide the body with energy
Proteins	Fish, beans, meat, milk and its products..	Proteins such as lipase, pepsin and protease act as enzymes as they play a crucial role in biochemical reaction where they act as catalysts. Proteins play an important role in coordination and sensitivity (hormones and pigments). Proteins have a transport functions. Example: Haemoglobin transport oxygen Proteins in the cell membrane facilitate the transport of substance across the cell membrane. Proteins provide a mechanical support and strength. Proteins such as myosin and actin are involved in movement. Proteins play the role of defense of the organisms. Example: Antibodies are proteins
Lipids	Oil, meat, cheese, butter, some seeds, ..	Fats are a source of energy. They supply energy to the body more than carbohydrates and proteins. Fat surrounds and protects important organs of the body such as the kidney and the heart, however too much fat around the organs is dangerous as it slows down their functioning.

		Fat forms an insulating layer beneath the skin to help keep us warm by preserving body heat and it also protects the skeleton and organs. Fat provides a source of fat soluble vitamins A, D, E and K in the body. Fat is a reserve of energy for long term storage and can be used if energy intake is restricted.

2. Essential amino acids (Student book).
3. The peptide bond formation: A condensation reaction occurs between the amino group of one amino acid and the carboxyl group of another, to form a dipeptide
4. In student- teacher book
5. In preparing food, we have to consider many plant food staff.
6. Primary, secondary, tertiary and quaternary structure
7. Peptide bond
8. Hydrolysis reaction
9. Addition of water molecules to sucrose to obtain two unit of glucose
10. By Chemical bond.



11. The major types of starch are: Amylose and amylopectin

Differences: Amylose is the simple structure of starch; it is unbranched chain of glucose while amylopectin is a branched structure of starch

Lesson 2. Test for the presence of different biological molecules in variety of context

a) Learning objective

By the end of this lesson, student-teacher should be able to:

- Write out procedures in the identification of biological molecules
- Explain the importance of the reagents used in the identification of biological molecules.
- Carry out tests for the identification of biological molecules
- Compare reducing and non-reducing sugars
- Appreciate the importance of identification of food values in the food industry and in processing and packaging.
- Show resilience making observations on color changes during food tests

b) Teaching resources

Starch powder, iodine solution, diluted hydrochloric acid, Benedict solution and sodium hydroxide, glucose powder, beakers, test tubes, Bunsen burner, water, droppers, pestle and mortar, measuring cylinders. If your school does not have laboratory equipment you can take student-teachers to the nearby school where they can perform the experiment.

c) Prerequisites/Revision/Introduction

- Start this lesson by asking questions such as how can you test for the presence of starch in bread? What about the presence of sugar in a solution?
- Let student-teachers give their views. Build on student-teachers' ideas and then connect to learning activity of this lesson

d) Learning activity 12.2

Guidance

For student-teachers effective learning through performing experimental activity 12.2.1 described in student textbook requires you to do the following:

- Plan and prepare all materials needed for this lesson.
- Provide clear instructions particularly when, what, how and why to record. For example, not respecting time could lead to poor results.

- You may help student-teachers in performing experiment by supplying other needed material.
- Ask them to do observations and record the observations
- Invite student-teachers to present their observation and make conclusions through interaction • Use their ideas and conclude the lesson through challenging questions such as why do you say that this is a starch not white powder like chalk powder?
- Build on conclusion and extend the lesson by connecting it to how expired Benedict or Iodine reagents and food substance could not give good results for promoting issue of standardized culture.

Answers to activity 12.2.1

Experiment A: The tested substance is starch and the presence of starch is indicated by the change of iodine color into dark blue/blue black.

Experiment B: The tested substance must be a reducing sugar (glucose solution), the

presence of reducing sugar is indicated by the change of blue color of benedict reagent to green/yellow, orange and finally red.

Answers to activity 12.2.2

The observation of the student-teachers, the color of Biuret reagent changes to pink. This confirms the presence of proteins in the sample tested.

Answers to activity 12.2.3

- The presence of lipids in cooking oils is indicated by milky colour.
- The test using Sudan III solution, lipid layer sitting on top of the water layer will have a red-orange.

Answers to activity 12.2.4

The expected observations and conclusions are given in the table below.

Experiment	Observation	Conclusion
To $3cm^3$ of DCPIP add drops of juice extracted from orange fruit	The solution decolorize of DCPIP blue colour	Presence of Vitamin C
To $2cm^3$ of water add $2cm^3$ of DCPIP	No change	Absence of vitamin C

Vitamin C is tested by using DCPIP (Dichlophenol indophenol), vitamin C decolorize DCPIP if there is not the presence of Vitamin C the blue color of DCPIP persist.

e) Application activities 12.2

1. Expected observations and conclusions on the experiment are in the table below.

Experiment	Observation	Conclusion
(i) In a test tube of 4 drops of solution C1 add 2-3 drops of Iodine	Blue black/dark blue color	Presence of Starch
In another test tube of 4 drops of C1 add an equal volume of Benedict 'solution and boil for 1 min	No change the blue color of Benedict solution persist	Absence of reducing sugar
In another test tube of 4 drops of C1 add an equal volume of Benedict 'solution and boil for 1 min No change the blue color of Benedict solution persist Absence of reducing sugar	Green/yellow, orange finally red color.	Presence of reducing sugar

1. The answer is given in the following table:

Food substance	**Reagent**	**procedure**	**Observation and Conclusion**
Milk	*Millon's	Take 2cm^3 of test solution Add 2 cm^3 of Millon's reagent Boil for 1-2 minutes	The colour of Millon's reagent change from colourless to pink, Presence of proteins
	*Biuret's	Take 2 cm^3 of test solution Add 2 cm3of Biuret's Shake	The blue color of Biuret solution changes to purple Presen ce of proteins

2. What is the substance A mentioned in student-teachers book?

3. The same results are observed (Questions in student- teacher book)

4.

Procedures	Observation	Conclusion
Take a sample of juice(1cm3) Add the juice in a test tube containing DCPIP.	The juice decolorize the blue color of DCPI	In the tomato juice there is presence of Vitamin C

5. • You can use Ethanol: Emulsion test
   • The observation: Ethanol changes from colourless to milky

Lesson 3. The structure of DNA

a) Learning objective

- Describe the structure of DNA
- Explain that the structure of the DNA molecule is described as a ladder twisted into spiral.
- Explain the Watson Crick hypothesis of the nature of DNA.

b) Teaching resources

Models of DNA, illustrations, computer simulations, suitable model materials, tooth picks, ribbons, electric wires, straws of different colours, and prepared slide on mitosis.

Visual: Images of nucleotides and base pairing.

Audio-video: Video showing Watson and Crick hypothesis of the nature of DNA.

c) Learning activity 12.3

Guidance

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 12.3 in their student-teacher books
- Provide the necessary materials.
- Move around in silence to monitor if they are having some problems

- Remember to assist slow student-teachers but without giving them the knowledge.
- Invites any three groups to present their findings to the rest of student-teachers.
- Ask other student-teachers to follow carefully the representations.
- Note on chalk board / Manila paper the student's ideas.
- Tick the correct findings and correct those ones which are incorrect and try again to complete those which are incomplete.
- Harmonize and conclude on the learned knowledge and still engage student-teachers in making that conclusion.

Answers to activity 12.3

The Tutor should guide the student- teachers to carry out the activity on their own.

Hint:

1. Let the student- teachers know that a basic unit of nucleotide is made up of pentose sugar, a nitrogenous base, and a phosphate sugar. And these nucleotide sequences make DNA. The unique arrangement in DNA makes a person unique.
2. Also, let the student- teachers know that double strands of DNA are joined together by: Hydrogen bonds and Chargaff's rules.
3. Let the student- teachers briefly describe hydrogen bonds and Chargaff's rules with

d) Application activity 12.3

(i) DNA structure (ii) Telomerase (iii) Study of telomere
(iv) Hydrogen (v) RNA

Lesson 4. Water and enzymes

a) Learning objective

- Explain how hydrogen bonding occurs between water molecules and relate the properties of water to its roles in living organisms.
- Discuss the water properties for life and its roles as a solvent in organisms
- Explain the criteria of naming enzymes

- Describe characteristics of enzymes and their mode of actions
- Analyze factors affecting enzyme action
- Investigate the effects of temperature, pH, enzyme and substrate concentration, and inhibitors on enzyme activity.
- Understand the roles of enzymes in industry and medicine.
- Apply enzymes actions in living organisms

b) Teaching resources

List of digestive enzymes, biology dictionary, internet, textbooks on enzymes nomenclature

c) Prerequisites/Revision/Introduction (knowledge, skills, attitudes and values)

The student-teachers should be able to state some enzymes particularly digestive enzymes such as maltase, sucrase, pepsin and Trypsin and give the role of each. You need therefore to ask question about the names of enzymes they know. You need to write them on chalkboard or white board. You can challenge them by asking to predict criteria used in naming enzymes. From the suggested names and prediction, move to the activity 12.1.

d) Learning activity 12.4.a

Guidance

Facilitate this activity by asking student-teachers to work in groups and do analysis of the names that they have suggested and other names that could help you and student-teachers to come up with criteria for enzymes nomenclature.

Student-teachers to come up with those names, you need to challenge them by asking questions about the similarities and differences that exist in the suggested enzymes.

You may have written those names of enzymes on flipchart so that it may facilitate the learning. Ask them to present what they have done in groups. Use the presented ideas to make a consolidation and come up with a conclusion.

Answers to activity 12.4.a.

a.

- Maltase hydrolyses maltose into glucose
- Lactase hydrolyses lactose into glucose and galactose
- Dehydrogenase catalyses the removal of hydrogen from a functional group
- Oxidase catalyes the oxidation of molecules
- Pepsin hydrolyse the proteins into polypeptides in the acidic medium in the stomach
- Renine promotes the coagulation of liquid and soluble casein.

b. Enzymes are named based on substrate catalyse, type of reaction they catalyse of by using specific name.

Answers to activity 12.4.b.

1. The medium of chemical reactions in organism is water.
2. The boiling point of water is greater than the boiling point of oils because of the existence of hydrogen bonds in water molecules

Answers to activity 12.4.2.a

Let student-teachers work in small groups. Make sure that they follow the procedure and come out with the following conclusions;

1. Both MnO_2 and the liver speed up the rate of reactions by which hydrogen peroxide decomposes into oxygen and water

2) $H_2O_2(l)\ H_2O(l) + O_2(g) \longrightarrow 2H_2O_2(l) \xrightarrow{MnO_2} 2H_2O(l) + O_2(g)$

Properties of enzymes

- Enzymes speed up the rate of metabolic reactions.
- Enzymes are protein in nature
- Enzymes lower the activation energy (Ea) required for reactions to take place.

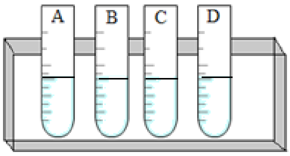
Answers to activity 12.4.2.b.

Refer to student book

Answers to activity 12.4.3.

To help student-teachers to come up with learning outcomes, you are advised to do the following:

- Make different groups and provide the printed handout of the procedure of the experiment.
- Provide the same amount of solution to be used to each group and emphasize on the following the procedure.



Each group of student-teachers conducts the experiments and record the following observation:

- The solution in tube C has light blue colour because amylase has hydrolysed starch into maltose.
- Solution in tube B and D are deep blue because of the presence of HCl that denatures the enzyme amylase.
- Tube A looks blue because the enzyme amylase was not active under the cold condition.

At the end of the experiment, allow student-teachers to read the note on factors affecting the rate of enzyme controlled reactions.

You give them a table having row of temperature and the one of temperatures in degrees, so that they can do analysis and then come up with an explanation and conclusion on Q_{10}. From their conclusion, extend it to questions or explanation about denaturation and end product inhibitor or allosteric inhibitor or allostery.

The teacher helps student-teachers interpret the solution of worked example questions from their textbook.

Answers to activity 12.4.4.

There are thousands upon thousands of chemical reactions that happen in the body that require enzymes to speed up their rate of reaction, or will never happen. Enzymes are very specific, so nearly each of these chemical reactions has its own enzyme to increase its rate of reaction.

Answers to activity 12.4.5.

For helping student-teachers to come up with understanding as well as skills related to mode of action of an enzyme, you need to:

- Use a simulation on the mode of action of enzymes which has to be observed by student-teachers once projected
- Project it and let student-teachers watch the video.
- From the video, you ask questions.
- If there is no simulation, provide two different keys in which one opens a class lock while another could not or use at least 2 padlocks with their respective keys and show how they cannot interchange their key.
- Let them practice and ask them why one key opens the lock while another could not. Ask other questions so that student-teachers come up with ideas related to mode of action of enzymes.
- Ask student-teachers to produce or draping a model on paper or Manila paper and use that chart in explaining the mode of action of enzymes.

e) Application activity 12.4.

1. Missing terms: catalysts – living – Activation – proteins – tertiary.
2. (a) The main role of enzymes is to speed up the rate of reactions in living organisms

   (b) If there were no enzymes in the cell, the metabolic reactions would stop and therefore the cell would die.

   (c) Heat increases the motions of molecules and leads to collisions between reactant molecules.

12.6. Summary of the unit

In this unit test for biological molecules, the experiment carried out using different reagents and food staff, indicate that:

- When testing starch using Iodine solution, the yellow color of Iodine solution turns to blue-black/dark blue if the starch is present. While during testing reducing sugar the blue colour of Benedict solution becomes green, yellow, orange and finally red.
- To test protein, the colorless Millon reagent turns to pink. Lipids can be tested by using Ethanol and water (Emulsion test) and the solution turn milky.

- In addition, the solution containing Vitamin C decolorize the solution of DCPIP.

12.7. Additional information for tutors

Notice: As a rule, a small amounts of sample should be used:

- Solid about one spatula needful(0.50-1.00g) of the substance is enough
- For liquid about 1-3cm3 (4 or 5drops) of the liquid should be used.

How to handle glassware?

While heating, it is useful to observe the following safety measures:

- Use the test tube holder or any improvised material like a folded piece of paper for holding the test tube-not your bare hands.
- Hold the test –tube at an inclined position not upright.
- Ensure uniform heating of the test tube contents by allowing heating around the surface in contact with the contents.
- Do not direct the open end of the test tube at any body
- Following instructions is very important Points to note when carrying out the test:
- Indicate the colour seen in the test tube at the end of the test.
- Be brief in the recording of observation Sources of errors:
- The blue –black or dark blue colour disappearing on heating and the experimenter missing it. No heating required
- Adding to little iodine, an excess does not cause any problem
- Forgetting to shake the solution after addition of iodine solution.
- Using unclean test tubes. With traces of starch this will give positive result even when the sample does not contain starch.
- Carbohydrates and lipids are compound of carbon, they are organic molecules, Lipids and carbohydrates differ in their amount of oxygen.
- The carbohydrates are divided into monosaccharide, disaccharides and polysaccharide. The monosaccharide is named according to the number of carbon the commonly known are: Triose(3carbon), Pentose(5Carbon) and hexose(6carbon).

- The monosaccharides can be ring form, the α-glucose and β glucose are ring form of glucose and differ by the position of OH group.

Lipids are polymer of Glycerol and fatty acids they are formed by condensation process the same to carbohydrates, lipids can be oils or fats if the fatty acids are unsaturated or saturated respectively.

The main types of lipids are: Tryglycerides, Cholesterol, phospholipids and wax, carbohydrates and Lipids are energy storage of the body even though carbohydrates are the ones which are commonly used, but the lipids produce more energy compared to carbohydrates.

Proteins are polymer of amino acids; the amino acids in polypeptide are joined one to another by a peptide bond.

Depending on how proteins are coiled we have; primary structure, secondary structure, tertiary structure and quaternary structure of proteins. In addition to those structures Globular proteins (soluble in water) and fibrous proteins (insoluble in water) are other types of protein. In this unit proteins and water, we talked about water and its properties; solvent, high heat capacity, freezing point and surface tension and how they are related to the biological importance of water.

Enzymes are biocatalysts. They speed up the rate of reactions. They are named according to the type of reaction of type of substrate. Except for some of the originally studied enzymes such as pepsin, rennin, and trypsin, most enzyme names end in "ase". The International Union of Biochemistry (I.U.B.) initiated standards of enzyme nomenclature which recommend that enzyme names indicate both the substrate acted upon and the type of reaction catalyzed. Under this system, the enzyme uricase is called urate: O2oxidoreductase, while the enzyme glutamic oxaloacetic transaminase (GOT) is called L-aspartate: 2-oxoglutarate aminotransferase. Each of the six main categories holds the following subcategories.

Oxidoreductases

- EC 1.1 includes oxidoreductases that act on the CH-OH group of donors (alcohol oxidoreductases)
- EC 1.2 includes oxidoreductases that act on the aldehyde or oxo group of donors
- EC 1.3 includes oxidoreductases that act on the CH-CH group of donors (CH-CH oxidoreductases)

- EC 1.4 includes oxidoreductases that act on the CH-NH2 group of donors (Amino acid oxidoreductases, Monoamine oxidase)
- EC 1.5 includes oxidoreductases that act on CH-NH group of donors
- EC 1.6 includes oxidoreductases that act on NADH or NADPH
- EC 1.7 includes oxidoreductases that act on other nitrogenous compounds as donors
- EC 1.8 includes oxidoreductases that act on a sulfur group of donors
- EC 1.9 includes oxidoreductases that act on a heme group of donors
- EC 1.10 includes oxidoreductases that act on diphenols and related substances as donors
- EC 1.11 includes oxidoreductases that act on peroxide as an acceptor (peroxidases)
- EC 1.12 includes oxidoreductases that act on hydrogen as donors
- EC 1.13 includes oxidoreductases that act on single donors with incorporation of molecular oxygen (oxygenases)
- EC 1.14 includes oxidoreductases that act on paired donors with incorporation of molecular oxygen
- EC 1.15 includes oxidoreductases that act on superoxide radicals as acceptors
- EC 1.16 includes oxidoreductases that oxidize metal ions
- EC 1.17 includes oxidoreductases that act on CH or CH2 groups

Transferases

- EC 2.1 includes enzymes that transfer one-carbon groups (methyltransferase)
- EC 2.2 includes enzymes that transfer aldehyde or ketone groups
- EC 2.3 includes acyltransferases
- EC 2.4 includes glycosyltransferases
- EC 2.5 includes enzymes that transfer alkyl or aryl groups, other than methyl groups
- EC 2.6 includes enzymes that transfer nitrogenous groups (transaminase)
- EC 2.7 includes enzymes that transfer phosphorus-containing groups (phosphotransferase, including polymerase and kinase)

- EC 2.8 includes enzymes that transfer sulfur-containing groups (sulfurtransferase and sulfotransferase)
- EC 2.9 includes enzymes that transfer selenium-containing groups

Hydrolases

- EC 3.1: ester bonds (esterases: nucleases, phosphodiesterases, lipase, phosphatase)
- EC 3.222: sugars (DNA glycosylases, glycoside hydrolase)
- EC 3.3: ether bonds
- EC 3.4: peptide bonds (Proteases/peptidases)
- EC 3.5: carbon-nitrogen bonds, other than peptide bonds
- EC 3.6 acid anhydrides (acid anhydride hydrolases, including helicases and GTPase)
- EC 3.7 carbon-carbon bonds
- EC 3.8 halide bonds
- EC 3.9: phosphorus-nitrogen bonds
- EC 3.10: sulfur-nitrogen bonds
- EC 3.11: carbon-phosphorus bonds
- EC 3.12: sulfur-sulfur bonds
- EC 3.13: carbon-sulfur bonds

Guidance on Skills lab 12

You can make any porridge from ingredient you want such as water + Maize flour + table sugar + liquid milk. This can be the sample to provide to student – teachers.

Therefore, listen to them to know how they are constructing their hypothesis and how they plan to verify them through hands-on skills gain from this unit.

12.8. End unit assessment 12 (answers)

1. a
2. Name of the reagents that are used to test for the following food substances are:
   a. Lipids…………………Alcohol or Sudan III dye
   b. Starch…………………Iodine solution
   c. Reducing sugar……….Benedict solution

3. The expected answers to the question
    - The blue color of DCPIP disappeared with the addition of pineapple juice because there is Vitamin C in pineapple juice.
    - Vitamin C is involved in oxidation in the body, reduction reaction, wound healing and production of collagen fibres.
    - Or simply it protects the body against diseases (scurvy)
4. $C_3H_6O_3$
5. The answer is summarized in the following table:

Fat (triglycerides)	Phospholipids
Glycerol plus 3 fatty acids	Glycerol plus 2 fatty acids, phosphate group
The main function is to form a compact energy store, insoluble in water so doesn't affect water potential.	Its main function is to forms a molecule that is part hydrophobic, part hydrophilic ideal for basis of cell surface membranes

6. They are used by the body to produce energy.

They are used in hormone production

7. a) Triose=$C_3H_6O_3$

   b) Pentose=$C_5H_{10}O_5$

8. Answers:

a) Alpha glucose is the β glucose. Ring monosaccharide are said to be alpha (β) if the -OH group located on carbon 1 is below the ring and beta (β) when the -OH group is above the ring.

b) Glycogen and cellulose: glycogen is made up of β-glucose and exists as granules and is more highly branched while the glucose in cellulose is β-glucose and it is the chief constituents of cell walls in living organisms

c) Amylopectin and amylose: Amylopectin and amylose all are form of starch, means that they are polymer of β glucose the only difference it is that Amylose is unbranched while Amylopectin is highly branched.

9. Tertiary structure.

10. a) latent heat of vaporization

    b) Solvent property of water

    c) High heat capacity

11. Notice: Explanation student book

Monomers	Bond	Polymer
Nucleotides	Phosphodiester linkages	Triacylglycerol
Monosaccharide	Glycosidic linkages	Polysaccharide
fatty acids	Ester linkages	Triacylglycerol
Amino acids	Peptide bonds	Polypeptides

12. During denaturation there the braking down peptide bond

13. The following are the answers:

a) The following are the explanations:

A catalyst is a substance that increases the rate at which reactions take place but does not get involved in the reaction and is reused many times. Catalysts are used in industrial processes and are found in living organisms.

The lock and key means that the active site of the enzyme has a specific shape as that of a lock and the shape of the substrate can fit in as a specific key in its lock.

Activation energy is the energy required by molecules to start a reaction.

Q10means the rate of a reactions doubles for every 100C increase in temperature, up to the optimum temperature.

b) There are hundreds of different enzymes in our cells because of hundreds of different reactions taking place in cell, each enzyme only catalyses one reaction.

c) Enzymes hold the substrate in such a way as to allow them to react more easily at lower temperature than usual.

14. The following are the answers:

a) Enzyme work faster at high temperature because the heat energy provides molecules with energy; the more heat the faster the molecules move around; more likely that a substrate will bump into an enzyme; increasing temperatures, increase the rate of reactions up to a maximum point called the optimum temperature.

b) High temperatures provide so much energy that the atoms making up the enzyme vibrate; the bonds to break down; the enzyme loses its globular shape (its tertiary structure) and becomes denatured.

However, a few bacterial enzymes found in hot springs and the industrial are temperature-resistant.

c) The number of H+ or OH- ions in a solution affects the distribution of charges over the surface of the enzyme. The pH affects the ionisation of side chain in amino acid residues and affects the hydrogen bonds and di-sulphur bridges which hold the enzyme in 3D shape. Extremes of pH denature the enzyme.

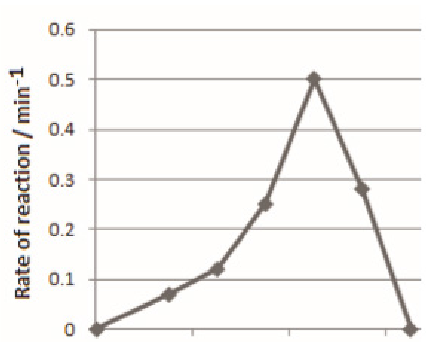
d) Enzymes catalyze different reactions and are found in different cellular environments; for example, extra-cellular digestive enzymes have to be able to work in acidic or alkaline conditions in the stomach or intestine respectively. In addition, each enzyme has a different combination of amino acid side chains.

e) Differences between reversible and irreversible enzyme inhibitors:

15. They have optimum temperatures of up to 900C. They can be used in reactions where high temperatures are involved. They are stable at high temperatures so can be re-used many times.

16. The following are the answers:

a) I plot the curve



b) The optimum temperature is 45^{0}C

c) The rate of the reaction is increasing with temperature / linear increase; rate doubles with every 10^{0}C increase in temperature; reference to Q_{10}.

d) Rate at 20^{0}C is 0.1, rate at 30^{0}C is 0.2; Rate of increase is 0.1/10^{0}C or 0.01 per ^{0}C

12.9. Additional activities (Questions and answers)

12.9.1 Remedial activities

1. What is the reagent which is used for?
   a) Testing proteins?
   b) Testing lipids
2. On your choice give the food in which we can find the following substances
   a) Starch b) Vitamin C c) Lipids
3. ………………is the reverse of a condensation reaction
4. How do we call a single sugar molecule?
   a) Monomers
   b) Monosaccharide
   c) Carbohydrates
   d) Proteins
5. How many numbers of hydroxyl groups in a glycerol molecule?
6. Name the bond in secondary structure of proteins.
7. What happen to the protein if is denatured?

Expected answers

1. a) We use Biuret test or Million's reagent b) We use Emulsion test (Ethanol) and Sudan III
2. a) Tubers such as potatoes, cassava, Seeds such as maize, rice and sorghum
   b) Orange and lemon fruits
   c) Oil, ground nuts, sunflower
3. Hydrolysis
4. (b) Monosaccharide.
5. There 3 OH group in Glycerol molecule
6. Secondary structure bond: peptide bond, hydrogen bond.
7. When a protein is denatured the proteins change the shape.

12.9.1. Consolidation activities

1. Explain the chemical test that you can carry to identify the presence of proteins in a food sample
2. There is no special reagent to test for the presence of non-Reducing sugar. Explain the methods and procedure that you can use to identify non-reducing sugar in a food sample.
3. The empirical formula of a compound is C51H98O6. Such compound is a:

   a) Protein b) Lipid c) Vitamin d) Carbohydrate

Expected answers

1. Answer:
   - Proteins are tested using Biuret reagent. The reagent turns purple when it is mixed with a protein.
   - A violet/purple colour is formed. The reaction takes place in alkaline solution.
   - The copper (II) sulphate has Copper (II) ions that interact with the nitrogen atoms in the peptide chain that makes protein resulting to a purple colour.
2. Answer:
   - Reducing sugar and non-Reducing sugar together with starch are carbohydrates.
   - The test for non-reducing sugar is the test for carbohydrates.
   - First of all, we test for the presence of Starch using Iodine solution
   - Second we hydrolyse the sample using dilute Hydrochloric acid, and Sodium hydroxide to neutralize the acidity
   - Third we test the presence of reducing sugar.
   - If the sample is positive for reducing sugar test, this indicates that before hydrolysis with HCl it was a non-reducing sugar.
3. b)

12.9.2. Extended activities

1. You are provided with the following:

- 2 test tubes containing 2cm3 each of suspensions of specimens' E and F and the solution Y.
- 4clean test tubes, solution G -0.1% ascorbic acid solution.
- A dropper.
- 5cm3 measuring cylinder.

Without shaking the test tubes carry out the following tests. Recordyour results in the table below and answer the questions that follow. Test Number of drops

Test	Number of drops
To 1 cm^3 of solution Y in a test tube add drops of suspension of E until the colour disappears	
To 1 cm^3 of solution Y in a second test tube add drops of F until the colour disappears	
To 1 cm^3 of solution Y in a third test tube add drops of solution G until the colour disappears.	
Boil 1 cm^3 of solution G for three minutes and cool. Add drops of this cooled solution to 1cm3of solution Y in a test tube until the colour disappears	

a. Use results in(i) and(ii) in the table aboveand calculate the percentage of ascorbic acid in the suspensions of E. Show your working.

b. Comment on difference in percentage of ascorbic acid in the two suspensions as calculated in the question 1.

c. Calculate the percentage of ascorbic acid in solution G before and after boiling

d. How can you explain the difference in percentage of ascorbic acid in the unboiled solution and boiled solution?

2. Starch and glycogen are important storage carbohydrates.

a. State one structural similarity and one structural difference between them.

b. State any two organs in which starch is stored in plants.

c. Where is glycogen stored in animals?

3. Explain why it is an advantage of storing energy in large molecules?

Expected answer

1.

Test	**Number of drops**
To 1 cm^3 of solution Y in a test tube add drops of suspension of E until the colour disappears	20
To 1 cm^3 of solution Y in a second test tube add drops of F until the colour disappears	10
To 1 cm^3 of solution Y in a third test tube add drops of solution G until the colour disappears.	5
Boil 1 cm^3 of solution G for three minutes and cool. Add drops of this cooled solution to 1 cm^3 of solution Y in a test tube until the colour disappears	7

- Percentage of ascorbic acid in suspension equals the number of the used quantity (5cm^3) over the number of drops of the solution (20cm^3) times the concentration of ascorbic acid solution. From here, $E=5/20\times0.1=0.025\%$
- Percentage of Ascorbic acid in suspension is calculated in the same way as the data summarized in the above table, so that: $F=5/10\times0.1=0.05\%$
- Note:5 drops of 0.1% ascorbic acid (solution G) produces the same effect (Decolorized solution Y) as drops of solution E (E%), so that $5\times0.1=20\times E$. From this equation: $E=5\times0.1=0.025\%$

7) Specimen F has a higher content of ascorbic acid than specimen E.

8) Before boiling the percentage is 0.1% while after boiling: $5/7\times0.1=0.07\%$

2. The following are the answers:

a. Similarities

- Long chain of alpha glucose
- Branching chain
- Long chain linked by glycosidic links / bonds.

b. Differences

- Starch is less branching while glycogen is profusely branching

- Starch is less soluble while glycogen is more soluble
- Starch exists as grains while glycogen exists as tiny granules

a) In plants, starch is stored in tubers (potatoes, cassava…) and in stem

b) In animals' glycogen is stored in liver and muscles

3. Large molecules of denser monomers take up a less space than an equivalent amount of the monomer. Also, large molecules are usually insoluble in water and not easily broken down. Starch and glycogen are therefore more efficient storage units than glucose.

UNIT 13

KIRCHHOFF'S LAWS IN ELECTRIC CIRCUITS

13.1. Key Unit competence

Interpret and solve problems in electric circuits using Kirchhoff's law

13.2. Prerequisite (knowledge, skills, attitudes and values)

- Charges concepts and forces between static charges
- Measurements of electrical current from unit 1
- Sources of errors during measurements learned in O level
- Curiosity, honesty, and respect for evidence, perseverance and tolerance of uncertainty through the study of electric charges.

13.3. Cross cutting issues to be addressed

- **Standardization culture**: Emphasize the need to use appropriate electrical components.
- **Financial education:** Emphasize the need to compare price against electric components while buying based on its functionality.
- **Environment and sustainability:** Recognize the safety measures taken for the sake of environmental protection.
- **Peace and values education:** Cooperation and teamwork spirit should be encouraged in learning process.

13.4. Guidance on introductory activity

- Ask student-teachers to look at the illustration of the unit and let them discuss what they see.
- Let them brain in five minutes to discover what is observed in the illustration of the unit.
- Let sample student-teacher expose their ideas in five minutes to discover more details in the illustration of the unit.
- Ask them to suggest what topics do they think this unit will focus on based on the illustration?
- Give time for some brainstorming and try to introduce the unit based on the discussion done.

13.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Simple electric circuit and its construction.	Interpret and use electric components in construction of simple electric circuits.	2
2	Measurement of electric current and voltage in a simple electric circuit	Develop positive values and attitudes such as curiosity, honesty, and respect for evidence, perseverance and tolerance of uncertainty through the study of electric current.	3
3	Different sources of electric current.	Identify sources of electric current.	2
4	Connection of electrical current source and resistors either in series , parallel or mix-up	Connect and interpret electric circuits with electric components arranged either in series or parallel.	5
5	Kirchhoff's laws (loop rule and junction rule) in electric circuits and their applications in solving problems in complex electric circuits.	State and interpret Kirchhoff's laws using loop and junction rules.	2
		Apply Kirchhoff's laws in interpreting and solving problems in electric circuits.	6
6	End unit assessment	Evaluation of the achievement of the learning objectives.	2

Lesson 1. Simple electric circuit and its construction

a) Learning objective

- Interpret and use electric components in construction of simple electric circuits.

b) Teaching resources

- Wires, electric current sources such as dry cells, batteries, receptors such as bulbs, water heaters, resistors, switches, circuits breakers, measuring instruments such as ammeters, voltmeters.

c) Prerequisites/Revision/Introduction

Measurements of physical quantities

d) Learning activity 13.1

Technical guidance

- This activity introduces the student-teacher to gain more skills about manipulation of electrical components and electric circuit construction.
- Divide your class into small groups of not more than five student-teachers, and let them read and interpret the activity based on their understanding and corresponding concepts about simple electric circuit and their construction.
- Let the student-teachers perform the activity using their prior knowledge about the provided electrical components and write the observation in the notebook.
- Schedule the discussion through presentation and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' observation and problems involved in the process of performing the experiment.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of expected observations.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in electric circuit construction in the student-teacher book and use the information in giving the expected feedback.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in measurement of physical quantities in the student-teacher book and use the information while reviewing the questions together.

Answers to activity 13.1

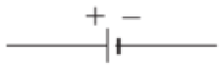
a. X generates electric current, Y transforms electricity to other form of energy and Z connects X to Y.

b. Example X is dry cell and Example of Y is bulb.

c. No. Ammeters and voltmeters are incorporated for the purpose of measuring the current through the conductors and the potential difference across two points.

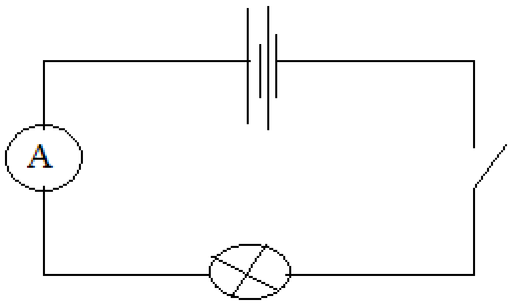
d. Three devices that we need are only sources, conductors and receptors. Therefore, no more components are needed.

e) Answers to Application activity 13.1

1. An electric circuit is a path in which electrons from a voltage or current source flow.
2. 

3. An open circuit is one where the continuity has been broken by an interruption in the path for current to flow.
4. (a)Electric source, ammeter, bulb/lamp, wire, switch

   (b)



Lesson 2. Measurement of electric current and voltage in a simple electric circuit

a) Learning objective

- Use practical skills in manipulating apparatus and using equipment.
- Explain the difference between resistance and resistor.
- Enjoy connecting resistors in series and parallel and determining the effective resistance.

b) Teaching resources

Electric sources, conductors / wires , receptors/ resistors , ammeters and voltmeters

c) Prerequisites/Revision/Introduction

- Ohms law and pouillet law.
- Measurement of physical quantities.

d) **Learning activity 13.2**

Technical guidance

- This activity introduces the student-teacher to gain more skills about manipulation of electrical components and electric circuit construction.
- Divide your class into small groups of not more than five student-teachers, and let them read and interpret the activity based on their understanding and corresponding concepts about simple electric circuit and their construction.
- Let the student-teachers perform the activity using their prior knowledge about the provided electrical components and write the observation in the notebook.
- Schedule the discussion through presentation and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' observation and problems involved in the process of performing the experiment.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of expected observations.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in electric circuit construction in the student-teacher book and use the information in giving the expected feedback.
- Remember that the responses from the discussions may differ but you can refer to the key concepts

Answers to Activity 13.2:

An ammeter with a scale range of 0 – 1 A, 0 – 5 A

When connected to the 1 A terminal, the upper scale running from 0 - 1 A should be used.

We determine the current represented by each smallest division on the upper scale as follows:

5 divisions correspond to........... 0.1 A

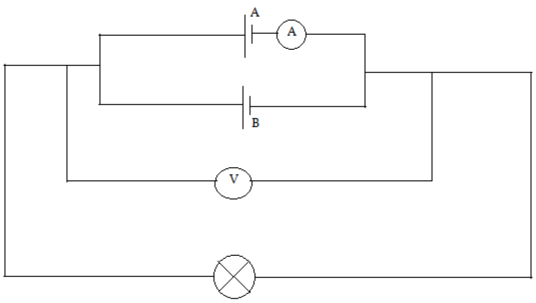
1 division corresponds to .... 0.1/5A = 0.02 A

In Figure, the pointer is on the second mark after the 0.7 mark, hence the ammeter reading is:

0.7 A + (2 divisions × 0.02 A) = 0.7A + 0.04 A = 0.74 A

e) Answers to application activity 13.2

1. Potential difference is the amount of work done(W) by bringing a unit positive charge(Q) from one point to another point. Its SI unit is Voltage(V).
2. Voltmeter
3. Volt is p.d between two points in a circuit in which one joule of electrical energy is transformed when one coulomb passes from one point to the other.
4. $p.d = \frac{w}{q} = \frac{5\,joules}{2coulombs} = 2.5J/C = 2.5V$
5. Voltmeter
6.



Lesson 3. Different sources of electric current

a) Learning objective

- Distinguish different sources of electric current
- Use practical skills in manipulating apparatus and using equipment.
- Explain the difference between resistance and resistor.
- Enjoy connecting resistors in series and parallel and determining the effective resistance.

b) Teaching resources

Electric sources, conductors / wires, ammeters and voltmeters

c) Prerequisites/Revision/Introduction

- Energy forms.
- Electrical energy
- Internal resistance

d) Learning activity 13.3

d) Technical guidance

- This activity introduces the student-teacher to gain more skills about manipulation of electrical components and electric circuit construction.
- Divide your class into small groups of not more than five student-teachers, and let them read and interpret the activity based on their understanding and corresponding concepts about simple electric circuit and their construction.
- Let the student-teachers perform the activity using their prior knowledge about the provided electrical components and write the observation in the notebook.
- Schedule the discussion through presentation and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' observation and problems involved in the process of performing the experiment.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of expected observations.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in electric circuit construction in the student-teacher book and use the information in giving the expected feedback.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in measurement of physical quantities in the student-teacher book and use the information while reviewing the questions together.

Answers to Activity 13.3

a. A source of electric current is any device that change any form of energy into electrical energy.

b. An electric source of energy is also known as generator.

c. List some of electric source include battery, dry cell, solar cell, alternator, dynamo, engine. All these devices generate electrical current.

d. Dry cell and battery changes chemical energy into electrical energy, dynamo and alternator changes mechanical into electrical energy, engine uses fuels to produce electrical energy,

e) Answers to Application activity 13.3

1. See the paragraph above application activity 13.3 in student teacher's book.
2. Fuel cells or engines produce electricity through chemical reactions and battery produces electricity by chemical reaction but no fuels filled to it.
3. Battery consists of electrochemical or archaically electrostatic dry cells.
4. and 5 Give space and time to student teachers to go and search on internet. Give them also time to present their findings.

Lesson 4. Connection of electrical current source and resistors either in series , parallel or mix-up

a) Learning objective

- Evaluate advantages and disadvantages of arranging electric components in series and parallel.
- Use practical skills in manipulating apparatus and using equipment.
- Enjoy connecting resistors in series and parallel and determining the effective resistance.

b) Teaching resources

Torches, Electric sources, conductors / wires, ammeters and voltmeters

c) Prerequisites/Revision/Introduction

- Energy forms.
- Electrical energy
- Internal resistance
- Ohms' law

d) Answers to activity 13.4

Technical guidance

- This activity introduces the student-teacher to gain more skills about manipulation of electrical components and electric circuit construction.
- Divide your class into small groups of not more than five student-teachers, and let them read and interpret the activity based on their understanding and corresponding concepts about simple electric circuit and their construction.
- Let the student-teachers perform the activity using their prior knowledge about the provided electrical components and write the observation in the notebook.
- Schedule the discussion through presentation and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' observation and problems involved in the process of performing the experiment.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of expected observations.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in electric circuit construction in the student-teacher book and use the information in giving the expected feedback.

Answers to Activity 13.4:

Guide and facilitate the activity based on procedures shown by activity 13.4. See student teachers book.

1. When bulbs are connected in series and one is removed from the circuit others stop to shine.
2. And (3) Two bulbs brightness is less than that of one bulb.

Task 2

1. When bulbs are connected in parallel and one is removed from the circuit other continues to shine.
2. And (3) Two bulbs brightness is the same that of one bulb.

e) Answers to Application activity 13.4

1. Diagram A: $R_1 = 3\Omega, R_2 = 11\Omega$

   Diagram B: $R_1 = 4\Omega, R_2 = 18\Omega$

   Diagram C: $R_1 = 4\Omega, R_2 = 18\Omega$

2. $I = \frac{emf}{R_{eq}} = \frac{18V}{\left(\frac{3\times 6}{3+6}+4\right)\Omega} = 3A$

$R_{eq1} = 2\Omega$

$I_{4\Omega} = I_{2\Omega} = 3A$

$V_{cb} = 3A\times 2\Omega = 6V$

$I_{6\Omega} = \frac{6V}{6\Omega} = 1A$

$I_{3\Omega} = \frac{6V}{3\Omega} = 2A$

3. $R_{eq} = 4.00\Omega + \frac{70}{17}\Omega + 9.00\Omega = 17.12\Omega$

$I = \frac{V}{R_{eq}} = \frac{34V}{\left(\frac{7\times 10}{7+10}+4+9\right)\Omega} \approx 2A$

$I_{4\Omega} = I_{9\Omega} = I_{4.12\Omega} = 2A$

$V_{4.12\Omega} = 2A\times 4.12\Omega = 8.24V$

$I_{7\Omega} = \frac{8.24V}{7\Omega} = 1.18A$

$I_{9\Omega} = \frac{8.24V}{9\Omega} = 0.92A$

4.

(i) 6 Ω

(ii) 9 Ω

(iii) 15Ω

(iv) 12 Ω

(v) 18 Ω

(vi) 36 Ω

5. increases, decreases

6. (b), (d)

7. (a), (e)

Lesson 5: Kirchhoff's laws (loop rule and junction rule) in electric circuits and their application in solving problems in complex electric circuits

a) Learning objective

- State and interpret Kirchhoff's laws using loop and junction rules.

b) Teaching resources

Ammeter, voltmeter, ohmmeter, Rheostat, conductors and resistors, batteries, connecting wires

c) Prerequisites/Revision/Introduction

- Ohm's law .
- Solving system of linear question by substitution or other methods.

d) Learning activity 13.5

Technical guidance

- Instruct learners to carry out activity 13.5
- After the activity, let learners submit their work to you. The purpose of this activity is to remind learners about combinations of resistances.
- Review their knowledge of the general formulae of resistances in series and in parallel.
- In order to introduce this lesson, the teacher can show two circuits represented by diagrams.
- Show that activity it's possible and easy to calculate the current owing in the circuit using general method and but also it's more challenging to calculate the currents without knowing methods; so we use other new rules called Kirchhoff's rules which will be studied in the next lesson.

Answers to the task 13.5:

$$I=\frac{12-6}{8+10}A=\frac{6}{18}A=\frac{1}{3}A,\quad P=RI^2$$

$$P_1=\left(\frac{1}{3}\right)^2\times 8w=0.89\,w, P_2=\left(\frac{1}{3}\right)^2\times 10w=1.11w$$

$$P_{12V}=12\times\frac{1}{3}=4w$$

e) Answer application activity 13.5

Based on direction shown here below and starting from junctions A and C we write the rule as follow:

a. Use Kirchhoff's first law to write down an expression for the current in BE, in terms of I_1 and I_2

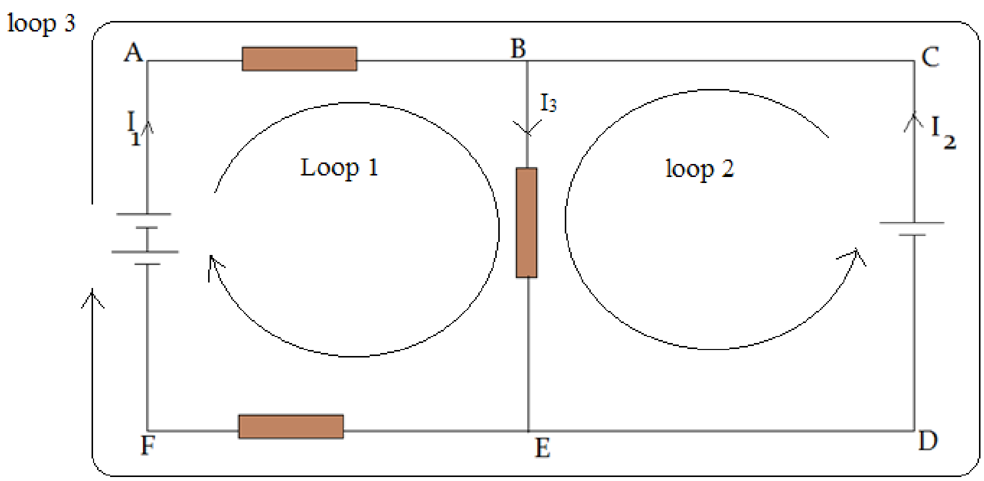
$$I_3=I_1+I_2$$

b. (i) LOOP 1 (ABEFA) :

$$3V-(10\Omega)I_1-(10\Omega)I_3-(10\Omega)I_1=0$$
$$3V-(20\Omega)I_1-(10\Omega)I_3=0$$

(ii) Loop 2 (CBED):

$$1.5V-(10\Omega)I_3=0$$



13.6. Summary of the unit

- A cell is a kind of a 'pump' which provides electrical energy needed to drive charges along a complete path formed by the wire through the bulb switch and back again to the cell.
- Potential difference is the work done in moving one coulomb of charge from one point to the other in an electrical circuit.
- An electric generator is a device which is used to produce electric energy, which can be stored in batteries or can be directly supplied to the homes, shops, offices.
- Circuits consisting of just one battery and one load resistance are very simple to analyze, but they are not often found in practical applications.
- For any n resistors connected in series combination, the effective resistance is

  $$R_{eq} = R_1 + R_2 + R_3 + \ldots + R_n$$

- For n resistors connected in parallel combination, the effective resistance is

  $$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

- A junction in a circuit is a point where three or more conductors meet. Junctions are also called nodes of branch points. A loop is any closed conducting path.
- Kirchhoff's junction rule: the algebraic sum of the currents into any junction is zero. That is,

  $$\sum \boldsymbol{I} = \mathbf{0}$$

  i.e The sum of the currents entering the junction must equal the sum of the currents leaving the junction.

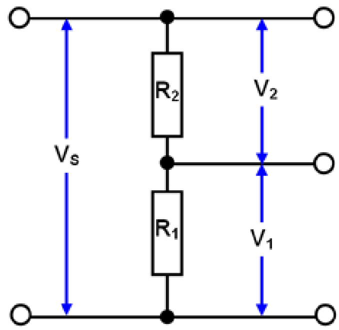
- Kirchhoff's loop rule: the algebraic sum of the potential differences in any loop, including those associated with emfs and those of resistive elements, must equal zero. That is,

  $$\sum \boldsymbol{V} = \mathbf{0}$$

13.7. Additional information for tutors

Potential Dividers

Potential dividers are resistors connected in series across a voltage source used to obtain a desired fraction of the voltage. An example is shown below:



The potential divider formula

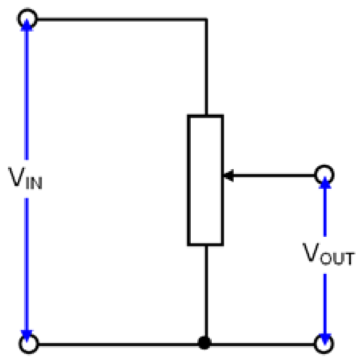
For an unloaded potential divider the current through each resistor is the same so the voltage is proportional to the resistance. This means that the pd across the pair of resistors is divided in the same ratio as the resistors themselves:

i.e. $V_1 / V_2 = I R_1 / I R_2$ **or** $\mathbf{V_1} / V_2 = R_1 / R_2$

If $R_1 >> R_2$ then V1 is more or less the supply voltage and if $R_1 << R_2$ then V1 is close to 0 V.

VS is an input to the potential divider and V1 is an output. The circuit itself provides a way to tap off a voltage between 0 V and V_S.

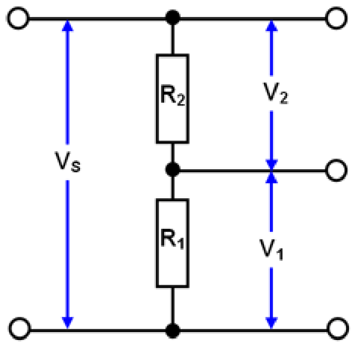
This can, of course be done continuously using a rheostat or potentiometer shown below:



Rotary potentiometers are used as volume controls in hi-fi systems.

The potential divider equation can be derived by rearranging the ratios above to give:

$V_1 = V_S \times (R_1 / (R_1+R_2))$



Lets do it now:

Use KVL: $Vs = I(R_1+R_2)$ so $I = Vs/(R_1+R_2)$

Now: $V_1/V_2 = IR_1/IR_2 = R_1/R_2$

And $V_1=I \times R_1$

So, $V_1= (Vs/(R_1+R_2)) \times R_1$

Therefore: $V_1 = V_S \times (R_1 / (R_1+R_2))$

The effect of the load on output

Connecting a load across R_1 reduces the output voltage.

This is because the effective resistance in the lower arm of the potential divider is now a parallel combination of R_1 and R load (less than R_1) so a smaller fraction of the voltage is 'tapped off'.

If $R_{load} >> R_1$ then there is no significant effect on the output voltage.

Consider what happens when a lit bulb goes out when "shorted out" by a piece of wire. It is because the low resistance of the wire in parallel reduced the combination's total resistance, compared to the rest of the circuit.

13.8. End unit assessment

1. Kirchhoff's curent law states that the sum of the currents entering the junction must equal the sum of the currents leaving the junction. Kirchoff's voltage law states that the algebraic sum of the potential differences in any loop, including those associated with emfs and those of resistive elements, must equal zero.
2. Electric source of current transforms any form of energy into electrical energy while receptors are those devices that transform electrical energy into any form of energy like heat, light, sound as well as mechanics.

3.

$$\frac{1}{R}=\sum\frac{1}{Ri}\Rightarrow\frac{1}{R}=\frac{1}{50}+\frac{2}{100}\Rightarrow R=25\Omega$$

$$I=\frac{10V}{25\Omega}=0.4A$$

4. In parallel connection the energy transformed is the same but in series potential difference depends on resistance property. Therefore **(B)** is the best answer.

5. The circuit has two nodes (at A and B). We have the choice of choosing only two of the three loops shown . This is because only two of the loops are independent.

   Node A: $I_1+I_2=I_3$ Node B: $I_3=I_1+I_2$ Loop1: $10-I_1R_1-I_3R_3=0$

   Loop2: $20-I_2R_2-I_3R_3=0$

By substitution, the answer can be shown to be I_1=-0.143A, and I_2=0.429A.

13.9. Additional activities

13.9.1 Remedial activities

1. Choose the correct answer; KCL is based on the fact that

a. There is a possibility for node to store energy

b. There cannot be an accumulation of charge at the node

c. Charge accumulation may be or may not be possible.

2. Choose the correct answer; The algebraic sum of voltages around any closed path in a network is equal to

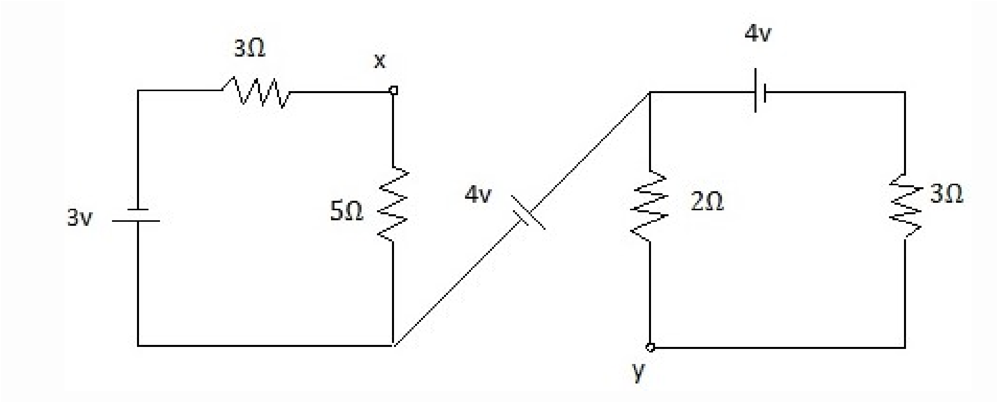
a. Infinity

b. 1

c. 0

d. Negative polarity

3. Choose the correct answer; Potential difference between X and Y is



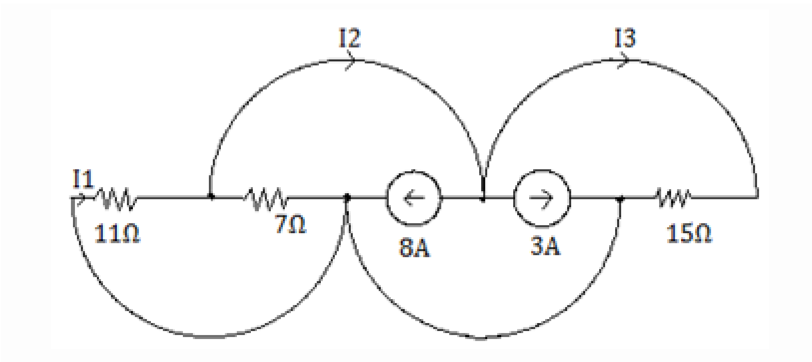
a. 4.275V

b. -4.275 V

c. 4.527V

d. -4.527V

4. Choose the correct answer; Determine currents I1 , I2 and I3



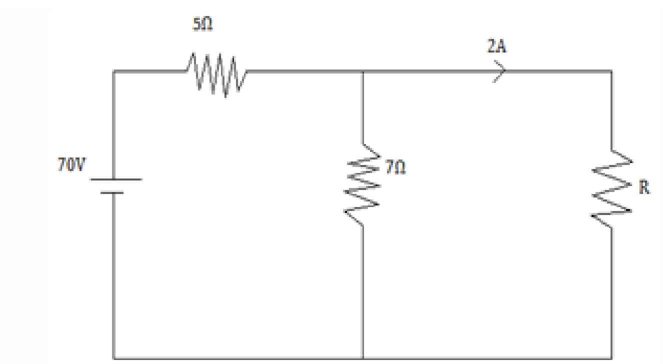
a) -3.3A, -8.5A, 2.4A

b) 3A, -8A, 2A

c) 3.3A, 8.5A, -2.4A

d) 3.2A, 8.6A, 2.3A

5. Choose the correct answer; Find R



a) 17.5 Ω

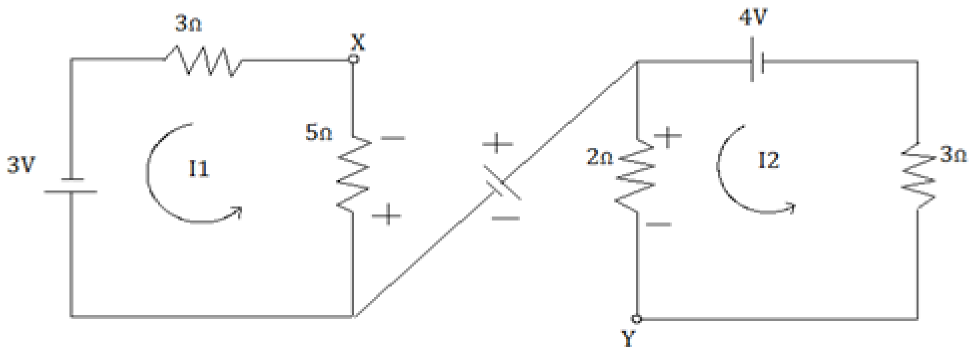
b) 17.2 Ω

c) 17.4 Ω

d) 17.8 Ω

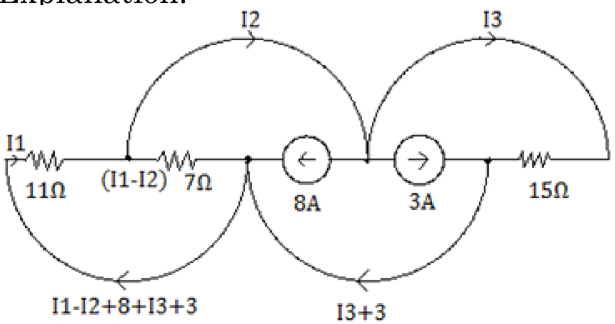
Responses to Remedial activities

1. b)
2. c)
3. Answer:b
   Explanation:



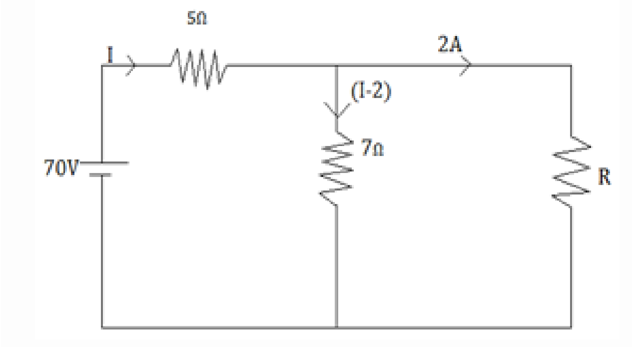
$$I_1 = \frac{3V}{3\Omega + 5\Omega} = \frac{3V}{8\Omega} = 0.375A$$
$$I_2 = \frac{4V}{5\Omega} = 0.8A$$
$$V_{xy} = V_x - V_y$$
$$V_x + 5I_1 + 4 - 2I_2 - V_y = 0$$
$$V_x - V_y = 2I_2 - 4 - 5I_1 = -4.275V$$

4. Answer: c
   Explanation:



$$I_1 = I_1 - I_2 + 8 + I_3 + 3$$
$$I_2 - I_3 = 11$$
$$and\ -11I_1 - 7(I_1 - I_2) = 0$$
$$-18I_1 + 7I_2 = 0$$
$$and\ -11I_1 - 15I_3 = 0$$
$$solving\ I_1 = 3.32\,A, I_2 = 8.5A,\ I_3 = -2.4A$$

5. Answer: a
   Explanation:



KVL:

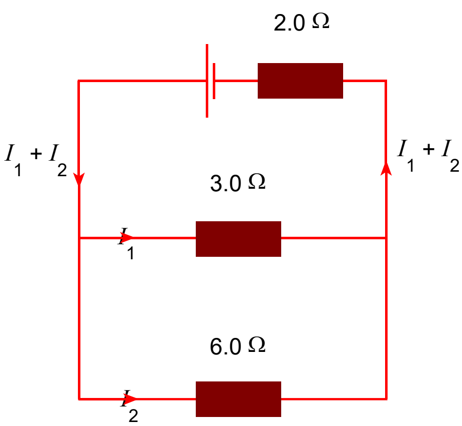
$$70 - 5I - 7(I - 2) = 0$$
$$I = 7A$$

KVL to 2nd loop:

$$7(I - 2) - 2R = 0$$
$$R = 17.5\Omega$$

13.9.2. Consolidation activities

1. A circuit consists of a cell of emf 1.6 V in series with a resistance 2.0 Ω connected to a resistor of resistance 3.0 Ω in parallel with a resistor of resistance 6.0 Ω. Determine the total current drawn from the cell and the potential difference across the 3.0 Ω resistor.



Solution

Consider the circuit loop consisting of the cell and the 3.0 Ω resistor:

$$1.6V = 3I_1 + 2(I_1 + I_2) = 5I_1 + 2I_2$$

Consider the circuit loop consisting of the cell and the 6.0 Ω resistor:

$$1.6V = 6I_2 + 2(I_1 + I_2) = 2I_1 + 8I_2$$

Subtracting the second equation from the first gives:

$$0V = 3I_1 + 6I_2 \rightarrow I_1 = 2I_2$$

Substituting $I_1 = 2I_2$ into the second equation gives:

$$1.6V = 12I_2 \rightarrow I_2 = 0.13A \ and \ I_1 = 0.27A$$

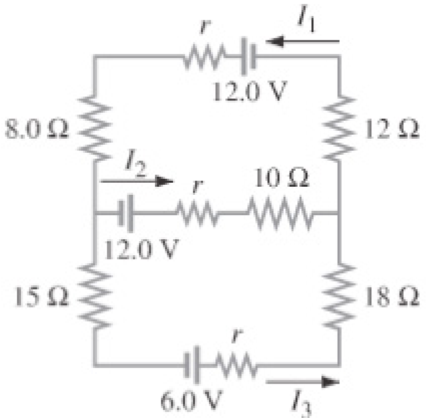
$$Current\ through\ cell = I_1 + I_2 = 0.40A$$

pd across 3.0 Ω resistor

$$V = I_1 \times 3.0\Omega = I_2 \times 6.0\Omega = 0.8V$$

13.9.3. Extended activities

1. Ten lamps are connected in series across a power supply. The voltage across each lamp is 6.0 V. What is the voltage of the supply?
2. Ten lamps are connected in parallel across a 12 V supply. What is the voltage across each lamp?
3. (a) Determine the currents I_1, I_2, and I_3 in figure below. Assume the internal resistance of each battery is r = 1.0 Ω



(b) What is the terminal voltage of the 6.0 V battery?

(c) What would the current I_1 be if the 12 Ω resistor is shorted out?

Answers

1. 60 V
2. 12 V
3. Since there are three currents to determine, there must be three independent equations to determine those currents. One comes from Kirchhoff's junction rule applied to the junction near the negative terminal of the middle battery.

$$I_1 = I_2 + I_3$$

Another equation comes from Kirchhoff's loop rule applied to the top loop, starting to the negative terminal of the middle battery and progressing clockwise.

$$12.0V - I_2(1.0\Omega) - I_2(10\Omega) - I_1(12\Omega) + 12.0\text{V} - I_2(1.0\Omega) - I_1(8.0\Omega) = 0 \rightarrow$$
$$24 = 11I_2 + 21I_1$$

The final equation comes from Kirchhoff's loop rule applied to the bottom loop, starting to the negative terminal of the middle battery, and progressing clockwise.

$$12.0V - I_2(1.0\Omega) - I_2(10\Omega) + I_3(1.0\Omega) - 6.0\text{V} + I_3(15\Omega) = 0 \rightarrow$$
$$6 = 11I_2 - 34I_3$$

Substituting $I_1 = I_2 + I_3$ into the top loop equation so that there are two equation with two unknowns

$$24 = 11I_2 + 21I_1 = 11I_2 + 21(I_1 + I_3) = 32I_2 + 21I_3;\ 6 = 11I_2 - 34I_3$$

Solving the bottom loop equation for I_2 and substitute into the top loop equation, resulting in an equation with only one unkown, which can be solved

$$6 = 11I_2 - 34I_3 \rightarrow I_2 = \frac{6 + 34I_3}{11}$$

$$24 = 32I_2 + 21I_3 = 32\left(\frac{6 + 34I_3}{11}\right) + 21I_3 \rightarrow 264 = 192 + 1088I_3 + 231I_3 \rightarrow 72 = 1319I_3 \rightarrow$$

$$I_3 = \frac{72}{1319} = 0.055A,\ I_2 = \frac{6 + 34I_3}{11} = 0.714A, I_1 = I_2 + I_3 = 0.769A$$

Also find the terminal voltage of the 6.0 V battery.

$$V_{terminal} = E - I_3 r = 6.0V - (0.055A)(1.0\Omega) = 5.85V$$

UNIT 14

ASEXUAL AND SEXUAL REPRODUCTION IN PLANTS

14.1. Key Unit competence

Describe modes of reproduction in plants and apply various methods of asexual reproduction as means of increasing crop yield.

14.2. Prerequisite (knowledge, skills, attitudes and values)

The student-teachers learnt about asexual reproduction in plants in senior three in unit thirteen. Create awareness of student-teachers the fact that the content in this unit will help them to gain knowledge, skills and attitudes that can lead them to career development in reproductive issues.

For the successive teaching learning process, student-tutors should have enough knowledge on plant anatomy. They have also to be well skilled on drawing a plant with all parts, manipulating the microscope so that they can observe micrographs under the microscope.

14.3. Cross cutting issues to be addressed

The **"peace and value education."** It should be integrated in sub-heading including pollination. As a plant with female flowers needs another plant with male flowers for pollination and fertilization, we also need each other.

- **Financial education:** This cross-cutting issue should be integrated in the subheadings which require observing micrographs under microscope. When guiding student-tutors on how to manipulate the microscope, you should give a caution of handling them carefully as they are very expensive, and that the country spends a lot of money to buy them.
- **Gender education:** This cross-cutting issue should be integrated in all subheadings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities, and when cleaning materials used during practical activities: both boys and girls should participate equally. It should also be integrated where ever teaching about the pollination and fusion of male and female gametes.

- **Inclusive education:** This cross-cutting issue should be integrated in all subheadings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: student-tutors with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, student-tutors without arms and legs; tutor and other student-tutors should help them to achieve the competences as required in all teaching-learning activities.

14.4. Guidance on introductory activity 14

- Write on how lower organisms such unicellular plant and another like cassava, sugar cane and apple reproduce asexually.
- Difference between sexual reproduction and asexual reproduction
- Describe the techniques used by people to grow Irish potatoes, cassava and bananas.
- Describe each of the following methods of asexual reproduction: fragmentation, budding and spore formation.
- Ask them to brainstorm on the above questions so that they can come up with good results and give room to student-teacher so that they may share their thoughts. Use student-tutors' ideas and then introduce a whole unit.
- Provide the chart, books or micrographs with student-tutors which show different flowers containing insects or birds for pollination.
- Engage student-teachers to use resources provided, and work on the introductory activity.
- Give student-teacher the time to present their findings.
- Receive answers and ideas from student-tutors and summarize them by valuing student-tutors' contributions.
- Inform student-tutors about the general knowledge, skills and values that they will get from this unit.
- Student-teacher should give answers related to pollination by insects and birds.
- The pictures are related to reproduction, as they represent flowers and pollination which are involved in reproduction in flowering plants.

14.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Comparison between Asexual and sexual reproduction	Differentiate asexual and sexual reproduction	3
2	Asexual reproduction (Methods, Advantages and disadvantages of asexual reproduction, Vegetative and artificial propagation in flowering plants and their Application in growing improved varieties of plants)	- Describe the various methods of asexual reproduction - Demonstrate asexual reproduction mechanisms in lower organisms. -Discuss the advantages and disadvantages of asexual reproduction. -Describe the characteristics of vegetative reproductive parts in a flowering plant. -Apply principles of artificial propagation in growing varieties of plants that are economically important	9
3	**Sexual reproduction** (Alternation of generation in bryophytes and pteridophytes Types, structure and functions of flowers, Pollination and double fertilisation in flowering plants, Events in a flower after fertilization) Structure, types and functions of seeds and fruits	-Explain the meaning of the term alternation of generations. -Describe the types and structure of flowers -Describe pollination and fertilization in flowering plants - Explain the events that takes place in a flower after fertilization - Appreciate the role of pollinating agents in flowering plants - Describe the types and structure of seeds and fruits - Draw and label structures of fruits and seeds.	15

	Fruit and seed dispersal with their adaptations	-Discuss the modes of dispersal of fruits and seeds	
	End unit assessment		1

Lesson 1. Comparison between asexual and sexual reproduction

a) Learning objective

Differentiate asexual and sexual reproduction

b) Teaching resources

Illustrations and computer aided materials.

c) Prerequisites/Revision/Introduction

This is the first lesson of unit 14 and is a double period lesson. Before you start this lesson, you are requested to introduce the whole unit as given in the guidance on the introductory activity of this unit. Start this lesson by asking student-teacher to differentiate asexual and sexual reproduction, let student-teacher give their views. Build on student-teachers' ideas and then connect to learning activity of this lesson.

d) Learning activity 14.1

Guidance

Facilitate student-teachers to do activity 14.1 and develop competencies in this lesson by doing the following:

- Ask student-teachers to brainstorm the difference between asexual and sexual reproduction.
- Supervise the work how it is conducted and give the student-teachers' opportunity to work in their respective groups.
- Ask student-t teachers to make discussion in group.
- Ask student-teachers to write the summary of the group discussions,
- Use student-tutors' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide student-teachers to come up with a summary, write it progressively on the chalkboard or flipchart and ask student-tutors to note it in their notebooks.

- Finally, assess the lesson through questions and then invite student-teachers to attempt application activity 14.1

Answers to the activity 14.1

a. A = Banana plantation B = Goat with its young

b. The banana young ones are coming from the parent one (Big)

c. They have been reproduced asexually

d. It has been reproduced sexually, it requires male and female gamete

e. The student teachers should compare sexual and asexual reproduction and Expected answers are under the unit 14 (lesson one) in student-teacher book

e) Application activities 14.1

1. Asexual reproduction is a type of reproduction done by a single organism without production of gametes while sexual reproduction is a type of reproduction in which two parents are involved, each capable of producing gametes. Full answers are under the unit 14 (lesson one) in student-teacher book.

Lesson 2. Asexual reproduction in plants

a) Learning objective

- Describe the various methods of asexual reproduction
- Demonstrate asexual reproduction mechanisms in lower organisms.
- Discuss the advantages and disadvantages of asexual reproduction.
- Describe the characteristics of vegetative reproductive parts in a flowering plant.
- Apply principles of artificial propagation in growing varieties of plants that are economically important

b) Teaching resources

Illustrations and computer aided materials, sweet potatoes vines, elephant grass, sugarcane or cassava stems, secateurs/sharp knife and rooting hormone.

c) Prerequisites/Revision/Introduction

Do introduction by asking student-teachers to brainstorm on asexual reproduction in lower organisms and write reports. Through question of revision on the asexual reproduction, do you think on the asexual reproduction?

Build on student-teachers' ideas and then go to the activity 14.2.2 given in student-teacher textbook. Student-teachers also have knowledge about vegetative and artificial propagation in flowering plants as they have learnt it from senior three in asexual reproduction and ask them to brainstorm on the asexual reproduction in plants by cuttings and build on student-teachers' ideas and then go to the activity 14.2.3 given in student-teacher textbook. Through question of revision on the asexual reproduction, build on student-teachers' ideas and then go to the activity 14.2.4 given in student-teacher textbook.

d) Learning activities

Guidance

Help student teachers to develop competencies that are related to this lesson you need to facilitate learners to do activities by doing the following:

- Ask learners to brainstorm the types of asexual reproduction in activity 14.2.1.a and activity 14.2.1.b on fragmentation method.
- Ask learners to brainstorm on the advantages and disadvantages of asexual reproduction.
- Ask learners to brainstorm on the asexual reproduction in plants by cuttings
- Ask learners to brainstorm on the application of artificial propagation in growing improved varieties of plants.
- Supervise the work how it is conducted and give the learners' opportunity to work in their respective groups.
- Ask learners to make discussion in group.
- Ask learners to write the summary of the group discussions,
- Use students' products and further questions if need for summarizing and concluding the lesson.
- Through questions, guide learners to come up with a summary, write it progressively on the chalkboard or flipchart and ask learners to note it in their notebooks.
- Finally, assess the lesson through questions and then invite students to attempt all given application activities.

Answers to activity 14.2.1.a

Expected answers are under the unit 14 (lesson two) in student-teacher book.

Answers to activity 14.2.1.b

Expected answers are under the unit 14 (lesson two) in student-teacher book

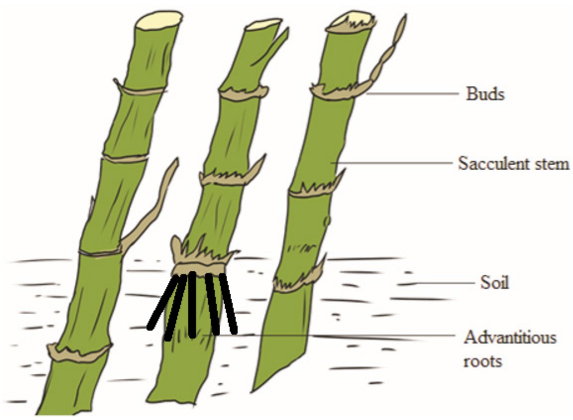
Answers to activity 14.2.2

Expected answers are under the unit 14 (lesson two) in student-teacher book.

Answers to activity 14.2.3

Observation and Interpretation of results

Through using of cassava stems, sugarcane, sweet potatoes planted in moist soil. After about 13 days, we observe the development of roots and leaves at nodes.



Answers to activity 14.2.4

Expected answers are under the unit 14 (lesson two) in student-teacher book.

e) Application activities

Answers to application activity 14.2.1

1. Expected answers are under the unit 14 (lesson two) in student-teacher book.
2. Fragmentation is a form of asexual reproduction where a new organism grows from a fragment of the parent. Each fragment develops into a mature, fully grown individual. Fragmentation is seen in many organisms such as fungi, photosynthetic algae and plants. **Answers to application activity 14.2.2**

Expected answers are under the unit 14 (lesson two) in student-teacher book.

Answers to application activity 14.2.3

1. Expected answers are under the unit 14 (lesson two) in student-teacher book.
2. The people prefer to grow cassava by cutting rather than germination of seed because of:
   - Many new plants can be produced in a limited space from a few stock plants.
   - It is simple and can be easily applied without having to learn the special techniques.
   - It is rapid because there is no need to produce rootstocks.

Answers to application activity 14.2.4

Expected answers are under the unit 14 (lesson two) in student-teacher book.

Lesson 3. Sexual reproduction in plants

a) Learning objective

- Explain the meaning of the term alternation of generations.
- Describe the types and structure of flowers
- Describe pollination and fertilization in flowering plants
- Explain the events that takes place in a flower after fertilization
- Appreciate the role of pollinating agents in flowering plants
- Describe the types and structure of seeds and fruits
- Draw and label structures of fruits and seeds.
- Discuss the modes of dispersal of fruits and seeds

b) Teaching resources

The teaching aids or other resources needed include: microscope, prepared slides and micrographs. You may use also charts, computer, projector and other specific materials for students with disabilities. You can also use the student-teachers' text books.

c) **Prerequisites/Revision/Introduction**

For a successful teaching-learning process of this lesson, students should have enough knowledge on plant anatomy and plant physiology.

d) **Learning activities**

Guidance

- Ask students to form groups, and provide learning-materials to be used in the activity.
- Ask students in their groups to work on the Activity 14.3.1 from the students' text books,
- Monitor how the students are progressing towards the knowledge to be learned. Boost those who are still behind (but without communicating to them the knowledge).
- Move around the class, listening to students as they discuss and looking at their answers.
- Correct those which are false, completes those which are incomplete, and confirms those which correct. Help learners to summarize the lesson (short notes) and assess the lesson.

Answers to activity 14.3.1

Expected answer is found in the student-teachers' text books, unit 14, and lesson 14.3.1

Answers to activity 14.3.2

1. A typical hermaphrodite or bisexual flower contains the following parts:

- Pedicel: it is the stalk which attaches the flower on the main floral axis.
- Receptacle: it is the swollen part at the end of the stalk where other parts of the flower are attached.
- The calyx: it is the set of sepals, generally having green colour. They protect the internal parts of the flower. In some plants, the sepals are coloured and are called petaloids.
- The corolla: it is the set of petals, with different colours and nectar glands that produce sugary substances which participate in attraction of pollinating agents. In some plants, the petals are green and are called sepaloids. Both calyx and corolla are collectively called perianth.

They are called floral envelope or accessory organs as they do not participate directly in reproduction, or in formation of fruits and seeds, they all insure the protection of internal parts of the flower.

- Androecium: is the male reproductive organ of the flower. It consists of many stamens. A stamen consists of: the filament which supports anther, and anther which contains the pollen grains or male gametes.
- Gynoecium/pistil: is the female reproductive organ. It consists of many carpels, and each carpel is made of: stigma (plural: stigmata), style and ovary with ovules.

i. The stigmata: receive pollen grains from anther during pollination.

ii. Style: supports the stigma in a good position to receive pollen grains.

iii. Ovary: a sac where ovules are produced. Ovules become seeds after fertilization.

2. A flower is a reproductive organ of a plant, which produces fruits and seeds
3. Expected answers are under the unit 14 (lesson three) in student-teacher book.

Answers to activity 14.3.3

1. The main pollinating agents include: insects (entomophily), wind (anemophily), water (hydrophily), humans (anthropophily), and birds (ornithophily).
2. The process of double fertilization in flowering plants begins when a pollen grain adheres to the stigma of the carpel, the female reproductive structure of a flower. The pollen grain then takes in moisture and begins to germinate, forming a pollen tube that extends down toward the ovary through the style. The growth of the pollen tube is controlled by the **pollen tube nucleus**. In the pollen tube, the generative nucleus divides mitotically into two haploid nuclei which are the **male gamete nuclei**. These follow behind the tube nucleus as the pollen tube grows down the style towards the ovule. The tip of the pollen tube then enters the ovary and penetrates through the micropyle opening, releasing the two sperms in the megagametophyte or ovule.

   The tube nucleus degenerates, leaving a clear passage for the entry of **male nuclei**. One nucleus fertilizes the egg cell to form a **diploid zygote (2N),** which will grow into a new plant embryo; the other fuses with polar nuclei to form a **triploid nucleus (3N)**, which will grow into a food-rich tissue known as endosperm, which nourishes the seedling as it grows. This process is described as **double fertilization** and is typical of angiosperms.

Answers to activity 14.3.4

a. The fruit can have a dry pericarp or fleshy pericarp. The fruits with fleshy pericarp include: berry and drupe. Drupe is a fleshy fruit with only one seed, E. g. avocado.

Berry is a fleshy fruit having many seeds inside of it. E.g. tomatoes, orange, and pawpaw. The fruits with dry pericarp include indehiscent fruit or dehiscent fruit.

Indehiscent fruits do not open. Seeds remain inside of the fruits. E.g. fruits of coconuts.

Dehiscent fruits open and release seeds.

Answers to activity 14.3.5

a. The main agents of fruits and seed dispersal are wind, water, and animals. Seeds dispersed by wind or water are typically lightweight, allowing them to be carried in air or to float on the surface of water. The wind carries also small seeds that have wing-like structure. Seeds dispersed by animals are typically contained in sweet, nutritious flesh fruits. They can be carried externally on their feet, fur, feathers, or beaks. Those seeds with hooks or sticky substances rely on the chance that they will attach themselves to a passing animal. Other seeds are eaten by animals and passed out in the faeces.

e) Application activities

Answers to application activity 14.3.1

1. Alternation of generation is a phenomenon in the plant life cycle in which a diploid stage a sporophyte alternates with a haploid stage of gametophyte.

2. For fertilization to occur, the sperm of bryophyte must swim to an egg. Without water, this movement is impossible.

3. The archegonium is special reproductive organs in which eggs are produced, while antheridium is special reproductive organs in which sperms are produced. These organs are very important in the life cycle of mosses as they produce gametes which are involved is sexual cycle of bryophytes.

4. In ferns it is the sporophyte that dominates over the gametophyte

5. Sporophyte is a dominant generation over the sporophyte generation.

6. Gametophyte (haploid) produces eggs and sperms by mitosis, formed from spores, while sporophyte (diploid) produces spores by meiosis, formed during fertilization with fusion of egg and sperm.

7. Bryophytes like Liverworts reproduce asexually by producing gemmae, small multicellular reproductive structures. Gemmae can divide by mitosis to produce a new individual.

Answers to application activity 14.3.2

1. The male structures are the stamen (filament and anther), the female structures are the carpels (ovary, style and stigma).
2. Many flowers together in a single structure might attract more insects, which might improve chances of pollination.
3. The female gametophyte develops in the ovules, which are contained in the ovary of the flower.
4. Flowers are reproductive organs that are composed of four kinds of specialized leaves: sepals, petals, stamens, and carpels. Stamens produce male gametophytes, and the carpels produce male gametophytes.

Answers to application activity 14.3.3

1. Angiosperms are typically pollinated by animals such as insects, birds and bats carry pollen from one flower to another as they gather nectar.
2. It is a food rich tissue that nourishes the embryo during germination. It is inside the embryo sac.
3. Brightly coloured petals attract insects and other animals such as birds to the reproductive structures of the flower and increase chances of pollination.
4. Double fertilization is means two fertilizations that takes place between the male and female gametophytes. It may be one of the reasons that explain why angiosperms have been so successful.
5. Both disintegrate and disappear after fertilization since they do not have any important role to play.

Answers to application activity 14.3.4

1. Drupe is a fleshy fruit with only one seed, E. g. avocado.
2. Drupe is a fleshy fruit with only one seed, E. g. avocado, while Berry is a fleshy fruit having many seeds inside of it. E.g. tomatoes, orange, and pawpaw.
3. If ovules in the flower do not develop, the seeds will not develop in the fruit.
4. Seeds dispersed by animals typically have a tough coat and are contained in fleshy fruits. Seeds dispersed by wind and water typically are lightweight and may be encased in wing-like structure.

Answers to application activity 14.3.5

1. It allows for long-distance dispersal and for germination under ideal conditions.
2. It enables the species to recover after a fire and ensures that seedlings grow in favorable environment.
3. The dispersal of seeds is important for the survival of the plant species because:
4. It minimises overcrowding of plants growing around the parent plant that could then result in too much competition for nutrients and light;
5. It allows the plant species to colonise new habitats which can offer suitable conditions.

14.6. Summary of the unit

- Asexual reproduction generates offspring that are genetically identical to a single parent. There are five common modes of asexual reproduction: fission, budding, vegetative reproduction, spore formation and fragmentation.
- Asexual reproduction needs one parent only while sexual reproduction usually needs two parents, asexual reproduction depends on mitosis while sexual reproduction depends on meiosis being present at some stage in life cycle to prevent chromosome doubling in every generation.
- The gametes are produced in asexual reproduction while sexual reproduction gametes are produced.
- In asexual reproduction offspring are identical to parent while in sexual reproduction offspring are not identical to parents. They show genetic variation as a result of genetic recombination.
- In asexual reproduction often results in rapid production of large numbers of offspring while in sexual reproduction there are less rapid increase in numbers
- Important advantages of asexual reproduction include: Rapid population growth. The disadvantage of asexual reproduction includes the following: asexual reproduction does not have genetic diversity, there is less variation produced with the offspring, asexual reproduction usually leads to struggle for existence as well as overcrowding.

- Vegetative and artificial propagation in flowering plants occur in cutting, layering and grafting.
- Artificial vegetative propagation is usually used in agriculture for the propagation of those plants which produce either very few seeds or do not produce viable seeds.
- This unit: “Sexual reproduction in plants” is divided into five sub-units such as: Alternation of generations in bryophytes and pteridophytes, types and structure of flowers, pollination and double fertilization in flowering plants; structures and types of fruits and seeds, and fruits and seeds dispersal and their adaptations.
- The unit deals with investigating the alternation of generations in bryophytes and pteridophytes which allows knowing stages of lifecycle of bryophytes and ferns and how they alternate.
- This unit describes the structures and types of fruits and seeds.
- This unit explains pollination and double fertilization in flowering plants.
- The unit describes structures and types of fruits and seeds and this unit talks about fruits and seeds dispersal and their adaptations.

14.7. Additional information for tutors

- This unit contains more practical activities you are advised to work on before you got to teach them the students in order to avoid the failure of any activities in front of the students.
- The longevity of life cycle is controlled by phytohormones. The vegetative cycle is controlled by growth the hormone. When the growth hormone is enough in the plant, the vegetative cycle will be quick and then alternation of generations becomes also quick**.**

Guidance on Skill lab 14

Encourage your student-teachers to apply the methods of asexual reproduction to improve the crop yield at the school level.

It is better to give them a video on the grafting and ask them to try. Indeed, such a process can take long time. So it requires the tutor to monitor the activity day by day.

14.8. End unit assessment 14 (answers)

PART A

A) Multiple choice questions

1. Answer is C
2. Answer is D
3. Answer is B
4. Answer is B

B) Questions with short and long answers

1. Some plants that are grown by grafting method are the following: mango, apple, banana, pear, grape, pineapple and peach.
2. Grafting is a horticultural technique whereby tissues of plants are joined so as to continue their growth together.
3. The potato tubers have nodes or eyes from which the new growth begins. The new stems growing from each eye are called sprouts which gives rise to the new plant.
4. Cutting method.
5. The names of the different methods of artificial vegetative propagation are the following: Cutting, Layering and Grafting
6. Vegetative reproduction is a type of asexual reproduction found in plants where new individuals are formed without the production of seeds or spores by meiosis. Examples of vegetative reproduction include in strawberry.

PART B

1. Answer are:

   a) True b) True c) False d) False e) False

2. Answers are:

   a) iv (Stem) b) ii (carpel) c) ii (fruit)...........d) ii (anthers)
   e) ii (gemmae) f) ii (fruit) g) ii (fronds).............h) i (gametophyte)

3. The seeds of angiosperms, because the seeds are enclosed in fruits, which are eaten by animals.
4. In seedless plants, the swimming of the male gametes is analogous to pollination in seed plants.

5. The diploid sporophyte; the gametophyte grows independently of sporophyte. The young sporophyte grows from the gametophyte.
6. Bryophytes produce sperms that must swim through water to reach the eggs of others.
7. Bryophytes are limited in size because they lack vascular tissues and therefore can draw only a few centimeters of water up from the ground by osmosis.
8. Favorable conditions may be short-lived (e.g. in autumn) and dormancy may increase the chances of germination occurring when there is prolonged period on favorable conditions (e.g. in spring). Dormancy increases the time during which seeds may be removed away from parents.
9. The gametophyte is dominant, recognizable stage and is the form that carries out most of plant's photosynthesis. The sporophyte depends on gametophyte for water and nutrients.
10. Bryophytes depend upon the presence of water to complete their life cycle, because the only way the sperm can reach the egg is to swim through standing water or dew.
11. The dominant stage in the lifecycle of ferns is the diploid sporophyte, which, when mature consists of roots, underground stems called rhizomes, and fronds, which are large leaves. On the underground of fronds grow sporangia, which grow in clusters called sori that release spores.
12. Students' answers should reflect the concept that angiosperms have protected seeds and many ways in which the seeds can be dispersed, which increase the chances of survival.
13. Vascular tissue support a tall plant and curries water and nutrients from the soil to its upper region. Thus, ferns, which have vascular tissues grow tall, whereas moss plants cannot grow tall because they lack vascular tissues. Plants require a method to transport water and nutrients throughout the plant body in order to survive.
14. Answers are:

    a) A= seed coast (testa), B= hypocotyl, C= endosperm (cotyledon).

    b) Endosperm or cotyledon is the source of nutrients for a growing seedling.
15. The bright-coloured parts of the flower might attract insects and other animals for pollination.

16. Endosperm is the stored food supply in angiosperm seeds that nourish the embryo plant.
17. Fruit could not form on flowers that lack carpels, because fruits develop from the ovary, which is the part of the carpel.
18. Pollination is the transfer of pollen grains from anther to the stigma, whereas fertilization is the fusion of a male gamete with a female gamete.
19. Answers are: A= sepals, B= petals, C= stamen, D= carpel or pistil, E= anther, F= filament, G= stigma, H= style, I= ovary, J= ovule. B (petals) as brightly coloured structures they attract insects and birds which can promote pollination. E (anther): it is where pollen grains are produced. G (stigma): receives pollen grain during pollination.
20. They all benefit. Bees obtain a food source, and flowers have a mean of pollination.
21. The main advantage of cross-pollination is to increase variation of offspring.
22. Stamens of wind-pollinated flowers have to be exposed to the air, whereas those of insect-pollinated flowers have to be enclosed so that insects have to brush past them.
23. Comparison between wind-pollinated and insect-pollinated flowers

Typical wind-pollinated flower	**Typical insect-pollinated flower**
Flower structure relatively simple	Complex structural modifications
Small petal not brightly coloured	Large coloured petal
Not scented	Scented
Nectarines absent	Nectarines present
Large branched and feathery stigma hanging outside flower to trap pollen	Small stigma, sticky to hold pollen and enclosed within flower
Stamens hanging outside flower to release pollen	Stamens enclosed within flower
Anthers attached only at midpoints at tip of filament so that they swing freely in air current	Anthers fixed at their bases or fused along their backs to the filaments so that they are immovable
Large quantities of pollen owing to high wastage	Less pollen produced
Pollen grains relatively light, small and smooth	Pollen grains relatively heavy, large and sticky.

24. Answers are:

a. Mediterranean squirting cucumber;

b. Sycamore or European maple;

c. Coconut;

d. Mistletoe.

14.9. Additional activities (Questions and answers)

14.9.1 Remedial activities

1. What is fertilization?
2. List five common modes of asexual reproduction.
3. a) Define vegetative reproduction.

   b) Mention any two disadvantages of vegetative reproduction.
4. Copy and complete the following sentence, by using the words: asexually, gametophyte, sporophyte, and sexually In all land plants the ………….. Generation is haploid and produces………… Whereas the …………….. Generation is diploid and reproduces
5. How do the leaves of bryophytes differ from the true leaves of ferns?
6. Which part of the life cycle of ferns is most dependent on water?
7. Differentiate dioecious plants from monoecious plants.

Answers to remedial activities

1. Fertilization is the moment when a sperm and egg join together, and the genes from the mother and father combine to form a new life. The prize is the egg, which is released from the ovary and then travels along the fallopian tube to meet the sperm.
2. There are five common modes of asexual reproduction: fission, budding, vegetative reproduction, spore formation and fragmentation.
3. Vegetative reproduction is the formation of a new individual from any vegetative part of the plant body.
4. Disadvantages of vegetative reproduction.

   i. Year after year same variety is produced. New varieties cannot be produced by this method.

   ii. Since all the plants are genetically alike, they are susceptible to same diseases.

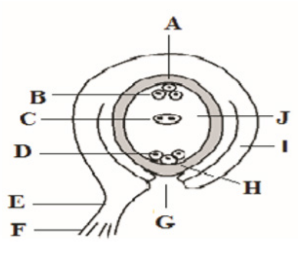
iii. The plants when grown repeatedly may lose vigor.

iv. Undesirable characters get transmitted from one generation to another.

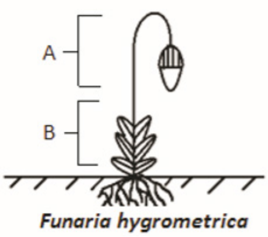
5. In all land plants the gametophyte generation is haploid and reproduces asexually, whereas the sporophyte generation is diploid and reproduces sexually.
6. Bryophyte leaves are haploid whereas true leaves of ferns are diploid.
7. Gametophyte.
8. Dioecious plants are plants that have male flowers and female flowers on separate plants (e.g. papaya) whilst monoecious plants are plants that have both male and female flowers on the same plant (e.g. maize).

14.9.1. Consolidation activities

1. State at least three differences between asexual and sexual reproduction.
2. Write on the spore formation.
3. Discuss the popular use of grafting.
4. Rose is propagated both by cutting and budding. What are the advantages of these methods?
5. Why do many angiosperms produce less pollen than conifers?
6. Name all parts labeled on the diagram below:



7. What is parthenocarpy?
8. Study the diagram below and answer to the question



a. Between A and B; which part is the gametophyte?

b. What name can you give to the remaining part A or B?

Answers to consolidation activities

1. Answer:

Asexual reproduction	Sexual reproduction
No gametes are produced Gametes are produced.	These are haploid and nuclei of two gametes fuse (fertilization) to form a diploid zygote.
Depends on mitosis	Depends on meiosis being present at some stage in life cycle to prevent chromosome doubling in every generation.
Offspring identical to parent	Offspring are not identical to parents. They show genetic variation as a result of genetic recombination

2. This may look similar to seed formation in flowering plants, but spore production only occurs in non-flowing plants and in other microscopic organisms. Examples of such organisms include fungi, green algae, protozoa, and ferns.

3. A popular use of grafting is to produce fruit trees, sometimes with more than one variety of the same fruit species growing from the same stem. Rootstocks for fruit trees are either seedlings or propagated by layering.

4. Both cutting and budding are artificial methods of vegetative propagation.

Advantages of cutting

i. is a very simple method.

ii. It takes less time and is less expensive.

Advantages of budding

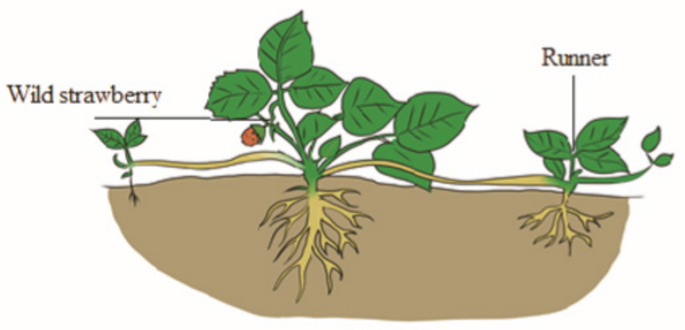
i. New varieties with desired characters like color or disease-resistance can be obtained by taking recourse to sexual process.

ii. It can be easily practiced.

5. Many angiosperms are insect-pollinated whereas most conifers are wind-pollinated.
6. The answers are: A= nucellus; B= three antipodals, C= polar nuclei/ primary endosperm cell; D= two synergids; E= funicle; F= placenta; G= micropyle, H= egg cell/ ovum; I= integuments; J= embryo sac.
7. Parthenocarpy. It is when fruits mature without fertilization?
8. Answers are: a) A, b) sporophyte.

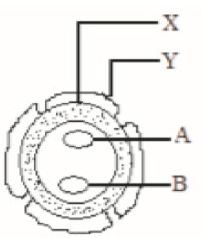
14.9.1. Extended activities

1. Explain isogamy.
2. Distinguish between Stocks from scion.
3. The diagram below shows one of the methods used in vegetative propagation of plants. Identify it and write short notes on how it is done.



Method X

4. Differentiate between cutting and grafting.
5. The diagram below represents a pollen grain.



Pollen grain

a. Names the parts labelled X, Y, A and B.

b. State any one function of the nucleus A and any one function of the nucleus B.

6. A flowering plant can avoid the self- fertilization by Protogyny or Protandry. Differentiate between Protogyny and Protandry.

Answers to extended activities

1. The isogamy is union of structurally similar physiologically different gametes.

2. The stock is the plant of which the root system is taken on while the scion or graft is the plant of which the shoot is selected

3. Method is layering; Layering is a method of propagating a plant in which a shoot is fastened down to form roots while still attached to the parent plant. Layering has evolved as a common means of vegetative propagation of numerous species in natural environments. Layering is also utilized by horticulturists to propagate desirable plants. Natural layering typically occurs when a branch touches the ground, whereupon it produces adventitious roots.

4.

Cutting	**Grafting**
A single individual is involved.	Two different individuals are involved.
Short pieces of stem or root are taken, cut obliquely at the lower end and placed in soil.	The root portion (stock) of one plant attached with the stem portion (scion) of the other plant; the ends of stock and scion are cut obliquely, placed face to face and tied.
It does not bring about any improvement in the subsequent plant.	It is practiced to improve the varieties or produce disease-resistant plants.
Examples: Coleus rose.	Examples: Mango, citrus, apple.

5. Answers

a. X= Intine; Y= exine; A= generative nucleus; B= pollen tube nucleus.

b. The generative nucleus divides to produce male gametes which fertilise the egg cell and polar nuclei, while the tube nucleus controls growth of pollen tube.

6. The answer is: Protogyny: it is when female reproductive organs mature before male reproductive organs, while Protandry is when male reproductive organs mature before female reproductive organs.

UNIT 15

STRUCTURE OF AN ATOM AND MASS SPECTRUM

15.1. Key Unit competence

Interpret simple mass spectra and use them to calculate R.A.M. of different elements.

15.2. Prerequisite (knowledge, skills, attitudes and values

Student-teachers will be able to learn the content of this unit if they understand the concept of: application of electrostatic, Physics, Senior 2, Atoms, elements and compounds S1 Chemistry Unit 5

15.3. Cross cutting issues to be addressed

a) Inclusive education

This unit involves a number of activities on the properties and discovery of atoms, and calculations involving mass spectrometer data. The activities require reading and writing. This may be challenging to students with special educational needs especially children with visual impairment. However, the teacher can make some arrangements like:

- Grouping students. Students with special educational needs are grouped with others and assigned roles basing on individual student's abilities.
- Providing procedure earlier before the activity so that students get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts or in Braille.
- Every important point is written and spoken. The written points helps students with hearing impairment and speaking aloud helps students with visual impairment
- Remember to repeat the main points of the lessons.

b) Gender

During group activities try to form heterogeneous groups (with boys and girls) or when students start to present their findings encourage both (boys and girls) to present.

c) Peace and values education

During group activities, the teacher will encourage learners to help each others and to respect opinions of colleagues.

15.4. Guidance on introductory activity 15

Before introducing the first lesson (**outline of the discovery of the atom constituents and their properties**) of this unit, let learners attempt the introductory activity.

Expected Answers to the introductory activity

1. Diagram A Red: 7 spheres, Blue: 7 spheres

   Diagram B Red: 10 spheres, Blue: 11 spheres

   Diagram C Red: 7 spheres, Blue: 8 spheres

2. In common, all 3 diagrams have red and blue spheres
3. a) Blue spheres represent the number of neutrons

   b) Red spheres represent the number of protons

Explanation: In the nucleus of an atom, the number of neutrons may be equal or greater than the number of protons, so the number of blues spheres are is higher in B and C

4. Symbols: A: ${}^{14}_{7}N$, B: ${}^{21}_{10}Ne$, C: ${}^{15}_{7}N$ (note: A and C are isotopes of nitrogen)
5. Yes there are. The missing particles are called **electrons**
6. When the atom is broken down three smallest particles are obtained: protons, neutrons and electrons

15.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	The constituents of an atom, their properties and the outline of their discovery	-Describe and compare the properties of sub-atomic particles -Outline the discovery of the sub-atomic particles. -Appreciate the contribution of different scientists to the discovery of the sub-atomic particles.	4

2	Concept of atomic number, mass number, isotopic mass and relative atomic mass	Explain the concept of atomic number, mass number, isotopic mass and relative atomic mass	4
3	Calculations of the relative atomic masses of elements	Calculate the relative atomic mass of an element, given isotopic masses and abundances.	4
4	Mass spectrometer: Description and functioning of its components	- Explain the fundamental processes occurring in the functioning of a mass spectrometer - Draw and label the mass spectrometer.	2
5	Interpretation of mass spectra and uses of the mass spectrometer	Interpret different mass spectra and state the uses of the mass spectrometer.	2
6	End unit assessment		2

Lesson 1. The constituents of an atom, their properties and the outline of their discovery

a) Learning objectives

- Describe and compare the properties of sub-atomic particles
- Outline the discovery of the sub-atomic particles.
- Appreciate the contribution of different scientists to the discovery of the sub-atomic particles.

b) Teaching resources

Textbooks, internet connection, computer and projector, videos on the discovery of sub-atomic particles

c) Prerequisites/Revision/Introduction

Student-teachers will learn better the discovery of the atom constituents and their properties if they have understanding on: the content of unit5 of S1: “Atoms, elements and compounds”.

d) Learning activity 15.1

- Before introducing the lesson, let learners attempt activity 15.1 which leads
- students to the second lesson of the unit
- As facilitator you are expected to guide learners through the following steps.
- Form groups of four and let the learners perform the activity 15.1
- Let learners to work together in their groups without intervene directly.
- Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Let some groups present their work to the class
- Allow the rest of the class to evaluate the work of their colleagues
- From the findings, highlight, the content which is correct, point out the one that is incomplete or false
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples.

Answers to activity 15.1

1. True. The answer to this question lies in the number and the arrangement of the electrons. The electrons constitute most of the atomic volume and thus are the parts that "fuse" when atoms combine to form molecules. Therefore, the number of electrons possessed by a given atom greatly affects its ability to interact with other atoms. As a result, the atoms of different elements, which have different numbers of protons and electrons, show different chemical behavior.
2. J. J. Thomson's study of cathode-ray tubes led him to postulate the existence of negatively charged particles that we now call electrons.

   a. Thomson also postulated that atoms must contain positive charge in order for the atom to be electrically neutral.

   Ernest Rutherford and his alpha bombardment of metal foil experiments led him to postulate the nuclear atom with a tiny dense centre of positive charge (the nucleus) with electrons moving about the nucleus at relatively large distances away; the distance is so large that an atom is mostly empty space.

b. The atom is composed of a tiny dense nucleus containing most of the mass of the atom. The nucleus itself is composed of neutrons and protons. Neutrons have a mass slightly larger than that of a proton and have no charge. Protons, on the other hand, have a 1+ relative charge as compared to the 1– charged electrons; the electrons move about the nucleus at relatively large distances. The volume of space that the electrons move about is so large, as compared to the nucleus, that we say an atom is mostly empty space.

c. Protons in an atom determines the identity of the atom .The number and arrangement of electrons in an atom determine how the atom will react with other atoms, i.e., the electrons determine the chemical properties of an atom. The number of neutrons present determines the isotope identity and the mass number. Neutrons bind protons together inside the nucleus.

e) Answers to Application activity 15.1

1. $5.93 \times 10^{-18}\ \text{C} \times \frac{1\ \text{electron charge}}{1.602 \times 10^{-19}\ \text{C}}$ = 37 negative (electron) charges on the oil drop

2. False. Hydrogen contains only 2 (1 proton and 1 electron)

3.

Particle	a) Relative masse	b) Relative charge
Neutron (n)	1.0087 a.m.u	0
Proton (p or P^+)	1.0073 a.m.u	+1
Electron (e^-)	0.00054858 a.m.u	-1

4.

	Carbon	Calcium	Chlorine	Chromium
Protons	6	20	17	24
Electrons	6	20	17	24

Lesson 2. Concept of atomic number, mass number, isotopic mass and relative atomic mass

Concept of atomic number, mass number, isotopic mass and relative atomic mass is the second lesson of the unit. Students are expected to compare the isotopes of an element, to assess the relationship between number of protons and the number of electrons, and to calculate mass number knowing the number of protons and number of neutrons.

a) Learning objective

Explain the concept of atomic number, mass number, isotopic mass and relative atomic mass

b) Teaching resources

The Periodic Table of Chemical Elements

Charts illustrating isotopes of some elements

c) Prerequisites/Revision/Introduction

Students will learn better a concept of atomic number, mass number, and isotopic mass if they have understanding on: Definition of atomic number, mass number and isotope (S1 chemistry: unit 5)

d) Learning activity 15.2

- Before introducing the lesson, let learners attempt activity 15.2 which leads students to the second lesson of the unit
- As facilitator you are expected to guide learners through the following steps.
- Form groups of four and let the learners perform the activity 15.2
- Let learners to work together in their groups without intervene directly.
- Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Let some groups present their work to the class
- Allow the rest of the class to evaluate the work of their colleagues
- From the findings, highlight, the content which is correct, point out the one that is incomplete or false
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples.

Answers to activity 15.2

The statement is true. Atoms of the same element may exhibit some physical properties like mass, density, velocity because even if they contain the same number of protons, they may contains different numbers of protons. Such atoms are known as **isotopes.**

e) Answers to application activity 15.2

1. a) For $^{35}_{17}Cl$: Atomic number =17. There are therefore 17 protons per nucleus.

Mass number = 35. There are therefore (35 – 17) neutrons. Because no charge is indicated, there must be equal numbers of protons and electrons, or 17 electrons.

For $^{37}_{17}Cl$: There are 17 protons, 20 neutrons, and 17 electrons per atom. These are isotopes of the same element Cl. Both have 17 protons, but they differ in their numbers of neutrons: one has 18 neutrons and the other has 20.

b) For $^{63}_{29}Cu$: Atomic number = 29. There are 29 protons per nucleus. Mass number = 63. There are 29 protons plus 34 neutrons.

Because no charge is indicated, there must be equal numbers of protons and electrons, that is there are 29 electrons.

For $^{65}_{29}Cu$: There are 29 protons, 36 neutrons, and 29 electrons per atom. These are isotopes. Both have 29 protons, but they differ in their numbers of neutrons: one isotope has 34 neutrons and the other has 36.

2. a) $^{9}_{4}\mathbf{Be}$ b) $^{51}_{23}\mathbf{V}$ c) $^{124}_{54}\mathbf{Xe}$ d) $^{69}_{31}\mathbf{Ga}$

3. a) Protons, Electrons b) Atomic number c) Mass number d) Isotope e) Neutron

Lesson 3. Calculations of the relative atomic masses of elements

a) Learning objective

Calculate the relative atomic mass of an element, given isotopic masses and abundances.

b) Teaching resources

The Periodic Table of Chemical Elements

Charts illustrating isotopes of some elements and their relative abundances

Flip charts or chalk board or smart board.

c) Prerequisites/Revision/Introduction

Student-teachers will learn better this lesson if they have a good understanding on the concept of isotopes and give some examples.

d) Learning activity 15.3

- Before introducing the lesson, let learners therefore attempt activity 15.3 which leads
- students to the second lesson of the unit
- As facilitator you are expected to guide learners through the following steps.
- Form groups of four and let the learners perform the activity 15.3
- Let learners to work together in their groups without intervene directly.
- Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Let some groups present their work to the class
- During the presentation ask some questions that lead to lesson conclusion such as calculating the relative atomic mass of an element, given isotopic masses and abundances.
- Allow the rest of the class to evaluate the work of their colleagues
- From the findings, highlight, the content which is correct, point out the one that is incomplete or false
- Summarize the contents and give more examples.

Answers to activity 15.3

1. Isotope of argon which is the most abundant in nature is argon-40.

   Explanation: A relative atomic mass of Argon from the periodic table is equal to 39.948, this value must be closer to the isotopic mass of the most abundant isotopes i.e. argon-40

   (the atomic weight of an element is always closer to the mass of the most abundant isotope or isotopes)

2. Applying the formula of RAM we can calculate that of X

   (0.7215×84.9118amu) + (10.2785×86.9092amu) = 61.263amu+29.209amu=85.467amu

   From the periodic table, X is Rubidium (Rb)

3. [10x + 11(100-x)]/100 = 10.8

$10x + 1100 - 11x = 1080$

$\therefore x = 1100 - 1080 = 20\%$

e) Answers to Application activity 15.3

1. Atomic weight = 0.7899(23.98504 amu) + 0.1000(24.98584 amu) + 0.1101(25.98259 amu)

   = 18.946 amu + 2.4986 amu + 2.8607 amu

   = 24.30 amu (to 2 decimal places)

2. Let x = fraction of ^{69}Ga. Then $(1 - x)$ = fraction of ^{71}Ga.

   $x\,(68.9257\text{ amu}) + (1 - x)\,(70.9249\text{ amu}) = 69.72\text{ amu}$

   $68.9257x + 70.9249 - 70.9249x = 69.72$

   $-1.9992x = -1.20$

   $x = 0.600$

   $x = 0.600$ = fraction of ^{69}Ga, hence the % abundance of ^{69}Ga is 60.0%

   $(1 - x) = 0.400$ = fraction of ^{71}Ga , hence % abundance of ^{71}Ga is 40.0%

3. $A_r = 204 \text{ x } \frac{1.55}{100} + 206 \text{ x } \frac{23.6}{100} + 207 \text{ x } \frac{22.6}{100} + 208 \text{ x } \frac{52.3}{100} = 207.2$

   Or

   $$A_r = \frac{(204 \text{ x } 1.55) + (206 \text{ x } 23.6) + (207 \text{ x } 22.6) + (208 \text{ x } 52.3)}{(1.55+23.6+22.6+52.3)} = 207.2$$

4. a) $A_r(X) = 204 \text{ x } \frac{5.84}{100} + 56 \text{ x } \frac{91.68}{100} + 57 \text{ x } \frac{2.17}{100} + 58 \text{ x } \frac{0.31}{100} = 55.91$

   b) X is iron

Lesson 4. Mass spectrometer: Description and functioning of its components

a) Learning objective

- Explain the fundamental processes occurring in the functioning of a mass spectrometer
- Draw and label the mass spectrometer.

b) Teaching resources

Textbooks, chalkboard or smart board and internet resources, computer and projector, video on the functioning of a mass spectrometer

c) Prerequisites/Revision/Introduction

The student-teachers will better understand the functioning of a mass spectrometer if they have a good understanding of the applications of electrostatic, Physics Senior 2, Unit 12, Graphs of linear motion Physics Senior 3 Unit 1, Atoms, elements and compounds Chemistry S1 Unit 5, concept of isotopes, Chemistry TTC Year 1, Unit 15, Lesson3.

d) Learning activity 15.4

This is a guided research activity. Student-teachers are asked to do research on functioning of mass spectrometer and answer questions in **activity** 15.4. You may help learners by giving them a list of important reference books available in the school library and the internet websites for relevant information.

- Give the learners clear instructions keeping in mind that in addition to subject matter skills and knowledge, this lesson also tends to develop research skills (report writing and referencing), lifelong learning skills, and communication (reading, writing and speaking skills) in English.
- The lesson starts with answering the **activity 1.4** questions.
- On each question you will have to first give learners time to share their answers then agree on what is right.
- Make sure that learners are able to explain the function of each spectrometer part in their own words.
- Summarise the lesson and verify learners' notes.

Answers to activity 15.4

See student teacher's book lesson 15.4.1: Description and functioning of its components

a) Answers to application activity 15.4

1. The words are filled in the passage as follows: Vaporization, ionization, velocity, acceleration, deflection, detector, mass spectrum

2. B **;** **3.** D **;** 4. C; **5.** D; **6.** C

Lesson 5: Interpretation of mass spectra and uses of the mass spectrometer

a) Learning objective

Interpret different mass spectra and state the uses of the mass spectrometer

b) Teaching resources

Textbooks, chalkboard or smart board or flip charts

c) Prerequisites/Revision/Introduction

The student-teachers will be able to make interpretation if they have a good understanding on: the concept of isotopes, the functioning of a mass spectrometer.

d) Learning activity 15.5

- Form groups of 5student-teachers and let them work on the activity 15.5
- Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Invite some groups to presents their and allow the rest of the class to analyse the colleagues' findings.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the learners' findings and emphasize on which are correct, incomplete or false
- Based on the key ideas from the learners presentations and his/her additions , the tutor write a summary on the interpretation of mass spectra.

Answers to activity 15.5

a. m/z is the mass/charge ratio - the mass of the ion divided by its charge.

b. Zirconium has 5 isotopes with relative isotopic masses of 90, 91, 92, 94 and 96.

   The most abundant one is Zr-90, followed by Zr-94 and Zr-92 which have similar abundances.

   Then Zr-91, and the least abundant is Zr-96

c. You would find a similar set of peaks but at exactly half the m/z values. The heights of the peaks are likely to be much less than the corresponding ones with 1+ ions, because a 2+ ion is less likely to form than a 1+ ion.

e) Answers to application activity 15.5

1. a) Three isotopes

   b) 24, 25, 26

   c) 79, 10, 11

2. C

3. a) The gaseous sample of X is converted into ions in a mass spectrometer when it is bombarded by high speed electrons from an electron gun.

   b) The different ions are directed in turn, into the detector by increasing the voltage in the acceleration chamber.

   c) Four isotopes because the mass spectrum shows 4 peaks

   d) $Ar = \frac{82 \text{ x } 1+ 83 \text{ x } 1 + 84\text{x}6 + 86 \text{ x } 2}{1+1+6+2} = 84.1$

   e) X is polonium.

15.6. Summary of the unit

The understanding of the atomic structure has undergone many developments during years and many scientists have played a great role.

For the discovery of electrons J.J. Thomson used cathode rays' tubes. Cathode rays are tiny negatively charged particles having a mass approximately equal to 1/1840 the mass of a hydrogen atom.

Rutherford described the planetary model of the atomic structure.

Bohr confirmed the planetary model and précising that electrons orbiting the nucleus occupy specific orbits,

The nucleus contains protons (positively charged) and neutrons.

The atomic number (proton number) is equal to the number of protons in the atom's nucleus.

The number of protons, positively charged, is equal to the number of electrons, negatively charged; hence the atom is neutral.

The mass number is the total number of protons and neutrons in the nucleus.

The mass of an atom is practically concentrated in the nucleus, the mass of electrons is negligible.

Ions do not have the same number of electrons as protons, and so have an overall charge.

Isotopes are atoms having the same number of protons but different numbers of neutrons.

The relative atomic mass is the weighted mean mass of an atom relative to ^{12}C, so that carbon is exactly 12 on this scale.

The **Relative isotopic mass** of an isotope is the relative mass of that isotope compared with the isotope which is given a mass of 12.00 units (12.00 atomic mass units).

$$\text{Relative isotopic mass} = \frac{\text{mass of 1 isotope of the element}}{\frac{1}{12} \text{ x mass of 1 atom of } {}^{12}_{6}C}$$

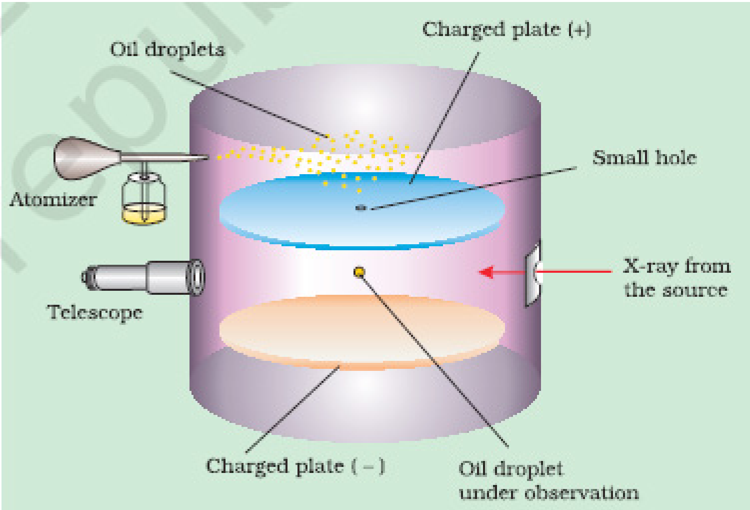
The **Relative atomic mass,** symbolized as R.A.M (Ar), is defined as the average of the relative isotopic masses of the different isotopes weighted in the proportions in which they naturally occur.

A mass spectrometer will separate ions of different mass and charge in a gaseous sample of ions. The instrument allows the researcher to determine the accurate mass of each ion, whether the ions are composed of individual atoms, molecules, or molecular fragments.

15.7. Additional information for tutors

Millikan's Oil Drop Method

In this method, oil droplets in the form of mist, produced by the atomiser, were allowed to enter through a tiny hole in the upper plate of electrical condenser. The downward motion of these droplets was viewed through the telescope, equipped with a micrometer eye piece. By measuring the rate of fall of these droplets, Millikan was able to measure the mass of oil droplets. The air inside the chamber was ionized by passing a beam of X-rays through it. The electrical charge on these oil droplets was acquired by collisions with gaseous ions. The fall of these charged oil droplets can be retarded, accelerated or made stationary depending upon the charge on the droplets and the polarity and strength of the voltage applied to the plate. By carefully measuring the effects of electrical field strength on the motion of oil droplets, Millikan concluded that the magnitude of electrical charge, q, on the droplets is always an integral multiple of the electrical charge, e, that is, $q = n$ e, where n = 1, 2, 3... .



The Millikan oil drop apparatus for measuring charge 'e'. In chamber, the forces acting on oil drop are: gravitational, electrostatic due to electrical field and a viscous drag force

when the oil drop is moving.

R.A. Millikan found that the charge on the electron to be -1.6×10^{-19} C. The current accepted value of electrical charge is – 1.6022 × 10–19 C. The mass of the electron (m_e) was determined by combining these results with Thomson's value of e/m_e ratio.

$$m_e = \frac{e}{e/m_e} = \frac{1.6022 \times 10^{-19}\,\text{C}}{1.758820 \times 10^{11}\,\text{C kg}^{-1}}$$
$$= 9.1094 \times 10^{-31}\,\text{kg}$$

15.8. End unit assessment 15 (answers)

Standard of performance: Accurately interpret simple mass spectra and use them to calculate

R.A.M. of different elements.

Assessment is an important part of teaching and learning. At the unit level, the teacher needs to know how well the key unit competence was achieved. End of unit assessment questions were suggested and two periods are reserved.

Expected Answers to "end unit assessment"

Multiple choice questions:

1. **D, Explanation:** mass of proton is almost 1836times that of the electron
2. **a. False.** Neutrons have no charge; therefore, all particles in a nucleus are not charged.
   b. **False.** The atom is best described as having a tiny dense nucleus containing most of the mass of the atom with the electrons moving about the nucleus at relatively large distances away; so much so that an atom is mostly empty space.
   c. **False.** The mass of the nucleus makes up most of the mass of the entire atom.
   d. **True**
   e. **False**. The number of protons in a neutral atom must equal the number of electrons.
3. a. The atom is not an indivisible particle but is instead composed of other smaller particles,called electrons, neutrons, and protons.
   b.The two hydride samples contain different isotopes of either hydrogen and/or lithium. Although the compounds are composed of different isotopes, their properties are similar because different isotopes of the same element have similar properties (except, of course, their mass).
4. **B**, **Explanation**: In mass spectrometer, the sample which is to be analysed is bombarded with electrons. As a result, ions are produced.
5. **D, Explanation**: Mass spectrometer separates ions on the basis of mass to charge ratio. , Most of the ions are singly charged. Hence, the mass to charge ratio is equal to the mass.
6. **C, Explanation**: In mass spectrometer, the ions are sorted out by accelerating them through electric and magnetic field. A record of number of different kinds of ions is called mass spectrum.
7. **C, Explanation**: The procedure for mass spectroscopy starts with converting the sample into gaseous state. This is done by chemical processes.
8. **D**, **Explanation:** Positive ions of specific mass pass through the slit and reach the collecting plate. These ions are measured.
9. **A**, **Explanation**: Impurities of masses different from the one being analysed does not interfere with the result in mass spectroscopy. This is a major advantage of this technique.

10. A, **Explanation**: The sample gas is introduced into the highly evacuated spectrometer tube and it is ionised by electron beam. The sample has to be in gaseous state

Short and long answer Open questions

11. Proton, neutron, and electron. Proton has positive charge, neutron has no charge, and electron has negative charge and it is the least massive of the three. Particles that constitutes nucleus are protons and neutrons.

12. $$RAM = \frac{(6.015121 \times 7.50) + (7.016003 \times 92.50)}{100} = 6.94093685$$

Writing the answer with two decimal places we prove that the RAM of lithium is 6.94

13. Top of Form

a) The hot metal coil releases electrons which are attracted to the electron trap which is positively charged. On their way, they hit atoms or molecules in the sample, and knock one or more electrons off to give positive ions. Those ions are repelled by another positively charged plate on the left out of the slit on the right-hand side.

b) (i) Mass and charge. The heavier the ion, the less it is deflected. The higher the positive charge, the more it is deflected.

(ii) Assuming that all of the ion streams have the same charge, then this must have the heaviest ions. To be more general about it, the least deflected ion stream will be the one with the highest mass/charge ratio.

(iii) You would need to increase the magnetic field.

c) To avoid the possibility of the ions hitting, and being deflected by, air molecules.

d) The detector is made of metal connected to a wire. When an ion hits the metal, an electron jumps off the metal to neutralise the ion. Electrons flow from the wire to replace those removed from the detector, and this flow is seen as an electric current which can be amplified and recorded. The greater the number of ions arriving, the greater the current.

14.a) RAM = [(113X) + 115(100-X)]/100 = 114.5

X = 25% for Indium-113

100- X = 75% for Indium-115

b) i)Magnesium exists as three isotopes hence it gives 3 peaks, one peak for each isotope

ii) Relative abundance for each isotopes

m/z	24	25	26
Abundance	1/1.266 = 78.98%	0.127/1.266 =10.04%	0.139/1.266 =10.98%

1.266 is the sum of relative `intensities

RAM of magnesium=[(24×78.98)+(25×10.4)+(26×10.98)]/100=24.41

15. Let us organize the given information in the following table.

Isotopes and their respective abundances	$^{16}O(99.1\%)$	$^{17}O(0.89\%)$	$^{18}O(0.01\%)$
$^{16}O(99.1\%)$	$h_1 = \frac{99.1\times 99.1}{100} = 98.2081$	$h_2 = \frac{99.1\times 0.89}{100} = 0.88199$	$h_3 = \frac{99.1\times 0.01}{100} = 0.00991$
$^{17}O(0.89\%)$	$h_2^{'} = \frac{0.89\times 99.1}{100} = 0.88199$	$h_3^{'} = \frac{0.89\times 0.89}{100} = 0.007921$	$h_4 = \frac{0.89\times 0.01}{100} = 0.000089$
$^{18}O(0.01\%)$	$h_3^{''} = \frac{0.01\times 99.1}{100} = 0.00991$	$h_4^{'} = \frac{0.01\times 0.89}{100} = 0.000089$	$h_5 = \frac{0.01\times 0.01}{100} = 0.000001$

We can conclude the following:

a. There will be 5 molecular ions' peaks and 3 atomic ions' peaks observed on the screen of the mass spectrometer

b. The molecular ions that are responsible of these peaks are

1) $(^{16}O\text{-}^{16}O)^+$ or $^{16}O_2^+$ at $\frac{m}{z} = 32$

2) $(^{16}O\text{-}^{17}O)^+$ and $(^{17}O\text{-}^{16}O)^+$ which overlap to form one peak at $\frac{m}{z} = 33$

3) $(^{16}O\text{-}^{18}O)^+$, $(^{17}O\text{-}^{17}O)^+$ or $^{17}O_2^+$ and $(^{18}O\text{-}^{16}O)^+$ which overlap to form one peak at $\frac{m}{z} = 34$

4) $(^{17}O\text{-}^{18}O)^+$ and $(^{18}O\text{-}^{17}O)^+$ which overlap to form one peak at $\frac{m}{z} = 35$

5) $(^{18}O\text{-}^{18}O)^+$ or $^{18}O_2^+$ at $\frac{m}{z} = 36$

c. From the table above, the heights of the peaks are given hereafter

1^{st} peak=98.20

2^{nd}peak=0.88x2=1.76

3^{rd} peak= (0.01x2) + 0.008=0.028

4^{th} peak=0.0001x2=0.0002

5^{th} peak=0.000001

15.9. Additional activities (Questions and answers)

15.9.1 Remedial activities

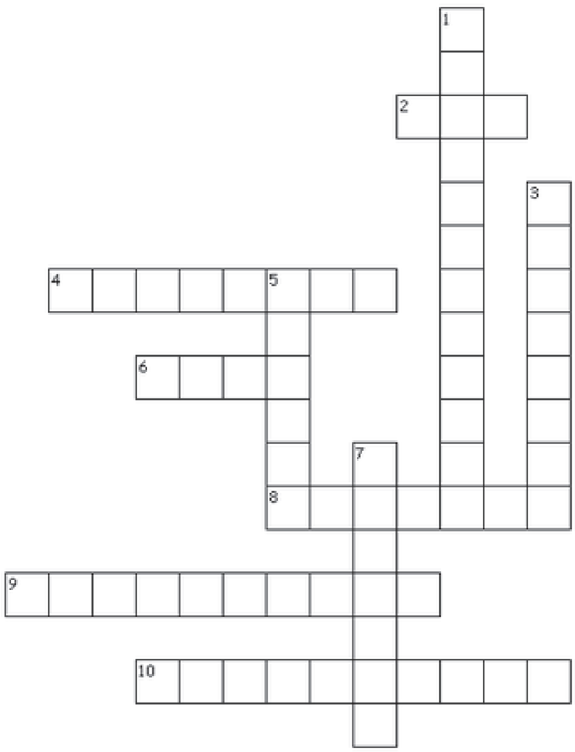
1. Atomic Structure Puzzle

Across

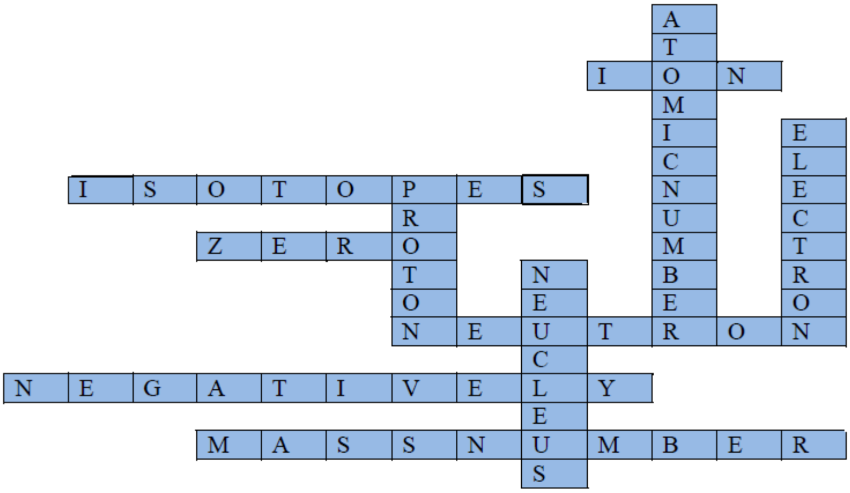
2. A charged atom is called an _______
4. Atoms with the same number of protons and electrons but a different number of neutrons
6. Neutral atoms have a ________ charge
8. I do not have a charge
9. If an electron is added to a neutral atom, the atom becomes ________ charged
10. Number of protons plus neutrons

Down

1. Number of protons
3. I move around the nucleus
5. My charge is positive
7. I am in the centre of the atom. I contain protons and neutrons



Answer:



2. Which of the following is (are) correct?

a. $^{40}Ca^{2+}$ contains 20 protons and 18 electrons.

b. Rutherford created the cathode-ray tube and was the founder of the charge-to-mass ratio of an electron.

c. An electron is heavier than a proton.

d. The nucleus contains protons, neutrons, and electrons.

Answer:

3. The listed atomic weight of gallium is 69.723 amu. Gallium has two stable isotopes, both of which are used in nuclear medicine. These two stable isotopes have the following masses: ^{69}Ga, 68.925580; ^{71}Ga, 70.9247005. Calculate the percent of each isotope in naturally occurring gallium.

Answer:

$$69.723 = \frac{(68.92558 \times X) + 70.924700(100 - X)}{100}$$

$$6972.3 = 68.92558X + 7092.4700 - 70.924700$$

$$1.99912X = 120.17$$

$$X = \frac{120.17}{1.99912}$$

$$\Rightarrow X = 60.13$$

$$100 - 60.13 = 39.87$$

The percent of ^{69}Ga is 60.13%; and that of ^{71}Ga is 39.87%

4. An element with three stable isotopes has 82 protons. The separate isotopes contain 124, 125, and 126 neutrons. Identify the element and write symbols for the isotopes.

Answer:

The element with 82 protons (atomic number of 82) is lead: Pb.

For the first isotope, A = 82 protons + 124 neutrons = 206. Similarly, A = 82 + 125 = 207 and A = 82 + 126 = 208 for the second and third isotopes, respectively. The symbols for these isotopes are ${}^{206}_{82}Pb$, ${}^{207}_{82}Pb$, and , which are usually abbreviated as ${}^{206}Pb$, ${}^{207}Pb$, and ${}^{208}Pb$.

5. The separation of ions in a mass spectrometer depends on

a. Only the charge on the ions
b. Only the mass of the ions
c. The mass and the charge of the ions
d. Only the velocity of the ions

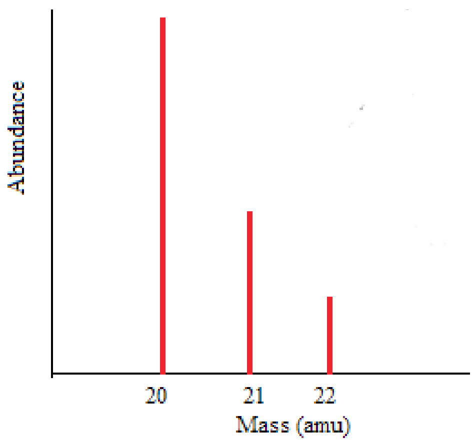
Answer: (C)

6. When injected into a mass spectrometer a compound gave a number of ion peaks. Two peaks,one of which was the molecular ion, had m/z values of 58 and 43. Which of the molecular fragments below might have been lost from the original molecule?

a. CH_3
b. OH
c. C_2H_5
d. CHO

Answer: (a)

7. According to the mass spectrum below, the relative atomic mass of the element shown is best expressed as



a. 20.0
b. Between 20.0 and 21.0
c. 21.0
d. Between 21.0 and 22.0

Answer: (b)

15.9.1. Consolidation activities

8. One of the oxides of tantalum is tantalum (V) oxide, Ta_2O_5. If the charge on the metal remained constant and then sulfur was substituted for oxygen,

a. How would the formula change?
b. Calculate the difference in the total number of protons between Ta_2O_5 and its sulfur analog?

Answer:

Sulfur is in the same group as oxygen, and its most common ion is S^{2-}. Therefore, the formula of the sulfur analogue would be Ta_2S_5.

Total number of protons in Ta_2O_5:

Ta, Z = 73, so 73 protons x 2 = 146 protons; O, Z = 8, so 8 protons x5 = 40 protons

Total protons = 186 protons

Total number of protons in Ta2S5:

Ta, Z = 73, so 73 protons x 2 = 146 protons; S, Z = 16, so 16 protons x 5 = 80 protons

Total protons = 226 protons

Proton difference between Ta_2S_5 and Ta_2O_5: 226 protons – 186 protons = 40 protons

9. A binary ionic compound is known to contain a cation with 51 protons and 48 electrons. The anion contains one-third the number of protons as the cation. The number of electrons in the anion is equal to the number of protons plus 1. Suggest the formula of this compound and the name of this compound?

Answer:

The cation has 51 protons and 48 electrons. The number of protons corresponds to the atomic number. Thus this is element 51, antimony.
There are 3 fewer electrons than protons. Therefore, the charge on the cation is 3+.
The anion has one-third the number of protons of the cation, which corresponds to 17 protons; this is element 17, chlorine. The number of electrons in this anion of chlorine is 17 + 1 = 18 electrons. The anion must have a charge of 1−.

The formula of the compound formed between Sb^{3+} and Cl^{-} is $SbCl_3$. The name of the compound is antimony (III) chloride. The Roman numeral is used to indicate the charge on Sb because the predicted charge is not obvious from the periodic table.

10. The mass spectrum of a hypothetical monatomic element A contains a peak at mass number 14 and another at mass number 16.

a. Sketch the mass spectrum assuming the peak at mass number 14 is three times the height of the peak at 16.

b. How many isotopes are present? Why?

c. Determine the relative abundances of the isotopes?

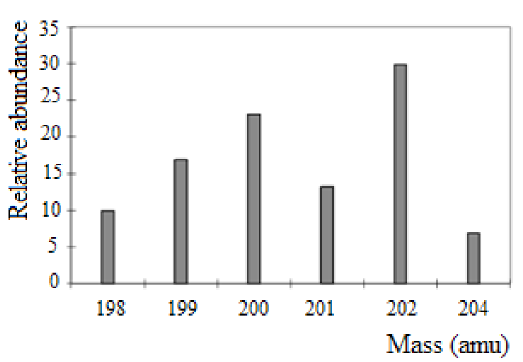
Answer:

a. Label of the vertical axis: relative abundance

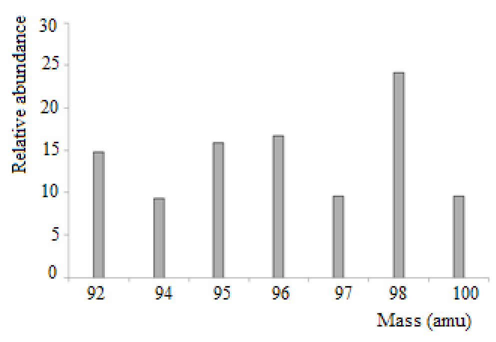
Label of the horizontal axis: mass (amu) or m/z

Then plot the height of the peaks as indicated in the question

11. The figures below represent the mass spectrum of mercury and Molybdenum respectively.



Mass spectrum of mercury



Mass spectrum of Molybdenum.

a. Calculate the atomic masses of mercury, and molybdenum from your data.

b. Compare your results to the actual atomic weights of these elements found on the periodic table. Calculate the percent difference for each.

$$\% \text{ difference} = \frac{|\text{experimental} - \text{theoretical}|}{\text{theoretical}} \times 100$$

a) **Answer:**

$$\text{RAM of Hg} = \frac{(180\times10)+(199\times17)+(200\times24)+(201\times13)+(202\times30)+(204\times7)}{100} = 200.84$$

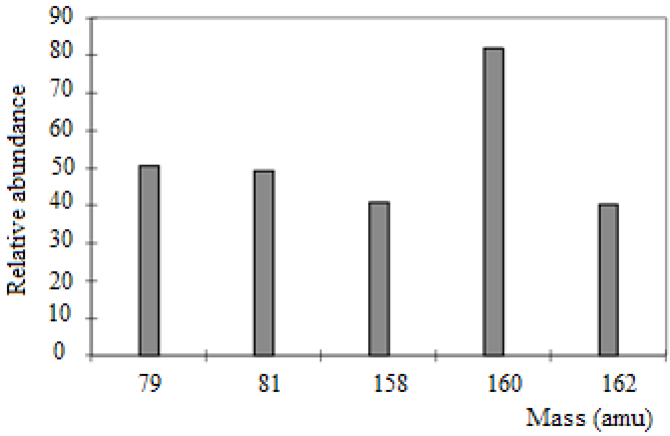
$$\text{RAM of Mo} = \frac{(92\times15)+(94\times9.90)+(95\times15.09)+(96\times15.20)+(97\times9.99)+(98\times28)+(100\times10)}{100} = 99.16$$

b)

$$\%\,\text{difference(Hg)} = \frac{|200.59-200.84|}{200.84}\times100 = 0.125\%$$

$$\%\,\text{difference(Mo)} = \frac{|95.94-99.16|}{99.16}\times100 = 3.25\%$$

12. The figure below represents the mass spectrum of Br_2



Explain why the mass spectrum of Br_2 contains 5 peaks. Explain why the 3 last peaks have the heights approximately in the ratio 1:2:1? What are the origins of these signals?

Answer: there are 2 isotopes of Bromine (^{79}Br and ^{81}Br), the peak at 79 is for $^{79}Br^+$ and that at 81 is for are those of $^{81}Br^+$.

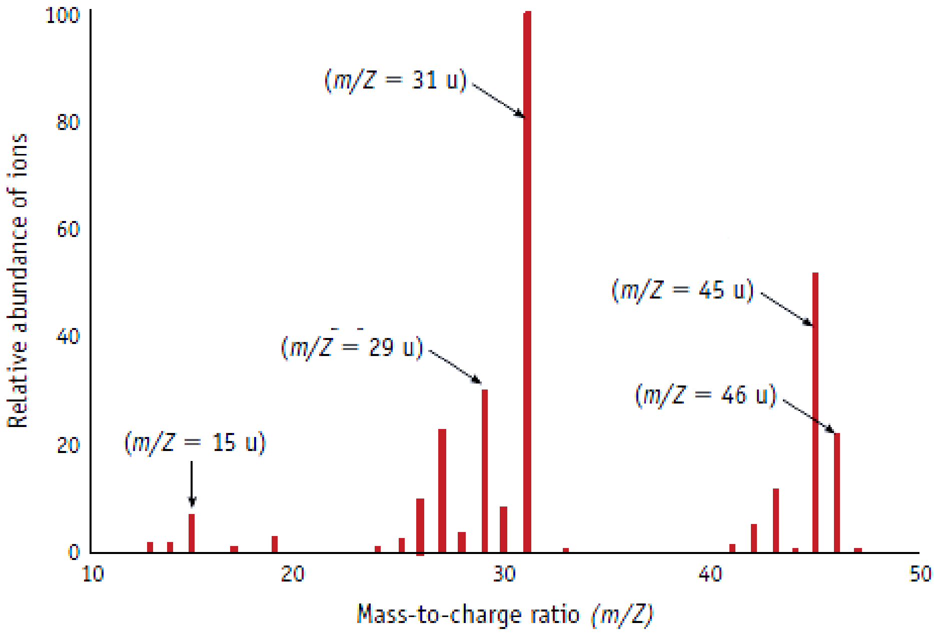
Other peaks formed due to the Br_2^+: the peak at 158 is for $(^{79}Br^{79}Br)^+$, the peak at 160 is for $(^{79}Br^{81}Br)^+$ or($^{81}Br^{79}Br)^+$, the peak at 162 is for $(^{81}Br^{81}Br)^+$. The height of 3 last peaks is approximately in the ratio 1:2:1 because at 160 two peaks overlap due to the two molecular ions with same m/z i.e $(^{79}Br^{81}Br\,)^+$ or $(^{81}Br^{79}Br)^+$.

When bromine is passed into the ionization chamber, an electron is knocked off the molecule to give a ***molecular ion,*** Br_2^+. After the fragmentation of Br_2^+, the Br^+ ions will pass through the machine and will give lines at 79 and 81. The *unfragmented* Br_2^+ ions will also record lines at 158, 160, and 162.

15.9.3. Extended activities

15.9.3. Extended activity

13. The mass spectrum of ethanol (CH_3CH_2OH) contains 1 prominent peak for a "parent" ion and other 4 peaks for "fragment" ions. (The figure of the mass spectrum of ethanol is shown below)



a. Write the formula of the parent ion

b. Write the formula of the fragment ions which correspond to each mass-to-charge ratio as they were shown on the figure

Answer:

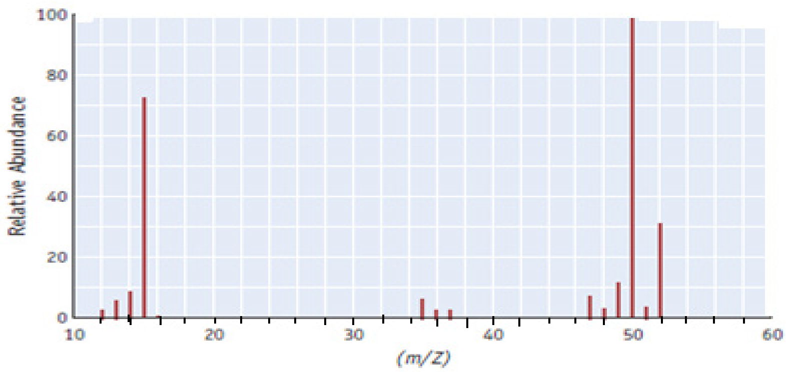
a. The parent ion is the heaviest ion observed and its m/z confirms the formula of the molecule. Therefore the formula of the "parent" ion is ($CH_3CH_2OH^+$) and it appear at m/z of 46

b. The formula for "fragment" ions are $CH_3CH_2O^+$ at 45, CH_2OH^+ at 31, $C_2H_5^+$ at 29, and CH_3^+ at 15

14. The mass spectrum of CH_3Cl is illustrated here. You know that carbon has two stable isotopes, ^{12}C and ^{13}C with relative abundances of 98.9% and 1.1%, respectively, and chlorine has two isotopes, ^{35}Cl and ^{37}Cl with abundances of 75.77% and 24.23%, respectively.

a. What molecular species gives rise to the lines at *m*/*Z* of 50 and 52? Why is the line at 52 about 1/3 the height of the line at 50?

b. What species might be responsible for the line at $m/Z = 51$?



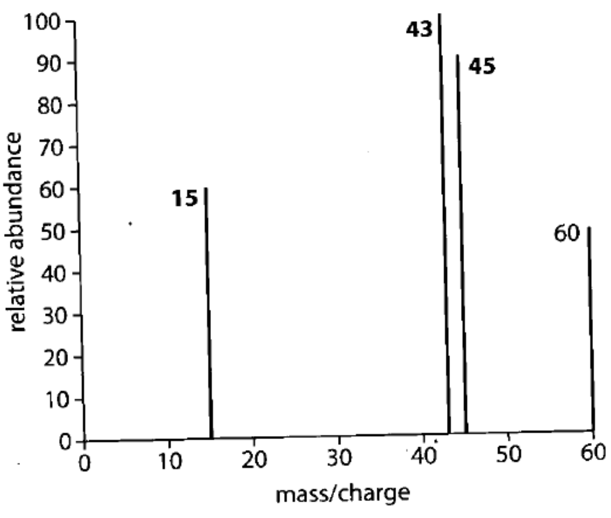
Answer:

a. $m/Z = 50$ is $^{12}C^{1}H_{3}{}^{35}Cl^{+}$; $m/Z = 52$ is $^{12}C^{1}H_{3}{}^{37}Cl^{+}$

b. The height of the line at $m/Z = 52$ is about 1/3 the height of the line at $m/Z = 50$ because the abundance of ^{37}Cl is about 1/3 that of ^{35}Cl.

c. $^{13}C^{1}H_{3}{}^{35}Cl^{+}$ (a small portion of this peak is also due to $^{12}C^{2}H^{1}H_{2}{}^{35}Cl^{+}$)

15. A molecule with an empirical formula CH_2O has the simplified mass spectrum below. Deduce the molecular formula and possible structure of the compound.



Answer:

Empirical formula = CH_2O; molecular formula = $C_nH_{2n}O_n$

We can see that the parent ion has a relative mass of 60.

Mr = n(12.01) + 2n(1.01) + n(16.00) = 30.03n

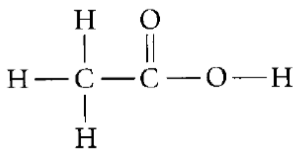
n = 60 ÷ 30.03 = 2

Molecular formula = $C_2H_4O_2$

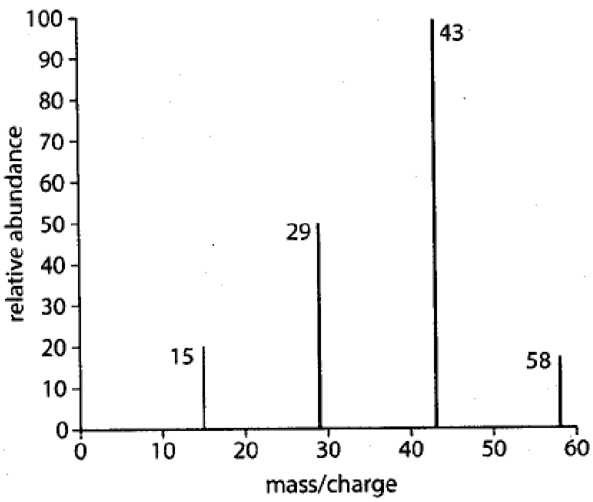
From the spectrum we can identify the following peaks:

Peaks	Explanation
15 (60−45)	Presence of CH_3^+ - loss of COOH from molecule
43 (60−17)	Presence of $C_2H_3O^+$ - loss of OH from molecule
45 (60−15)	Presence of $COOH^+$ - loss of CH_3 from molecule

The structure consistent with this fragmentation pattern is:



16. The simplified mass spectrum of a compound with empirical formula C_2H_5 is shown below.
   a. Explain which ions give rise to the peaks shown.
   b. Deduce the molecular structure of the compound.



Answer:

a. Empirical formula = C_2H_5; molecular formula = $C_{2n}H_{5n}$

We can see that the parent ion has a relative mass of 58.

Mr = 2n(12.01) + 5n(1.01) = 24.07n

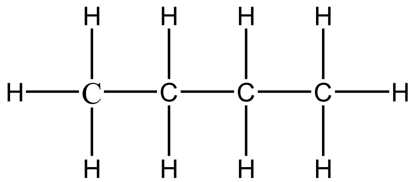
n = 58 ÷ 27.07 = 2

Molecular formula = C_4H_{10}

From the spectrum we can identify the following peaks:

Peaks	Explanation
15 (58–43)	Presence of $[CH_3]^+$ - loss of $CH_3CH_2CH_2$ from molecule
29 (58–29)	Presence of $[CH_3CH_2]^+$ - loss of CH_3CH_2 from molecule
43 (58–15)	Presence of $[CH_3CH_2CH_2]^+$ - loss of CH_3 from molecule
58 (58–0)	Presence of $[CH_3CH_2CH_2CH_3]^+$ parent ion

b. molecular structure of the compound is $CH_3 – CH_2–CH_2–CH_3$ or



17. The existence of isotopes in magnesium can be shown using a mass spectrometer. The operation of mass spectrometer can be described in terms of five main stages. The first is evaporation and the last is detection

a. After evaporation, the magnesium is then ionized. Outline how it is ionised

b. State the names, in the correct order, of the other two stages, and in each case state the technique used

c. The relative abundances of the three isotopes of magnesium are as follows:

$^{24}Mg=78.6\%$, $^{25}Mg=10.1\%$, $^{26}Mg=11.3\%$

Calculate the relative atomic mass of magnesium using the values, giving your answer to three decimal places

Answer:

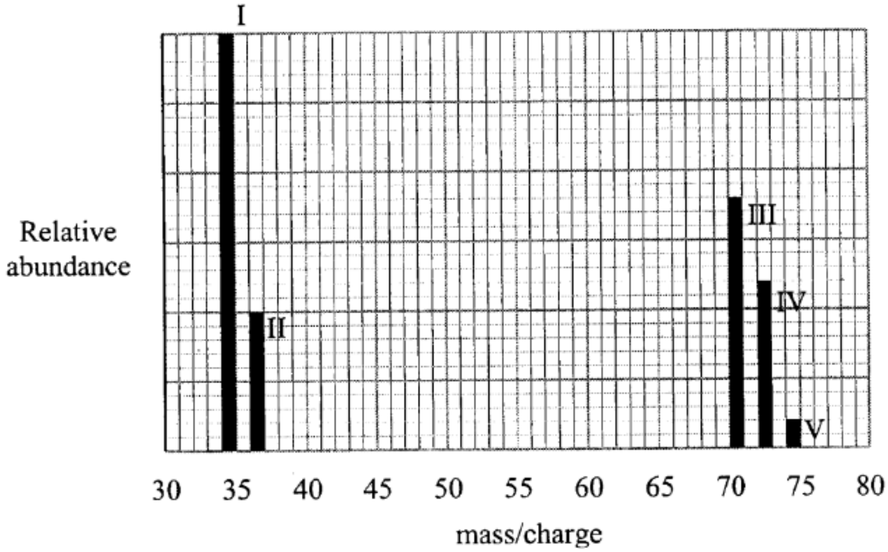
a. In the ionization chamber, the beam of high-energy electrons is emitted from a filament that is heated to several thousand degrees Celsius. In normal operation, the emitted electrons have energy of about 70 electron volts (eV). These high-energy electrons strike the stream of molecules which has been admitted from the sample system and ionize the molecules in the stream by removing electrons from them; the molecules are thus converted to positive ions.

b. Acceleration: Electric field – attracts ions towards it until all have the same kinetic energy

   Deflection: magnetic field -The magnetic field causes the beam to curve. The radius of curvature depends on the mass and charge of the particles

c. $$RAM = \frac{(24\times78.6)+(25\times10.1)+(26\times11.3)}{78.6+10.1+11.3} = 24.327$$

18. The diagram below represents the spectrum of chlorine, consisting of five peaks, labeled I, II, III, IV, and V respectively. Peak I is due to the 35Cl+ ion



a. What analytical technique would give a spectrum like that shown above?
b. State why the spectrum of chlorine consists of more than two peaks
c. Suggest what peaks II and IV might be due to.
d. Using the spectrum above, find the isotopic composition of chlorine and justify your answer

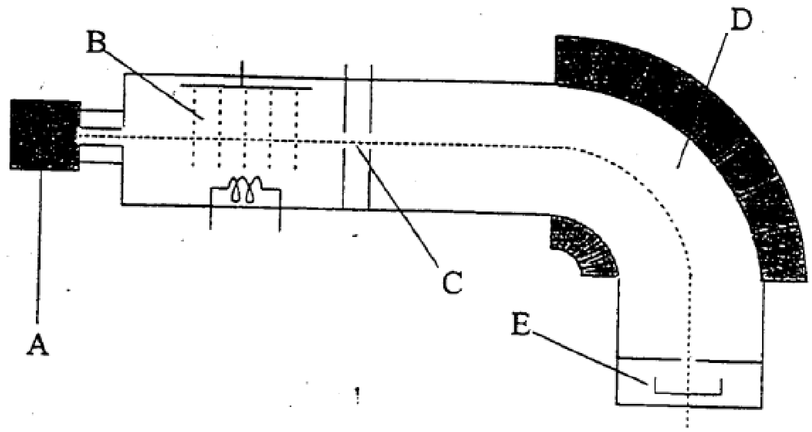
Answer:

a. Mass spectrometry
b. It is because in addition to the two peaks for each isotope of chlorine(peak I and II), there are other three peaks resulting to the combination of isotopes to form three different molecular ions(peak III, III, and IV)

c. Peak II is due to $^{37}Cl^+$ ion, and peak IV is due to Cl_2^+ molecular ions containing one ^{35}Cl and one ^{37}Cl atom

d. ^{35}Cl is approximately 3 times more abundant than ^{37}Cl i.e. in the 3:1 ratio. The percent composition is obtained by dividing each value in the ratio by the sum of the 2 values as follow. $3/4 \times 100 = 75\%$ and $1/4 \times 100 = 25\%$

19. Below is a diagram of a simple mass spectrometer.



a. State which of the sections below corresponds to which lettered part of the spectrometer.

Section	Letter
Accelerating potential	
Gaseous sample	
Electron bombardment ionisation	
Detector	
Magnetic field to deflect ions	

b. Why must the inside of the mass spectrometer be kept at a high vacuum

c. The spectrometer is setup so that ion X^+ is focused on the detector. The settings are left uncharged and an ion with a mass less than that of X^+ travels through the magnetic field. State and explain whether this ion will be deflected more than, or less than, X^+.

Answer:

a.

Section	Letter
Accelerating potential	C
Gaseous sample	A
Electron bombardment ionisation	B
Detector	E
Magnetic field to deflect ions	D

b. Most of the sample molecules are not ionized at all but are continuously drawn off by vacuum pumps which are connected to the ionization chamber.

c. This ion which has the mass less than that of X+ will deflect more than X+.

Reason: The greater the mass-to-charge (m/e) ratio of the ion, the larger the radius of the curved path.

20. The separation of ions in a mass spectrometer depends on

a. Only the charge on the ions

b. Only the mass of the ions

c. The mass and the charge of the ions

d. Only the velocity of the ions

Answer: (C)

21. When injected into a mass spectrometer a compound gave a number of ion peaks. Two peaks,one of which was the molecular ion, had m/z values of 58 and 43. Which of the molecular fragments below might have been lost from the original molecule?

a. CH_3

b. OH

c. C_2H_5

d. CHO

Answer: (A)

UNIT 16

ELECTRON CONFIGURATIONS OF ATOMS AND IONS

16.1. Key Unit competence

Relate Bohr's model of the atom with hydrogen spectrum and energy levels, (practice writing electronic configurations using s, p, d, f orbitals) and interpret graphical information in relation to ionization energy of elements.

16.2. Prerequisite (knowledge, skills, attitudes and values

- Rutherford's nuclear model
- The composition of an atom and the dot/cross diagrams of at least the first 20 elements.

16.3. Cross cutting issues to be addressed

a) Inclusive education

This unit involves a number of activities on the properties and discovery of atoms, and calculations involving mass spectrometer data. The activities require reading and writing. This may be challenging to students with special educational needs especially children with visual impairment. However, the teacher can make some arrangements like:

- Grouping students. Students with special educational needs are grouped with others and assigned roles basing on individual student's abilities.
- Providing procedure earlier before the activity so that students get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts or in Braille.
- Every important point is written and spoken. The written points helps students with hearing impairment and speaking aloud helps students with visual impairment
- Remember to repeat the main points of the lessons.

b) Gender

During group activities try to form heterogeneous groups (with boys and girls) or when students start to present their findings encourage both (boys and girls) to present.

c) Peace and values education

During group activities, the teacher will encourage learners to help each others and to respect opinions of colleagues.

16.4. Guidance on introductory activity

Before introducing the first lesson (**Bohr's atomic model: Concept of energy levels and atomic spectra**) of this unit, let learners attempt the introductory activity.

Expected answer to introductory activity

The potential energy of a person walking up ramp increases in uniform and continuous manner whereas potential energy of person walking up steps increases in stepwise and quantized manner. This can be explained by the values of energy which are continuous for the person walking up ramp while they are discrete (discontinued) for the person walking up steps

16.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Bohr's atomic model: Concept of energy levels and atomic spectra	Explain the Concept of energy levels and spectra Explain how the data from emission spectra provide evidence for discrete energy levels within the atom.	3
2	Hydrogen spectrum and spectral line series (Lyman and Balmer series: Line spectra as evidence for discrete energy levels)	Describe hydrogen spectral lines and spectral line series	2
3	Quantum theory of the atom	Explain the quantum theory of the atom using the quantum numbers.	3

4	Quantum numbers for energy levels, sub-energy levels and orbitals	Explain the existence of quantum numbers for energy levels, sub-energy levels and orbitals	3
5	Number and shape of 's' and 'p' orbitals	Describe the atomic orbitals. Determine the number and shapes of orbitals in given level or principal quantum number	2
6	Electronic configuration of atoms and ions: Rules governing the electronic configurations (Aufbau principle, Pauli Exclusion Principle and Hund's rule)	Explain the rules governing the electronic configuration: Aufbau principle and Hund's rule Determine the electronic configurations of the atoms and ions in terms of s, p, d and f orbitals.	2
7	Electronic configuration and stability (half and completely filled orbital configurations are stable)	Describe the electronic configuration and stability of atoms and ions	1
8	Relationship between ionization energy, energy levels and factors influencing ionization energy: The graphs of ionization energy versus the number of electrons removed	- Explain the relationship between the electronic configuration and the stability of the atom - Relate information of ionization energies to electronic configurations of the elements - Derive the electronic configuration of an element from data on successive ionization energies	1
9	Interpretation of a graph of first ionization energy versus the atomic numbers of elements.	Interpret the graphs of first ionisation energy against the atomic number	1

10	Factors influencing the magnitude of ionization energy (atomic radii, nuclear charge, shielding effect).	Describe the factors which influence the first ionisation energy	1
11	End unit assessment		1

Lesson 1: Bohr's atomic model: Concept of energy levels and spectra

a) Learning objective

- Explain the Concept of energy levels and spectra
- Explain how the data from emission spectra provide evidence for discrete energy levels within the atom.

b) Teaching resources

Textbooks, manila paper or chalk board, computer and projector, videos on absorption and emission spectra

c) Prerequisites/Revision/Introduction

Student-teachers will understand better the concept of electronic structure if they have a good understanding on the periodic table, Senior 1, atomic structure TTC Year1, Unit 15.

d) Learning activities

- Form group of four students and let them do activity 16.1
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.1 The feedback will be given in the next session after the correction.

Answers to activity 16.1

1. In Rutherford described a nuclear atom; an atom with a dense centre of positive charge (the **nucleus**) with electrons moving around the nucleus at a distance that is large relative to the nuclear radius.
2. Bohr described a planetary atom in which a small positive nucleus is surrounded by negatively charged electrons traveling in specific energy levels or orbits.
3. As the person walking up steps cannot stand between steps, an electron cannot stand between energy levels. Likewise, as the potential energy of person walking up steps increases in stepwise and quantized manner, an electron can absorb energy or release energy in **"packets"** when it moves from one orbit to another.

e) Answers to application activity 16.1

1. Two more examples that can be used to illustrate the concept of quantization include
   - The gravitational potential energies of textbooks in shelves in a library.
   - The pitches of overtones of a given fundamental note on a piano keyboard.
2. The main weakness of Rutherford's nuclear atom consists in its inability to account for the stability of atoms. The Rutherford model of a nuclear atom does not show the arrangement of electrons outside the atomic nucleus.

   According to classical physics, a stationary, negatively charged particle would be pulled into the positively charged nucleus. Therefore, electrons cannot have fixed position around the nucleus. This perspective suggests that the electrons in an atom must be in motion like the planets orbiting the sun. However, in accordance with the laws of classical theory of electromagnetism, orbiting electrons should be constantly accelerating and should radiate energy. By losing energy, the electrons would be drawn closer and closer to the nucleus and soon spiral into it. In reality atoms are stable in contradiction with the expectations of classical physics.

Lesson 2. Hydrogen spectrum and spectral line series

a) Learning objective

Describe hydrogen spectral lines and spectral line series

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating Hydrogen spectral lines and spectral line series.
- Manila papers, flipcharts and YouTube videos with computers and projectors if applicable.

c) Prerequisites/Revision/Introduction

The student-teacher will deeper learn the concept of spectral series if they have a good understanding of the concept of atomic absorption and emission spectra studied in Lesson 1of this unit.

d) Learning activity 16.2

Guidance

- Form group of four students and let them do activity 16.2
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.2.

Answer for activity 16.2

Atoms of the gas neon tube get excited, and when they fall back to their ground state, they emit light that is characteristic of neon.

e) Answers to application activity 16.2

1. In Hydrogen spectral lines, infinity level means very far away from the hydrogen atom. An electron that supposedly belongs to such energy level in a hydrogen atom escapes from the electrostatic attraction of the nucleus and the atom becomes ionised.

2. $Data: n_i = 5; n_f = 2$

$Unknown: E = ?; \nu = ?; \lambda = ?$

Answer

$$E = -hCR_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

a) $E = -2.179\times10^{-18} J\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$$= -2.179\times10^{-18} J\left(\frac{1}{2^2} - \frac{1}{5^2}\right) = -\frac{2.179\times10^{-18} J\times21}{100} J = -4.58\times10^{-19} J$$

The obtained energy has a negative sign. It means that a photon is emitted.

a) $\nu = \frac{E}{h} = \frac{4.5759\times10^{-19} J}{6.626\times10^{-34} J.s} = 6.9059\times10^{14} Hz$

b) $\lambda = \frac{c}{\nu} = \frac{3\times10^{8} ms^{-1}}{6.9059\times10^{14} Hz} = 4.344\times10^{-7} m$

3. $\nu = \frac{E}{h} = 6.9059\times10^{14} Hz$ $\lambda = \frac{c}{\nu} 4.344\times10^{-7} m$

$\lambda = 4.344\times10^{-7} m = 4.344X10^{2}nm$

Lesson 3: Quantum theory of the atom

a) Learning objective

Explain the quantum theory of the atom using the quantum numbers.

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating Hydrogen spectral lines and spectral line series.
- Manila papers, flipcharts and YouTube videos with computers and projectors if applicable.

c) Prerequisites/Revision/Introduction

The student-teacher will deeper learn the concept of spectral series if they have a good understanding of the concept of atomic absorption and emission spectra studied in Lesson 1of this unit.

d) Learning activity 16.3

- Form group of four students and let them do activity 16.3
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.3

Answer for activity 16.3

See student-teacher's book lesson 16.3: Quantum theory of the atom

e) Answers to application activity 16.3

Bohr used Planck's and Einstein's ideas about quantized energy proposing that hydrogen atoms had only certain fixed energy states. • Each of these states was associated with a fixed circular orbit of the electron around the nucleus.

Bohr proposed that atoms do not radiate energy while in one of their fixed (stationary) energy states.

When the electron moves to a different orbit, the atom changes to another energy state. • This happens only by the atom absorbing or emitting a photon.

Spectral lines represent emission of a photon of specific energy (and n) as an electron drops from a higher energy state to a lower one.

An atomic spectrum consists of lines instead of a continuum because the atom's energy has only certain discrete levels, or states.

In Bohr's model, the quantum number n determines the radius of the electron's orbit and is directly related to the atom's energy.

The lower the value of n, the smaller is the radius of the orbit and the lower is the energy level of the atom.

When the electron is in the n = 1 orbit, the atom is in its lowest (first) energy level, called the ground state. • The second energy level (second stationary state) and all higher levels are called excited states.

Despite its success in accounting for spectral lines of the H atom, the Bohr model **failed** to predict the spectrum of any other element.

The model worked well for one-electron species, but not for atoms or ions with more than one electron.

The existence of discrete atomic energy levels is retained from Bohr's model in the current atomic model.

If an electron has both particle and wave properties, its position in an atom can't be readily determined. Werner Heisenberg postulated the uncertainty principle: it is impossible to know simultaneously the exact position and velocity of a particle like an electron. At best, the probability of finding an electron in a given volume of space can be determined.

Applying wave mathematics to the electron wave, Erwin Schrödinger derived an equation that is the basis for the quantum-mechanical model of hydrogen atom.

The allowed wave-like motion of the electron leads to an atom with certain fixed energy states much like Bohr assumed.

The electron's exact location cannot be determined. Solutions of Schrödinger's wave equation are functions,Ψ , that describe atomic orbitals. An atomic orbital is a 3-dimensional space where there is a great chance of finding an electron.

Sub lesson 3.1. Quantum numbers for energy levels, sub-energy levels and orbitals

a) Learning objective

Explain the existence of quantum numbers for energy levels, sub-energy levels and orbitals

b) Teaching resources

Charts illustrating different types energy, sub-energy levels and orbitals.

Manila papers, flipcharts and videos, computers and projectors.

c) Prerequisites/Revision/Introduction

The student-teachers will better learn the concept energy levels, sub-energy levels and orbitals if they have a good understanding of quantum theory of the atomic structure studied in Lesson 3 of this unit.

d) Learning activity 16.3.1

- Form group of four students and let them do activity 16.3.1
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.3.1

Expected answer for activity 16.3.1

See student-teacher's book lesson 16.3.1: Quantum numbers for energy levels, sub-energy levels and orbitals

e) Answer for application activities 16.3.1

1. a), c), e)
2. b), c), e), f)

Sub lesson 3.2: Number and shape of 's' and 'p' orbitals

a) Learning objective

- Describe the atomic orbitals.
- Determine the number and shapes of orbitals in given level or principal quantum number

b) Teaching resources

Flip charts, chalkboard, smart board

Charts illustrating different types energy, sub-energy levels and orbitals.

c) Prerequisites/Revision/Introduction

The student-teachers will better learn the concept energy levels, sub-energy levels and orbitals if they have a good understanding of the quantum theory of the atomic structure studied in Lesson 3 and the concept of levels, sub-levels and orbitals (Lesson 4) of this unit.

d) Learning activity 16.3.2

- Form group of four students and let them do activity 16.3.2
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.3.2

Aswer for activity 16.3.2

See student-teacher's book, lesson 16.3.2: Number and shape of "s" and "p" orbitals

e) Answers to application activity 16.3.2

See student-teacher's book, lesson 16.3.2: Number and shape of "s" and "p" orbitals

Sub lesson 4.1: Electronic configuration of atoms and ions: Rules governing the electronic configurations

a) Learning objective

- Explain the rules governing the electronic configuration: Aufbau principle and Hund's rule
- Determine the electronic configurations of the atoms and ions in terms of s, p, d and f orbitals.

b) Teaching resources

Textbooks, smart board, chalk board,

c) Prerequisites/Revision/Introduction

The student-learners master the concepts of atomic structure, the quantum model of the atom and the concept of atomic orbital.

d) Learning activity 16.4.1 (a)

- Form group of four students and let them do activity 16.4.1
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.4.1

Answer for activity 16.4.1 (a)

See student-teacher's book, lesson 16.4: Electronic configuration of atoms and ions

e) Answers to application activity 16.4.1 (a)

$_{1}H$, $1s^1$

$_{3}Li$, $1s^2 2s^1$

$_{5}B$, $1s^2 2s^2 p^1$

$_{11}Na$, $1s^2 2s^2 p^6 3s^1$

$_{18}Ar$, $1s^2 2s^2 p^6 3s^2 3p^6$

$_{19}K$, $1s^2 2s^2 p^6 3s^2 3p^6 34s^1$

$_{21}Sc$, $1s^2 2s^2 p^6 3s^2 3p^6 3d^1 4s^2$

$_{24}Cr$, $1s^2 2s^2 p^6 3s^2 3p^6 3d^5 4s^1$

$_{26}Fe$, $1s^2 2s^2 p^6 3s^2 3p^6 3d^6 4s^2$

$_{29}Cu$, $1s^2 2s^2 p^6 3s^2 3p^6 3d^{10} 4s^1$

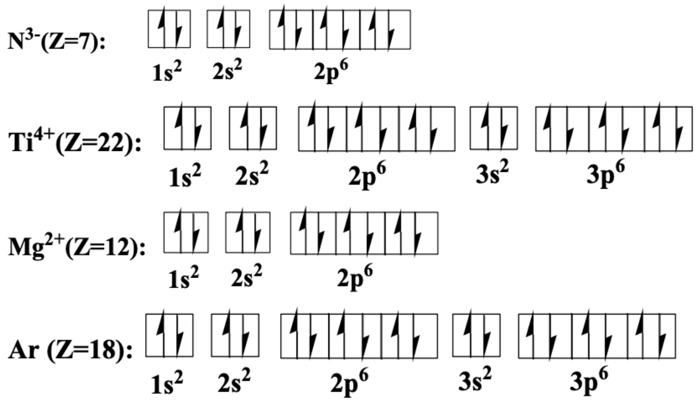
Answers to application activity 16.4.1 (b)

S(Z=16): $1s^22s^22p^62s^22p^4$

P^{3-} Z=15):$1s^22s^22p^63s^23p^6$

Mg^{2+}(Z= 12): $1s^22s^22p^6$

Answers to application activity 16.4.1 (c)



N^{3-} and Mg^{2+} are isoelectronic as it is the case for Ti^{4+} and Ar since each chemical species from the first pair has 10 electrons and each element of the second pair has 18 electrons, respectively.

Answers to application activity 16.4.1 (d)

a. Ge (Z=32), [Ar]$3d^{10}4s24p^2$
b. S (Z=16), [Ne]$3s^23p^4$
c. Co^{2+} (Z=27), [Ar]$3d^54s^2$
d. Br- (Z=35), [Ar] $3d^{10}4s^24p^6$
e. Sr (Z=38), [Kr]$5s^2$

Sub lesson 4.2: Electronic configuration and stability

a) Learning objective

Describe the electronic configuration and stability of atoms and ions

b) Teaching resources

Textbooks, smart board, chalk board,

c) Prerequisites/Revision/Introduction

The student-learners master the concepts of atomic structure, the quantum model of the atom and the concept of atomic orbital.

d) Learning activity 16.4.2

- Form group of four students and let them do activity 16.4.2
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.4.2

Answers to activity 16.4.2

See student-teacher's book, lesson 16.4.2: Electronic configuration and stability (half and completely filled orbital configurations are stable)

e) Answers to application activity 16.4.2

1. Electronic structures

K (Z=19), $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Ne (Z=10), $1s^2 2s^2 2p^6$

Al^{3+} (Z=13), $1s^2 2s^2 2p^6$

Cl (Z=17), $1s^2 2s^2 2p^6 3s^2 3p^5$

O^{2-} (Z=16), $1s^2 2s^2 2p^6 3s^2 3p^2$

2. a) (i) $Cu^{+}(Z=29): 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

$Cu^{2+}(Z=29): 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$

Cu^{+} is more stable than Cu^{2+} since Cu^{+} has a totally filled 3d-orital whereas Cu^{2+} has neither full nor half-filled 3d-orbital.

b) $Fe^{2+}(Z=26): 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

$Fe^{3+}(Z=26): 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

Fe^{3+} is more stable than Fe^{2+} since Fe^{3+} has a half-filled 3d-orital whereas Fe^{2+} has neither full nor half-filled 3d-orbital.

Lesson 5.1: Relationship between ionization energy, energy levels and factors influencing ionization energy

a) Learning objectives

- Explain the relationship between the electronic configuration and the stability of the atom
- Relate information of ionization energies to electronic configurations of the elements
- Derive the electronic configuration of an element from data on successive ionization energies

b) Teaching resources

Flip charts, smart board or chalk board or manila paper, periodic tables

c) Prerequisites/Revision/Introduction

The student-teachers will learn better this content if they master the concept of electronic configuration using the spdf notation.

d) Learning activity 16.5.1

- Form group of four students and let them do activity 16.5.1
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.5.1

Answers to activity 16.5.1

1. The electronic structure of the given chemical species:

$$Na(Z=11): 1s^2 2s^2 2p^6 3s^1$$
$$Mg(Z=12): 1s^2 2s^2 2p^6 3s^2$$
$$Mg^{2+}(Z=12): 1s^2 2s^2 2p^6$$

$Al(Z=13): 1s^2 2s^2 2p^6 3s^2 3p^1$

$Al^{3+}(Z=13): 1s^2 2s^2 2p^6$

$O^{2-}(Z=16): 1s^2 2s^2 2p^6 3s^2 3p^6$

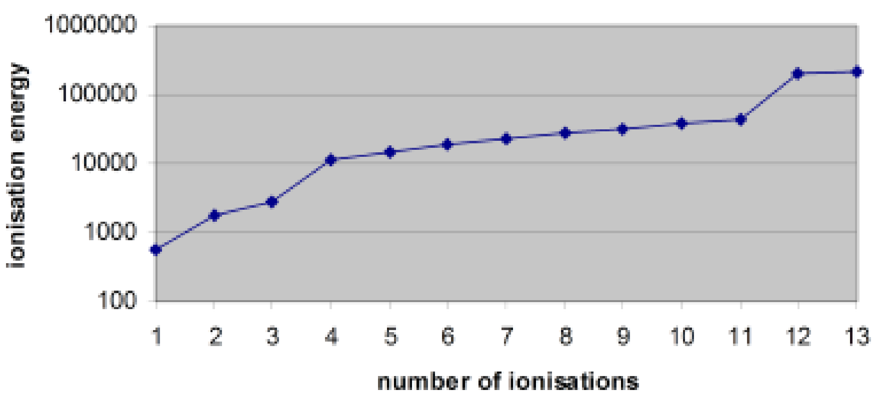
2. The common feature possessed by the ions in (1) is the full valence shell.
   Ions achieve a full valence shell as noble gases in order to become stable.
3. Aluminium atom lost 3 electrons when it changed to Aluminium ion.
4. The group and period of Aluminium, Sodium and Oxygen are shown in the following table.

Element	Group	Period
Aluminium	III	3
Sodium	I	3
Oxygen	VI or 16	2

e) Answers to Application activity 16.5.1

Student-teacher's book, lesson 16.5: Relationship between ionization energy, energy levels and factors influencing ionization energy.

1. **First ionisation energy,** required energy to remove the first electron from a gaseous atom
2. Helium is the smallest atom and its shell is full.
3. For the first ionisation energy, an electron is removed from a full sub-shell of neon. Therefore, an electron is removed from a sodium atom, it becomes stable. Therefore, it becomes hard to remove a second electron.
4. Graph to show the successive ionisation energies for aluminium.



The graph shows the following facts:

Between the 1rst and the 2nd IE: steady increase⇛Electron removed from a higher sub-shel

Between the 2nd and the 3rd IE: smouth increase⇛ 2 electrons in the same sub-shel

Between the 3rd and the 4th IE: **sharp** increase ⇛4th electron removed from an inner shel

Between the 4th and the 11th IE: smooth increase⇛ 8 electrons in the same shell

Between the 11th and the 12th IE: **sharp** increase⇛12th electron removed from an inner shell

Between the 12th and the 13th IE: smooth increase⇛ 2 electrons in the same shell

Therefore the electron configuration of aluminium is : $1s^2 2s^2 2p6^3 s^2 3p^1$

Lesson 5.2: Interpretation of a graph of first ionization energy versus the atomic numbers of elements

a) Learning objective

Interpret the graphs of first ionisation energy against the atomic number

b) Teaching resources

Flip charts, smart board or chalk board or manila paper, periodic tables

c) Prerequisites/Revision/Introduction

The student-teachers will learn better this content if they master the concept of electronic configuration using the spdf notation.

d) Learning activity 16.5.2

- Form group of four students and let them do activity 16.5.2
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.

- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.5.2

Answers to activity 16.5.2

Electronic configuration for the first twenty elements and first ionisation energy values

Element	electronic configuration	IE/kJmol^{-1}
Hydrogen	$1s^1$	1312
Helium	$1s^2$	1272
Lithium	$1s^22s^1$	520
Beryllium	$1s^22s^2$	899.5
Boron	$1s^22s^22p^1$	800.6
Carbon	$1s^22s^22p^2$	1086.5
Nitrogen	$1s^22s^22p^3$	1402.3
Oxygen	$1s^22s^22p^4$	1313.9
Fluorine	$1s^22s^22p^5$	1681
Neon	$1s^22s^22p^6$	2080.7
Sodium	$1s^22s^22p^63s^1$	495.8
Magnesium	$1s^22s^22p^63s^2$	737.7
Aluminium	$1s^22s^22p^63s^23p^1$	577.5
Silicon	$1s^22s^22p^63s^23p^3$	786.5
Phosphorus	$1s^22s^22p^63s^23p^3$	1011.8
Sulphur	$1s^22s^22p^63s^23p^4$	999.6
Chlorine	$1s^22s^22p^63s^23p^5$	1251.2
Argon	$1s^22s^22p^63s^23p^6$	1520.6
Potassium	$1s^22s^22p^63s^23p^64s^1$	418.8
Calcium	$1s^22s^22p^63s^23p^64s^2$	589.8

See student-teacher's book, lesson 16.5.2: Interpretation of a graph of first ionization energy versus the atomic numbers of elements.

e) Expected Answers to application activity 16.5.2

1. $Ne \rightarrow Ne + e^-$
2. Magnesium has the last sub-shell that is full and has a smaller size

3. $Mg^{+} \rightarrow Mg^{2+}$
4. Neon has a last shell that is full and it has a smaller size than magnesium..
5. The first electron of aluminium that is removed is from a higher sub-level.

Lesson 5.3: Factors influencing the magnitude of ionization energy

a) Learning objective

Describe the factors which influence the first ionisation energy

b) Teaching resources

Flip charts, smart board or chalk board or manila paper, periodic tables

c) Prerequisites/Revision/Introduction

The student-teachers will learn better this content if they master the concept of electronic configuration using the spdf notation.

d) Learning activity 16.5.3

- Form group of four students and let them do activity 16.5.3
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 16.5.3

Expected answer for activity 16.5.3

The first ionisation of neon is higher than that of fluorine because neon has a small radius than fluorine.

The first ionisation energy of potassium is lower than that of sodium because inner electrons in potassium is more effective than that of sodium.

e) Answers to application activity 16.5.3

1. The first ionisation energy of krypton is lower than that of argon because krypton has a higher number of shells and therefore has a higher shielding effect.
2. The value of the first ionisation energy of sulphur is lower than that of phosphorus because the electron of phosphorus is removed from a stable sub-shell (sub-shell that is half filled.
3. The third ionisation energy of magnesium is very much larger than the second ionisation energy of magnesium because the third electron is removed from an inner shell.

16.6. Summary of the unit

According to the Bohr's model electrons revolve the nucleus at certain specific orbit. If an electron absorbs energy, it is promoted to high energy level. When it falls from a higher to a lower energy level, a quantum of radiation is emitted. This radiation can be detected as a line in the emission spectrum of the element.

The radiant energy is emitted or absorbed discontinuously in the form of small discrete packets of energy called quantum. The energy of each quantum is directly proportional to the frequency of the radiation, i.e. E = h.

The wavelength of the photon associated with an electronic transition from an energy level n_i to another energy level n_f is given by Balmer's equation

$$\frac{1}{\lambda} = R_H(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

The volume in space in which there is a high probability of finding an electron is called **orbital**.

$$\Delta E = nh\nu = n\frac{hc}{\lambda} \quad \text{with n=1,2,3,...}$$

A set of 4 quantum numbers is used to describe an electron in the orbital.

The principal quantum number, **n** ($n = 1,2,3,...,\infty$) describes the energy levels, the azimuthal quantum number or angular momentum quantum number **l** ($l = 0,2,...,n-l$), the shapes of the orbitals, the magnetic quantum number m_l ($m_l = -l, -l+1,...,0,1,2,3,+l$) the possible spatial orientations of the orbitals and the spin quantum number represents one of the two possible values for the electron spin. Electrons fill orbitals from the lowest energy to the highest energy orbital ensuring that the energy of the atom is at a minimum. The filling of orbitals with electrons is governed by Pauli's exclusion principle, the Hund's rule and the Aufbau principle.

The electronic structure gives information on the position of an element in the periodic table and helps to explain the shape of the curve of ionisation energy

16.7. Additional information for tutors

Foundation of classical quantum theory

a. **Atomic spectrum**

If a metal or one of its compounds is heated in the flame of a burner, a colour characteristic of the metal appears. This is the well-known **flame reaction**. If the coloured light is separated by means of a prism, a few strong line spectra are observed, and the wavelength of each line is characteristic of the metal involved. For instance, the yellow flame reaction of Na corresponds to two yellow lines

of its spectrum in the visible region, and the wavelengths of these two lines are 5.890×10^{-7} m and 5.896×10^{-7} m, respectively.

If a gas is sealed in a high vacuum tube, and a high voltage is applied, the gas discharges and emits light. Separation of this light by means of a prism will give a series of discontinuous line spectra. Since the wavelengths of this light are characteristic of the atom, the spectrum is called its **atomic spectrum.**

The Swiss physicist Johann Jakob Balmer (1825-1898) separated the light emitted during discharge from low-pressure hydrogen. He realized that the wavelength λ of a series of spectral lines could accurately be expressed by a simple equation (1885). The Swedish physicist Johannes Robert Rydberg (1854-1919) found that the wavenumber , σ, of a spectral line could be expressed by an equation as indicated below (1889). The wave number is the number of waves contained in a unit length (e.g., per 1 cm)

$$\sigma = 1/\lambda = R\{ (1/ni^2) - (1/nj^2) \}\text{cm}^{-1}$$

where ni and nj are positive integer (ni < nj) and R is a constant characteristic of the given gas. For hydrogen it is 1.09678×10^7 m^{-1}.

Generally the wavenumbers of the spectral lines of hydrogen atom can be expressed by the difference of two terms, R/n^2.

The spectra of atoms other than hydrogen are much more complicated, but their wavenumbers are also expressed by the difference of two terms.

b. The Bohr theory

At the end of the 19th century, physicists had difficulty in understanding the relation between the wavelengh of radiation from a heated solid and its relative intensity. There was some disagreement between the prediction based on the theory of electromagnetism and the experimental results. The German physicist Max Karl Ludwig Planck (1858-1947) attempted to solve the problem, which had annoyed physicists of the day, by introducing a novel hypothesis which was later called the **quantum hypothesis** (1900).

According to his theory, a physical system cannot have arbitrary quantities of energy but is allowed only to have discontinuous quantities. By thermal radiation, that is, the radiation of energy as electromagnetic waves from a substance, an electromagnetic wave with the frequency ν from the surface of solid is generated from an oscillator that oscillates at the surface of the solid with that frequency. According to Planck's hypothesis, the energy of this oscillator can only have

discontinuous values as depicted by the following equation.

$\boldsymbol{\varepsilon = nh\nu (n = 1, 2, 3, ...)}$

where n is a positive integer and h is a constant, 6.626×10^{-34} J s, which is called **Planck's constant**.

The novel idea that energy is a discontinuous quantity was not easily accepted by the scientists that time. Planck himself regarded what he proposed as a mere hypothesis only necessary for solving the problem of radiation from a solid. He had no intention to expand his hypothesis to a general principle.

The phenomenon of emission of electrons from the surface of a photo-irradiated metal is called the **photoelectric effect**. For a given metal, emission will take place only when the frequency of the irradiated light is above a certain value characteristic of that metal. The reason for this was not known at that time. Einstein was able to explain this phenomenon by applying the quantum hypothesis to the photoelectric effect (1905). Around that time, scientists began to believe that the quantum hypothesis was a general principle governing the microscopic world.

The Danish physicist Niels Hendrik David Bohr (1885-1962) attempted to combine Planck's quantum hypothesis with classical physics to explain the discontinuity of atomic spectra. Bohr made the following assumptions.

Electrons in atoms are allowed to be in certain stationary states. Each stationary state is associated with a definite energy.

1. No energy emissions occur while an electron is in a stationary state. When it moves from a high-energy stationary state to a low-energy stationary state (a transition), an emission of energy takes place. The amount of energy, hν, is equal to the energy difference between the two stationary states.

2. In any stationary state, an electron moves in a circular orbit around the nucleus.

3. An electron is allowed to move with an angular momentum that is an integral multiple of **h/2π**, i.e., **mvr = n(h/2π)**, n = 1, 2, 3,...

The energy of an electron belonging to a hydrogen atom can be calculated using these hypotheses. In classical mechanics, the electrostatic force exerted on an electron and the centrifugal force exerted on it are balanced. Hence,

$\mathbf{e^2/4\pi\varepsilon 0r^2 = mv^2/r}$ where e, m and v are the electric charge, mass and velocity of the electron, respectively (the subscript e is omitted for simplicity), r is the distance between the electron and the nucleus, and

ε0 is the dielectric constant of a vacuum, $8.8542 \times 10^{-2} C^2 N^{-1} m^2$.

16.8. End unit assessment 16 (answers)

Standard of performance: Accurately relate Bohr's model of the atom with hydrogen spectrum and energy levels, practice writing electronic configurations using s, p, d, f orbitals and interpret graphical information in relation to ionization energy of elements.

Answers to the end unit assessments questions

1. (b) is the correct ground-state electron configuration of molybdenum.

In **(a)** the orbital 3f does not exist.

In **(c)** the proposed electronic structure [Kr] $4d^5 5s^2$ corresponds to another element (Technetium: Z=43) next to Molybdenum (Z=42).

In **(d),** Hund's rule is violated since electrons pair up in 4d-orbital before 5s-orbital is full.

2. The electron configuration of Nitrogen corresponds to the ground state and that of Boron to an excited

state. b) and c) are correct because they obey all rules governing electron configuration. a) violate the Aufbau principle and d) violate the Hund's rule.

3.

$$Data: \lambda = 660nm = 660 \times 10^{-9} m = 6.60 \times 10^{-7} m,$$

$$Unknown: \nu = ?$$

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8} ms^{-1}}{6.60 \times 10^{-7} m} = 4.54 \times 10^{14} Hz$$

4. 1p, 3f and 2d are the incorrect orbital designations.

5. The wavelength of an electromagnetic radiation is calculated using the expression

$$\lambda = \frac{c}{\nu}$$

a) $\lambda(CD\ laser) = \dfrac{3 \times 10^{8} ms^{-1}}{3.85 \times 10^{14} Hz} = 7.79 \times 10^{-7} m$

b) $\lambda(DVD\ laser) = \dfrac{3 \times 10^{8} ms^{-1}}{4.62 \times 10^{14} Hz} = 6.49 \times 10^{-7} m$

c) $\lambda(Blu-ray\ laser) = \dfrac{3 \times 10^{8} ms^{-1}}{7.41 \times 10^{14} Hz} = 4.05 \times 10^{-7} m$

6. a) There are 3 subshells in the n=3 level.

b) The subshells in the n=3 level are s, p and d.

c) There are 7 orbitals with n=4 and l=3

d) There are 1 orbital with n=3 and l=2 and m_l=-2

e) There are 16 orbitals in the level n=4

7. Given that λ/4=1.17nm

λ= 1.17nm x 4 = 4.68nm

8. a) The **wave a** has the longer wavelength since there are 5 crests in the given distance.

b)There are 4 wavelength units in wave a and 8 wavelength units in wave b. Therefore, we have

$$4\lambda_a = 1.6\times10^{-3}m$$

$$\Rightarrow \lambda_a = \frac{1.6\times10^{-3}m}{4} = 4\times10^{-4}m$$

$$8\lambda_b = 1.6\times10^{-3}m$$

$$\Rightarrow \lambda_b = \frac{1.6\times10^{-3}m}{8} \Rightarrow \lambda_b = 2\times10^{-4}m$$

c) Wave b has higher frequency and photon energy.

d)The frequency and energy for waves a and b are calculated hereafter.

i. Wave a

$$\nu_a = \frac{c}{\lambda_a} = \frac{3\times10^{8}ms^{-1}}{4\times10^{-4}m} = 7.5\times10^{11}Hz$$

The photon energy is calculated using the expression

$$E_a = h\nu_a = 6.626\times10^{-34}J.s\times7.5\times10^{11}Hz = 4.969\times10^{-22}J$$

ii. Wave b

$$\nu_b = \frac{c}{\lambda_b} = \frac{3\times10^{8}ms^{-1}}{2\times10^{-4}m} = 1.5\times10^{12}Hz$$

The photon energy is calculated using the expression

$$E_b = h\nu_b = 6.626\times10^{-34}J.s\times1.5\times10^{12}Hz = 9.939\times10^{-22}J$$

The wave b is the one which has a higher speed since it performs a higher number of cycles per unit time (twice faster than wave a).

e) The type of electromagnetic radiation that is illustrated is visible light. (Refer to the electromagnetic spectrum in Student book, **Figure 2.2**).

9. Increasing energy order
   a. 5p < 5d
   b. 3p < 4s
   c. 4d < 6s

10. a. 3d
   b. 4p
   c. 6d
   d. 6s

11. a. 3s
  b. 3d
  c. 6s
  d. 4f

12. Al: $1s^2 2s^2 2p^4 3s^2 3p^3$, it violate the build up principle.

Correct electronic configuration: $1s^2 2s^2 2p^6 3s^2 3p^1$

B: $1s^2 2s^2 2p^5$, the total of the superscripts is greater than the atomic number of boron.

Correct electronic configuration: $1s^2 2s^2 2p^1$

F: $1s^2 2s^2 2p^6$, the total of the superscripts is greater than the atomic number of fluorine.

Correct electronic configuration: $1s^2 2s^2 2p^5$

13. B is correct

A and D violate the Hund's rule

C violate both theHund's rule and the Pauli exclusion principle

14. The ionisation energy increases smoothly from the first to the fourth ionisation number and it has relatively low values. This is the case because the four electrons belong to the same outermost shell. The gradual increases is due to the increase in effective nuclear charge as more and more electrons are removed.

The graph shows a steep increase in ionisation energy because the fifth electron is removed from an inner shell where it is experiences a stronger attraction towards the nucleus.

The ionisation energy increases smoothly from the fifth to the sixth ionisation energy. This means that the fifth and sixth electrons belong to the same energy level. The gradual increase is due to the increase in effective nuclear charge as more and more electrons are removed.

14. a) The first ionisation energy is the energy required to remove one electron from each atom of a mole of gaseous atoms.

b) The factors influencing the first ionisation energy include:

(i) **Size of atom:** As the distance between the nucleus and valence shell electrons increases, the force of attraction between nucleus and valence electron decreases. Therefore, the valence electrons are loosely held to the nucleus and lower energy is required to remove them, i.e Ionisation energy decreases with increase in atomic size vice versa.

(ii) **Nuclear charge:** As the nuclear charge increases, the force of attraction between nucleus and valence electrons increases and hence makes it is difficult to remove an electron from the valence shell. The stronger the nuclear charge, the higher the Ionisation energy.

(iii) **Screening effect or Shielding effect:** The electrons present in inner shells between nucleus and valence shell reduce the attraction between nucleus and the outermost electrons. This shielding effect increases with the increasing number of inner electrons. The strong the Shielding effect makes it easier to remove an electron and hence lowers the ionisation energy.

(iv) **Penetration effect:** The extent to which electrons in degenerate orbitals are close to the atomic nucleus varies in the order **s > p > d > f**. Hence s-electrons experience stronger attraction from the nucleus than the electrons p, d and f-electrons. Thus Ionisation energy to remove an electron from a given energy level decreases in the order **s > p > d > f**.

(v) **Electronic Configuration:** Electronic Configuration plays a crucial role in determining the value of Ionisation energy. Atoms having stable configuration show the least tendency to lose electron and hence have high value of I. E.

c) The element W belongs to group IV or 14. In fact the largest energy gap exists between the 4^{th} and 5^{th}

Ionisation energy. This means the first four electrons that are removed are on the same energy level which is the outermost shell. The fifth electron belongs to an inner shell where it is more attracted by the nucleus and thus require significantly high energy to get removed.

15. a. A, sharp increase between the first and the second ionisation energy values.

    b. B and D, sharp increase after the second ionisation energy. they belong to Group 2.

    c. Group 4 or 14 because the ionisation energy increases smoothly up to the fourth ionisation energy and then there is a big increase.

    d. B

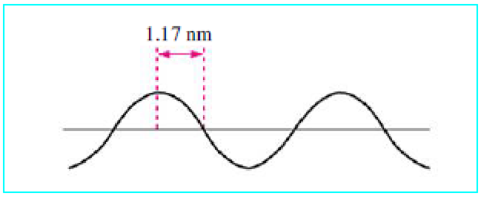
16.9. Additional activities (Questions and answers)

16.9.1. Remedial Activities

1. What are the seven colours making the white light spectrum? Rank them in ascending order of their wavelengths.

   Answer. Violet, Indigo, Blue, Green, Yellow, Orange, Red.

2. A hypothetical electromagnetic wave is pictured here. What is the wavelength of this radiation?



Answer. The distance shown in the diagram corresponds to $\frac{1}{4}$ of the distance between two successive crests. Therefore,

$\lambda = 4 \times 1.17nm = 4.68nm = 4.68 \times 10^{-9} m$

3. What is the frequency (in 1/s) of light with wavelength equal to 5 x 10^{-6} cm?

   a. 6 x 10^{15} b. 6 x 10^{14} c. 1.5 x10^{15} d. 1.5x10^{3}

   Answer. a

4. What is the wavelength of photons of light of frequency = 1150 kilocycles/sec

   a. 26 m b. 3.4 x 10^{11} m c. 261 m d. 3.4 x 10^{14} m

   Answer c.

5. What is the wavelength of a wave having a frequency of 3.76 x 10^{14} s^{-1}?

   Answer. $\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8} ms^{-1}}{3.76 \times 10^{14} s} = 7.98 \times 10^{-7} m$

6. What is the frequency of a wave carrying energy of 8.35 x 10^{-18} J?

   Answer. $\nu = \frac{E}{h} = \frac{8.35 \times 10^{-18} J}{6.626 \times 10^{-34} J.s} = 1.26 \times 10^{16} Hz$

7. What is meant by first ionization energy?

   Answer. First ionization energy is the energy required to remove the first electron from a gaseous atom.

8. Explain the jump in ionization energy related to the valence electrons of the element?

   Answer: The jump occurs after the valence electrons have been removed.

16.9.2. Consolidation activities

1. What electron transition in a hydrogen atom, ending in the orbit n=2will produce light of wavelength 1090 nm?

Answer

- Data: $\lambda = 1090nm = 1.090\times10^{-6}m, n_f = 3$
- Unknown: $n_i = ?$
- **Solution:** The wavelength of the radiation is calculated using Balmer's relation.

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$ Rearranging the equation yields

$$n_i = \sqrt{\frac{n_f^2 R_H \lambda}{R_H\lambda - n_f^2}}$$

$$n_f = \sqrt{\frac{3^2\times1.097\times10^7 m^{-1}\times1.090\times10^{-6}m}{1.097\times10^7 m^{-1}\times1.090\times10^{-6}m - 3^2}} = \sqrt{\frac{98.73}{89.73}} = \sqrt{1.100} = 1$$

The electron transition corresponding to λ=1090nm in hydrogen atom is from n=3 to n=1.

2. The number of electrons a single d orbital can hold is

   a. 10 b. 6 c. 2 d. 14

Answer: a

3. How many d electrons can the second energy level hold?

   a. 0 b. 2 c. 6 d. 10

Answer: a

4. What is the total number of orbitals containing electrons in a nitrogen atom?

   a. 5 b. 3 c. 4 d. 6

Answer: b

5. Of the orbitals shown, the one with the lowest energy is

   a. 2s b. 3s c. 3d d. 2p

Answer: a

6. The maximum number of electrons that can occupy a 3p sublevel is

   a. 1 b. 2 c. 3 d. 6

Answer: d

7. The electron configuration of an atom is $1s^2 2s^2 2p^6 3s^2 3p^3$. The atomic number of the atom is

   a. 15   b. 11   c. 5   d. 3

Answer: a

8. The electron configuration of an atom is $1s^2 2s^2 2p^6 3s^2 3p^6$. The number of unpaired electrons in this atom is

   a. 2   b. 3   c. 5   d. no correct answer given

Answer: d

9. The electron configuration of an atom is $1s^2 2s^2 2p^6 3s^2 3p^6$. The number of orbitals occupied by electrons is

   a. 5   b. 9   c. 11   d. 15

Answer: b

10. The maximum number of electrons in the 4d sublevel is

   a. 2   b. 6   c. 8   d. 10

Answer: d

16.9.3. Extended activities

Suggestion of Questions and Answers to gifted and talented students.

i. Which of the following are permissible sets of quantum numbers for an electron in a hydrogen atom:

   a) $n = 2; l = 1; m_l = 1$ **Permissible 2p**

   b) $n = 1; l = 0; m_l = -1$ **Not permitted**

   c) $n = 4; l = 2; m_l = -2$ **Permissible 4d**

   d) $n = 3; l = 3; m_l = 0$ **Not permitted**

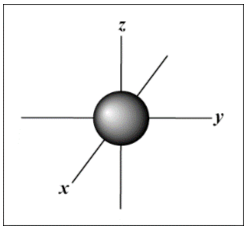
ii. Sketch the shape AND orientation of the following types of orbitals:

   a) s

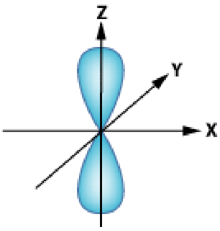
   b) p_z

Answer

   a) s orbital



b) p_z orbital



iii. An energetically excited hydrogen atom has its electron in a 5f subshell. The electron drops down to the 3d subshell, releasing a photon in the process.

a). Give the n and l quantum numbers for both subshells and give the range of possible ml quantum numbers.

b). Find the wavelength of light is emitted by the process in metres and micrometres.

c). The hydrogen atom now has a single electron in the 3d subshell. What is the energy in kJ/mol required to remove this electron?

Solution

a). For 5f, n=5 and l=3

For 3d, n=3 and l=2

b). $Data: n_i = 5, n_f = 3$

$$R_H = 1.097\times10^7 m$$

$$h = 6.6262\times10^{-34} J.s$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = R_H\left(\frac{1}{3^2} - \frac{1}{5^2}\right) = \frac{16R_H}{225}$$

$$\lambda = \frac{225}{16R_H} = \frac{225}{16\times1.097\times10^7 m^{-1}} = 1.28\times10^{-6} m = 1.28\mu m$$

c) $E = hc = h\dfrac{c}{\lambda} = 6.626\times10^{-34} J.s \times \dfrac{3\times10^{8} ms^{-1}}{1.28\times10^{-6} m} = 1.552\times10^{-19} J$

The energy in kilojoule per mole is given as

$$IE = \frac{E\times N_A}{1000} = \frac{1.552\times10^{-19}\times6.022\times10^{23}}{1\times10^{3}} kJmol^{-1} = 93.4 kJmol^{-1}$$

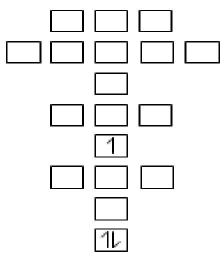
($N_A = 6.022\times10^{23}$ is the Avogadro number. It expresses quantity of matter in terms of the number of particles contained in one mole.

iv. Atomic Hotels

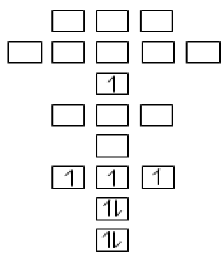
Group roles: A Leader; B Recorder; C Reporter

1. The Atomic Hotel is a special hotel designed for electrons. The hotel has a strict policy called the Aufbau principle that states "ground" floors must be filled first and in order. It costs more to get rooms on higher floors. In the atomic world energy is money. Therefore "excited" electrons get rooms on higher floors, thus the exception to hotel policy.

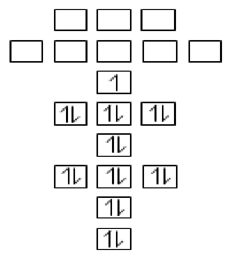
   Looking back through the old guest logs, the following layouts can be sketched. Determine which electrons had more "money". Highlight those electrons as excited.



May 23.
A

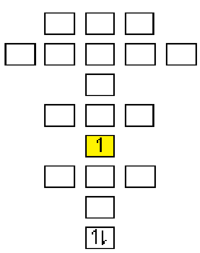


June 19.
B

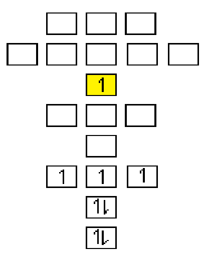


September 10.
C

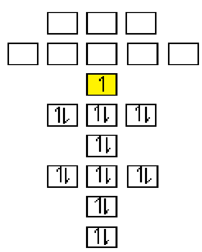
Solution:



May 23,
A



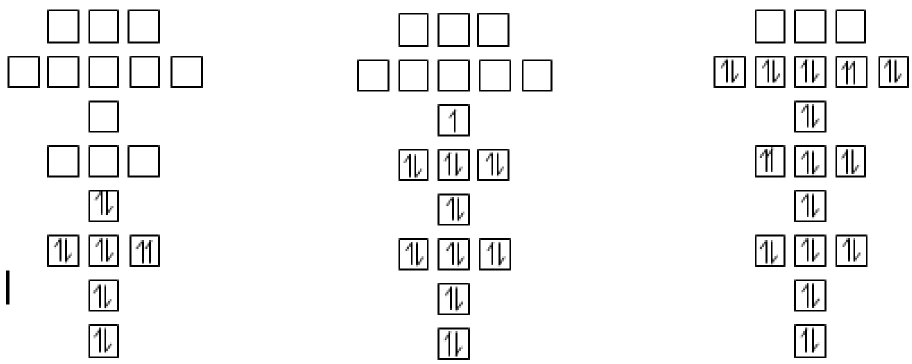
June 19,
B



September 10,
C

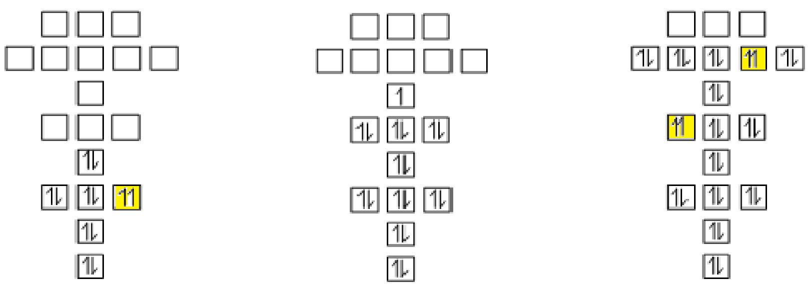
2. Another policy that the hotel enforces is called the Pauli Exclusion Principle. It was determined in 1925 that electrons can occupy the same room, but only if they have opposite spins so they do not interfere with one another.

   Copy the diagram below and highlight the electrons below which did not follow the Pauli Exclusion Principle.



April 2, A | December 1, B | July 4, C

Solution:



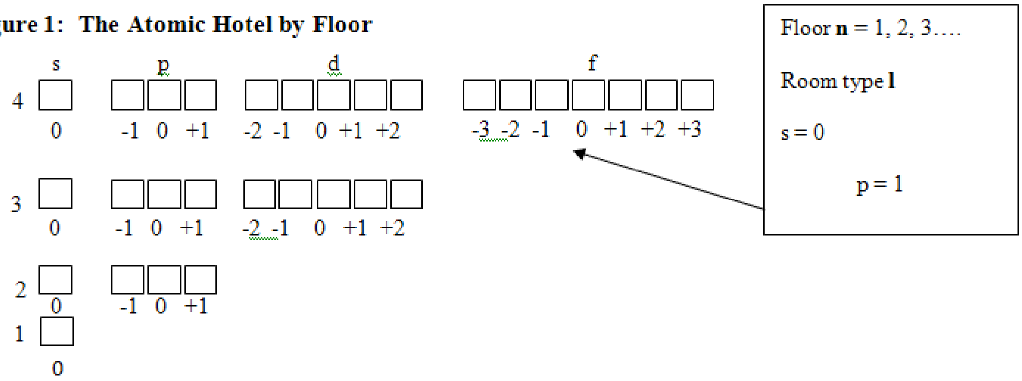
April 2, A | December 1, B | July 4, C

3. The Pauli Exclusion Principle serves to identify each electron. Four numbers (n, l, m_l, and m_s) are assigned to each guest in the hotel. The number n, is the principle quantum number which corresponds to the "floor" the electron is on. The letter l describes the room layout or the "floor area" in which the electron is staying (s = 0, p = 1, d = 2, etc.).

   There is only one s type room on each floor; there are three p type rooms on each floor from the second up; there are five d type rooms on each floor starting with the third floor and going up; and there are seven f type rooms on each floor starting with the fourth floor and moving upwards.

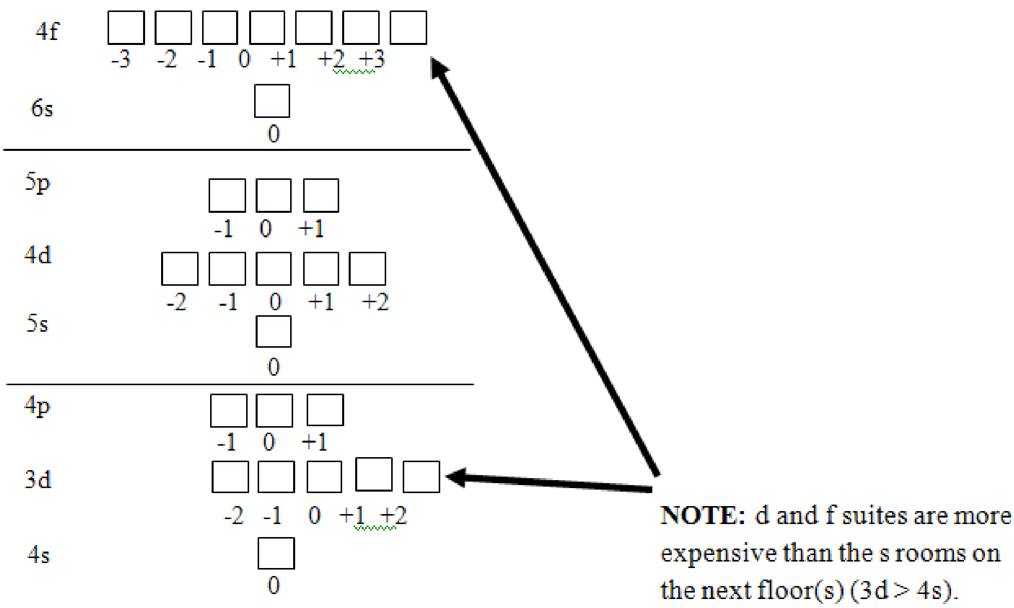
The letter m_l describes the specific room (most analogous to a room number.) Figure 1 shows a diagram of the hotel rooms available by floor.

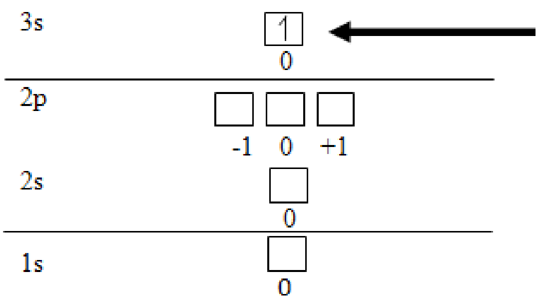
Figure 1: The Atomic Hotel by Floor



The preferred hotel diagram is one which shows the hotel rooms by cost (which, as stated in part I is the also the order in which the rooms are filled. Generally, the most inexpensive rooms are on the first floor, with prices increasing with floor.

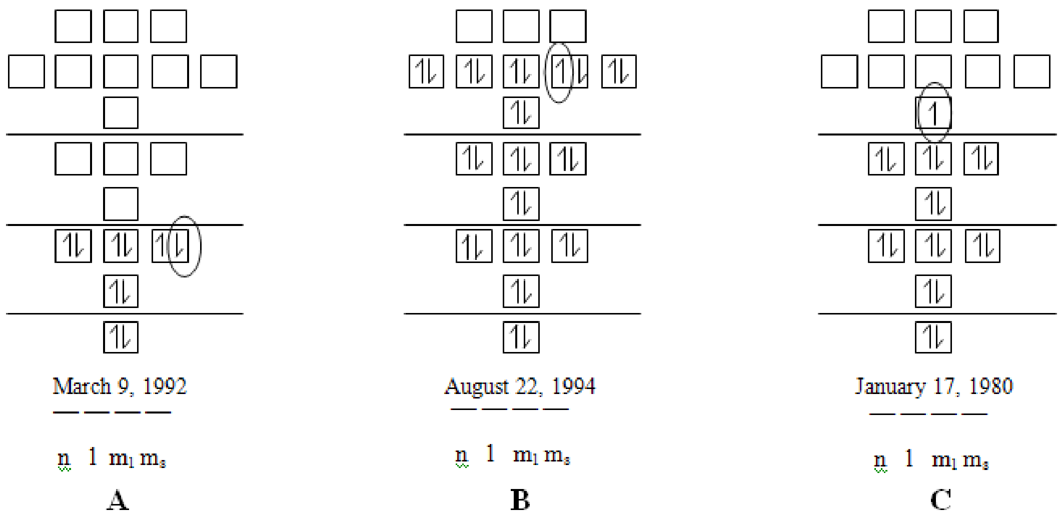
Note that d rooms are more expensive than the s or p rooms on the next floor. Electrons can pair up in a single room, therefore, the hotel has to have a way of identifying each one separately. This is done with m_s, the spin quantum number which is +½ or -½.



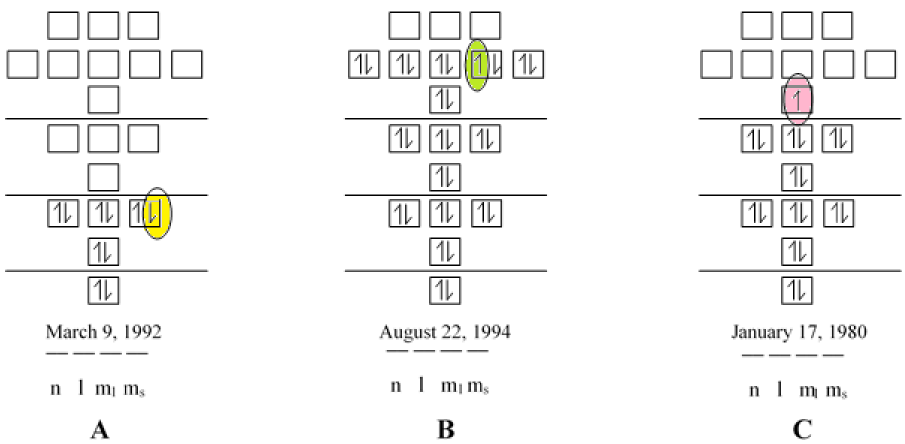


Example: an electron with the numbers 3, 0, 0, ½ is staying on the 3rd floor, in section s, in room #0, and is in + ½ spin state.

Using the above pattern, identify the circled electrons using the four quantum numbers.



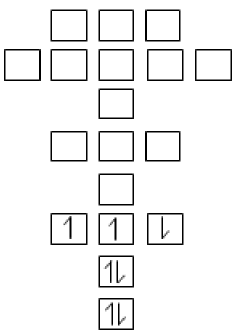
Answer



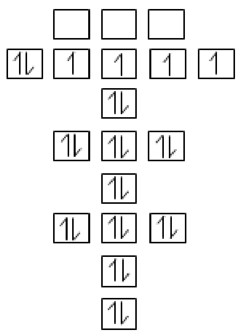
In A: The electron is in Floor: 2^{nd} floor Section: p Room: +1 Spin state: $-\frac{1}{2}$	**In B:** The electron is in Floor: 2^{nd} floor Section: p Room: +1 Spin state: $-\frac{1}{2}$	**In C:** The electron is in Floor: 4^{th} floor Section: s Room: 0 Spin state: $+\frac{1}{2}$

4. There is one more policy that helps the hotel run smoothly and keep customers happy. Hund's Rule states that if electrons are being placed in the same section of a floor (rooms that cost the same) then each one gets their own room and has the same spin until the floor is half-filled. If any more electrons want to stay in that same section, then they must pair up with another electron and assume the opposite spin. This does not necessarily apply to electrons that have purchased more expensive rooms.

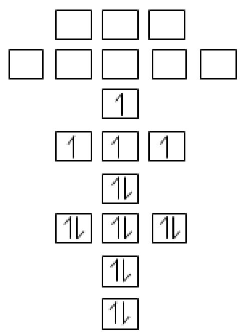
In the diagrams below identify the areas in which Hund's Rule was broken. Describe how the rule is being broken in each case.



February 12, 1997

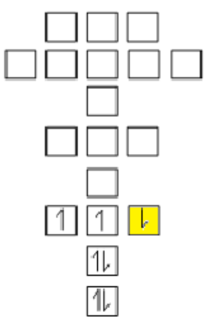


November 26, 1995



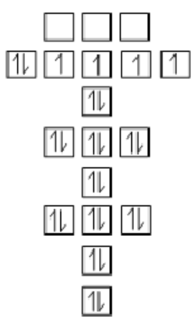
July 10, 1983

Answer



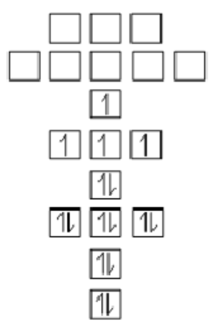
February 12, 1997

A



November 26, 1995

B



July 10, 1983

C

The electron in yellow room should have an up spin until the floor is half-filled, i.e with 3 electrons.

5. Observations:

a). How many "rooms" are there in an "s" suite of a floor?

Answer: 2 rooms

b). How many "rooms" are there in a "p" suite of a floor?

Answer: 3 rooms

c). How many "rooms" are there in a "d" suite of a floor?

Answer: 10 rooms

d). How many electrons can stay on the first floor?

Answer: 2 electrons

e). How many electrons can stay on the second floor?

Answer: 8 electrons

f). Describe how the rooms in each section are numbered.

Answer: Electrons in each section are numbered using m_l.

g). In diagram C (Section 4 above), describe why the electron could go into the 4s orbital instead of the 3p.

Answer: The electrons with more money (excited) could occupy more expensive rooms (orbitals with higher energy).

h). Why might section 3d fall between section 4s and 4p?

Answer: section 3d might fall between section 4s and 4p its cost is higher than that of 4s and lower than that of 4p.

i). Write out the electron configurations for each of the following elements: B, N, F and Na. Then identify the atoms whose atomic hotels were drawn in 1C, 2B, 3A, 3B, 3C, and 4B.

$$B(Z=5): 1s^2 2s^2 2p^1$$
$$N(Z=7): 1s^2 2s^2 2p^3$$
$$F(Z=9): 1s^2 2s^2 2p^5$$
$$Na(Z=11): 1s^2 2s^2 2p^6 3s^1$$

Counting the number of electrons allows to get the atomic number of each labelled element and determine it. Therefore, 1C is Potassium (Z=19), 2B is Potassium (Z=19), 3A is Oxygen (Z=10), 3B is Zinc (Z=30), 3C is Potassium (Z=19), 4B is Cobalt (Z=27)

UNIT 17

FORMATION OF IONIC AND METALLIC BONDS

17.1. Key unit competence

Describe how properties of ionic compounds and metals are related to the nature of their bonding.

17.2. Prerequisite (knowledge, skills, attitudes and values)

Students will learn better the formation of ionic and metallic bond if they have understanding on the symbols of elements and compounds, concept of bonding, the arrangement of elements in the periodic table and electronic configuration of at least the first 20 elements.

17.3. Cross-cutting issues to be addressed

a) Gender:

In this unit, gender cross-cutting issue must be dealt with by showing the relationships of the oppositely charged species with female and male. For example, the ionic bonding cannot be formed in presence of an anion without a cation! On the other hand, the metallic bonding cannot be formed between metal cations without electrons! This shows the complementarity between both sexes in the everyday life's context.

b) Comprehensive Sexuality Education:

There is General need of people to associate in order to be stronger, more productive, etc. The bonding character in atoms can be related to relationship in human beings. There is a serious issue of peer pressure and bandwagon (ikigare) in youth. When introducing this unit, it would be an opportunity to guide student-teachers on making informed decisions in their relationships. Help student-teachers to:

- Understand that relationship is very important. As atoms bond to gain stability so human beings also need to bond (relate) due to different reasons. Students should know that some relationship is natural (biological), for example, we do not choose family members but we can choose our friends.

- Understand that in choosing friends they have to be careful and make sure they make good friends who will support them to achieve their future goals.
- Reflect on their educational goals, the type of friends they have and their characters.
- Assess if the friends they have are likely to help them achieve their future goals or destroy their future.
- Make appropriate decisions.
- Be aware that elders (parents, school staffs) are willing to give guidance and advise them on this issue.
- Understand that the attraction between girls and boys is normal (like there is strong force of attraction between opposite charges which leads to formation of strong bonds). However, self control is very crucial to avoid undesirable consequences like contracting diseases like HIV/AIDS and other STIs; unwanted pregnancies, etc. Underline the necessity of cooperation and working in group rather than working in isolated way.

This can be done in a short whole class discussion but some points can be given to students as an assignment to be done during their free time. This may be a good entry point for the Integrated Science tutor to confront the individual student-teachers who need advise on relationship matter.

17.4. Guidance on introductory activity 17

Ionic and metallic bonds are the principal bonds studied since ordinary level.

- To introduce this unit, remember to use the activities which link the previous knowledge about bonding and the materials used in everyday life. Here the activity is proposed to you the teacher and for students.
- In the introductory activity, there are two figures, Figure 17.1(a) and Figure 17.1(b). *Figure 17.1* (a) shows different materials used in daily life. *Figure17.1(b)* shows the properties of ionic compounds.
- Use the introductory activity to make students have primary knowledge about ionic and covalent bonding and compounds.

Expected answers to questions in the Introductory activity

1. Figure 17.1(a)

a. Metals (Metal spoon, Wires, Saucepan, Hammer, Gas tank, etc)

- Plastics (Plastic spoon; plastic dishes, Plastic cover of wires, of knives, of machete, etc; battery cover; etc.
- Clothes (Dress, pants, shoes, etc)
- Porcelain (Vases, pot, room floor, etc)
- Wood (Stool, knife cover, etc)
- Glass (Lamp bulb, cup, etc)

b. The students answer freely

c. Frying need heat resistant and good heat conductor materials. Dishes, cups and plates do not mainly need the conductivity of heat.

d. Yes, dishes can be made of metal. Sometimes, ceramic and glass materials do not resist highly to heat and its thermal conductivity is limited.

2. Figure 17.2(b)

a. Explanation of the observations from the set up.

i. Because distilled water is a bad conductor of electricity

ii. Also solid table salt is a bad conductor of electricity

iii. Solution of table salt is a good conductor of electricity.

b. The changes observed

i. It is broken into small parts (it is brittle)

ii. It dissolves (it is soluble) in water

iii. No change. It has higher melting point.

17.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Explanations of why atoms of elements form bonds	Explain why atoms bond together.	2
2	Gain of stability by losing and gaining electrons	Explain the mechanisms by which atoms of different elements attain stability.	2
3	Ionic bonding	Outline the concept of ionic bonding Describe the properties of ionic compounds.	5
4	Metallic bonding	Describe the formation of metallic bonds. State the physical properties of metals and forces of attraction that hold atoms of metal.	2
5	End unit assessment		1

Lesson 1: Explanations of why atoms of elements form bonds

a) Learning objective

Explain why atoms bond together.

b) Teaching resources

Use the Leaner's text book, Manila paper, Learning videos and/or printed images depending on the availability of each.

c) Prerequisites/ Revision/ Introduction

For learners to learn better the "Explanations of why atoms of elements form bonds" they need to have prerequisites on the classification of chemical elements in metals and non-metals and their atomic structures.

d) Learning activity 17.1

- Before introducing the lesson, you will have to introduce the whole unit by allowing learners to do introductory activity and thereafter proceed to *Activity 17.1*which is specific to the first lesson.
- As you enter the class, inform the students on the activity taking place.

- Ask learners to sit in groups of 4 to 5 students and ask them to choose their group leader.
- Ask students to read carefully the introductory activity, discuss on it and answer the related questions.
- Ask students to read carefully the *activity 17.1* in the textbook and answer the related questions.
- Monitor the progress of the group discussion and assist them especially those who are still struggling, avoid communicating to them while helping them. Only give them a hint to discover for themselves.
- Invite group representatives to present their findings.
- Allow the learners to evaluate the findings.
- Integrate the cross-cutting issues indicated in the lesson and real life experiences.
- Summarise the learned knowledge and give examples which illustrate the learned content by confirm the correct answers, eliminate the wrong ones or complete the incomplete statements.
- In the already formed groups, allow the student-teachers to do the application *activity 17.1* and go through the class correcting.
- Give feedback basing on the answers given.

Answers to Activity 17.1

a. Chlorine

b. Chlorine has higher electronegativity than Argon; the electron configuration of chlorine ($1s^2s^22p^63s^23p^5$) shows that it needs only one electron to reach the more stable form of noble gases, where the outer shell is filled with the electrons and the configuration of argon ($1s^2s^22p^63s^23p^6$) shows that it does not need any more electrons. This stability makes it unreactive.

c. Argon

e) Answer to the Application Activity 17.1

The atoms of most elements form chemical bonds because the atoms become more stable when bonded together. Objects with high potential energy "seek" a lower energy, becoming more stable as a result. Atoms form chemical bonds to achieve lower potential energy.

Lesson 2: Gain of stability by losing and gaining electrons

a) Learning objective

Explain the mechanisms by which atoms of different elements attain stability.

b) Teaching resources

- Glass prisms
- Lamp torches
- Charts illustrating different types of atomic spectra
- Manila papers, flipcharts and YouTube videos with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Refer to lesson 1 above and use the concept of quantization of energy and radius to meet the above expectations.

d) Learning activity 17.2

Refer to Learning activity 17.2 which is suggested in the student's book

- Welcome the class to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- In the groups learners discuss, attempt *activity 17.2* and record their answers.
- Each group representative presents the Answers to his/her group to his/her classmates.
- You can make any corrections if any and provide *application activity17.1*.
- Make corrections with students to make sure there are no misconceptions

Answer to Activity 17.2

a. Sodium has one electron on the outer most shell.

i. Sodium needs seven electrons to be stable or to obey octet rule.

ii. The easiest way for Sodium to become stable or to obey Octet rule, is losing one electron to remain with 8 electrons on the outer most shell.

b. Chlorine has seven electrons on the outer most shell.

i. Chlorine needs one electron to become stable.

ii. The easiest way for Chlorine is gaining one electron in order to get 8 electrons on the outer most shell.

c. Neon has 10 electrons, 8 electrons are found on the outer most shell. It obeys Octet rule, it doesn't need to gain or loose electrons to become stable.

e) Answers to Application Activity 17.2

a. Statemement of the following Rules

i. Octet Rule states that elements gain or lose electrons to attain an electron configuration of the nearest noble gas.

ii. Duet Rule states that elements gain or lose electrons to attain an electronic configuration of the nearest noble gas.

b. i) Yes, because Sodium is not stable.

ii. The target of Sodium losing an electron and Chlorine gaining an electron is to obey Octet Rule or to attain the electronic configuration of their nearest noble gas.

C.Na^+ and Cl^-: They are stable, they attain the electronic configuration of the nearest noble gases, they obey Octet Rule.

Lesson 3: Ionic bonding

a) Learning objective

- Outline the concept of ionic bonding
- Describe the properties of ionic compounds.

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating Hydrogen spectral lines and spectral line series.
- Manila papers, flipcharts and YouTube videos with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Refer to lesson 2 above and use the concept of quantization of energy and radius to meet the above expectations.

d) Learning activity 17.3

Refer to *Learning activity 17.3* which was suggested in the student's book

- Welcome the learners to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- Assign the groups with tasks that can include group discussion or research.
- In the groups learners discuss, attempt *activity 17.3* and record their answers.
- Each group representative presents the Answers to his/her group to his/her classmates.
- During the presentation ask some questions that lead to lesson conclusion.
- Give feedback and use the exercises given in the Textbook to familiarize more on the contents.
- You may use the *Application Activity17.3* as the work or homework for evaluation; and after that it is just done, correct it and help those who were unable to give the correct answers.

Answers to Activity 17.3

a. Ionic bond is the bond formed between the metal and the non-metal atoms.

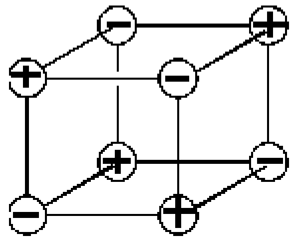
b. The properties of a table salt (of ionic compounds in general)

- Appearance: Crystalline solid
- Solubility: Soluble in water and insoluble in organic solvent
- Temperature required to melt: High (more than 100^{o}C)
- Electrical conductivity: Solid does not conduct and its aqueous solution conducts.

e) Answers to Application Activity 17.3

1. Diagram of a part of the structure of sodium chloride.

a. All charges marked

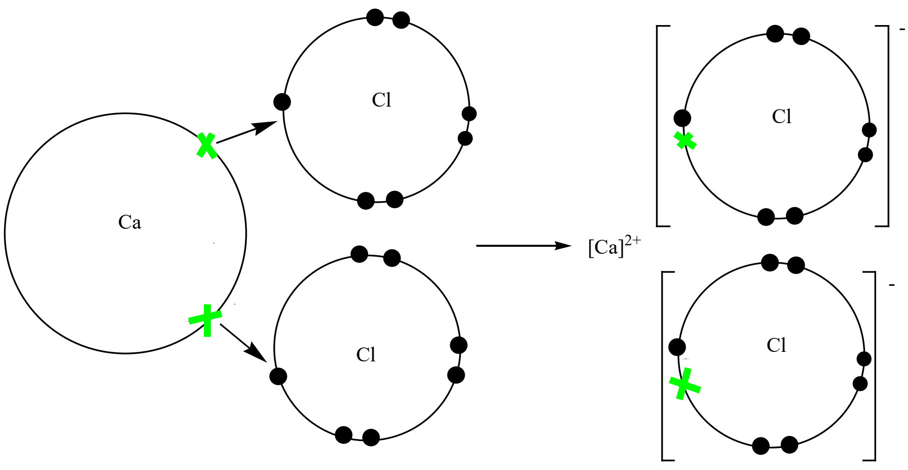


b. The kinetic energy increases leading to the increase in motion of ions which go far apart between them and then the state changes from solid to liquid.

c. This electron comes from sodium.

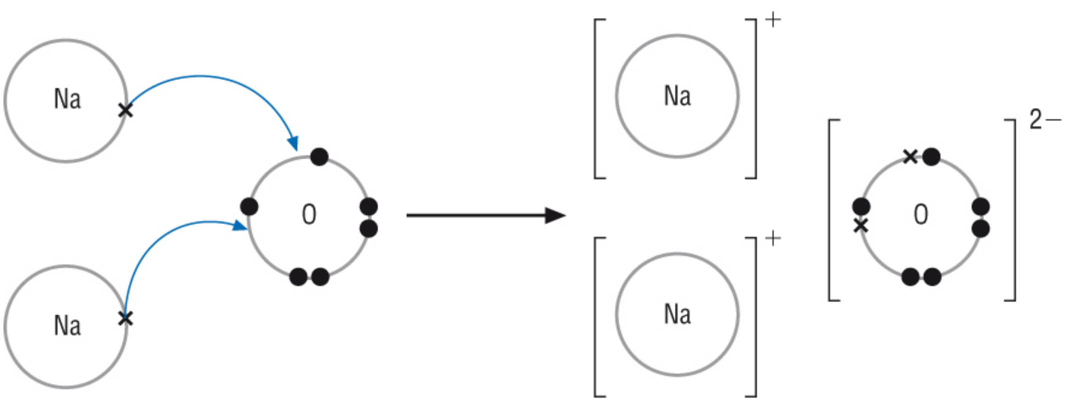
2. Diagrams illustrating the formation of ionic compounds some substances:

a. Calcium chloride

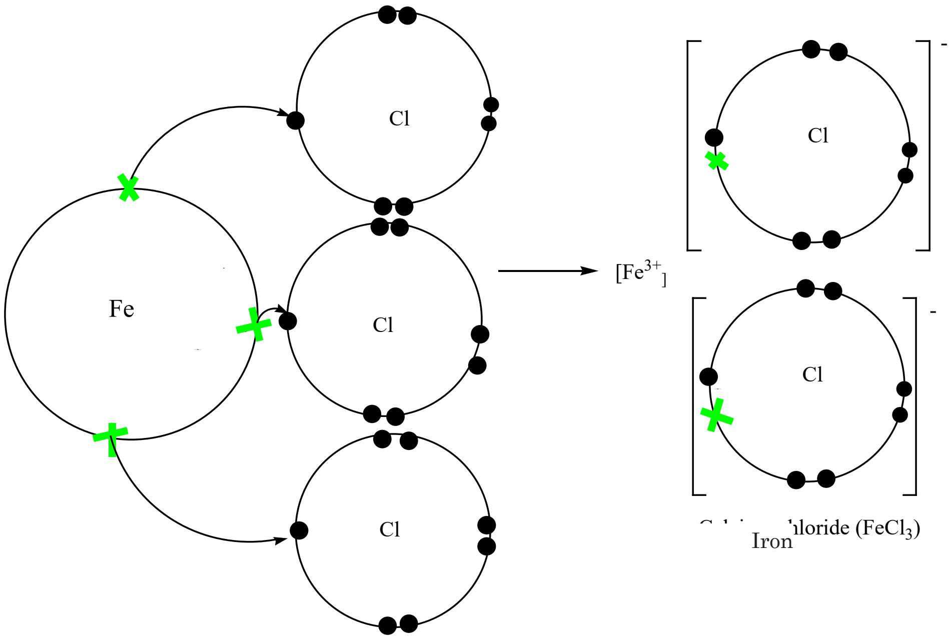


Calcium chloride ($CaCl_2$)

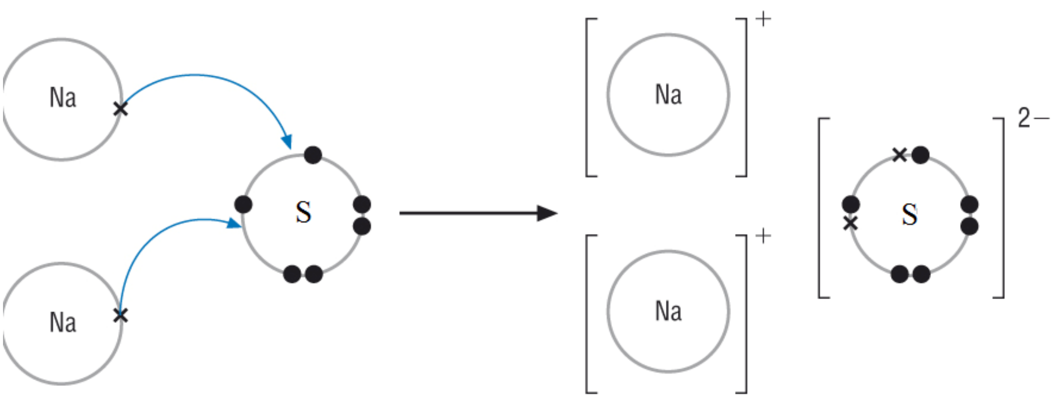
b. Sodium peroxide



c. Iron (III) chloride



d. Sodium sulphide



3. Solid sodium chloride and solid magnesium oxide.

a. **(i) Na^+: $1s^2\ 2s^2\ 2p^6$**

(ii) Cl^-: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
(iii) Mg^{2+}: **$1s^2\ 2s^2\ 2p^6$**
(iv) O^{2-}: **$1s^2\ 2s^2\ 2p^6$**

b. The electrostatic forces between positively charged and negatively charged ions.

c. The charges in NaCl are lower than those in MgO. Also sodium ion is larger than sodium making the inter-nuclear radius to be longer and hence weaker in NaCl than in MgO.

Lesson 4: Metallic bonding

a) Learning objective

- Describe the formation of metallic bonds.
- State the physical properties of metals and forces of attraction that hold atoms of metal.

b) Teaching resources

- Charts illustrating different types and shapes of orbitals
- Manila papers, flipcharts and Movies with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Refer to lesson 1above and use the concept of energy levels so as to meet the above expectations. A particular attention must be put on the concept of orbital.

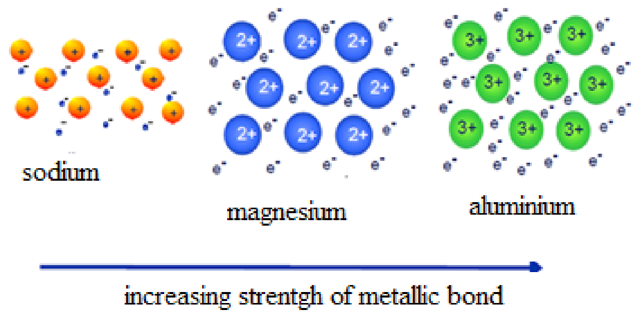
d) Learning activity 17.4

Refer to *Learning activity 17.4* which is suggested in the student's book.

- Welcome the class to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- Assign the groups with tasks that can include group discussion or research.
- In the groups learners discuss, attempt *activity 17.4* and record their answers.
- Each group representative presents the Answers to his/her group to his/her classmates.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the learners' findings and emphasize on which are correct, incomplete or false
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples.
- Let student-teachers attempt *application activity 17.4.* They should do the *application activity* in any method you wish to use.

Answers to Activity 17.4

1. Any examples (at least three) of metals.
2. They are sonorous, have higher melting and boiling points, etc.
3. Aluminium metal is chosen for example,
   a. Aluminium atoms
   b. Internal structure of aluminium.



e) Answers to Application Activity 17.4

1. a. Magnesium has a higher melting and boiling point than sodium.

- The *electronic structures:* Sodium has one outer electron which it can delocalize to form the metallic bond; magnesium has two. So with magnesium there will be a higher electron density in the bond. Magnesium also has an extra proton. There will therefore be stronger attractions between the nuclei and the delocalized electrons, making the bond harder to break, and so more energy is needed to melt or boil the magnesium.
- The *packing:* Each magnesium atom is in close contact with 12 others, whereas sodium only has 8 near-neighbours. This creates more bonding in the magnesium.
- The *atomic radii:* Magnesium atoms are smaller than sodium atoms because of the extra proton in the magnesium. Magnesium nuclei are therefore closer to the bonding electrons, strengthening the bond.

b. In their structure, there are free/delocalised electrons that carry charges. For a substance to conduct electricity it must have mobile ions or electrons. Because the electron cloud is mobile, electrons are free to move throughout its structure. Electrons attracted to the positive end are replaced by those entering from the negative end.

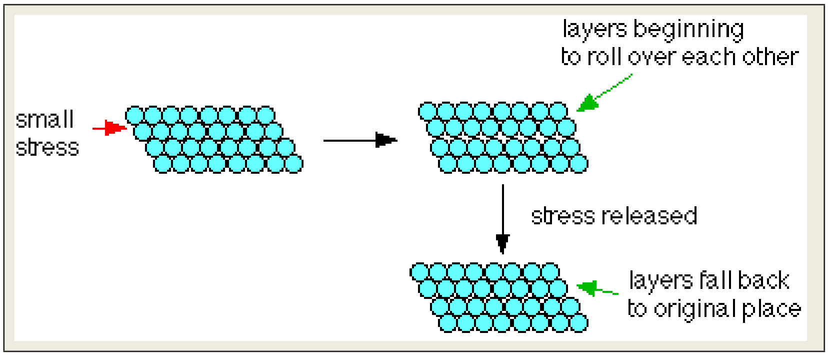
c. Free electrons are able to transfer energy away from the heat source. This due to the presence of delocalized electrons that vibrate in fixed positions when heat energy is applied to one end of the metal hence allowing it to be conducted from one point to another.

2. Pure metals are usually malleable and ductile.

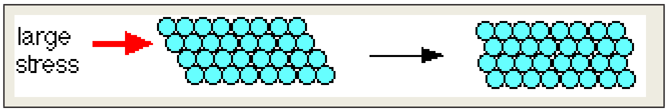
a. • *Malleable*: Something that can be shaped in its solid form.

• *Ductile*: Something that can be drawn into tubes or wires.

b. Metals are described as ***malleable*** (can be beaten into sheets) and ***ductile*** (can be pulled out into wires). This is because of the ability of the atoms to roll over each other into new positions without breaking the metallic bond. If a small stress is put onto the metal, the layers of atoms will start to roll over each other. If the stress is released again, they will fall back to their original positions. Under these circumstances, the metal is said to be ***elastic.***



If a larger stress is put on, the atoms roll over each other into a new position, and the metal is permanently changed.



c. Heating a piece of metal tends to shake the atoms into a more regular arrangement with fewer grain boundaries (breaks in the regular pattern). The grain boundaries stop the layers of atoms from rolling over each other easily, and so removing them make the metal softer. Hitting the metal breaks up the regular structure again, producing lots of small crystal grains, and so increasing the number of grain boundaries. That makes it more difficult for the layers of atoms to roll over each other, and so hardens the metal.

d. Copper and zinc atoms are not of the same size. A structure containing both of them will be much more irregular than one containing identically sized atoms. This will make it more difficult for the layers to slide over each other, and so the alloy is harder than the individual metals.

17.6. Summary of the Unit

The atoms of most elements form chemical bonds because the atoms become more stable when bonded together. It is easiest to apply the "**Octet Rule"** to predict whether two atoms will form bonds and how many bonds they will form. Most ***atoms need 8 electrons to complete their outer shell***. The octet rule states that elements gain or lose electrons to attain an electron configuration of the nearest noble gas.

Ionic bond, covalent bond and metallic bond are the main types of bonding. Here, let us talk about ionic and metallic bonding only.

- **Ionic bond**

An ionic bond is a chemical bond formed between two ions with opposite charges. Ionic bonds form when one atom gives up one or more electrons to another atom. These bonds can form between a pair of atoms or between molecules and are the type of bond found in salts.

The ionic bond is formed by **complete transfer of electrons from one to the other, being a metal atom and the other a non-metal atom.**

Due to the atoms are neutral,

- When an atom gives up an electron, it is positively charged, forming what is called ***a positive ion*** or **cation**. The positive charge of a monovalent cation is equal in magnitude but opposite to that of the electron (1,602 x 10^{-19} C) sign.
- If an atom captures one electron, it will be negatively charged, thereby forming ***a negative ion*** or ***anion***. The negative charge of a monovalent anion is therefore the same as the electron.

When two counter-ions have been formed, i.e. a cation and an anion, they attract each other through **electrostatic forces**, and so, they can form a stable molecule. These ***electrostatic attractive forces*** (sometimes called **Coulomb forces)** are therefore responsible for the formation of ionic compounds.

The properties of ionic compounds relate to **how strongly the positive and negative ions attract each other** in an ionic bond and these are the following:

1. They have high melting points and high boiling points
2. *Most ionic compounds are soluble in water*
3. They are hard and brittle
4. They conduct electricity when molten or dissolved in water
5. They form crystals

- **Metallic bond**

A metallic bond ***is a type of chemical bond*** formed between positively charged atoms in which the free electrons are shared among a lattice **of cations.** It is the main type of chemical bonds that forms between metal atoms (pure metals and alloys and some metalloids).

Because electrons are delocalized around positively-charged nuclei, metallic bonding explains many properties of metals. The three main factors that affect the strength of a metallic bond are:

- The more protons the stronger the force of attraction between the positive ions and the delocalized electrons
- The more delocalized electrons the stronger the force of attraction between the positive ions and the delocalized electrons
- The smaller the atom, the stronger the force of attraction between the positive ions and the delocalized electrons and vice-versa, the larger the atom, the weaker the force of attraction between the positive ions and the delocalised electrons.

The main physical properties of metallic metals are given below.

1. Electrical Conductivity
2. Thermal Conductivity
3. Ductility
4. Malleability
5. Metallic Luster

17.7. Additional information for tutors

"The concept of lattice energy and the factors that influence the magnitude of the lattice energy"

The lattice energy can be defined as the amount of energy needed to separate the constituent ions of an ionic solid. An ionic solid is composed of two oppositely charged ions: cation and anion. The ionic solid shows unique properties which are quite different from its constituent elements. For example, sodium chloride is composed of sodium and chlorine. We know that sodium is a solid metal and chlorine is a non-metal. When both are bonded together to form sodium chloride, the whole process involves various steps.

Sodium chloride is an ionic solid which consists of ions formed by the transfer of electrons. These ions are attracted towards each other to get together and form a crystal.

In a crystal of sodium chloride, these ions are stacked up alternatively into the cube-shaped arrangement. The shape of ionic solids depends upon the size of constituent ions. Overall all ionic compounds make a crystal shape where ions are held together into a crystal lattice which is an arrangement of alternating ions held together by opposite charges. A crystal consists of matter that is formed from an ordered arrangement of atoms, molecules, or ions. The lattice that forms extends out in three-dimensions. Because there are repeated units, crystals have recognizable structures.

Large crystals display flat regions (faces) and well-defined angles. For example,

- **NaCl** *is* **Face centered Cubic** where Cl^- ions are face centered cubic (FCC) and Na^+ ions are in holes.
- *CsCl is* **Body Centered Cubic** where Cs^+ ions are simple cubic (SC) and Cl^- ions are in center.

The factor which determines the strength of these crystals is called lattice energy. As the lattice energy increases, the strength and stability of the crystal lattice increases. Lattice energy mainly depends upon the charge of ions and inter-ionic distance in a crystal lattice. Therefore these two factors determine the trend of lattice energy.

- **Charge on ions**

As the charge on oppositely charged ions increases, the electrostatic force of attraction increases between them which results in high lattice energy. Therefore an ionic solid with divalent ions have much larger lattice energies compare to solids with monovalent ions. For example, the lattice energy for sodium chloride (NaCl) is +786 kJ/mol whereas for magnesium oxide (MgO), it is +3800 kJ/mol.

- **Radius or size of ion**

As the ionic radius decreases, ions get closer to each other increasing the strength of the attractions as well as the lattice energy of ionic solid. The similar trend can be observed in alkali halide. Overall as we go down in a group, ionic radius increases and lattice energy decrease. In a period from left to right as the charge on ion increases, lattice increases.

17.8. End unit assessment 17 (answers)

Suggested answers to the End Unit Assessment

1. False. Sodium chloride has a lower melting point than magnesium oxide because the charges in NaCl are lower than those in MgO. Also sodium ion is larger than sodium making the inter-nuclear radius to be longer and hence weaker in NaCl than in MgO.

2. When a stress is applied to the ionic lattice, the layers shift slightly. The layers are arranged so that each cation is surrounded by anions in the lattice. If the layers shift then ions of the same charge will be brought closer together. Ions of the same charge will repel each other, so the lattice structure breaks down into smaller pieces.

3. This because in an ionic lattice, there are many strong electrostatic attractions between oppositely charged ions.

4. When the ionic compound is dissolved in water, an aqueous solution is formed. The ions are released from the lattice structure and are free to move so the solution conducts electricity just like the molten (liquid) ionic compound.

5. This question is about metallic bonding.
   a. A metallic bond is a type of chemical bond formed between positively charged atoms in which the free electrons are shared among a lattice of cations. It is a lattice of positive metal 'ions' in a 'sea' of delocalised electrons.
   b. The electrons in the electron sea are free to move and carry charge. The electrons simply slide over each other instead of separating. Electrons in a crystal may be replaced by others.
   c. In aluminium structure, there are many delocalised electrons than in that of magnesium.

6. Silver and sodium chloride.
   - Sodium chloride is brittle but silver is not. If the layers, in sodium chloride, shift then ions of the same charge will be brought closer together. Ions of the same charge will repel each other, so the lattice structure breaks down into smaller pieces. But this is not the case in metallic structure of silver.
   - Sodium chloride is soluble in water but not silver. Sodium chloride is a polar molecule.

7. This is about calcium oxide.
   a. The atoms in calcium oxide are bonded by ionic bond. Refer to the Student Book to describe the nature and strength of the ionic bonding (in solid calcium oxide).

b. At 25°C, CaO is a solid and the particles are in a regular lattice and only able to vibrate about a mean position in that lattice. As you increase the temperature, the particles gain energy and vibrate more vigorously within the lattice. At the melting point, the energy of the vibrations is just sufficient to overcome the forces holding the particles in the lattice and the lattice breaks down and the particles become free to move about in molten calcium oxide. As the temperature is increased further, the particles gain more kinetic energy and move faster.

c. It has high melting and boiling point, it is hard, it forms crystals, when solid does not conduct electricity, etc.

17.9. Additional activities (Questions and answers)

17.9.1. Remedial activities

1. Explain why metals are malleable and ductile but ionic-crystalline compounds are not.

Answer: The metallic bond is the same in all directions throughout the metallic structure allowing the atoms to slide past each other. This sliding is why metals are ductile and malleable. Ionic compound must break bonds to slide past one another, which causes the ionic material to split and crack.

2. Explain why metal surfaces are shiny.

Answer: Metals are shiny or have luster due to the many available orbitals, which can absorb and give off a wide spectrum of light.

3. Describe the electron-sea model of metallic bonding. Explain why metals are good electrical conductors.

Answer: In the electron-sea model of bonding the valence electrons are free to move in the large number of vacant orbitals. These empty overlapping orbitals (the "p", "d" and "f" orbitals) allow the electrons to delocalize with the ability to move freely from one atom to the next. Metals are such good conductors due to the freedom with which the valence electron can move.

4. Why does not solid sodium chloride conduct electricity?

Answer: This only works if ions are free to move in the sodium chloride. In solid sodium chloride, they are locked into a rigid lattice and aren't free to move.

17.9.2. Consolidation activities

1. Define the terms
   a. Lattice dissociation enthalpy

Answer: Lattice dissociation enthalpy is the enthalpy change needed to convert 1 mole of solid crystal into its scattered gaseous ions.

   b. Lattice formation enthalpy.

Answer: Lattice formation enthalpy is the enthalpy change when 1 mole of solid crystal is formed from its scattered gaseous ions.

2. NaCl, NaBr and MgO all have the same crystal structure.
   a. Explain why the lattice dissociation enthalpy of NaBr is a bit less than that of NaCl.

Answer: Lattice dissociation enthalpy is a measure of the forces of attractions between the positive and negative ions. Bromide ions are bigger than chloride ions, and so the distance between the centres of the positive and negative ions in the lattice is greater in NaBr. Increasing distance weakens the forces of attraction between them, and hence the lattice enthalpy.

   b. Explain why the lattice dissociation enthalpy of MgO is about 5 times greater than that of NaCl

Answer: There are two factors at work here. Magnesium ions are smaller than sodium ions, and oxide ions are smaller than chloride ions. That means that the distance between the positive and negative ions is quite a lot less in MgO than in NaCl, and so the forces of attraction will be greater in MgO.

But the main factor is the charge on the ions. In MgO, both positive and negative ions carry two charges. In NaCl, they only carry one. The strength of the attractions is much greater in MgO than in NaCl.

(In fact, the strength of the attractions is proportional to the charges on the ions. If you double the charges on both positive and negative ions, the strength of the attractions will go up 4 times. The question says that the MgO lattice enthalpy is about 5 times greater than that of NaCl. The extra is due to the shorter distance between the ions in MgO.)

3. Why do metals have high density compared to non-metals or plastics?

Answer: Most common metals like aluminium, copper, and iron are denser than plastic or wood. The atoms that make up metals are generally heavier than the atoms in plastic and wood and they are packed closer together. The difference in density between different metals is usually based on the size and the mass of the atoms but the arrangement of the atoms in most metals is mostly the same.

17.9.3. Extended activities

1. Sodium chloride and magnesium oxide have exactly the same structure. Their melting and boiling points are:

Melting point /K	NaCl	MgO
	1074	3125
	1686	3873

a. Explain why the values for magnesium oxide are much higher than those for sodium chloride.

Answer: Melting and boiling points depend on the attractions between the ions. In MgO, 2+ magnesium ions are attracting 2- oxide ions. These attractions will be much stronger than those between 1+sodium and 1- chloride ions.

b. Explain why ionic compounds such as sodium chloride have brittle crystals.

Answer: A small shock to the crystal brings ions of the same charge alongside each other. The repulsions will shatter the crystal. (Use diagram to explain well).

2. Molten sodium chloride undergoes electrolysis. Electrolysis is a chemical change produced by passing an electric current through a molten substance or a solution in water.

a. Explain (including an electrode equation) what happens at the cathode.

Answer: Positive sodium ions are attracted to the negatively charged cathode. When they get there, they are neutralised when electrons from the electrode jump on to the ion. Neutral sodium atoms are formed, which come together as a drop of molten sodium metal. $Na \rightarrow Na^+ + e$

b. Explain (including an electrode equation) what happens at the anode.

Answer: Negative chloride ions are attracted to the positively charged anode. When they get there, they release electrons to the electrode, and form chlorine atoms. These immediately pair up to give chlorine gas, $Cl_2 + 2e- \rightarrow 2Cl^-$

c. Explain why this enables an electric current to flow around the external circuit.

Answer: Electrons are being removed from the cathode, leaving a space on the cathode. Electrons are being added to the anode. The power source can move electrons through the external circuit from the anode to the cathode to replace those being removed. Movement of electrons is an electric current.

UNIT 18

VARIATION IN TRENDS OF THE PHYSICAL PROPERTIES

18.1. Key Unit competence

Use atomic structure and electronic configuration to explain the trends in the physical properties of the elements.

18.2. Prerequisite (knowledge, skills, attitudes and values

The student-teachers will learn deeper the content of this unit if they have a good understanding on the atomic and electronic structures.

18.3. Cross cutting issues to be addressed

This unit involves a number of activities on the variation in trends of the physical properties. The activities require reading and writing. This may be challenging to students with special educational needs especially children with visual impairment. However, the teacher can make some arrangements like:

- Grouping students. Students with special educational needs are grouped with others and assigned roles basing on individual student's abilities.
- Providing procedure earlier before the activity so that students get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts or in Braille.
- Every important point is written and spoken. The written points helps students with hearing impairment and speaking aloud helps students with visual impairment
- Remember to repeat the main points of the lessons.

a) Gender

During group activities try to form heterogeneous groups (with boys and girls) or when students start to present their findings encourage both (boys and girls) to present.

b) Peace and values education

During group activities, the teacher will encourage learners to help each others and to respect opinions of colleagues.

18.4. Guidance on introductory activity

Before introducing the first lesson (outline of the discovery of the atom constituents and their properties) of this unit, let learners attempt the introductory activity.

Expected Answers to the introductory activity

If at your school there is a library where books are classified according to different subjects; this can be a basic to understand why elements are classified in the periodic table. The elements in the periodic table can be classified into corresponding groups and periods. The elements can be classified based on their atomic numbers but also based on their chemical/physical properties.

After observing a periodic table, you may found that a modern periodic table comprised 18 groups and 7 periods. The electronic configuration of elements indicates the location of element is its corresponding group and period. The Period of an element is equal to the highest energy level of electrons or principal quantum number. The number of electrons in the last orbital shows the group of element.

18.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Historical background of the Periodic Table	Outline the historical back ground of the Periodic Table.	1
2	Comparison of Mendeleev's table with the modern Periodic Table	Compare Mendeleev's table with the modern Periodic Table	2
3	Location of the elements in the Periodic Table based on the electronic configuration	Classify the elements into respective groups and periods using electronic configuration	3
4	Classification of the elements into blocks (s, p, d, f-block)	Classify the elements into blocks (s, p, d, f-block).	2

5	Factors that influence the change of each physical property of the elements across a period and down a group	Explain factors that influence the change of each physical property of the elements across a period and down a group	1
6	Variation of the physical properties down the group and across the period	- Explain the trends in the physical properties of the elements across a period and down a group. - Relate trends in physical properties of the elements to their electronic configuration.	4
7	End unit assessment		1

Lesson 1: Historical background of the Periodic Table

a) Learning objective

Outline the historical back ground of the Periodic Table.

b) Teaching resources

Charts of periodic table of chemical elements

Flip charts, smart board, chalk board

c) Prerequisites/Revision/Introduction

The student-teachers will learn deeper this lesson if they have a good understanding of the concept of periodic table studied in senior 1.

d) Learning activity 18.1

- Before introducing the lesson, let learners therefore attempt activity 18.1 which leads
- students to the second lesson of the unit
- As facilitator you are expected to guide learners through the following steps.
- Form groups of four and let the learners perform the activity 18.1
- Let learners to work together in their groups without intervene directly.

- Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Let some groups present their work to the class
- Allow the rest of the class to evaluate the work of their colleagues
- Summarize the contents based on the student-teachers findings.

Answers to activity 18.1

1. Yes, I noticed similarities between relatives at a family reunion.\
2. Physical characteristics indicate among the family members their relationship.
3. Physical traits include hair color and type, attached earlobes, adorable freckles, eye color and hairline among family members.

See student-teacher's book, lesson 18.1: Historical background of the Periodic Table

e) Answers to application activity 18.1

1. Scientist have undergone a systematic classification of the chemical elements in order to first classify the big groups of metals and non-metals.
2. Elements are classified in groups and periods so that elements having similar properties fall in the same group and corresponding to the same principal quantum number fall in the same period.
3. K(Z=19): $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ Cl(Z=17): $1s^2 2s^2 2p^6 3s^2 3p^5$

Lesson 2: Comparison of Mendeleev's table with the modern Periodic Table

a) Learning objective

Compare Mendeleev's table with the modern Periodic Table

b) Teaching resources

Charts of the periodic table of chemical elements

Smart board, chalkboard, textbooks

c) Prerequisites/Revision/Introduction

The student-teacher will get accurately compare the Mendeleev and the modern periodic table if they have a good understanding on the criteria used in the development of the periodic table and the atomic structure.

d) Learning activity 18.2

- Form group of four students and let them do activity 18.2
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 18.2

Answer for activity 18.2

1. A modern periodic table groups elements in 18 columns and seven lines. Elements are arranged in increasing order of atomic number. There are no blank spaces between two elements on the modern periodic table. Elements with similar properties are found in the same columns.
2. Gaps found on the Mendeleev periodic table correspond to elements not yet discovered at the Mendeleev's time which should be discovered later.
3. 118 elements

e) Answers to application activity 18.2

1. See student teacher's book, lesson18.2: Comparison of Mendeleev's table with the modern Periodic Table,
2. Cobalt and nickel in the Mendeleev's periodic table were located in group VIII after iron.

Lesson 3: Location of the elements in the Periodic Table based on the electronic configuration

a) Learning objective

Classify the elements into respective groups and periods using electronic configuration

b) Teaching resources

Charts of the periodic table of chemical elements

Smart board, chalkboard, textbooks

c) Prerequisites/Revision/Introduction

The student-teachers will learn better the content of this lesson if they have a good understanding on the electronic structure using the spdf notation.

d) Learning activity 18.3

- Form group of four students and let them do activity 18.3
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 18.3

Answers to activity 18.3

1. a. The electronic configuration of the element $_{25}Mn$ is: 2, 8, 8, 7 or $1s^2 2s^2 2p^6 3s^2 3p^6 \mathbf{4}s^2 3d^5$

   The electronic configuration of the element $_{11}Na$ is: 2, 8, 1 or $1s^2 2s^2 2p^6 \mathbf{3}s^1$

   b. Information about the element $_{25}Mn$: For the element $_{25}Mn$, the value **4** is the highest energy level of electrons or principal quantum number. Thus the period of Mn is 4. Since the last sub shell is s and d, the element manganese (Mn) is located in group 7 of the modern periodic table.

This element has the electron configuration **ns** and **(n-1)d**, thus, it informs us that the element is located in group of element corresponding to transition metals.

c. X belong to 7^{th} group and Y belongs to 1^{st} group

X belongs to 4^{th} period and Y belongs to 3^{rd} period.

2. An element with 1.5 atomic number and located between hydrogen and helium does not exist. The atomic number is equal to the number of protons and equal to the number of electrons for a neutral aton. It is not possible of existence of half proton or electron.

e) Answers to application activity 18.3

1. a) X is located in Group 1 of the periodic table, it is an alkaline metal: The answer is True

   b) Y is in p block: True

   c) Z is an halogen: True, it is located in group 17.

   d) U is lanthanide: False because it is located in d-block while the lanthanides are located in f- block.

   e) T is noble gas: True because T is located in group 18 which include the noble gases.

2. The main body of the periodic table is a 18 × 7 grid. It comprises 18 columns and 7 lines. The period relates to the principal energy level. The Group of an element is equal to the number of outermost or valence electrons of element or number of electrons in the highest energy level of elements.

Lesson 4: Classification of the elements into blocks (s, p, d, f-block)

a) Learning objective

Classify the elements into blocks (s, p, d, f-block).

b) Teaching resources

Charts of the periodic table of chemical elements, smart board, chalkboard and textbooks.

c) Prerequisites/Revision/Introduction

The student-teachers will learn better the content of this lesson if they have a good understanding on the electronic structure using the spdf notation.

d) Learning activity 18.4

- Form group of four students and let them do activity 18.4
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 18.4

Answers to activity 18.4

1. Condensed electronic configurations for the suggested elements

   Al (Z = 13) : $[Ne]3s^2 3p^1$

   K(Z = 19) : $[Ar]4s^1$

   Fe(Z = 26) : $[Ar]3d^6 4s^2$

   Br(Z = 35) : $[Ar]3d^{10} 4s^2 4p^5$

   Sr(Z = 38) : $[Kr]5s^2$

   Zr(Z = 40) : $[Kr]4d^1 5s^2$

   Nd((Z = 60) : $[Kr]4f^4 6s^2$

   Yb(Z = 70) : $[Kr]4f^{14} 6s^2$

2. For Al, K, Fe, Br, Sr, Zr, Nd, and Yb the last sub-shell occupied with electron is **3p, 4s, 3d, 4p, 5s, 4d, 4f and 4f** respectively. Elements with the same last sub-shell occupied with electrons can be grouped together. They are said to be in the same block.

e) Answers to application activity 18.4

1. a) four blocks: s bloc; p, d block and f block.

    b) the criterion used for that classification is the last shell that is occupied by electrons.

2. s-block elements will tend to form positive ions whereas p bloc elements tend to form negative ions.

3. Examples of elements of:

    s block: lithium and calcium

    p block: silicon and fluorine

    d block: manganese and titanium

    f block: luthenium and uranium

4. Since d block elements are placed in between of s and p and their properties are also in between the properties of s block elements and those of p block elements and therefore, they are called as transition elements.

5. The elements in groups 3 through 12 are called the transition metals, first series.

The f-block elements are called inner- transition elements because of their location in the periodic table due to their electronic configuration. Atoms fill f-orbitals that are in principal energy levels that are lower than the outermost electrons. The inner-transition elements are two series of elements known as the lanthanides and a series of Actinides.

Lesson 5. Factors that influence the change of each physical property of the elements across a period and down a group

a) Learning objective

Explain factors that influence the change of each physical property of the elements across a period and down a group

b) Teaching resources

Charts of the periodic table of chemical elements

Smart board, chalkboard, textbooks

c) Prerequisites/Revision/Introduction

The student-teachers will learn better the content of this lesson if they have a good understanding on the electronic structure using the spdf notation.

d) Learning activity 18.5

- Form group of four students and let them do activity 18.5
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 18.5

Answers to activity 18.5

The elements in the periodic table display many trends which can be used to predict their physical properties. These properties are periodic functions of their atomic number.

All Periodic Table Trends are influenced by three factors:

- Energy Level: Higher energy levels are further away from the nucleus.
- Nuclear charge (number of protons): More charge pulls electrons in closer.
- Shielding or screening effect.

e) Answers to application activity 18.5

The energy levels and Shielding have an effect on the GROUP whereas the nuclear charge has an effect on a PERIOD.

Lesson 6. Variation of the physical properties down the group and across the period

a) Learning objectives

- Explain the trends in the physical properties of the elements across a period and down a group.
- Relate trends in physical properties of the elements to their electronic configuration.

b) Teaching resources

Charts of the periodic table of chemical elements

Smart board, chalkboard, textbooks

c) Prerequisites/Revision/Introduction

The student-teachers will learn better the content of this lesson if they have a good understanding on the electronic structure using the spdf notation.

d) Learning activity 18.6

- Form group of four students and let them do activity 18.6
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting how the methods of metal extraction depend mainly on the reactivity of the metal and make clear different ways to concentrate the ore.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 18.6

Answers to activity 18.6

1. a) For elements of the same period the ionisation increases from left to right because the nuclear charge is increasing.

   b) For elements of the same group, the ionisation energy decreases downwards because when the group is descended, the number of shells increases and outermost shell electrons are far away from the nucleus. Therefore, it requires small amount of energy to remove it.

2. See student teacher's book, lesson18.6: Variation of the physical properties down the group and across the period

e) Answers to application activity 18.6

1. a) the atomic radius decreases a period because as the nuclear charge increases, electrons are more strongly pulled by the nucleus. This result in the reduction of the atomic size.

   b)The electronegativity decreases down the group with increasing size of the atom

   c) Electron affinity increases across a period because from left to right within a period, atoms accept more easily electron and therefore more energy is released.

2. a) (i) In metals the melting point generally decreases down the group with decreasing strength of the metallic bonding. In non-metal, the melting point increases down the group with increasing molecular mass.

   (ii) Across a period the melting point does not follow a regular trend because it depends on both the nature of the bonding and the structure.

   b) (i)The metallic character decreases across a period as the atomic size decreases.

   (ii) Across a period the metallic character increases with increasing atomic size

3. When an electron is removed from an atom, the remaining electrons are pulled more strongly by the nucleus and the removing of the following electrons require more and more energy.

4. (a) Cl , (b) Na^+, (c) O^{2-}, (d) Al^{3+}, (e) Au^{3+}.

5. Calcium has a smaller size and calcium has a greater charge than potassium. Therefore the removal of the first electron requires more energy. The second electron of potassium is removed from an inner shell and that is stable.

18.6. Summary of the unit

The **periodic table** is an arrangement of the elements in order of their atomic numbers so that elements with similar properties fall in the same column or group.

The physical and chemical properties of the elements are periodic functions of their atomic number.

Dmitri Mendeleev was the first to suggest an acceptable arrangement of the elements in 1869..

Elements in the periodic table can be placed into two broad categories, **metals** and **non metals**.

Metals and non metals on the periodic table are often separated by a stairstep diagonal line, and several elements near this line are often called metalloids (Si, Ge, As, Sb, Te, and At).

The group to the farthest right of the table is known as the noble gases.

Elements are also classified into blocks (s, p, d, f-block) based on their electron configurations:

The first two groups constitute the ***s*** block and

The last six groups the **p** block.

The ***d***-block elements are known as the ***transition*** elements.

The ***f***-block elements, are sometimes called the ***inner transition*** elements.

Physical properties of elements follow the trends described below.

Atomic radius,

Atomic radius ***increases*** **down the group** since furthest electron energy levels are occupied.

Going **across a period**, the atomic radius ***decreases*** because the increasing nuclear charge pulls the electrons closer the nucleus, resulting in a decrease in the atomic radius.

Electronegativity

From left to right across a period of elements, electronegativity increases.

From top to bottom down a group, electronegativity decreases.

Important exceptions of the above rules include the noble gases, lanthanides and actinides.

As for the transition metals, although they have electronegativity values, there is little variance among them across the period and up and down a group.

Ionization energy

The ionization energy of the elements within a period generally **increases** from left to right.

The ionization energy of the elements within a group generally **decreases** from top to bottom. This is due to electron shielding.

The noble gases possess very high ionization energies because of their full valence.

Electron Affinity (EA)

There is not a definitive trend as you go down the periodic table; sometimes EA increases, sometimes it decreases.

Electropositivity or Metallic character

Across a period, the metallic character decreases and down a group, the metallic character increases.

Electrical and thermal conductivity

- Across a period, the conductivity increases as the number of delocalised electrons increases and then decreases as the metallic character decreases
- Down a group, the conductivity increases. The delocalised electrons become less attracted by the nuclei.

Density

- The density of elements tends to increase across a period up to group3 and then starts to decrease and become very low at group 5 or so.
- Down the group, the density increases because there is a large increment in mass compared to size which only increases of one shell.

Melting and boiling points

For groups 1 and 2, the melting and boiling points decrease down the group. For groups 7/17(halogens) and 18/0(noble gases), the melting and boiling points increase down the group. Across a period, melting and boiling points depend upon the structure and the bonding in the elements.

18.7. Additional information for tutors

The Periodic Table of Elements categorizes like elements together. Dmitri Mendeleev, a Russian scientist, was the first to create a widely accepted arrangement of the elements in 1869. Mendeleev believed that when the elements are arranged in order of increasing atomic mass, certain sets of properties recur periodically. Although most modern periodic tables are arranged in eighteen groups (columns) of elements, Mendeleev's original periodic table had the elements organized into eight groups and twelve periods (rows).

On the periodic table, elements that have similar properties are in the same groups (vertical). From left to right, the atomic number (z) of the elements increases from one period to the next (horizontal). The groups are numbered at the top of each column and the periods on the left next to each row. The main group elements are groups 1,2 and 13 through 18. These groups contain the most naturally abundant elements, and are the most important for life. The elements in between group 2 and 13 are known as transition metals. The two rows of elements starting at z=58, are sometimes called inner transition metals and have been extracted and placed at the bottom of the table, because they would make the table too wide if kept continuous. The 14 elements following lanthanum (z=57) are called lanthanides, and the 14 following actinium (z=89) are called actinides.

Elements in the periodic table can be placed into two broad categories, metals and non metals. Most metals are good conductors of heat and electricity, are malleable and ductile, and are moderate to high melting points. In general, non-metals are non conductors of heat and electricity, are non malleable solids, and many are gases at room temperature. In the table above, metals and non metals on the periodic table are often separated by a stairstep diagonal line, and several elements near this line are often called metalloids (Si, Ge, As, Sb, Te, and At). Metalloids are elements that look like metals and in some ways behave like metals but also have some non metallic properties. The group to the farthest right of the table is known as the noble gases. Noble gases are treated as a special group of non metals.

Electronegativity Trends

Electronegativity can be understood as a chemical property describing an atom's ability to attract and bind with electrons. Because electronegativity is a qualitative property, there is no standardized method for calculating electronegativity. However, the most common scale for quantifying electronegativity is the Pauling scale named after the chemist Linus Pauling.

The numbers assigned by the Pauling scale are dimensionless due to the qualitative nature of electronegativity.

Electronegativity values for each element can be found on certain periodic tables. An example is provided below.

H 2.1																	He —
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne —
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar —
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr —
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe —
Cs 0.7	Ba 0.9	La-Lu 1.1-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn —

Figure 18.1: Periodic Table of Electronegativity values

Electronegativity measures an atom's tendency to attract and form bonds with electrons. This property exists due to the electronic configuration of atoms. Most atoms follow the octet rule (having the valence, or outer, shell comprise of 8 electrons). Because elements on the left side of the periodic table have less than a half-full valence shell, the energy required to gain electrons is significantly higher compared with the energy required to lose electrons. As a result, the elements on the left side of the periodic table generally lose electrons when forming bonds. Conversely, elements on the right side of the periodic table are more energy-efficient in gaining electrons to create a complete valence shell of 8 electrons. The nature of electronegativity is effectively described thus: the more inclined an atom is to gain electrons, the more likely that atom will pull electrons toward itself.

- **From left to right across a period of elements,** electronegativity **increases**. If the valence shell of an atom is less than half full, it requires less energy to lose an electron than to gain one. Conversely, if the valence shell is more than half full, it is easier to pull an electron into the valence shell than to donate one.
- **From top to bottom down a group, electronegativity decreases.** This is because atomic number increases down a group, and thus there is an increased distance between the valence electrons and nucleus, or a greater atomic radius.

- **Important exceptions of the above rules include the noble gases, lanthanides, and actinides.** The noble gases possess a complete valence shell and do not usually attract electrons. The lanthanides and actinides possess more complicated chemistry that does not generally follow any trends. Therefore, noble gases, lanthanides, and actinides do not have electronegativity values.
- As for the transition metals, although they have electronegativity values, there is little variance among them across the period and up and down a group. This is because their metallic properties affect their ability to attract electrons as easily as the other elements.

According to these two general trends, the *most electronegative element is **fluorine***, with 3.98 Pauling units.

Ionization Energy Trends

Ionization energy is the energy required to remove an electron from a neutral atom in its gaseous phase. Conceptually, ionization energy is the opposite of electronegativity. The lower this energy is, the more readily the atom becomes a cation. Therefore, the higher this energy is, the more unlikely it is the atom becomes a cation. Generally, elements on the right side of the periodic table have a higher ionization energy because their valence shell is nearly filled. Elements on the left side of the periodic table have low ionization energies because of their willingness to lose electrons and become cations. Thus, ionization energy increases from left to right on the periodic table.

Another factor that affects ionization energy is *electron shielding*. Electron shielding describes the ability of an atom's inner electrons to shield its positively-charged nucleus from its valence electrons. When moving to the right of a period, the number of electrons increases and the strength of shielding increases. As a result, it is easier for valence shell electrons to ionize, and thus the ionization energy decreases down a group. Electron shielding is also known as *screening*.

- The ionization energy of the elements within a period generally increases from left to right. This is due to valence shell stability.
- The ionization energy of the elements within a group generally decreases from top to bottom. This is due to electron shielding.
- The noble gases possess very high ionization energies because of their full valence shells as indicated in the graph. Note that helium has the highest ionization energy of all the elements.

Some elements have several ionization energies; these varying energies are referred to as the first ionization energy, the second ionization energy, third ionization energy, etc. The first ionization energy is the energy required to remove the outermost, or highest, energy electron, the second ionization energy is the energy required to remove any subsequent high-energy electron from a gaseous cation, etc. Below are the chemical equations describing the first and second ionization energies:

First Ionization Energy:

$X(g) \rightarrow X^{+}(g) + e^{-}$

Second Ionization Energy:

$X(g)^{+} \rightarrow X(g)^{2+} + e^{-}$

Generally, any subsequent ionization energies (2nd, 3rd, etc.) follow the same periodic trend as the first ionization energy.

Ionization energies decrease as atomic radii increase. This observation is affected by nn (the principle quantum number) and Zeff (based on the atomic number and shows how many protons are seen in the atom) on the ionization energy (I). The relationship is given by the following equation:

$I = R_H Zeff/2n^2$

- Across a period, Zeff *increases* and n (principal quantum number) *remains the same*, so the ionization energy *increases*.
- Down a group, n *increases* and Zeff *increases slightly;* the ionization energy *decreases*.

Electron Affinity (EA)

The opposite of IE is described by **electron affinity (EA),** which is the energy change when a gas-phase atom accepts an electron:

$A(g) + e^{-} \rightarrow A-(g) \qquad \Delta H \equiv EA$

EA is also usually expressed in kJ/mol. EA also demonstrates some periodic trends, although they are less obvious than the other periodic trends discussed previously. Generally, as you go across the periodic table, EA increases its magnitude.

There is not a definitive trend as you go down the periodic table; sometimes EA increases, sometimes it decreases. The figure below shows EA values versus position on the periodic table for the *s*- and *p*-block elements.

The trend isn't absolute, especially considering the large positive EA values for the second column. However, the general trend going across the periodic table should be obvious.

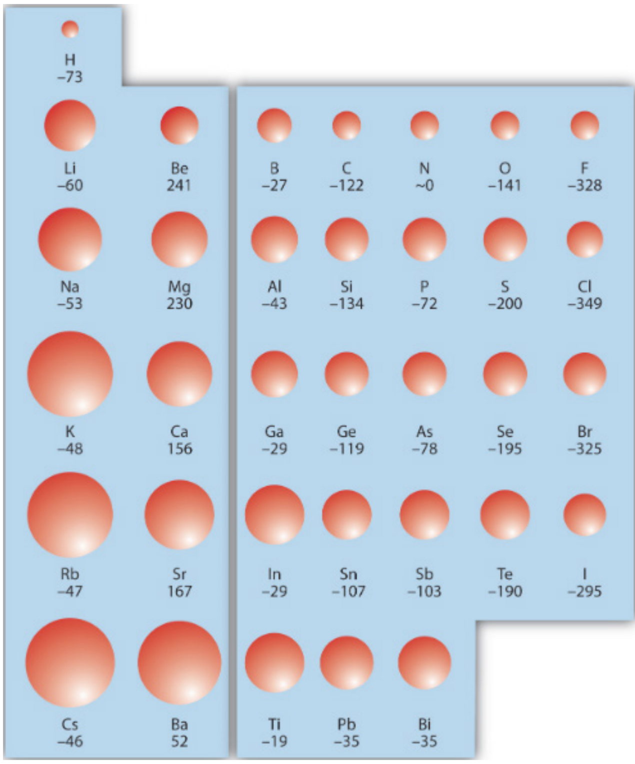
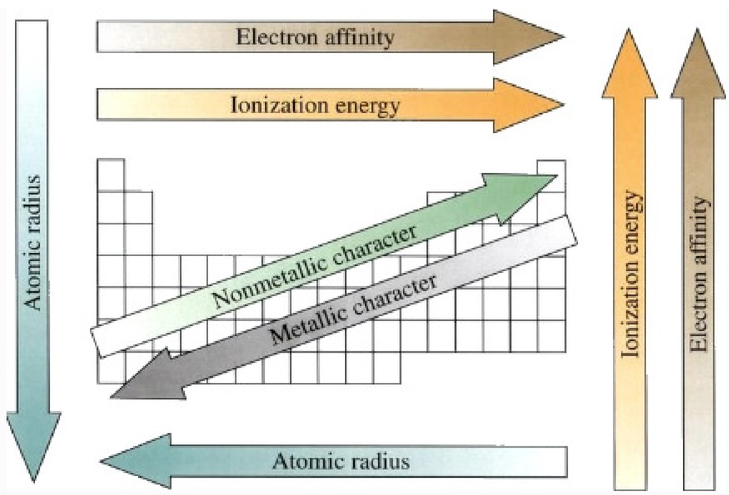


Figure 18.2: Electron Affinity on the Periodic Table. Values are in kJ/mol.

The variations in trends of atomic radius, metallic character, electron affinity and ionisation energy are summarised in the diagram below.



18.8. End unit assessment 18 (answers)

1. Limitation of the Newland's classification

Answer: The arrangements of elements into octaves failed beyond calcium.

- Newlands assumed that only 56 elements existed in nature and no more elements would be further discovered in the nearer future. But later on several new elements were discovered, whose properties couldn't be defined as per the Law of Octaves.
- In order to fit elements into law of octaves Newlands not only adjusted two elements in the same slot but also adjusted some unlike elements under the same note.
- Cobalt and nickel are in the same slot and are positioned in the same column with fluorine, chlorine and bromine possessing different properties than these elements.
- Iron possessing similar properties as cobalt and nickel, is placed far away from these elements
- Thus, Newlands' Law of Octaves can be obeyed well by the lighter elements only.

2.

T							G
E	J	A	R	K	B	Q	P
	F	O	H	M	V	D	
N	I	U	S	C	W	L	Y

3. a) Nitrogen has three electrons in 2p subshell it means the 2p subshell is half filled resulting in a stable configuration. Oxygen has four electrons in 2p subshell, it is unstable.

   b) Noble gases have completely filled energy level, they are stable.

4. a) Alkali metals are highly reactive.

   b)The additional of 10d-orbital offer a poor screening effect for outer electrons from the increase of nuclear charge of Gallium. This is why atomic radius of Gallium(135pm) is smaller than that of Aluminium(143pm)

5. Na > Al > S > Cl ">", "has greater atomic size"
   This demonstrate a periodic trend

6. $Mg^{2+} < Na^{+} < F^{-} < O^{2-} < N^{3-}$ "<", "smaller than"

18.9. Additional activities (Questions and answers)

18.9.1 Remedial activities

1. Besides gallium, which other elements have since been discovered that were left by Mendeleev in his periodic table? (any two)

   Answer: scandium and Germanium

2. What were the criteria used by Mendeleev in creating his periodic table?

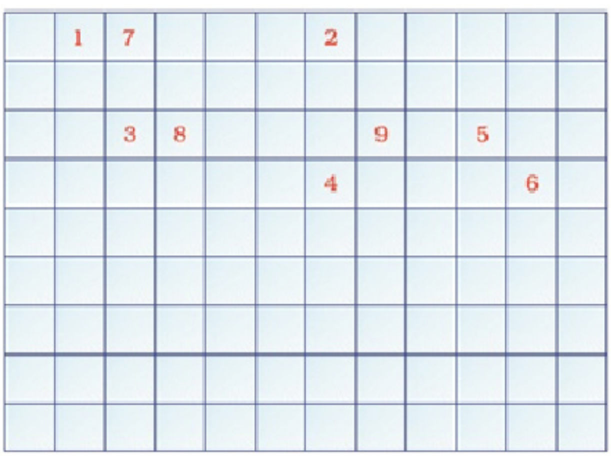
   Answer: Mendeleev's periodic table was based on the observation that the properties of elements are periodic function of their atomic masses. This means that elements are arranged in the increasing order of their atomic masses, then their properties get repeated after regular intervals

3. How could the modern periodic tale remove various anomalies of Mendeleev's periodic table?

   Answer: Mendeleev was unable to give fixed position to hydrogen and isotopes in the periodic table. In Mendeleev's periodic table , the increasing manner of atomic mass of the elements is not always regular from one to its next. It was believed that more fundamental property than atomic mass could explain periodic properties in a better manner.

   It was Henry Moseley who demonstrated that atomic number of an element could explain periodic properties in a better way than atomic mass of an element and arranged the elements in increasing order of their atomic numbers. Then it was found that the various anomalies of Mendeleev's periodic table were removed by the modern periodic table.

4. Complete the following cross word puzzle



Across

1. An element with atomic number 12
3. Metal used in making cans and member of group 14
4. A lustrous non-metal which has 7 electrons in its outer shell

Down:

2. Highly reactive and soft metal which imparts yellow clour when subjected to flame and is kept in kerosene.
5. The first element of the second period.
6. An element which is used in making fluorescent bulbs and is second member of group 18 in the modern periodic table.
7. a radiactive element whih is the last member of halogen family.
8. a metal which is an important constituent of steel and forms rust when exposed to moist air.
9. the first metalloid in modern periodic table whose fibres are used in making bullet-proff vests

5. Mendeleev predicted the existence of certain elements not known at that time and named two of them as Eka-silicon and Eka-aluminium.
   a. Name the elements which have taken the place of these elements
   b. Mention the group and the period of these elements in the modern periodic table.
   c. Classify these elements as metals , non-metals or metalloid.
   d. How many valence electrons are present in each one of them?

Answer

a. Gallium and germanium
b. Gallium and germanium are found i groip 13 and 14 respectively. They are both located in period 4.
c. They are metalloid.
d. Three and four valence electrons for gallium and germanium respectively.

6. Explain the following statements
   a. electropositive nature of the element(s) increases down the group and decrease across the period.

b. electronegativity of the elements decreases own the group and increases across the period.

c. atomic size increases down the group and decreases across the period.

d. metallic character inccreases down the group and decreses across the period.

Answer:

Seestudent-teacher's book.

7. On the basis of the above trends explained in number (11) of the periodic table , answer the following about the elelments with atomic number 3 to 9

18.9.2 Consolidation activities

1. Which physical and chemical properties of the elements were used by Mendeleev in creating his periodic table? List two observations which constituted a challenge to Mendeleev's periodic law.

Answer:

Physical properties: The atomic masses of the elements were taken into account and the elements were arranged in order of increasing atomic masses. The influences of their physical properties such as melting points, boiling points, density, etc. are related to atomic masses.

Chemical properties: The distribution of the elements into different groups was linked with formation of hydrides by combining with hydrogen and formation of oxides by combining with oxygen. This is linked with the valency of the elements.

The two main observations which posed challenge to Mendeleev's periodic table are as follows:

(i) Position of isotopes: Since the isotopes of an element differ in their atomic masses, they must be assigned separate slots or positions in the periodic table.

(ii) Anomalous positions of some elements: In the Mendeleev's periodic table, certain elements with higher atomic masses precede or placed before the elements with lower atomic masses. For example, the element Ar (Atomic mass = 39.9) is placed before the element K (Atomic mass = 39.1).

2. Analyse the part of the periodic table given below, answer the questions that follow.

Group Period	I	II	III	IV	V	VI	VII	Zero
1	H							He
2	Li	Be	B	C	N	O	F	Ne
3	Na	Mg	Al	Si	P	S	Cl	Ar
4	K	Ca						

a. Na has physical properties similar to which elements and why?

b. Write the electronic configuration of N and P

c. State one property common to fluorine and chlorine

Answer:

a. Na has physical properties similar to Li and K. All the three elements have one electron each in the valence of their atoms. These are known as alkali metals.

b. Electronic configuration of N(Z=7):$1s^2 2s^2 2p^1$ Electronic configuration of P(Z=15): $1s^2 2s^2 2p^6 3s^2 3p^1$

c. Both the elements have seven electrons in the valence shells as their atoms

3. On the basis of quantum numbers, justify that the sixth period of the periodic table should have 32 elements.

Answer:

The sixth period of the periodic table must have elements whose electronic configuration starts from 6s and continue filing 4f, 5d and 6p orbitals. As the electron enters 7s orbital such element will come under 7th period.

The number of electrons that can be accommodated in 6s, 4f, 5d and 6p orbitals are 2, 14, 10 and 6 respectively whose total is 32. Hence the sixth period of the periodic table should have 32 elements

4. How does atomic radius vary in period and in group? Explain the variation.

Answer:

Variation of atomic size down the group: The atomic radius increases from top to bottom in the group.

Reason: as we go down the group electrons are added in a new shell. At the same time the nuclear charge increases down the group. Though the effect of increase in nuclear charge is to reduce the atomic radius, this effect is offset by the effect of new shell and as a result, the atomic radius increases down the group.

Across the period: the atomic radius decreases along the period

Reason: along the period, electrons are added on the same shell while the nuclear charge increases. As a result of increase in nuclear charge, atomic radius decreases.

5. What are the various factors that affect the ionization enenery of the main group elements tends to decrease down a group?

   Answer: (i) There is an increase in the number of main energy shells (n) in moving from one element to the other

   (ii) There is also an increase in magnitude of the screening effect due effect due to the gradual increase in number of inner shells. The valence electrons are shielded from the nuclear attraction.

6. Explain why cations are smaller and anions larger than their corresponding parent atoms?

   Answer:

   Cations are formed by loss of one or more electrons from the parent atom. As a result the number of electrons is decreased while the number of protons remains the same. The number of positive charges becomes greater than the negative charges which results in greater attraction (increase in effective nuclear charge per electron).

   Anions are formed by the gain of one or more electrons by the gain of one or more electrons by the gaseous atom. Here nuclear charge remains the same whereas the number of electrons increases by one or more. The nuclear attraction is decreased as the number of protons is smaller than that of electrons. i.e. the effective nuclear charge per electron decreases in the case of anions and hence the electrons are less tightly bound by the nucleus which results in increased size of the ion.

18.9.3 Extended activities

1. Explain 'Dobereiner's Triads and its drawback.

Answer:

Dobereiner classified elements into groups of three where the atomic weight of the middle element was approximately the average of the atomic weights of the other two.

Example: A triad of lithium (Atomic weight = 7), Sodium (Atomic weight = 23), Potassium (Atomic weight = 39)

Mean of Li and atomic mass values = $\frac{7+39}{2} = 23$

This is the atomic weight of the middle element, sodium.

The two drawbacks of Dobereiner's triads are:

1) A large number of elements could not be grouped into triads. For e. g., iron, manganese, nickel, cobalt, zinc and copper are similar elements but cannot be placed in the triads.

2) It was also observed that dissimilar elements were being grouped into triads.

2. What is meant by periodicity? What is the cause of periodicity?

Answer:

The recurrence of characteristic properties of elements, arranged in the periodic table at regular intervals, is called periodicity. Elements having similar electronic configuration have similar properties. Thus the cause of periodicity is the repetition of similar electronic configuration.

3. Plot a graph of melting point against atomic number and discuss any trend observed. Are there any deviations from the trend? Suggest an explanation for the trend and for any deviations.

Answer:

Collect data about the melting points of period 3 elements for example and plot the corresponding graph.

In the analysis, take into the type of bonding and the structure of each element.

4. Elements with atomic numbers of 114 and just above are thought to be in an "island of nuclear stability" in a sea of less stable nuclei. Another island of nuclear stability is predicted to occur at approximately atomic number 164. For element 164, predict its properties.

Answer:

The properties of element 164 should be similar to those of Pb and element 114. There is a new type of orbital, a g orbital, that has to be filled before the third lanthanide/actinide series; there are nine different g orbitals. Thus, element 164 would be below element 114.

UNIT 19

COVALENT BOND AND MOLECULAR STRUCTURES

19.1. Key unit competence

Demonstrate how the nature of the bonding is related to the properties of covalent compounds and molecular structures.

19.2. Prerequisite (knowledge, skills, attitudes and values)

Before learning this unit, students should have a prior knowledge in ionic bonding as seen in the previous units. This will help them relate the information about formation of why atoms bond to achieve the stability. Learners also should be helped to recall the formation of covalent bonds also seen in ordinary level chemistry. It is also important for students to recall how electronic configuration of different elements is written.

19.3. Cross-cutting issues to be addressed

a) Comprehensive Sexuality Education

Refer to the Unit 17 Tutor's Guide. However, you can still emphasize this cross cutting issue though it was mentioned previously.

b) Peace values education

It is very important to note that like atoms of non metals share their electrons to complete their octet, likewise people need each other in many perspectives irrespective of their race, economic, political and social status, etc, for the success of human beings.

c) Inclusive education

This unit involves number of structures that require drawing. It is therefore imperative to note that learners with visual impairment are helped by drawing big enough pictures or find them spaces near the chalk board.

d) Environment sustainability:

Many compounds which have negative impact on the environment like greenhouse gases and acid rain gases are covalent in nature.

You can also emphasize on the way to sustain the environment by reducing the release of such covalent compounds.

19.4. Guidance on introductory activity

- Before introducing the first lesson of this unit, "Theories on the formation of covalent bond", let learners attempt introductory activity.
- This activity intends to discover the new bonding (covalent) and relate it with the compounds formed with the covalent bonds: covalent compounds.
- Let student-teachers observe the figure shown in the introductory activity and answer the questions which follow. The expected answers are given here below.

Answers to questions in the Introductory activity

1. Electronegativity
2. No, because it has not enough strength to remove the electron. The electronegativity difference is not high. They continue sharing even though the bond is polar.
3. It will be shared equally. The bow remains in the middle.
4. Oxygen atom has two electrons to share. Hydrogen atom having only one must come with another to have two electrons to be shared with those of oxygen.
5. There are two types: One formed between the same atom, of the same strength (non-polar) and another formed between two different atoms, of different strengths (polar).

19.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Theories on the formation of covalent bond	• Explain the formation of covalent bonds and describe the properties of covalent compounds. • Apply octet rule to draw Lewis structures of different compounds	4
2	Coordinate or dative covalent bond	Explain the formation of dative covalent bonds in different molecules.	2

3	Overlap of atomic orbitals to form covalent bonds	Differentiate sigma from pi bonds in terms of orbital overlap and formation	2
4	The concept of valence bond theory and formation of (σ) and (π) bonds	Describe the concept of valence bond theory	2
5	Hybridisation and types of hybridisation	Relate the shapes of molecules to the type of hybridization	3
6	VSEPR theory to explain the formation of shapes of covalent molecules (geometry) and bond angles	• Explain the VSEPR theory • Apply the VSEPR theory to predict the shapes of different molecules/ions.	5
7	Polarity of the covalent bond in relation to difference in electronegativity	Relate the difference in electronegativities to the types of bonds.	2
8	Physical properties of covalent structures: simple and giant molecular structure	Relate the structure of simple and giant molecular covalent compounds to their properties.	3
9	Intra molecular forces	• Describe the intra molecular forces • Describe the effect of inter and intra molecular forces on the physical properties of certain molecules.	3
	End unit assessment		2

Lesson 1: Theories on the formation of covalent bond

a) Learning objectives

- Explain the formation of covalent bonds and describe the properties of covalent compounds.
- Apply octet rule to draw Lewis structures of different compounds.

b) Teaching resources

Use the Leaner's text book, Manila paper, Learning movies and/or printed images depending on the availability of each.

c) Prerequisites/ Revision/ Introduction

For learners to learn better the "Theories on the formation of covalent bond" they need to have prerequisites on the chemical bonding especially classification of chemical bonding types and their definition and the formation of ionic bonds.

d) Learning activity 19.1

Before introducing the lesson, you will have to introduce the whole unit by allowing student-teachers to do introductory activity and thereafter proceed to Activity 19.1 which is specific to lesson 1. Note that this lesson will take a long time.

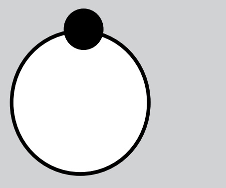
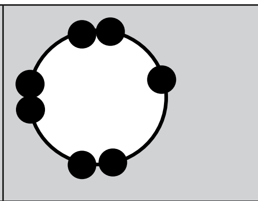
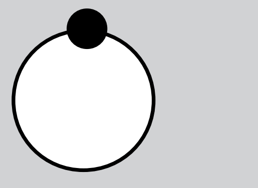
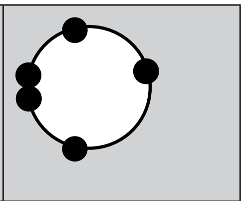
- You have to take one period for the general introduction using the introductory activity provided in the Student Book.
- Form groups of 4-5 depending on the size of the class.
- Distribute the introductory activity and estimate the time for it.
- In the second period, you start the lesson.
- Let the student-teachers proceed and do *Activity 19.1* of lesson 1.
- Allow the learners to work together in groups.
- Invite group leaders to present their findings. In this step you can guide the learners to evaluate the findings by confirming the correct answers, eliminating the wrong ones or completing some statements.
- You summarise the learned knowledge and give examples which illustrate the learned content. Here you can also give other necessary examples that could have not indicated in first steps clarifying the steps taken in writing the Lewis Structures.
- Now invite the student-teachers, in their respective groups, to use their books (Student Books) to make a good summary of the content of the lesson.
- In the same groups, allow the student-teachers to do the application *activity 19.1* using the summary they made.
- Go through each group correcting in order to help them, if some problems arise.
- Give feedback basing on the answers given and add the necessary missing..

Answers to Activity 19.1

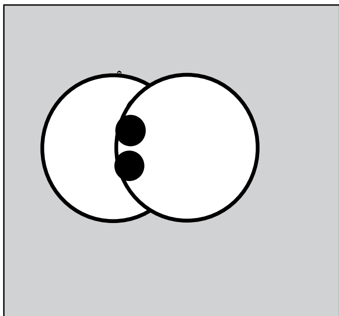
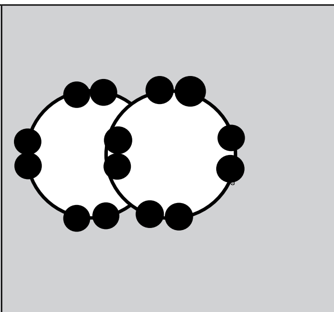
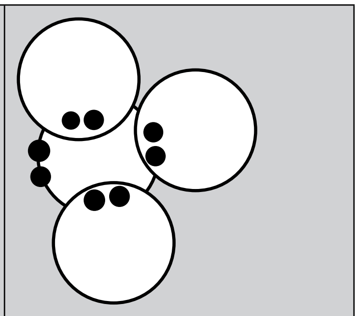
1. They get stability when one (of a non-metal) gains electron(s) from another (of a metal); in this process, each atom fulfils the Octet Rule (and Duet Rule for some small elements like hydrogen); it gains the structure of a noble gas which is the more stable form.

2. Covalent bonding

   a. Diagrams drawn.

			
Hydrogen	Chlorine	Potassium	Nitrogen

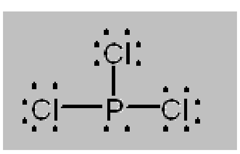
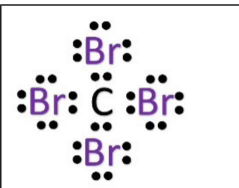
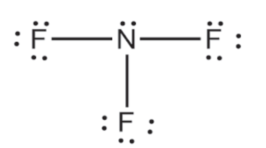
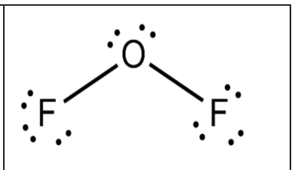
   b. Illustrations of H_2, Cl_2 and NH_3 molecules

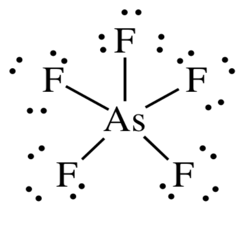
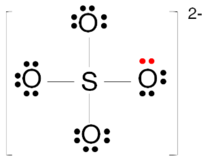
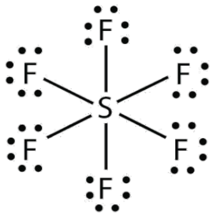
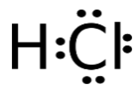
		
H_2	Cl_2	NH_3

e) Answers to the Application Activity 19.1

1. A covalent is a chemical bond that involves the sharing of electron pairs between atoms

2. Electron dot diagrams (Lewis Structures)

			
a. PCl_3	**b. CBr_4**	**c. NF_3**	**d. OF_2**

			
e. AsF_5	**f. SO_4^{2-}**	**g. SF_6**	**h. HCl**

Lesson 2: Coordinate or dative covalent bond

a) Learning objective

Explain the formation of dative covalent bonds in different molecules.

b) Teaching resources

- Charts illustrating different types of bonding
- Manila papers, flipcharts and movies with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Refer to lesson 1 above and use the concept of formation of covalent bonds and the Lewis structures especially those which present exceptions of not completing the “Octet Rule”.

d) Learning activity 19.2

Refer to Learning activity 19.2 which is suggested in the Student’s book

- Welcome the class to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- In the groups learners discuss, attempt *activity 19.2* and record their answers.
- Each group representative presents the Answers to his/her group to his/her classmates.
- You can make any corrections if any and provide *application activity19.1.*
- Make corrections with students to make sure there are no misconceptions
- Add the important points that facilitate the understanding of dative covalent bond

- Ask the students to answer the *application activity 19.2.*given in their books. It is better if it is done in pairs to ensure the understanding

Answer to Activity 19.2

A *dative covalent bond*, or *coordinate bond* is a type of covalent bonding (i.e., electron sharing) where the shared electron pair(s) are completely provided by one of the participants in the union, and not by contributions from the two of them.

e) Answers to Application Activity 19.2

1. A coordinate bond is basically a covalent bond where both electrons come from the same atom. On the other hand a covalent bond is one where both the atoms share a pair of electrons (single covalent bond). The atoms are held together due to the attraction between their nuclei.
2. An aluminium chloride molecule reacts with a chloride ion to form the $AlCl_4^-$ ion.
   a. Dative covalent bond
   b. $AlCl_3$ is described as being ***electron deficient.*** The lone pair on the chloride ion can be used to overcome that deficiency, and a compound is formed involving a co-ordinate bond.
3. Co-ordinate bonding can be described as dative covalency.
   a. • *Covalency*: Sharing a bond pair of electrons.
   - *Dative:* The bond pair shared is donated by only one species involving in the bonding.

   b. $NH_3 + H^+ \rightarrow NH_4^+$, $Cl^- + AlCl_3 \rightarrow AlCl_4^-$, etc.

Lesson 3: Overlap of atomic orbitals to form covalent bonds

a) Learning objective

Differentiate sigma from pi bonds in terms of orbital overlap and formation

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating the shapes of atomic orbitals (s and p-orbitals only).
- Manila papers, flipcharts and movies may be used with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Refer to lesson 1 and 2 above and use the concept of formation of covalent bonds according to the Lewis Theory in order to introduce and understand the new theory which shows how the covalent bonds are formed by overlapping the atomic orbitals. Here, the students must use the knowledge about atomic orbitals and their shapes as learnt in the previous units.

d) Learning activity 19.3

Refer to *Learning activity 19.3* which was suggested in the student's book

- Welcome the learners to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- Assign the groups with tasks that must take approximately 5 minutes.
- In the groups learners discuss, attempt *activity 19.3* and record their answers.
- Each group representative presents the paragraph formed by his/ her group.
- After the presentation, ask some questions that lead to more clarifications and reach the conclusion.
- Now, use the *Application Activity19.3* to evaluate the understanding of the lesson (allow students to use the Textbook to find the best answers).
- It is better to mark them group by group starting from the one finishing before.
- After all, you have to give the missed important information about the lesson.

Answers to Activity 19.3

Covalent bonding occurs between non-metal elements when pairs of electrons are shared by atoms. Atoms will covalently bond with other atoms to attain the nearest noble gas configuration, the very stable state. Here when elements share their electrons, they do not become positive or negative, since they are neither gaining nor sacrificing compounds,

they have reached the stability and stay bound. Thus no ions are formed by covalent bonding.

e) Answers to Application Activity 19.3

1. Explanations of the terms:
   a. Bond length: Average distance between two atoms bonded together.
   b. Bond energy: The amount of energy necessary to break one mole of bonds of a given kind (in gas phase).
2. Valence Bond Theory states that the build-up of electron density between two nuclei occurs when a valence atomic orbital of one atom merges with that of another atom.
3. Lewis Theory says that atoms can achieve an octet of valence electrons by sharing valence electrons and shared electrons count for each atom's octet. Valence bond theory describes well how the shared electrons (described by Lewis) is a consequence of the overlap of two separate atomic orbitals on different atoms that creates a region with one pair of electrons shared between the two atoms.

Lesson 4: The concept of valence bond theory and formation of (σ) and (π) bonds

a) Learning objective

Describe the concept of valence bond theory

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating the shapes of atomic orbitals (s and p-orbitals only).
- Manila papers, flipcharts and related movies may be used with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

In order to understand well "the concept of valence bond theory and formation of (σ) and (π) bond" it is better to have understood better the previous lesson (lesson 3). It seems that the lesson 3 (overlap of atomic orbitals to form covalent bonds) is an introductory theory of this lesson. The Valence Bond Theory is here to explain well how atomic orbitals overlap to form the covalent bonds.

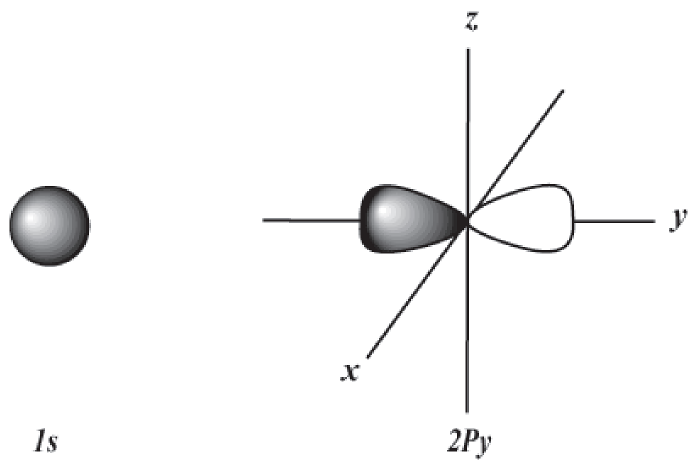
d) Learning activity 19.4

This is a lesson that is in logical sequence with the previous lessons (1, 2 & 3). Refer to *Learning activity 19.4* suggested in the Student's Book in the teaching/learning process of this lesson.

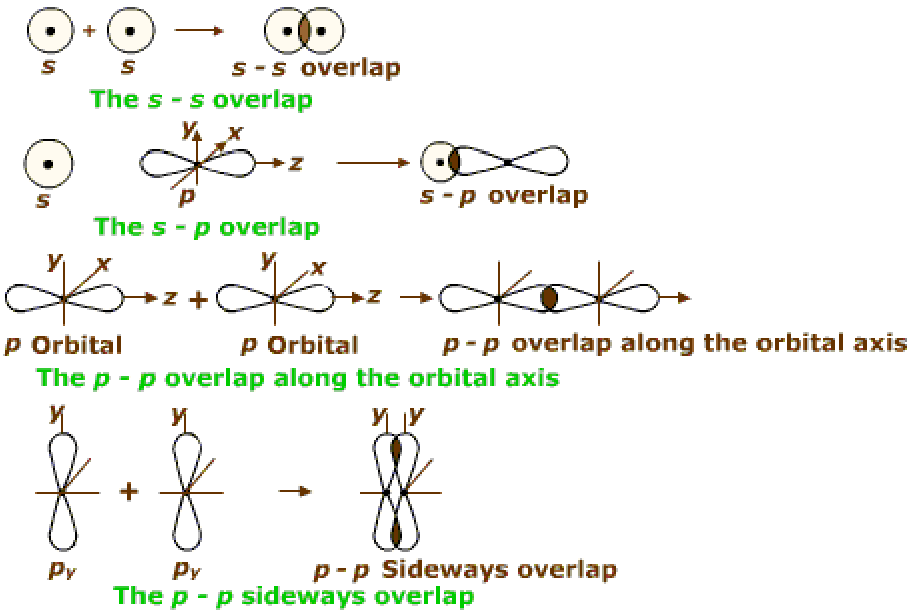
- Welcome the class to the new lesson.
- In pairs, assign the students with *Activity 19.4* and ask them to attempt carefully.
- Choose randomly four or five representative of the whole class to present their answers.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the students' findings and emphasize on which are correct, incomplete or false
- Ask two other students to add new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples.
- Let student-teachers attempt *application activity 19.4.* They should do the *application activity* in any method you wish to use depending on time, the understanding you evaluated, etc.
- The answers expected to the learning and application activities are outlined here below.

Answers to Activity 19.4

1. Names and shapes of s-orbital and p-orbital.



2. Different possible combinations of the orbitals overlapping.



e) Answers to Application Activity 19.4

1. According to the *valence bond (VB) theory*, a covalent bond is formed when two orbitals overlap (share the same space) to produce a new combined orbital containing two electrons of opposite spin.

2. It could not explain the structures and bond angles of molecules with more than three atoms like H_2O, NH_3, etc.

3. Basing on the pattern of overlapping, there are two types of covalent bonds: *sigma* (formed due to overlapping of atomic orbital along the inter nucleus axis) and *pi-bonds* (formed by sidewise overlapping of atomic orbitals).

Lesson 5: Hybridisation and its types

a) Learning objective

Relate the shapes of molecules to the type of hybridization

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating the shapes of atomic orbitals (s and p-orbitals only).
- Manila papers, flipcharts and related movies may be used with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

This lesson refers to the previous lessons of this unit and links to Biology course about the hybridization in living things. It requires also the knowledge about different types of orbitals and the existence of different oxidation states for the same atom.

d) Learning activity 19.5

This lesson shows different atomic orbitals may be intermixed to form new hybrid orbitals. Referring to the previous lesson (lesson 4), students are able now to attempt the provided learning activity *(activity 19.5).*

- Form working groups of 4 students and assign the groups with the learning activity.
- In the groups, students discuss, attempt *activity 19.5* and record their answers.
- Choose some groups (at most 5 groups) to present their findings (their answers).
- Make the evaluation of the findings of the students and clearly give comments and clarifications basing on what presented.
- Invite other students to give their comments, additions, or ask problems about some challenges they are facing.
- Correct the false information, answer the questions asked, etc.
- Summarize the contents by giving more examples and more clarifications.
- Let student-teachers attempt *application activity 19.4* in the same groups they were using. It would be better if you mark them immediately in order to be able to give feedback leaning on the answers provided by the students.

Answers to Activity 19.5

Hybridization is the process that involves the "*cross breeding*" of atomic orbitals to create "*new*" orbitals.

Sp, sp^2, sp^3, sp^3d and sp^3d^2 are the common types of hybridization.

e) Answers to Application Activity 19.5

1. Hybridization is the process of "intermixing of atomic orbitals of nearly same energies to form same number of identical and degenerate new type of orbitals".

2. Five different hybridizations.

Hybridisation type	Shape	Angle(s)
Sp	Linear	180^o
sp^2	Trigonal planar	120^o
sp^3	Tetrahedral	$109^o28'$
sp^3d	Trigonal bipyramidal	120^o & 90^o
sp^3d^2	Octahedral	90^o

Lesson 6: VSEPR theory to explain the formation of shapes of covalent molecules (geometry) and bond angles

a) Learning objectives

- Explain the VSEPR theory
- Apply the VSEPR theory to predict the shapes of different molecules/ ions.

b) Teaching resources

- Ball and stick molecular models
- Learning movies with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

Knowledge about the five already learnt lessons in this Unit is sufficient to study this new lesson which is introducing the new theory.

d) Learning activity 19.6

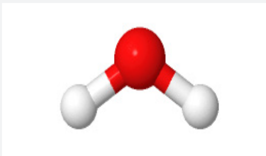
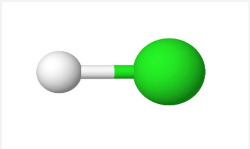
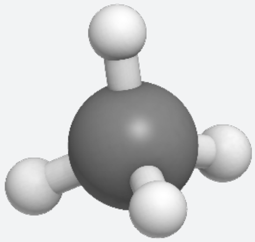
This lesson must be introduced using a *learning activity 19.6* which is provided in the Student's Book. Make sure that you have Ball and Stick molecular models. The lesson may be conducted in the laboratory or in the classroom.

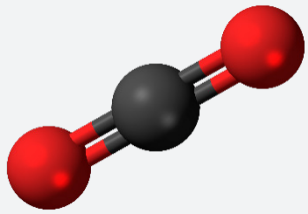
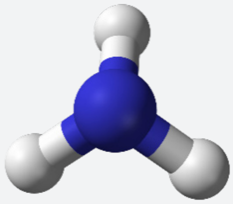
- Welcome the class to the new lesson.
- Form working groups of 6 students and ask them to attempt the *activity 19.6*. This is a practical activity; the students are required to make a report.
- Each group chooses the representative to present the findings as asked in the activity.
- Allow other students (not presented) to compare the results: shapes, bond angles, etc.

- Take your time to introduce more in the contents inviting the students to use their books to know the required shapes, names of these shapes and the approximate bond angles.
- Emphasize on the cause of different shapes or the reduction of bond angles for those having the same electron arrangements.
- Invite the students to give their views and problems they are encountering.
- Summarize the contents and answer the problems asked by giving more examples and more clarifications.
- Let student-teachers attempt *application activity 19.6*. They should do the *application activity* in any method you wish to use.
- After marking the answers provided for the application activity 19.6, you have ideas on what to re-emphasize and to clarify more. This is the time.

Answers to Activity 19.6

Find out the ball and stick molecular models in the laboratory and try to construct the following molecules: H_2O, HCl, CH_4, CO_2 and NH_3

Molecule	**Shape**	**Name of the shape**	**Approximate bond angle**
H_2O		Bent shape (V-shape)	110°
HCl		Linear	180°
CH_4		Tetrahedral	110°

CO_2		Linear	180^{o}
NH_3		Trigonal pyramidal	110^{o}

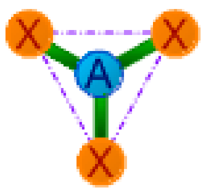
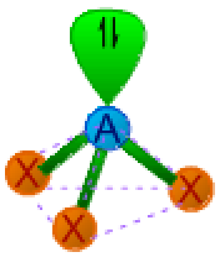
e) Answers to Application Activity 19.6

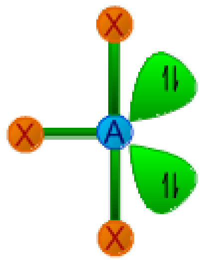
1. There are two types of valence shell electron pairs such as Bond pairs and Lone pairs.
   a. Bond pair: The pair of electrons involved in covalent bond.

      Lone pair: The pair of electrons residing on one atom and not shared by other atom, unshared pair.

   b. Bond pair - Bond pair >Lone Pair - Bond pair > Lone pair - Lone pair

2. About covalent bonding
   a. Table

Molecule	**Sketch of shape**	**Bond angle(s)**	**Name of shape**
BF_3		120^{o}	Trigonal planar
NF_3		Around $109^{o}28'$	Trigonal pyramidal

ClF_3		90°	T-shape

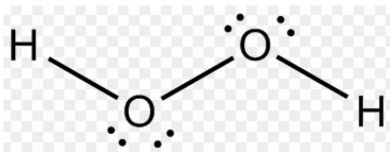
b. • In BF_3 molecules: Only dispersion forces because it is non-polar molecule.

- In NF_3 molecules: Dipole-dipole interactions and dispersion forces.

c. Dative covalent bond. The lone pair on nitrogen of NF_3 is given to the electron deficient, BF_3.

3. The diagram shows a hydrogen peroxide molecule.

a. Lone pairs on hydrogen peroxide.



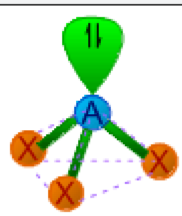
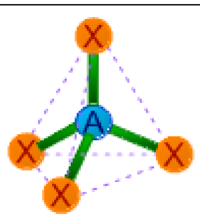
b. 109.5°

c. Lone pairs are not involved in bond formation and are in attraction with only one nucleus. Hence they occupy more space.

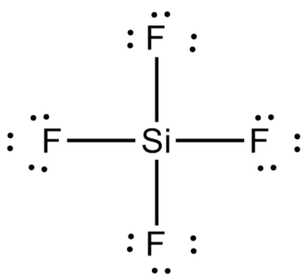
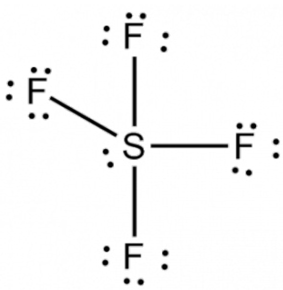
4. Phosphorus and nitrogen.

a. Dative covalent bond. The lone pair on nitrogen of PH_3 is given to the electron deficient, H^+.

b. Shapes, their names and bond angles.

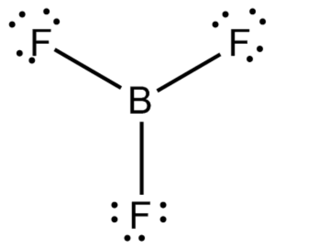
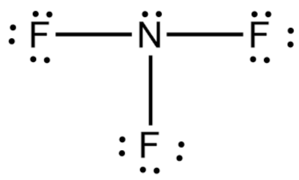
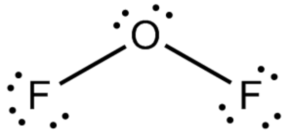
Species	**Shape**	**Name**	**Bond Angle**
Phosphine		Trigonal pyramidal	<109°28’
Phosphonium		Tetrahedral	109°28’

5. The molecules BCl_3 and CCl_2.
   a. Because there is no lone pair to repel the sharing pairs.
   b. Bond angle is <120°. It is different to that of BCl_3 because there is a lone pair on carbon which repels the C-Cl bonds.
   c. Tetrahedral. Examples: CH_4, CCl_4, NH_4^+, PO_4^{3-}, SO_4^{2-}, etc.
6. The shape of the XeF_4 molecule is shown below.
   a. Bond angle in XeF_4: 90°
   b. They are opposite to minimize the repulsion effect.
   c. Square planar.
7. Complete table:

Chemical Formula	**SiF_4**	**SF_4**
Lewis Structure (with formal charges)		
Molecular shape (in words)	**Tetrahedral**	**See Saw**
Hybridization	**sp^3**	**sp^3d^2**
Number of all pairs of electrons	**16**	**17**

8. Boron, nitrogen and oxygen form fluorides with molecular formulae BF_3,NF_3 and OF_2

a. Shape of each molecule

BF_3	NF_3	OF_2
		

Give the bond angle in each case.

- **BF_3: 120°** (No lone pair on the boron)
- **NF_3: 107°** (The lone pair on the nitrogen atom repels the bonding pairs from 109°28' to 107°)
- **OF_2: 104°** (The 2 lone pairs on oxygen force the angle down to 104°)

Lesson 7: Polarity of the covalent bond in relation to difference in electronegativity

a) Learning objective

Relate the difference in electronegativities to the types of bonds.

b) Teaching resources

- The Periodic Table of elements containing the electronegativities of elements.
- Manila papers, flipcharts and Movies with computers and projectors may be needed or used.

c) Prerequisites/ Revision/ Introduction

Now that you have enough knowledge about the covalent bonding and its formation, you are aware that the atoms forming the covalent bonds may be similar or different. The knowledge of electronegativity of atoms is the important point to use in order to study well this lesson.

d) Learning activity 19.7

Refer to *learning activity 19.7* provided in the student's book.

- Welcome the class to the new lesson.

- In their groups (4 to 6) depending on the size of your class, ask the students to observe attentively two figures in the *activity 19.7* and read carefully the related questions.
- Ask the students to try to provide answers; this will help them to have a brainstorming behaviour and this will lead to the good understanding of the equality and inequality that may be seen in the covalent bonding.
- After completing the task (the activities given), ask students in general some of the questions found in the activity and after that you got some answers, you base on them to give more clarifications.
- Immediately, let student-teachers attempt *application activity 19.4* individually. They submit and the time you will finish to mark, let them have more clarifications from you (this will be done after noticing the misconceptions that may be had by some students).

Answers to Activity 19.7

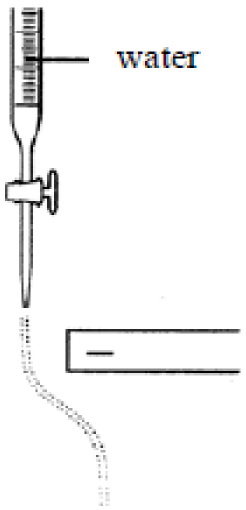
1.

   a. Electronegativity

   b. Non-polar because the same atoms are sharing.

   c. In chlorine (Cl) zone.

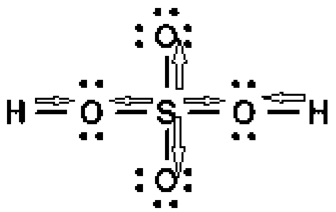
2. The water is deflected from its vertical path towards the charged rod as shown in the figure. This is because water molecule is a polar molecule. It has two (partially) charged ends. When it passes in the proximity of a charged species, there is the attraction or repulsion of that occurs between the oppositely and similarly charges respectively.

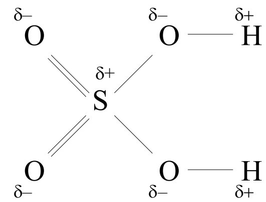


e) Application Activities

Answers to Application activity 19.7

1. Polar bond or polar covalent bond is a covalent bond between atoms of different electronegativities; it is a bond with a (partial) positive end and a (partial) negative end.
2. Polarity of each bond present in the formula of Sulphuric acid.





3. CS_2 (S=C=S) is a non-polar, linear molecule. Carbon forms slightly polar bonds with sulphur, but due to the symmetrical arrangement of the bonds, the polarities cancel out. For HCN (H-C≡N), not only is the nitrogen electronegative intrinsically but it is also pulling on three electron pairs in its triple bond with carbon. In contrast with the single bond with hydrogen on the other side, this makes the molecule polar with a dipole moment towards the N.
4. The jet of water was deflected.
   a. As it is polar; it presents the charged ends that interact with the charged species.
   b. The jet is again deflected because water has both positive and negative ends.
   c. The liquid jet will not be deflected because it is non-polar. No charges to interact with the charged species in proximity.

Lesson 8: Physical properties of covalent structures: simple molecular structure and giant structures

a) Leaning objective

Relate the structure of simple and giant molecular covalent compounds to their properties.

b) Teaching resources

- Charts illustrating different types of giant covalent structures (diamond, graphite or silicon dioxide)
- The Periodic Table of elements which includes the electronegativities.

c) Prerequisites/ Revision/ Introduction

This lesson requires the knowledge about the covalent compounds. Remember that the compounds that are linked with covalent bonds are called "covalent compounds". The electronegativity is the measure that is used as a tool to know if the compound is covalent.

d) Learning activity 19.8

Refer to the *learning activity 19.8* suggested in the student's book.

- Welcome the class to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- Assign the groups with tasks that can include group discussion or research.
- In the groups learners discuss, attempt *activity 19.8* and record their answers.
- Each group representative presents the Answers to his/her group to his/her classmates.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the learners' findings and emphasize on which are correct, incomplete or false
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples and giving more clarifications.
- Use the *application activity 19.8* to test for the understanding of the lesson. In groups, the students may use their books to give best answers in learning process.
- If there is any questions in the results obtained from the students, emphasize and clarify more to have a good and common understanding.

Answers to Activity 19.8

1. PH_3, CO_2, H_2O, SiO_2, Cl_2, Br_2 and I_2 and graphite.
   a. *Solid:* SiO_2, I_2 and graphite; *Liquid:* H_2O and Br_2; *Gas:* PH_3, CO_2 and Cl_2.

b. Covalent bond

c. Covalent compounds

d. This depends on their structures. Those having giant structures have high melting points.

2. Points about diamond.
   - It is very hard solid
   - It is made by carbon atoms
   - It is crystalline
   - It shines and sparkle
   - It is used in jewellery

e) Answers to Application Activity 19.8

1. In the crystal structure of a diamond, the four outer electrons of each carbon atom participate in covalent bonding (are localized). In graphite, only three of the four outer electrons are covalently bonded to other carbon atoms. Each carbon atom has a delocalized electron that participates in chemical bonding but is free to move throughout the plane of the molecule.

2. Each carbon atom has a delocalized electron that participates in chemical bonding but is free to move throughout the plane of the molecule. While the electrons are delocalized, graphite conducts electricity, has a soft, slippery feel, and is used in pencils and as a dry lubricant for things like locks.

3. This is because the bonds between its sheets are really weak in comparison to the bonds in between their carbon atoms in each layer.

4. Graphite is used as a lubricant due to its slippery nature. Graphite has layers of carbon atoms, with weak forces, residing in between its layers because of which it is quite slippery.

5. Diamond and graphite are both forms of carbon.

   a. Both are macromolecular/giant atomic/giant covalent/giant molecular;

- Hardness:
  - C atoms in diamond joined to 4 other C atoms
  - C atoms in graphite joined to 3 other C atoms diagram with clear extended hexagonal plane/pattern i.e. shows trigonal planar shape
  - Diamond is hard / its crystal is strong because of rigid/ not layered structure

- Graphite is soft as a layer can slide over each other; as there only (weak) van der Waals' forces between layers;

▪ Melting point (for either allotrope):
  Covalent bonds which are strong / many / hard to break must be broken/ overcome

b. Other difference: Diamond is non-conductor of electricity, graphite is conductor *OR* appropriate difference in appearance.

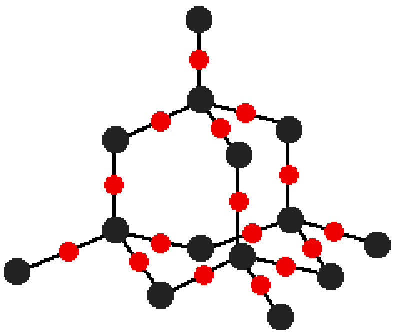
6. Iodine and diamond are both crystalline solids at room temperature.

a. • Similarity in the bonding: Both are covalent

- Difference in the structures: Iodine = molecular /I_2 and Diamond = giant molecular/macromolecular/giant

b. Iodine: Weak van der Waals' forces / induced dipole-induced dipole and Diamond: Covalent bonds would need to be broken many / strong covalent bonds **OR** much energy needed

7. Silicon dioxide has a macromolecular structure. Draw a diagram to show the arrangement of atoms around a silicon atom in silicon dioxide. Give the name of the shape of this arrangement of atoms and state the bond angle.

	*Shape:* Tetrahedral *Bond angle:* $109^{o}28'$

Lesson 9: Intermolecular forces

a) Learning objective

Describe the intra molecular forces and the effect of inter and intra molecular forces on the physical properties of certain molecules.

b) Teaching resources

- Charts illustrating different types of intermolecular forces in some molecules like Cl_2, HCl, HF and DNA strands.
- Manila papers, flipcharts and Movies with computers and projectors if applicable.

c) Prerequisites/ Revision/ Introduction

The knowledge about the existence of intramolecular forces or bonding to make different compounds (ionic, metallic or covalent) is the main thing that helps to know the existence of intermolecular forces, the bonds that held together two or more, same molecules together.

d) Learning activity 19.9

Learning activity 19.9 is a research activity. This is conducted in computer lab with internet connection or in library.

- Form working groups of 6 students and let them conduct a research as described in the activity. This is done in the first period.
- In the following period, the students are now in the classroom where the presentations of their findings will be occurring.
- Before presenting, take the time to collect together (in groups) the individual findings.
- The next period is now for the presentations. Each group representative presents the what his/her group has found.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the students' findings and emphasize on which are correct, incomplete or false.
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples and clarifying the important points like the types of intermolecular forces, the hydrogen bonding as the special type of dipole-dipole interaction, the effect of the forces on the physical properties of compounds and link to biological molecules like proteins and DNA.
- Let student-teachers attempt *application activity 19.9.* They should do the *application activity* in any method you wish to use. This will ensure you about the understanding of your class about the lesson. The activity is given as homework to be submitted the following day.

Answers to Activity 19.9

For the investigation of the intermolecular forces, See the Student teacher's Book. The main tips to consider are given below

INTERMOLECULAR FORCES	FACTORS TO INCLUDE (FOR EACH)
Dispersion forces	• What holds the molecules together • The relative strength of the intermolecular force • A drawing (diagram/ model) of the force
Induced dipole-dipole forces,	
Dipole-dipole forces	
Hydrogen bonding	

e) Answers to Application activity 19.9

1. Definitions
   a. Dispersion force: Attractive force between molecules that have temporary dipole moments.
   b. Dipole-dipole attraction: Attraction force between two polar chemicals where the positive side of one is attracted to the negative side of the other.
   c. Hydrogen bond: Intermolecular force in which a H atom weakly bonds with a highly electronegative atom such F, O or N.
2. Boiling points of some hydrogen halides.
   a. The boiling points of the hydrogen halides from HCl to HI increase as the size of the halide increases (down the group) where the magnitude of the van der Waals intermolecular forces is increasing.
   b. HF has ability to form hydrogen bond.
3. Intermolecular forces serve to hold particles close together, whereas the particles' kinetic energy provides the energy required to overcome the attractive forces and thus increase the distance between particles. Changes in physical state may be induced by changing the temperature, hence, the average kinetic energy of a given substance
4. The intermolecular forces (dispersion forces) increase as the mass increases.
5. Ne has only dispersion forces, whereas HF is polar covalent and has hydrogen bonding, dipole-dipole, and dispersion forces.
6. Order of increasing boiling point temperature:
   a. $SiH_4 < HCl < H_2O$
   b. $F_2 < Cl_2 < Br_2$
   c. $CH_4 < C_2H_6 < C_3H_8$
   d. $N_2 < O_2 < NO$

7. The ethylene glycol contains two OH groups which increase the polarity.

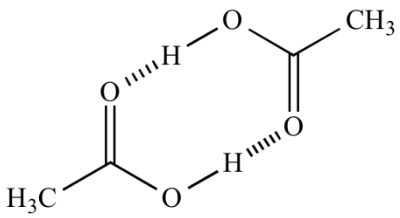
8. Only rather small dipole-dipole interactions from C-H bonds are available to hold n-butane in the liquid state. Chloroethane, however, has rather large dipole interactions because of the Cl-C bond; the interaction is therefore stronger, leading to a higher boiling point.

9. 1-propanol contains an OH group, which makes it more polar.

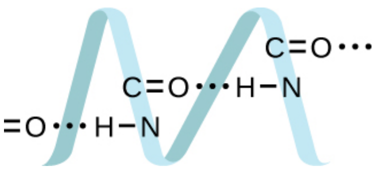
10. −85 °C. Water has stronger hydrogen bonds so it melts at a higher temperature.

11. The hydrogen bond between two hydrogen fluoride molecules is stronger than that between two water molecules because the electronegativity of F is greater than that of O. Consequently, the partial negative charge on F is greater than that on O. The hydrogen bond between the partially positive H and the larger partially negative F will be stronger than that formed between H and O.

12. Intermolecular forces: Hydrogen bonding.



13. H-bonding is the principle IMF holding the DNA strands together. The H-bonding is between the N-H and C=O.



14. Identify the intermolecular forces present in the following solids:
    a. CH_3CH_2OH: *hydrogen bonding and dispersion forces*
    b. $CH_3CH_2CH_3$: *dispersion forces*
    c. CH_3CH_2Cl: *dipole-dipole attraction and dispersion forces*

15. Because the molecules are not attracted to each other as much as in polar molecules, these molecules are much less likely to have high surface tension.

19.6. Summary of the Unit

The sharing of pair of electrons between two atoms is referred to as a **covalent bond**. Normally, each atom that is participating in the covalent bond formation, contributes equal number of electrons to form pair(s) of electrons. The pair of electrons shared between the atoms is also known as **bond pair**.

To explain the formation of covalent bond, a simple qualitative model was developed by **Gilbert Newton Lewis** in **1916**. He said that *"Atoms can achieve an octet of valence electrons by sharing valence electrons. Shared electrons count for each atom's octet"*. There are ***three general ways*** in which the octet rule breaks down:

- Molecules ***with an odd number of electrons*** like NO
- Molecules ***in which an atom has less than an octet*** like BF_3
- Molecules ***in which an atom has more than an octet*** like PCl_5

A ***dative covalent bond***, or ***coordinate bond*** is a type of covalent bonding (i.e., electron sharing) where the shared electron pair(s) are completely provided by one of the participants in the union, and not by contributions from the two of them.

Covalent bonding *occurs when atoms share electrons* (Lewis Model), *concentrating electron density between nuclei*. The build-up of electron density between two nuclei *occurs when a valence atomic orbital of one atom merges with that of another atom* (Valence Bond Theory). According to the Valence Bond Theory, *a covalent bond is formed when two orbitals overlap (share the same space) to produce a new combined orbital containing two electrons of opposite spin*. There are ***two types of covalent bonds*** based on the pattern of overlapping as follows:

- **σ-bond:** The covalent bond formed *due to overlapping of atomic orbital along the inter nucleus axis.*
- **π-bond:** The covalent bond formed by ***sidewise overlapping of atomic orbitals.***

Hybridization is the process of "*intermixing of atomic orbitals of nearly same energies to form same number of identical and degenerate (having equivalent energies) new type of orbitals*". Orbitals which are formed in hybridization process are called *hybrid orbitals*.

In order to predict the geometry of molecules, *Nyholm* and *Gillespie* developed a qualitative model known as Valence Shell Electron Pair Repulsion Theory (*VSEPR Theory*). Determination of shape of a molecule using this theory is done as follows:

- The first step in determination of shape of a molecule is to *write the Lewis dot structure* of the molecule.
- Then *find out the number of bond pairs and lone pairs in the valence shell of central atom*.
- While counting the number of bond pairs, *treat multiple bonds as if they were single bonds*. Thus electron pairs in multiple bonds are to be treated collectively as a single super pair.
- Use *the above table to predict the shape of molecule based on steric number and the number of bond pairs and lone pairs*.

A quantity termed ***'electronegativity'*** is used to determine the polarity of the covalent bond; whether a given bond will be ***non-polar covalent***, ***polar covalent***, or ***ionic***.

- If the electronegativities are equal (i.e. if the electronegativity ***difference is 0***), the bond is ***non-polar covalent.***
- If the difference in electronegativities between the two atoms is ***greater than 0***, but less than 2.0, the bond is ***polar covalent.***
- If the difference in electronegativities between the two atoms is ***2.0, or greater***, the bond is ***ionic.***

Covalently bonded substances fall into two main types:

Simple molecular structures: Substances composed of relatively small covalently bonded structures. Their physical properties are:

- Low melting and boiling points
- Poor electrical conductivity
- Solubility
- Soft and low density

Giant covalent structures: They contain very many atoms, each joined to adjacent atoms by covalent bonds (diamond and silica for example. Properties of giant covalent structures are:

- **Very high melting points.**
- **Variable electrical conductivity.**

Intermolecular forces are the forces between molecules forces between molecules that bind them together. They include (listed from weakest to strongest):

- Van der Waals dispersion forces: occur due to instantaneous dipoles. They *increase as the atomic size increases*

- Van der Waals dipole-dipole interactions: The *higher the difference in electronegativity, the strong the dipole-dipole interactions will be.*
- Hydrogen bonding: This is *a special kind of dipole-dipole interaction that occurs between a hydrogen atom bonded to a high electronegative atom.*

If you are asked to rank molecules in order of ***melting point***, ***boiling point***, ***viscosity***, ***surface tension*** *or* ***vapour pressure***, what they are actually asking is for you to rank them by strength of intermolecular forces (either increasing or decreasing).

Protein structure is partially determined by hydrogen bonding. As a protein folds into place, a series of hydrogen bond “zips” the molecule together, holding it in a specific three-dimensional form that gives the protein its particular function.

Hydrogen bonds hold complementary strands of DNA together. Nucleotides pair precisely based on the position of available hydrogen bond donors (available, slightly positive hydrogens) and hydrogen bond acceptors (electronegative oxygens).

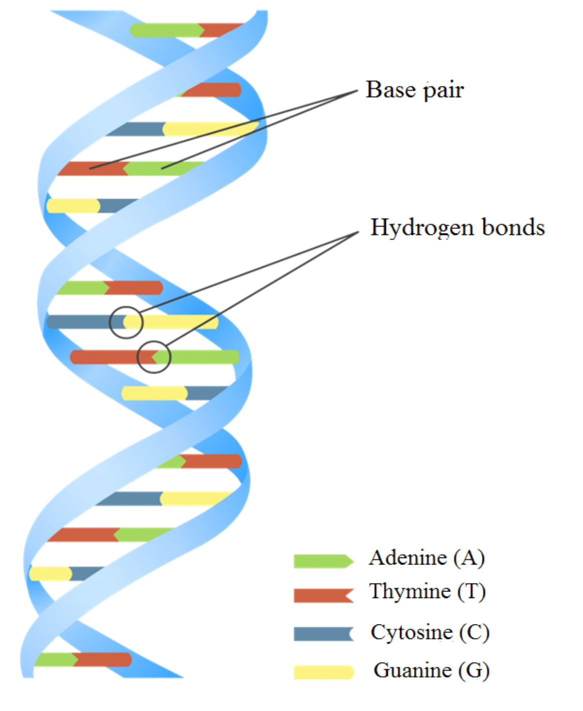
19.7. Additional information for tutors

“HYDROGEN BONDING IN DNA”

Two separate DNA molecules form a double-stranded helix in which the molecules are held together via *hydrogen bonding*. Deoxyribonucleic acid (DNA) is found in every living organism. It is more important because:

- It contains the genetic information that determines the organism’s characteristics,
- It provides the blueprint for making the proteins necessary for life, and
- It serves as a template to pass this information on to the organism’s offspring.

A DNA molecule consists of two (anti-) parallel chains of repeating nucleotides, which form its well-known double helical structure, as shown in the figure below.

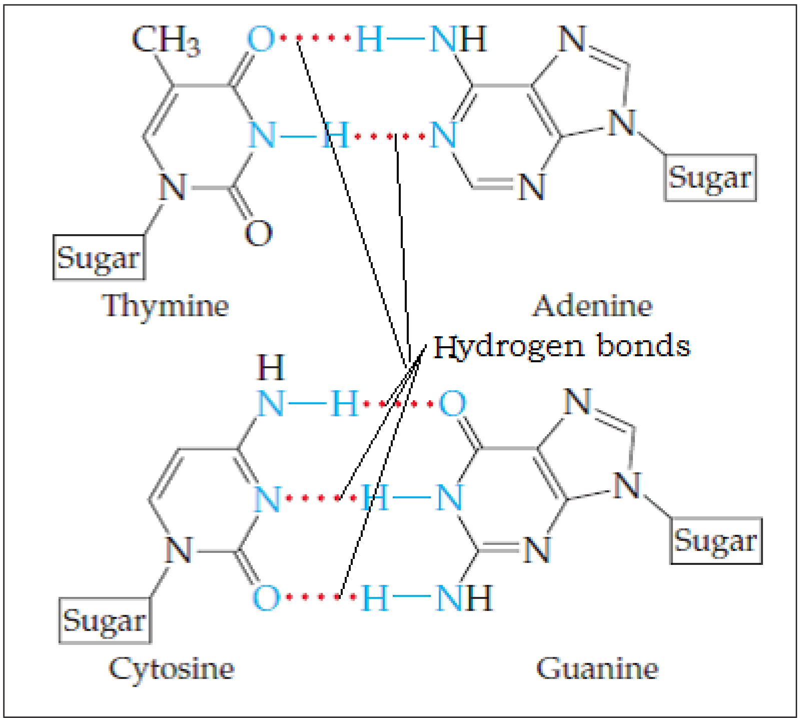


Each nucleotide contains a (deoxyribose) sugar bound to a phosphate group on one side, and one of four- nitrogenous bases on the other.

- Two of the bases, cytosine (C) and thymine (T), are single-ringed structures known as pyrimidines.
- The other two, adenine (A) and guanine (G), are double-ringed structures called purines.

These bases form complementary base pairs consisting of one purine and one pyrimidine, with adenine pairing with thymine, and cytosine with guanine.

Each base pair is held together by ***hydrogen bonding***. **A** and **T** share ***two*** hydrogen bonds, **C** and **G** share ***three***, and both pairings have a similar shape and structure.



The cumulative effect of millions of hydrogen bonds effectively holds the two strands of DNA together. Importantly, the two strands of DNA can relatively easily “unzip” down the middle since hydrogen bonds are relatively weak compared to the covalent bonds that hold the atoms of the individual DNA molecules together. This allows both strands to function as a template for replication.

19.8. End unit assessment 19

Suggested answers to the End Unit Assessment

1. d) Bond angles may depart from the idealized angles because lone pairs of electrons take up less space than bond pairs.

2. (a) 3 N-Cl bonds and 10 lone pairs of electrons

3. (e) PF_3 - pyramidal

4. (d) Sidewise overlap of two parallel p orbitals.

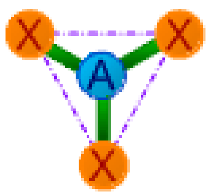
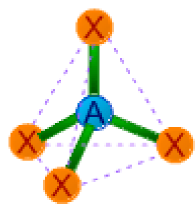
5. (c) 90^o and 120^o

6. (e) Both oxygens are described by sp^3 hybridization.

7. Boron trifluoride and a fluoride ion.

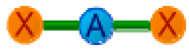
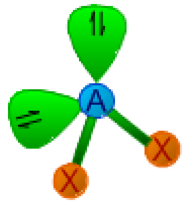
$BF_3 + F^- \rightarrow BF_4^-$

a. Draw diagrams to show the shape of the BF_3 molecule and the shape of the BF_4^- ion. In each case, name the shape. Account for the shape of the BF_4^- ion and state the bond angle present.

	BF_3	BF_4^-
Shape		
Name of the shape	Trigonal planar	Te rahedral
Bond angles	120^o	$109^o28'$

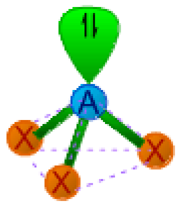
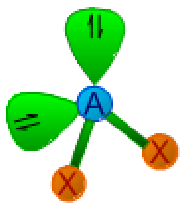
b. The lone pair of electrons on F^- are donated to the electron deficient BF_3. This is a coordinate (dative covalent) bond.

8. Molecule of $BeCl_2$ and Cl_2O.

	$BeCl_2$	Cl_2O
Shape		
Name of the shape	Linear	Bent

9. Ammonia, NH3, reacts with sodium to form sodium amide, NaNH2, and hydrogen.

Ammonia molecule and an amide ion, NH2−.

	NH_3	NH_2^-
Shape		
Name of the shape	Trigonal pyramidal	Bent

a. 107^{o}

b. This is because in an amide ion there are many lone pairs comparing to the number of lone pairs in ammonia.

10. Electronegativity values of some elements.

a. A measure of a substance's ability to attract electrons.

b. The Strongest type of intermolecular force present

i. F_2: Dispersion forces

ii. CH_3F: Dipole-dipole interaction.

iii. HF: Hydrogen bonding

b. It arises when the more electronegative atom like fluorine meets hydrogen atom on the adjacent molecule.

11. Methanol's structure

a. Because the electronegativity of oxygen is different to that of hydrogen.

b. The boiling point of methanol molecules are bonded together with stronger hydrogen bonds while, in oxygen, only dispersion forces are present.

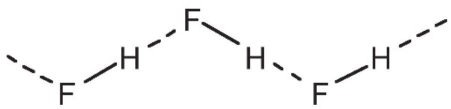
12. From the boiling points of some hydrogen halides.

a. In order to increase the kinetic energy and the molecules go far apart each other.

b. The number of electrons as shown by the molecular mass is between the two. So, the intermolecular forces (van der Waals forces) magnitudes are in that order.

c. HF molecules can form hydrogen bonds between them.

d. Sketch to illustrate how two molecules of HF interact in liquid hydrogen fluoride.



13. Data concerned with halogens.

a. A measure of the ability of an atom of the element to attract electrons.

b. The boiling point increases from HCl to HI as the molecular weights increase. This is because the intermolecular forces (van der Waals) are increasing gradually.

c. Because it has a special, stronger type of intermolecular forces (hydrogen bonding).

14. The sulphate ion

a. SO_4^{2-}

b. 109.5^{o}

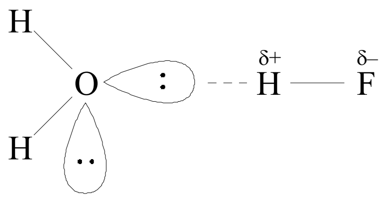
15. a. Presence of directly linked H atom and a highly electronegative atom like H, O or N.

b. Dipole-dipole interaction. S is not electronegative enough to form H bonding.

c. Water molecules are linked by H bonds by H_2S is only van der Waals (dipole-dipole interaction).

16. In a protein molecule, there are N-H bonds where H is bonded with a very electronegative N atom. Here, the H bonding can form.

17. The diagram below shows how a water molecule interacts with a hydrogen fluoride molecule.



a. 104.5°

b. The electron arrangement would be a tetrahedral because of four electron pairs around hydrogen. However two of these pairs are lone pairs. The latter has a higher repulsive effect and repel the bond pairs reducing the bond angle from 109°28' to 104.5°.

c. Hydrogen bonding

d. The fluorine atom which is the most electronegative atom attracts the electron from hydrogen and there remains the deficiency of electrons.

e. The angle changes from 104.5° to around 107° because the lone pairs are slightly reducing. One is somehow changed to bonding pair.

18. White phosphorus and red phosphorus.

a. Macromolecular means "Giant lattice".

b. Covalent bonds. It is needed to break covalent bonds to melt red phosphorus and it is needed to break Van der Waal's forces to melt white phosphorus. Covalent bonds are stronger than Van der Waal's forces.

19.9. Additional activities (Questions and answers)

19.9.1. Remedial activities

1. What is a co-ordinate (or dative covalent) bond?

Answer: This is a covalent bond (a pair of shared electrons) in which both electrons came from the same atom.

2. Use the periodic table containing the electronegativity value to answer the following questions.

a. List these bonds in order of increasing polarity: H-F, F-F, C-Cl, C-Br, C-O, N-H

b. By writing δ+ and δ- as appropriate above each of the atoms in the bond, show the polarity of the following bonds: C-O, C-Cl, C-Br, C-N, C-C, N-H, H-Br, O-H

Answer:

a. F-F (electronegativity difference = 0)

C-Br (electronegativity difference = 0.3)

C-Cl (electronegativity difference = 0.5)

N-H (electronegativity difference = 0.9)

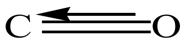
C-O (electronegativity difference = 1.0)

H-F (electronegativity difference = 1.9)

b. Polarities

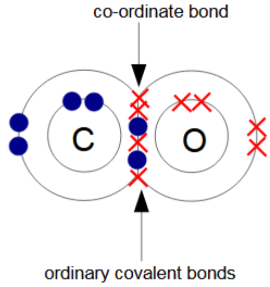
$\overset{\delta+}{C}$ — $\overset{\delta-}{O}$	$\overset{\delta+}{C}$ — $\overset{\delta-}{Cl}$	$\overset{\delta+}{C}$ — $\overset{\delta-}{Br}$	$\overset{\delta+}{C}$ — $\overset{\delta-}{N}$	$\overset{\delta+}{H}$ — $\overset{\delta-}{Br}$	$\overset{\delta-}{N}$ — $\overset{\delta+}{H}$	C — C

Carbon monoxide can be represented as:



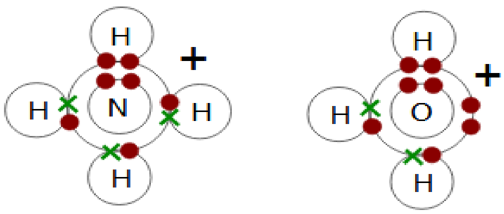
Redraw this using a dots-and-crosses diagram to make clear the difference between the bond shown by the arrow and those shown by the ordinary lines.

Answer:



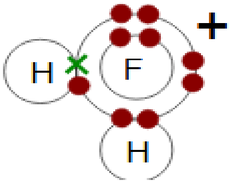
4. The ammonium ion, NH_4^+, and the hydroxonium ion, H_3O^+, contain ordinary covalent bonds and co-ordinate bonds. Draw dots-and-crosses diagrams to show the bonding in both of these ions, making clear which sort of bond is which.

Answer:



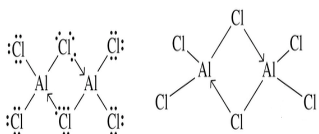
5. Draw a dots-and-crosses diagram for the ion H_2F^+.

Answer:



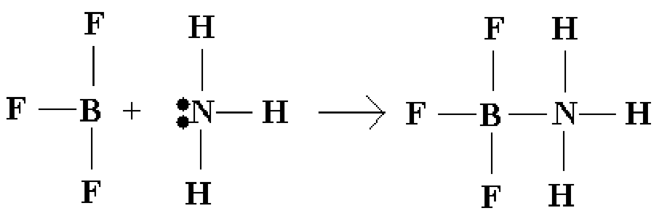
6. Aluminium chloride sublimes (turns directly from a solid to a gas) at about 180°C.Measurements of its relative molecular mass show that its formula is Al_2Cl_6 in the vapour at that temperature. Draw a dots-and-crosses diagram (showing outer electrons only) to show how the aluminium chloride is bonded in Al_2Cl_6.

Answer:



7. Ammonia, NH_3, and boron trifluoride, BF_3, combine to make a compound $NH_3{\bullet}BF_3$. Draw a dots-and-crosses diagram (showing outer electrons only) to show the bonding in this new compound.

Answer:



19.9.2. Consolidation activities

1. Most metal ions in solution react with water to give what are called *hydrated ions*. For example, magnesium ions in solution exist as $[Mg(H_2O)_6]^{2+}$. The water molecules attach to the magnesium ions via co-ordinate bonds.

   a. Explain what it is about water that enables it to form co-ordinate bonds.

   b. The electronic structure of magnesium is $1s^2\ 2s^2\ 2p^6\ 3s^2$. What is the electronic structure of a magnesium ion, Mg^{2+}?

c. Explain briefly which orbitals are used in the magnesium ion for attaching the water molecules too.

d. Beryllium is in the same group as magnesium, but unlike the rest of Group 2 forms a hydrated ion with only four water molecules attached. Can you think of a reason (or perhaps two reasons) why that might be?

Answer:

a. The lone pairs of electrons on the oxygen atom.

b. $1s^2 2s^2 2p^6$

c. If it is going to form six co-ordinate bonds, it will need six empty orbitals on the magnesium ion.

d. These will be hybridised versions of the 3s, the three 3p orbitals and two of the 3d orbitals.

There are two things which you might have thought of.

One is that the beryllium ion is going to be very small (its electronic structure is just $1s^2$), and so it may be impossible to fit six water molecules around it. But in fact that possibility can never arise anyway. The main reason is that beryllium does not have enough orbitals of the right energy. There are not any 2d orbitals – only the 2s and the three 2p orbitals, and it uses a hybridized version of these to join to the four water molecules. To fit six water molecules around it would need it to use 3-level orbitals as well. There is too big an energy gap between the 2- and 3-level orbitals for this to work.

2. Iodine and graphite crystals both contain covalent bonds and yet the physical properties of their crystals are very different.

a. For iodine and graphite, state and explain the differences in their melting points and in their electrical conductivities.

b. Draw the shape of the $BeCl_2$ molecule and explain why it has this shape.

Answer:

Iodine and graphite crystals both contain covalent bonds.

a. I_2 sublimes when heated, it has low melting point and graphite has (very) high melting point. I_2 is (simple) molecular / I_2 / I-I presents Van der Waals forces / induced or temporary dipole-dipole / London forces which are weak or easily overcome (so low melting point). Graphite is macromolecular / giant covalent / giant molecular /

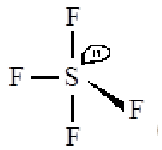
giant atomic / (Many) covalent bonds need to be broken which takes much energy / bonds are strong. Only graphite conducts as it has delocalised / free / mobile electrons. All e- in iodine are used in bonding and lone pairs OR as it has no delocalised / free / mobile e-.

b. Diagram Cl–Be–Cl (clearly linear). (Equal) repulsion between 2 bonding pairs / bonds.

3. Explain how the concept of bonding and lone (non-bonding) pairs of electrons can be used to predict the shape of, and bond angles in, a molecule of sulphur tetrafluoride, SF_4. Illustrate your answer with a sketch of the structure.

Answer:

Five electron pairs including one lone pair repel as far apart as possible. Lone pair – bond pair repulsion > bp – bp pushes S–F bonds closer together Shape is:



Angles <90 and <120

19.9.3. Extended activities

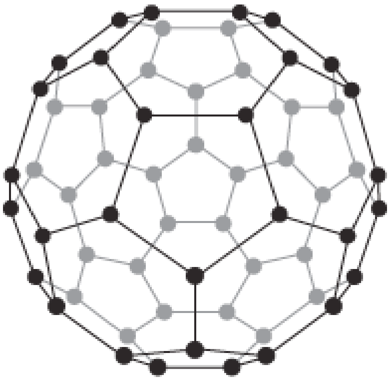
Questions

i. Boron nitride, BN, has a structure like that of graphite. Explain the bonding in BN?

Answer:

Hexagonal boron nitride (h-BN) is the equivalent in structure of graphite. Like graphite, its plate-like microstructure and layered lattice structure give it good lubricating properties.

ii. One of the simple molecular allotropes of carbon is buckminsterfullerene, C_{60}.



Buckminsterfullerene

What is the hybridisation and what is the bond angle formed by carbon atoms in C_{60}?

Answer:

Hybridisation type: **sp^2**, bond angle: **120^o**

iii. DNA consists of a double helical structure.

a. Describe the bonding between the two strands in DNA and state which part of each strand is joined by it.

b. How does the strength of this bonding relate to the mechanism of the replication of DNA?

Answer:

DNA consists of a double helical structure.

a. Each base pair is held together by *hydrogen bonding*. A and T share *two* hydrogen bonds, C and G share *three*.

b. The two strands of DNA can relatively easily "unzip" down the middle since hydrogen bonds are relatively weak compared to the covalent bonds that hold the atoms of the individual DNA molecules together. This allows both strands to function as a template for replication.

iv. Complete the table below by choosing one molecule from the following list to match the description given.

H_2CO, PH_3, SO_3, $CHBr_3$, H_2, CO and SiF_4

Description	Molecule
A molecule which is tetrahedral and polar	
A diatomic molecule with only dispersion forces between its molecules	
A molecule which is trigonal planar and polar	
A molecule which is pyramidal and has dipole-dipole forces between its molecules	

Answer:

Table to complete

Description	Molecule
A molecule which is tetrahedral and polar	$\mathbf{CHBr_3}$
A diatomic molecule with only dispersion forces between its molecules	$\mathbf{H_2}$
A molecule which is trigonal planar and polar	$\mathbf{H_2CO}$
A molecule which is pyramidal and has dipole-dipole forces between its molecules	$\mathbf{PH_3}$

UNIT 20

MOMENTS AND EQUILIBRIUM OF BODIES

20.1. Key Unit Competence

Explain the principle of moments and apply it to the equilibrium of a body.

20.2. Prerequisite (knowledge, skills, attitudes and values)

The success of this unit relies partly on the mastery of knowledge, skills, attitudes and values acquired in Physics subject in previous units about forces and Newton's laws of motion ($S_1$and S_3 O' level).

20.3. Cross cutting issues to be addressed

Inclusive education (promote education for all while teaching). Regardless of physical appearance and abilities student - teachers should all be treated equally. This makes the student - teachers to find out that they are all of great importance.

Peace and value Education (respect others view and thoughts during class discussions). Remember that someone‘s idea is very important. It may be correct or Not but what is important is to build on that Idea.

Gender (equal opportunity of boys and girls in the lesson participation). Care should be taken that both Sexes are given equal opportunities.

20.4. Guidance on introductory activity

This activity aims at capturing student-teachers attention and minds towards this concept

- Divide your student-teachers into groups (Grouping may depend on the nature of your class or number of student-teacher you have.
- Tell the student - teachers to open the introductory activity in the student-teacher‘s book.
- Asks the groups to observe the pictures and answer the related questions.

- While students are doing this activity, you move around and mark their work.
- When everyone is done and you are done, invite some member(s) or group(s) to discuss their findings to the whole class.
- Ask other members whether their answers correspond to the discussed points and if there is any point that is different from what have been raised to mention it. You can talk about those points (in a discussion together with other students)
- Together with students harmonize the points and make a summary on the board. Allow student - teachers to write the main points in their notebooks
- Linking to the summary and what have discussed in class, emphasize on moment and equilibrium of bodies . You can take some minutes and explain them.

20.5. List of lessons

#	**Lesson title**	**Learning objectives**	Number of periods
1	Vector and scalar quantities	- Recall force, vectors and stability - Distinguish a vector and scalar quantity - Appreciate the importance of vectors and scalars in life Describe forces and its moment about a point State and describe principles of moment - Recognize the importance of moments life.	3
2	Types of equilibrium: stable, unstable and neutral	Describe the types of equilibrium: stable, unstable and neutral	3

3	Condition for equilibrium of a body about an axis and Stevinus proof	Establish the condition for equilibrium of a body about an axis State Stevinus proof Analyse free body diagrams	3
4	Forces and moments in equilibrium	- Explain forces in equilibrium - Analyze the forces that keep a body in equilibrium. - Appreciate balancing of forces in life - Explain couples and torques - Analyse diagrams of coplanar forces	3
5	Archimedes principle and centre of gravity.	- Describe archimedes and the principle of the lever - Locate the centre of gravity of a flat object Solve problems involving vectors and scalars. - Describe equilibrium of a system of objects - Solve problems involving moments and equilibrium	4
6	End unit assessment		2

Lesson 1: Vector and scalar quantities

a) Learning objective

- Recall force, vectors and stability
- Distinguish a vector and scalar quantity
- Appreciate the importance of vectors and scalars in life

- Describe forces and its moment about a point
- State and describe principles of moment
- Recognize the importance of moments life.

b) Teaching resources

Meter ruler, knife edges, and standard masses, see saw

c) Prerequisites/Revision/Introduction

Previous units about forces and Newton's laws of motion ($S_1$and S_3 O'level).

d) Learning activity 20.1

Guidance

- Divide student-teachers in groups of 5 members.
- Tell the student - teachers to open the activity 20.1 in the student-teacher's book and do it.
- Assist student - teachers in answering the questions by relating them to vector and scalar quantity.
- Permit one learner from one group to read their findings and explain to the rest of the class.
- Moderate the logical sequence of learner's findings
- Summarise learner's production.
- Guide student - teachers to make connection of physics concept discussed above to how they occur in real life.

Answers to activity 20.1

Task 1

- your friend moves in forward direction
- you have a tendency to move forward.
- The motion stops and student-teachers are at rest.

Task 2

a. downward
b. do not move i.e remain at rest
c. upward
d. to left.

e) Answers to application activity 20.1

1. A ball will stay still if the forces on it are **balanced**. If the forces on it are unbalanced, the ball will get **faster** or **slower**. The overall force is called the **resultant** force. If something gets faster, we say it is **accelerating.**

2. **Vertically**

   $8 = 5 + W + R \rightarrow R = 3 - W$

   Taking moments about R

   $(5 \times 2) + (W \times 1) = 8 \times 2 \rightarrow W = 1\,N$

   Thus

   $R = 3 - W = 3N - 1N = 2\,N$

Lesson 2: Types of Equilibrium: stable, unstable and neutral

a) Learning objective

Describe the types of equilibrium: stable, unstable and neutral

b) Teaching resources

A desk, bottle, knife edge, and a cone

c) Prerequisites/Revision/Introduction

Under your guidance and linking this lesson to the previous one, make student - teachers to describe the types of equilibrium. Ask them questions like give examples of objects in equilibrium in everyday lives.

d) Learning activities

Guidance

- Let the student - teachers carry out activity 20.2 in student - teacher's book (if it is a mixed school, the number of boys and girls in each group should be balanced).
- Arrange student - teachers in groups (select any number of student - teachers depending on the size of the class) make sure that they work in harmony.
- Help them in selecting their group leaders.

- Recognise student - teachers with special needs in group making. Encourage them to actively participate in their respective groups.
- Move around the class guiding student - teachers as they are performing the activity. In case of any assistance you can make bright student - teachers to assist the weak ones.
- Let the student - teachers discuss their findings in their groups and finally present to the whole class.
- Consolidate the lesson by developing and giving your ideas basing on student - teachers' ideas.

As the lesson progresses, look at the following key points as they will help student - teachers to understand the concept;

Answers to activity 20.2

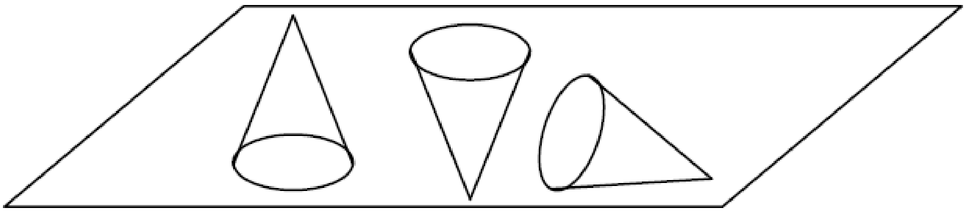
(i) The desk returns back in the original position (stable equilibrium).

(ii) The bottle rolls horizontally at the same height (neutral equilibrium).

(iii) The knife edge falls in new position (unstable equilibrium).

(iv) A body is in either Stable, Unstable or in neutral equilibrium depending how it behaves when subjected to a small displacement.

e) Answers to application activity 20.2



stable equilib.	unstable equilib.	neutral equilib.

Lesson 3: Conditions for equilibrium of bodies about the axis and Stevinus proof

a) Learning objective

- Establish the condition for equilibrium of a body about an axis

- State Stevinus proof
- Analyze free body diagrams

b) Teaching resources

Objects in the environment

c) Prerequisites/Revision/Introduction

Previous lesson

d) Learning activity 20.3

Guidance

- Take student –teachers outside of the class
- Ask them to observe the motion of various objects in the environment
- Ask them to answer the questions in activity 20.3
- Recognise student - teachers with special needs. Encourage them to actively participate in the lesson.
- In case of any assistance you can make bright student - teachers to assist the weak ones.
- Let the student - teachers discuss their findings and finally present to the whole class.
- Consolidate the lesson by developing and giving your ideas basing on student - teachers' ideas.

Answers to activity 20.3

Yes. Some are at rest and other in motion (oscillating).

They are at rest because the net force (resulting) and net torque acting on them is equal to zero.

e) Answers to application activity 20.3

1. **Approach.** This figure is the free-body diagram for the beam, showing all the forces acting on the beam. It also shows the components of and. We have three unknowns, , and (we are given), so we will need all three equations, .

Solution

The sum of forces in the vertical (y) direction is

$$\sum F_y = 0$$

$$F_{Hy} + F_{Ty} - mg - Mg = 0$$

i. In the horizontal (x) direction, the sum of forces is

$$\sum F_x = 0$$

$$F_{Hx} - F_{Tx} = 0$$

ii. For the torque equation, we choose the axis at the point where and act (so our equation then contains only one unknown,). We choose torques that tend to rotate the beam counterclockwise as positive. The weight of the (uniform) beam acts at its center, so we have

$$\sum \tau = 0$$

$$-(F_{Hy})(2.20\, m) + mg(1.10\, m) = 0$$

We solve for F_{Hy}:

$$F_{Hy} = \left(\frac{1.10\, m}{2.20\, m}\right) mg = (0.500)(25.0\, kg)(9.80\ m/s^2) = 123\, N.$$

iii. Next, since the tension $\overrightarrow{F_T}$ in the cable acts along the cable ($\theta = 30.0^0$), we see from figure above that $\tan\theta = F_{Ty}/F_{Tx}$, or

$$F_{Ty} = F_{Tx}\tan\theta = F_{Tx}(\tan 30.0^0) = 0.577 F_{Tx}$$

iv. Equation (i) above gives

$$F_{Ty} = (m + M)g - F_{Hy} = (53.0\, kg)(9.80\, m/s^2) - 123\, N = 396\, N;$$

Equation (iv) and (ii) give

$$F_{Tx} = F_{Ty}/0.577 - 687\, N$$

$$F_{Hx} = F_{Tx} = 687\, N$$

The components of $\overrightarrow{F_H}$ are $F_{Hy} = 123\ N$ and $F_{Hx} = 687\ N$.

The tension in the wire is

$$F_T = \sqrt{F_{Tx}^2 + F_{Ty}^2} = 793\ N$$

2. Approach. This figure is the free-body diagram for the ladder, showing all the forces acting on the ladder. The wall, since it is frictionless, can exert a force only perpendicular to the wall, and we label that force $\overrightarrow{F_W}$. The cement floor exerts a force $\overrightarrow{F_C}$ which has both horizontal and vertical force components: F_{Cx} is frictional and F_{Cy} is the normal force. Finally, gravity exerts a force mg=(12.0 kg)(9.80 m/s^2)=118 N on the ladder at its midpoint, since the ladder is uniform.

Solution

Again we use the equilibrium conditions, $\sum F_x = 0, \sum F_y = 0, \sum \tau = 0$. We will need all three since there are three unknowns $F_W, F_{Cx}, and\ F_{Cy}$. The y component of the force equation is

$$\sum F_y = F_{Cy} - mg = 0$$

So immediately we have

$$F_{Cy} = mg = 118\ N$$

The x component of the force equation is

$$\sum F_x = F_{Cx} - F_W = 0$$

To determine both F_{Cx} and F_W, we need a torque equation. If we choose to calculate the torques about an axis through the point where the ladder touches the cement floor, then $\overrightarrow{F_C}$, which acts at this point, will have a lever arm of zero and so won't enter the equation. The ladder touches the floor a distance $x_0 = \sqrt{(5.0\ m)^2 - (4.0\ m)^2} = 3.0\ m$ from the wall. The lever arm for mg is half this, or 1.5 m, and the lever arm for F_W is 4.0 m. we get

$$\sum \tau = (4.0\ m)F_W - (1.5\ m)mg = 0$$

Thus

$$F_W = \frac{(1.5\ m)(12.0\ kg)(9.8\ m/s^2)}{4.0\ m} = 44\ N$$

Then, from the component of the force equation,

$F_{Cx} = F_W = 44\ N$

Since the components of $\overrightarrow{F_C}$ are $F_{Cx} = 44\ N$, and $F_{Cy} = 118\ N$, then

$F_C = \sqrt{(44\ N)^2 + (118\ N)^2} = 126\ N$, and it acts at an angle to the floor of

$\theta = \tan^{-1}(118\ N/44\ N) = 70^0$

NOTE The force $\overrightarrow{F_C}$ does not have to act along the ladder's direction because the ladder is rigid and not flexible like a cord or cable.

Lesson 4: Forces and moments in equilibrium

a) Learning objective

- Explain forces in equilibrium
- Analyze the forces that keep a body in equilibrium.
- Appreciate balancing of forces in life
- Explain couples and torques
- Analyse diagrams of coplanar forces

b) Teaching resources

A seat, uniform meter rule, knife edge, a balance and a mass

c) Prerequisites/Revision/Introduction

Previous lesson

d) Learning activity 20.4

Guidance

- Let the student - teachers carry out activity 20.4 in learner's book (if it is a mixed school, the number of boys and girls in each group should be balanced).
- Put student - teachers in groups (select any number of student - teachers depending on the size of the class) make sure that they work in harmony.
- Help them in selecting their group leaders.
- Recognise student - teachers with special needs in group making. Encourage them to actively participate in their respective groups.

- Move around the class guiding student - teachers as they are performing the activity. In case of any assistance you can make bright student - teachers to assist the weak ones.
- Let the student - teachers discuss their findings in their groups and finally present to the whole class.
- Consolidate the lesson by developing and giving your ideas basing on student - teachers' ideas.

Answers to activity 20.4

When you lift the seat alone, the sea is too heavy. But when you lift it together with your friend, it is easier than before because your forces are added. When you friend pull in opposite direction the seat will be in motion if the forces applied are different or at rest if the forces are equal.

e) Application activity 20.4

Guidance

- Take student-teachers in physics laboratory.
- Divide your student-teachers into groups (Grouping may depend on the nature of your laboratory or number of student-teacher you have.
- Distribute the apparatus required: uniform meter rule, knife edge, a balance and a mass
- Tell the student - teachers to open the activity 20.4 in the student-teacher's book and do it.
- Help them to tabulate their results from the activity and ask them to plot a graph.
- Let them interpret their graphs.
- Guide them to find a gradient from the graph and deduce the mass M of an object provided.
- Hold a class discussion on their findings.

Lesson 5: Archimedes' principle of the lever and centre of gravity of bodies

a) Learning objective

- Describe archimedes and the principle of the lever

- Locate the centre of gravity of a flat object
- Solve problems involving vectors and scalars.
- Describe equilibrium of a system of objects
- Solve problems involving moments and equilibrium

b) Teaching resources

Pencil, a ruler, a notebook or other regular shaped material

c) Prerequisites/Revision/Introduction

Referring on application activity 20.4 above.

d) Learning activity 20.5

Guidance

- Let the student - teachers carry out activity 20.5 in learner's book (if it is a mixed school, the number of boys and girls in each group should be balanced).
- Put student - teachers in groups (select any number of student - teachers depending on the size of the class) make sure that they work in harmony.
- Help them in selecting their group leaders.
- Recognise student - teachers with special needs in group making. Encourage them to actively participate in their respective groups.
- Move around the class guiding student - teachers as they are performing the activity. In case of any assistance you can make bright student - teachers to assist the weak ones.
- Let the student - teachers discuss their findings in their groups and finally present to the whole class.
- Consolidate the lesson by developing and giving your ideas basing on student - teachers' ideas.

Answers to activity 20.5

Task 1

A lever is a beam connected to ground by a hinge or pivot called a fulcrum.

Task 2

Yes, it is balanced, the cause of the balance is that the net force and net torque are zero. The point of balance is called the center of gravity. We can locate it using experiments done in O'level.

e) Answers to application activity 20.5

$$n = m_f g + m_d g + mg = (50\ kg)(10\ m/s^2) + (20\ kg)(10\ m/s^2) + (10\ kg)(10\ m/s^2)$$

$$n = 800\ N$$

$$Sum\ of\ clockwise\ moments = sum\ of\ anticlockwise\ moments$$

$$m_f \times d = m_d \times \frac{l}{2}$$

$$50\ kg \times d = 20\ kg \times \frac{2m}{2} \rightarrow d = 0.4\ m$$

20.6. Summary of the unit

- For a rigid body to be in equilibrium, two conditions must be satisfied. First, the vector sum of forces must be zero. Second, the sum of torques about any point must be zero. The torque due to the weight of a body can be found by assuming the entire weight is concentrated at the center of gravity, which is at the same point as the center of mass if $\vec{g}$ has the same value at all points.

  $$\sum F_x = 0\ ,\ \sum F_y = 0,\quad \sum \tau = 0$$

- Equilibrium has many different meanings, depending on what subject (chemistry or physics) or what topic (energy or forces). Dealing with energy, there are three types of equilibrium.

  Abody is in either Stable, Unstable or in neutral equilibrium depending how it behaves when subjected to a small displacement.

- In physics and engineering, a free body diagram (force diagram, or FBD) is a graphical illustration used to visualize the applied forces, movements, and resulting reactions on a body in a given condition

20.7. Additional information for tutors

Consider an object under the action of several forces such that the resultant force

$$\sum \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots = 0$$

Construction for showing that if the net torque about origin O is zero, the net torque about any other origin, such as O', will be

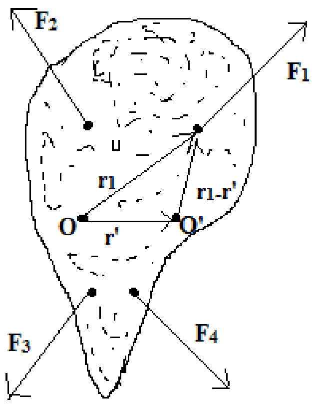


Figure describes the situation (for clarity, only four forces are shown), the point of application of $\vec{F}_1$ is specified by the position vector $\vec{r}_1$, similarly, the points of application of $\vec{F}_2, \vec{F}_3$, ... are specified by $\vec{r}_2, \vec{r}_3$, ...(not shown)

The net torque about **O** is:

$$\sum \vec{\tau}_O = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \vec{r}_3 \times \vec{F}_3 + \cdots$$

Now consider another position vector $\vec{r}'$ relative to **O'**. the point of application of $\vec{F}_1$ relative to this point is identified by the vector $\vec{r}_1 - \vec{r}'$ likewise, the point of application of $\vec{F}_2$ relative to **O'**, is $\vec{r}_2 - \vec{r}'$, and so forth. Therefore the torque about **O'** is:

$$\sum \vec{\tau}_{O'} = (\vec{r}_1 - \vec{r}') \times \vec{F}_1 + (\vec{r}_2 - \vec{r}') \times \vec{F}_2 + \cdots$$
$$\sum \vec{\tau}_{O'} = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \cdots = -\vec{r}' \times (\vec{F}_1 + \vec{F}_2 + \cdots)$$

Since the net force is assumed to be zero, the last term in this last expression vanishes and we see that

$\sum \vec{\tau}_{O'} = \sum \vec{\tau}_O$, hence ,

If an object is in translational equilibrium and the net torque is zero about one point, it must be zero about any other point.

Finding and using the center of Gravity

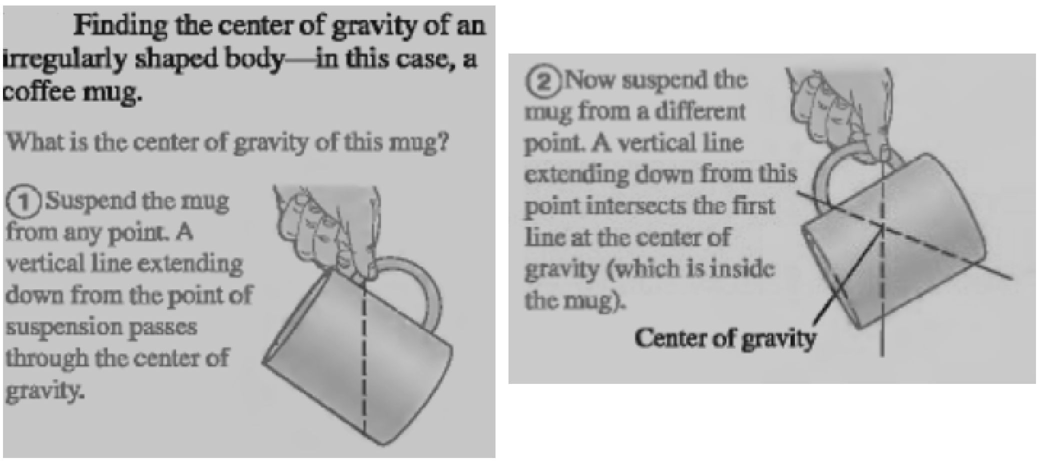
We can often use symmetry considerations to locate the center of gravity of a body, just as we did for the center of mass.

The of gravity of a homogeneous sphere, cube, circular sheet, or rectangular plate is at its geometric center. The center of gravity of a right circular cylinder or cone is on its axis of symmetry.

For a body with a more complex shape, we can sometimes locate the center of gravity by thinking of the body as being made of symmetrical pieces. For example we can approximate the human body as a collection of a solid cylinders, with a sphere for the head. Then we can compute the coordinates of the center of gravity of the combination letting m_1, m_2,.. be the masses of the individual pieces and (x_1, y_1, z_1), (x_1, y_1, z_1),... be the coordinates of their centers of gravity.

When a body acted on by gravity is supported or suspended at a single point, the center of gravity is always at or directly above or below the point of suspension. If it were anywhere else, the weight would have a torque with respect to the point of suspension, and the body could not be in rotational equilibrium.

Figure below shows how to use this fact to determine experimentally the location of the center of gravity of an irregular body.



The lower the center of gravity and the larger the area of support, the more difficult it is to overturn a body. Four-legged animals such as Deer and Horses have a large area of support bounded by their legs; hence they are naturally stable and need only small feet or hooves. Animals that walk erect on two legs, such as humans and birds, need relatively large feet to give them a reasonable area of support. If a two legged animal holds its body approximately horizontal, like a chicken or the dinosaur Tyrannosaur rex, it must perform a delicate balancing act as it walks to keep its center of gravity over the foot that is on the ground. A chicken does this by moving its head, T.rex probably did it by moving its massive tail.

Problem solving in statics questions

1. Choose one object at a time for consideration. Make a careful **free-body diagram** by showing all the forces acting on that object and the points at which these forces act. If you aren't sure of the direction of a force, choose a direction; if the actual direction of a force is opposite, your eventual calculation will give a result with a minus sign.
2. Choose a convenient **coordinate system**, and resolve the forces into their components.
3. Using letters to represent unknowns, write down the **equilibrium equations** for the **forces:** $\sum F_x = 0$ and $\sum F_y = 0$, assuming all the forces act in plane.
4. For the **torque equation, $\sum\tau=0$** , Choose any axis perpendicular to the x-y plane that might make the calculation easier. Pay careful attention to determining the lever arm for each force correctly. Give each torque a + or – sign to indicate torque direction. For example if torques tending to rotate the object counterclockwise are positive, then those tending to rotate it clockwise are negative.
5. **Solve** these equations for the unknowns. Three equations allow a maximum of three unknowns to be solved for. They can be forces, distances, or even angles.

20.8. End unit assessment (answers)

1. Volume

2. Force

3. Is a quantity that is completely specified by its magnitude

4. Specifies both a magnitude and a direction.

5. 0 kilograms.

6. (a) **The principle of moments** states that when in equilibrium the total sum of the anticlockwise moment is equal to the total sum of the clockwise moment.

(b) **The first or force condition:** the vector sum of all forces acting on the body must be zero and the second is the sum of all the torques acting on the object must be zero.

7. We first resolve $\overrightarrow{F_A}$ into its horizontal (x) and vertical (y) components. Although we don't know the value of F_A, we can write $F_{Ax} = -F_A \cos 60^0$ *and* $F_{Ay} = F_A \sin 60^0$. $\overrightarrow{F_B}$ has only an x component. In the vertical direction, we have the downward force exerted by the vertical cord equation to the weight of the chandelier = (200 kg)(g), and the vertical component of $\overrightarrow{F_A}$ upward. Since $\sum F_y = 0$, we have

$$\sum F_y = F_A \sin 60^0 - (200\text{ kg})(\text{g}) = 0$$

So

$$F_A = \frac{(200\text{ kg})(\text{g})}{\sin 60^0} = 2260\ N$$

In the horizontal direction,

$$\sum F_x = F_B - F_A \cos 60^0 = 0$$

Thus,

$$F_B = F_A \cos 60^0 = (231\ N)(9.8\ m/s^2)\cos 60^0 = 1130\ N$$

The magnitude of $\overrightarrow{F_A}$ and $\overrightarrow{F_B}$ determine the strength of cord or wire that must be used. In this case, the wire must be able to hold more than 230 kg.

8.

$\sum \text{F}_\text{y} = \text{X} + \text{Y} - 3\text{ N} = 0$ (1)

$\sum \text{F}_\text{y} = 0$ (2)

$\sum \tau_\text{A} = (3\text{ N} \times 0.4\text{ m}) - (\text{Y} \times 0.6\text{ m}) = 0$ (3)

From (3)

$$\text{y} = \frac{(3\text{ N}\times 0.4\text{ m})}{0.6\text{ m}} = 2\text{ N}$$

From (1),

$$\text{X} = 3\text{ N} - \text{Y} = 3\text{ N} - 2\text{ N} = 1\text{ N}$$

20.9. Additional activities

20.9.1 Remedial activities

1. A uniform 300 N trapdoor in a floor is hinged at one side. Find the net upward force needed to begin to open in and the total force exerted on the door by the hinges (a) if the upward force is applied at the center and (b) if the upward force is applied at the center of the edge opposite the hinges.

Answer

Apply the first and second conditions for equilibrium to the trap door.

For $\sum\tau=0$ take the axis at the hinge. Then the torque due to the applied force must balance the torque due to the weight of the door.

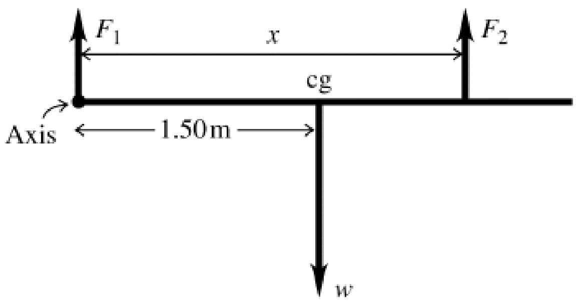
a. The force is applied at the center of gravity, so the applied force must balance the torque due to the weight of the door, or 300 N. in this case the hinge exert no force.

b. With respect to the hinges, the moment arm of the applied force is twice the distance to the center of mass, so the force has half the magnitude of the weight, or 150 N. the hinges supply an upward force of 300 N-150 N = 150 N.

2. Two people are carrying a uniform wooden board that is 3.00 m long and weighs 160 N. If one person applies an upward force equal to 60 N at one end, at what point does the other person lift? Begin with a free-body diagram of the board.

Answer

Apply the first and second conditions of equilibrium to the board. The free body diagram for the board is given in figure below. Since the board is uniform its center of gravity is 1.50 m from each end. Apply ∑F_y =0 , with +y upward. Apply ∑τ=0 with the axis at the end where the first person applies a force and with counterclockwise torques positive.



$$\sum F_y = F_1 + F_2 - w = 0 \rightarrow F_2 = w - F_1$$

$$F_2 = 160\ N - 60\ N = 100\ N$$

$$\sum \tau = F_2 x - w(1.50m) = 0 \rightarrow x = \frac{w(1.50m)}{F_2} = \frac{(160\ N)(1.50m)}{100\ N}$$

$$= 2.40\ m$$

The other person lifts with a force of 100 N at a point 2.4 m from the end where other person lifts.

3. Two people carry heavy electric motor by placing it on a light board 2.00 m long. One person lifts at one end with a force of 400 N, and the other lifts the opposite end with a force of 600N.

a. What is the weight of the motor, and where along the board is its center of gravity located?

b. Suppose the board is not light but weighs 200 N, with its center of gravity at its center, and the two people each exerts the same forces as before. What is the weight of the motor in this case, and where is its center of gravity is located?

Answer

Apply the first and second conditions of equilibrium to the board.

Let +y be upward. Let x be the distance of the center of gravity of the motor from the end of the board where the 400 N force is applied.

a. If the board is taken to be massless, the weight of the motor is the sum of applied forces, 1000 N.

$$\text{The motor is at distance} = \frac{(2.00\ m)(600\ N)}{(1000\ N)} = 1.20\ m$$

From the end where the 400 N force is applied, and so is 0.800 m from the end where the 600 N force is applied.

b. The weight of the motor is

W=400 N+600 N-200N =800 N

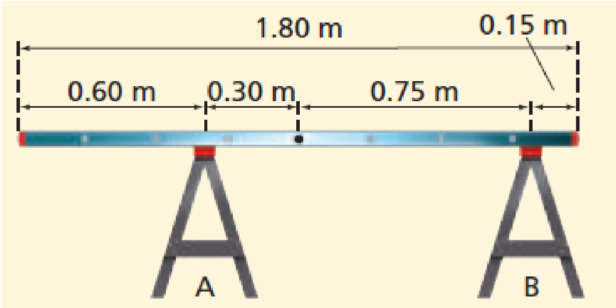
Apply $\sum\tau=0$ with the axis at the end board where 400 N act gives

(600N)(2.00m)=(200 N)(1.00 M)+(800 N)x→x=1.25 m

The center of gravity of the motor is 0.75 m from the end of the board where 600 N force is applied.

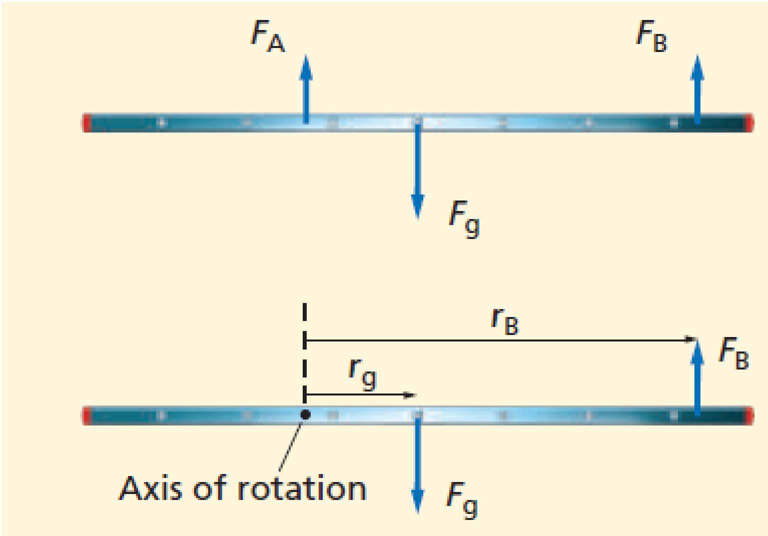
20.9.2. Consolidation activities

1. A 5.8-kg ladder, 1.80 m long, rests on two sawhorses. Sawhorse A is 0.60 m from one end of the ladder, and sawhorse B is 0.15 m from the other end of the ladder. What force does each sawhorse exert on the ladder?



Answer

Lets start with a free-body diagrams



For a ladder that has a constant density ,its center of mass is at the center of rung. Applying $\sum F_y = 0$

We get:

$$\sum F_y = F_A + F_B - F_g = 0 \rightarrow F_A = F_g - F_B$$

Choose the axis of rotation at the point where F_A acts on the ladder. Thus the torque due to F_A is zero.

$$\sum \tau = r_B F_B - r_g F_g = 0 \rightarrow r_B F_B = r_g F_g$$

$$F_B = \frac{r_g F_g}{r_B} = \frac{r_g mg}{r_B}$$

Using the expression $F_A = F_g - F_B$

Substitute if the expression for F_B and F_g

$$F_A = F_g - F_B = F_A = mg - \frac{r_g mg}{r_B} = mg\left(1 - \frac{r_g}{r_B}\right)$$

$$r_g = \frac{l}{2} - 0.60\ m = 0.90m - 0.60\ m = 0.30\ m$$

$$r_B = 0.90\ m - 0.15\ m + 0.30\ m = 1.05\ m$$

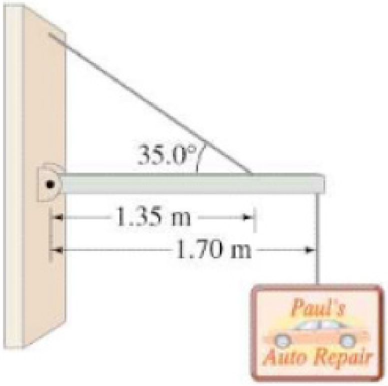
Calculate F_B

$$F_B = \frac{r_g mg}{r_B} = \frac{(0.30\ m)(5.8\ kg)(9.8\ m/s^2)}{1.05\ m} = 16\ N.$$

Calculate F_A

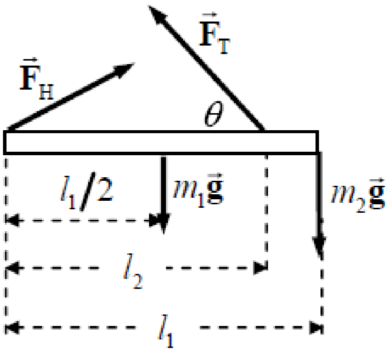
$$F_A = mg\left(1 - \frac{r_g}{r_B}\right) = (5.8\ kg)(9.8\ m/s^2)\left(1 - \frac{0.30\ m}{1.05\ m}\right) = 41\ N$$

2. A shop sign weighing 245 N is supported by a uniform 155 N beam as shown in the figure. Find the tension in the guy wire and the horizontal and vertical forces exerted by the hinge on the beam.



Answer

FBD



The beam is in equilibrium. Use the conditions of equilibrium to calculate the tension in the wire and the forces at the hinge. Calculate torques about the hinge, and take counterclockwise torques to be positive.

$$\sum \tau = (F_T \sin\theta)l_2 - m_1 g\, l_1/2 - m_2 g l_1 = 0 \rightarrow F_T = \frac{m_1 g\, l_1/2 + m_2 g l_1}{(\sin\theta) l_2}$$

$$F_T = \frac{\frac{1}{2}(155\ N)(1.70\ m) + (245\ N)(1.70\ m)}{(\sin 35.0^0)(1.35\ m)} = 708.0\ N$$

$$\sum F_x = F_{Hx} - F_T \cos\theta = 0 \quad \rightarrow \quad F_{Hx} = F_T \cos\theta = (708.0\ N)\ \cos 35.0^0$$

$$= 579.99\ N$$

$$\sum F_y = F_{Hy} - F_T \sin\theta - m_1 g - m_2 g = 0 \rightarrow F_{Hy} = m_1 g + m_2 g - F_T \sin\theta$$

$$F_{Hy} = 155\ N + 245\ N - 708.0\ N \sin 35.0^0 = -6.092\ N\ \ (down)$$

3. A uniform, 255 N rod that is 2.00 m long carries a 225 N weight at its right end and an unknown weight W toward the left end (fig. below). When W is placed 50.0 cm from the left end of the rod, the system just balances horizontally when the fulcrum is located 75.0 cm from the right end.

   (a) Find W.

   (b) If W is now moved 25.0 cm to the right, how far and in what direction must the fulcrum be moved to restore balance? **(2marks)**

Answer

1. In each case, to achieve balance the center of gravity of the system must be at the fulcrum.

Let the origin be at the left hand end of the rod and take the +x axis to lie along the rod.

Let $w_1 = 255\ N\ (the\ rod)\ so\ x_1 = 1.00\ m$, let $w_2 = 225\ N\ so\ x_2 = 2.00\ m$, and let $w_3 = W$. In part (a) $x_3 = 0.50\ m$ and in part (b) $x_3 = 0.750\ m$

(a) $x_{cm} = 1.25\ m,$

$$x_{cm} = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3}{w_1 + w_2 + w_3}$$

.

$$W_3 = \frac{(w_1 + w_2)x_{cm} - w_1x_1 - w_2x_2}{x_3 - x_{cm}}$$

$$W = \frac{(480\ N)(1.25\ m) - (255N)(1.00\ m) - (225N)(2.00\ m)}{0.500\ m - 1.25\ m} = 140\ N$$

(b) Now $w_3 = W = 140\ N$ and $x_3 = 0.750\ m\ x_{cm} =$

$$\frac{(255N)(1.00\ m)+(225N)(2.00\ m)+(140N)(0.75\ m)}{(255N)+(225N)+(140N)} = 1.31\ m$$

W must be moved a distance 1.31 m-1.25 m=6 cm to the right.

20.9.3. Extended activities

1. A uniform ladder 5.0 m long rests against a frictionless, vertical wall with its lower end 3.0 m from the wall. The ladder weighs 160 N. the coefficient of static friction between the foot of the ladder and the ground is 0.40. a man weighing 740 N climbs slowly up the ladder. Start by drawing a free-body diagram of the ladder.
   (a) What is the maximum frictional force that the ground can exert on the ladder at its lower end?
   (b) What is the actual frictional force when the man has climbed 1.0 m along the ladder?
   (c) How far along the ladder can the man climb before the ladder starts to slip?

Answer

1. Let n_2 be the upward normal force exerted by the ground and n_1 be the horizontal normal force exacted by the wall. The maximum possible static friction force that can be exerted by the ground is .

(a) Since the wall is frictionless, the only vertical forces are the weights of the man and the ladder, and the normal force . For the vertical forces to balance,

$n_2 = w_l + w_m = 160\ N + 740\ N = 900\ N$

The maximum frictional force is $\mu_s n_2 = (0.40)(900\ N) = 360\ N$

(b) Note that the ladder makes contact with the wall at a height of 4.0 m above the ground. Balancing torques about the point of contact with the ground,

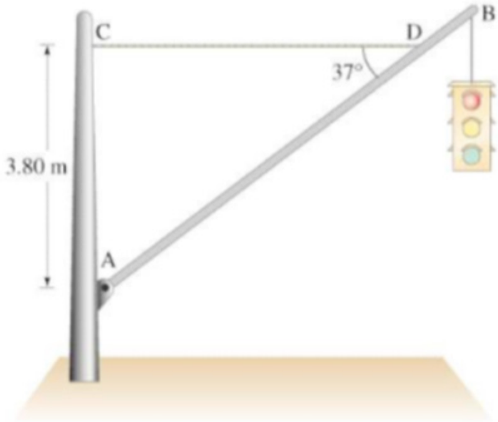
$(4.0\ m)n_1 = (1.5\ m)(160\ N) + (1.0\ m)(3/5)\,(740\ N) = 684\ N$

So $n_1 = 171.0\ N$

(c) Setting the friction force, and hence n_1, equal to maximum of 360 N and solving for the distance x along the ladder ,

$$(4.0\ m)(360\ N) = (1.5\ m)(160\ N) + (x)(3/5)\ (740\ N)\quad ,so\ x = 2.7\ m$$

2. A traffic light hangs from a pole as shown in figure below. The uniform aluminum pole AB is 7.5 m long and has a mass of 12.0 kg. The mass of the traffic light is 21.5 kg.



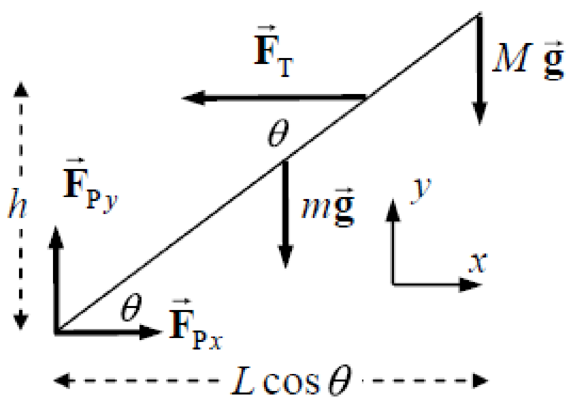
Determine

(a) The tension in the horizontal massless cable CD;

(b) The vertical and horizontal components of the force exerted by the pivot A on the aluminum pole.

Answer

FBD



(a) The pole is in equilibrium, and so the net torque on it must be zero. From the FBD, calculate the net torque about the lower end of the pole, with counterclockwise torques as positive. Use that calculation to find the tension in the cable. The length of the pole is L.

$$\sum\tau = F_T h - mg(L/2)\cos\theta - MgL\cos\theta = 0$$

$$F_T = \frac{(m/2 + M)gL\cos\theta}{h} = \frac{(6.0\,kg + 21.5\,kg)(9.80\,m/s^2)(7.50\,m)\cos 37^0}{3.80\,m} = 424.8\,N$$

(b) The net force on the pole is also zero since it is in equilibrium. Write the Newton's 2nd law in both the x and y directions to solve for the forces at the pivot.

$$\sum F_x = F_{Px} - F_T = 0 \rightarrow F_{Px} = F_T = 424.8\,N$$

$$\sum F_y = F_{Py} - mg - Mg = 0 \rightarrow F_{Py} = (m+M)g = (33.5\,kg)(9.80\,m/s^2) = 328.3\,N$$

UNIT 21

PROJECTILE AND UNIFORM CIRCULAR MOTION

21.1. Key Unit competence

Analyse and solve problems related to projectile and circular motion.

21.2. Prerequisite (knowledge, skills, attitudes and values)

The student teacher will learn better this unit if he/she has the Knowledge, skills, values and attitudes related introduction of circular motion for Ordinary level, concept of circle for Primary and ordinary level, Motion for ordinary level, Free fall of bodies in ordinary level, basic trigonometric function in ordinary level and able to use ICT tools like computer, XO laptop.

21.3. Cross cutting issues to be addressed

Gender: Let the student teacher carry out activities in learner's book (if it is a mixed school, the number of boys and girls in each group should be balanced).

Inclusive education:

- All differences should be taken into consideration in solving different activities in this unit.
- Help them in selecting their group leaders. Identify student teacher with special needs in group making. Encourage them to actively participate in their respective groups.

Peace and value: When student teachers are working activities, tell them that they can respect each other's opinion (don't blame someone, respect his/her ideas). Put learners in groups (select any number of learners depending on the size of the class) make sure that they work in harmony.

Environmental and sustainability: Are integrated through different activities in projectile and circular motion in different examples for our environment.

21.4. Guidance on introductory activity

- Invite student teachers to perform what is provided in introductory activity
- Request student teachers to answer questions asked and brainstorm what they find out
- Encourage student teachers to think in critically and innovative way
- Keep in mind that student teachers may not be able to find the right answers. You must guide them and orient their answers.
- In the second activity let student observe the image and think critically what happen for the bicyclist and guide them for writing their findings.

Possible answer: *The force of the ground on the wheel needs to be on a line through the center of gravity. The net external force on the system is the centripetal force. The vertical component of the force on the wheel cancels the weight of the system while its horizontal component must supply the centripetal force. This process produces a relationship among the angle θ, the speed v, and the radius of curvature r of the turn similar to that for the ideal banking of roadways.*

21.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Projectile motions	Define and explain terms used in projectile motion.	2
2	Applications of projectile motion	- Discuss the different applications of projectile motion and solve problems involving projectile motion. - Appreciate applications of projectile and circular motion	3
		- Illustrate examples of projectile motion	2

		- Derive equations of projectile motion - Determine the maximum height and horizontal range in projectile motion. - Resolve projectile motion in horizontally and vertically components	3
3	Circular motion: Meaning and related key terms (angular displacement, linear and angular velocity, period, frequency, angular and linear acceleration)	Define and explain terms used in circular motion.	1
4	Relationship between angular and linear parameters	Relate linear and angular motion	1
5	Acceleration in circular motion: Constant and tangential acceleration	Derive equations of circular motion	2
6	Centripetal force	- Describe and determine centripetal force - Appreciate centripetal force acts to towards the centre circular motion.	3
7	Applications of circular motion (vertical and horizontal circles, conical pendulum, spinning drier and road banking)	- Discuss different applications of circular motion and solve problems involving circular motion. - Show concern of the effects of gravity on body projected at an angle to the horizontal	3
	End unit assessment		1

Lesson 1: Introduction to projectile

a) Learning objective

Define and explain terms used in projectile motion.

b) Teaching resources

Ball, Conical pendulum (bob, thread and fixed point)

c) Prerequisites/Revision/Introduction

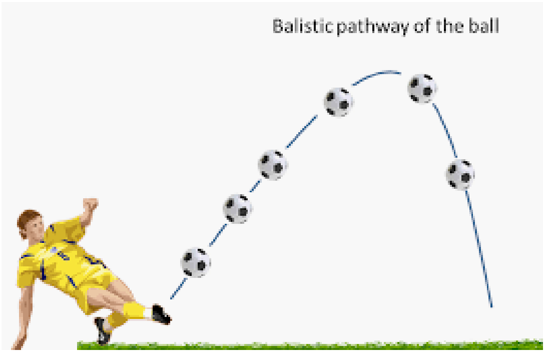
Review on introduction to free fall of bodies for Ordinary level on how to calculate the height for upward and downward directions, how to calculate velocity. Let student brainstorm on what they have seen in that Unit.

d) Learning activity 21.1

- **Guidance**
  - Help the student teacher to go outside of the class for doing the experiment
  - Make sure that you have the required materials listed in the activity
  - Tell the student teacher to go with notebook where they will write their findings

Answers

1.a)



b, c) The flight trajectory of a ball is influenced by its initial linear velocity, launch angle, spin rate, spin axis orientation and the air density. In football (soccer) many shots and passes are played with side spin to produce a curved trajectory in the horizontal plane. The curved trajectory results from an imbalance of pressure distribution around the spinning ball causing it to deflect as a result of the Magnus effect.

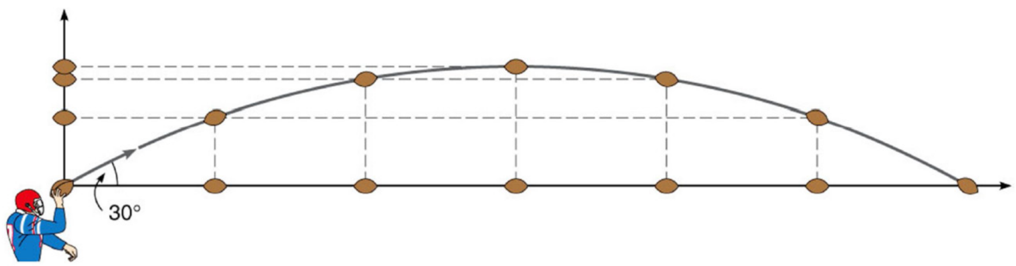
2. a) No. it hits below the center of target.

b) The trajectory depends on the launch angle.

e) Answers to application activity 21.1

1. Make sure that the network is available, let student teacher search themselves and tell them to bring to you what they have been researched. Brainstorm on what they find out.

2.



For the lowest angle, the horizontal velocity is much greater than the initial vertical velocity.

The ball does not go very high, so its time of flight is short.

Lesson 2: Applications of projectile motion

a) Learning objective

- Discuss the different applications of projectile motion and solve problems involving projectile motion.
- Appreciate applications of projectile and circular motion

b) Teaching resources

Cannonball, stone, computer, projector

c) Prerequisites/Revision/Introduction

- - Review on different concepts used in projectile
- - Review on kinematics for ordinary level

d) Learning activity 21.2

- **Guidance**
  - Download this movie and let student teacher observe it

    https://www.youtube.com/watch?v=NSHLOX_-pTo

- This movie is related to the activity 21.2 on the task 1
- Facilitate student teacher in observing the movie above critically
- Ask student
- Let student practices the experiment and guide them in getting the answers

Answers to activity 21.2

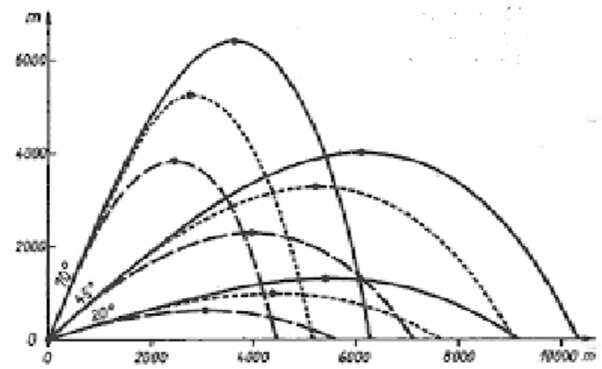
Task 1

a. Air resistance and gravitational force on it

b. A ball kicked at 45^0 fall at a long distance compared that of 60^0

Task 2: a) Bullets fired into the air usually fall back with terminal velocities much lower than their muzzle velocity when they leave the barrel of a firearm. Nevertheless, people can be injured, sometimes fatally, when bullets discharged into the air fall back down to the ground. **Refer to activity 21.2 in student teacher textbook**

b)



Task 3: Both cannonballs fall the same vertical distance with the same acceleration g and therefore strike the ground at the same time. When a cannonball is pointed to the upward angle it strikes first. In this case, the cannonball that is simply dropped hits the ground first. Now consider the case when the cannon is pointed downward. The fired cannonball hits first. So upward, the drop cannonball hits first; downward, the fired cannonball hits first. There must be some angle where both hit at the same time.

e) Answers to application activity

1) In the absence of air resistance, there is no acceleration in the horizontal or direction and the object moves as in the URM. In the y direction, the object moves as in the UDRM until when the object reaches the maximum height. Refer to fig 21.6 in student teacher's book explain or show y and x components only depends to launching angle and initial velocity . At maximum point velocity at y is zero and that along x is unchanged so in that way we explain that these components are independent.

2) Its vertical acceleration is **g** because the force of gravity is downward. Its horizontal acceleration is **zero** because no horizontal force acts on it.

The minimum speed of a projectile occurs at the top of its path. If it launched vertically, its speed at the top is zero. If it is projected at an angle, the vertical component of velocity is still zero at the top, leaving only the horizontal component. So the speed at the top is equal to the horizontal component of the projectile's velocity at any point.

3) The first step in the analysis of this motion is to resolve the initial velocity into its vertical and horizontal components.

$$y_m = -\frac{v_0^2 \sin^2\theta}{2g} = -\frac{(100)^2 \sin^2 45^0}{2\times -9.8} = 255.10\,m$$

$$x_{\max} = \frac{v_0^2 \sin 2\theta}{9.8} = \frac{(100)^2 \sin(2\times 45)^0}{9.8} = 1020.4\,m$$

Lesson 3. Circular motion: Meaning and related key terms

a) Learning objective

Define and explain terms used in circular motion.

b) Teaching resources

Whirling water in bucket*, stop watch, Protractor, ball,* thread

c) Prerequisites/Revision/Introduction

Student teacher should have the prerequisites on concept of circle in mathematics, introduction to kinematics in ordinary level, Calculation of angles in mathematics.

d) Learning activity 21.3

- **Guidance**

  Facilitate student teacher by brainstorming about what they have been shown

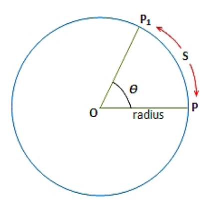
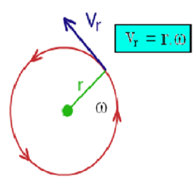
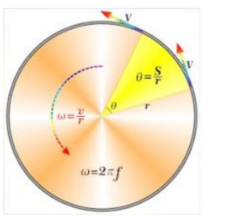
  Take a sample of ideas from different groups and give space and time for presentation

  Keep in mind that there is not wrong answer but build on each student teacher's ideas to come up with the meaning of circular motion.

- **Answers to activity 21.3**

  The student teachers will explain the body is changing the velocity direction keep the radius by keeping the size of velocity. They should again recognize that the circular motion is possible because of centripetal force A body moving at constant speed in a circular path experiences an acceleration directed towards the centre of the circular path. This acceleration is called a centripetal acceleration and is provided by a centripetal force. The force might be due to gravity, electro-static attraction, the tension is a string etc.

e) Answers to application activity 21.3

			
Angular and linear coordinates	Linear velocity	Angular velocity	Angular acceleration

Lesson 4. Relationship between angular and linear parameters

a) Learning objective

Relate linear and angular motion

b) Teaching resources

stop watch, Protractor, ball, thread, tape measure, projector, computer

c) Prerequisites/Revision/Introduction

– Review on terms used in circular motion and its application

d) Learning activity 21.4

- **Guidance**
  - Help student teacher to analyse the picture and ask them to write their observation find out in that activity.
  - Guide them in answering questions related to activity
  - Invite student teacher to make research on internet and make sure that the network is available in smart classroom.
- **Answer refer to notes under activity 21.4**

The variables **v, r** and **w** means:

1. **V** stands for the linear velocity of a circular motion
   – **r** stands for radius of a circular motion
   – ω stands for angular velocity of a circular motion
2. In the movement of the wheel, ω shows the angles of the wheel changing per second

e) Answers to application activity 21.4

1. Solution

Known:

Radius (r) = 0.5 meters, 1 meter, 3 meters

The angular speed = 10 radians/second

Unknown: The linear velocity

$v = r\,\omega$ *v = the linear velocity, r = radius, ω = the angular velocity*

(a) The linear velocity (v) of a point located at r = 0.5 meters

$v = r\,\omega$ = (0.5 meters)(10 rad/s) = 5 meters/second

(b) The linear velocity (v) of a point located at r = 1 meter

$v = r\,\omega$ = (1 meter)(10 rad/s) = 10 meters/second

(c) The linear velocity (v) of a point located at r = 2 meters

$v = r\,\omega$ = (2 meters)(10 rad/s) = 20 meters/second

2. Known:

Radius (r) = 5 cm and 10 cm

The angular speed (ω) = 5000 revolutions / 60 seconds = 83.3 revolutions / second = (83.3)(6.28 radian) / second = 523.3 radians / second

Wanted: The magnitude of the linear velocity

(a) The magnitude of the linear velocity of a point located 0.05 m from the center

$v = r\,\omega = (0.05\text{ m})(523.3\text{ rad/s}) = 26\text{ m/s}$

(b) The magnitude of the linear velocity of a point located 0,1 m from the center

$v = r\,\omega = (0.1\text{ m})(523.3\text{ rad/s}) = 52\text{ m/s}$

3. Known:

Radius (r) = 30 cm = 0.3 meters

The linear velocity (v) = 10 meters/second

Wanted: the angular velocity

$\omega = v / r = 10 / 0.3 = 33$ radians/second

4. Known:

Radius (r) = 20 cm = 0.2 meters

The angular speed = 120 rev / 60 seconds = 2 rev / second = (2)(6.28) radians / second = 12.56 radians / second

Wanted: distance

Velocity of the edge of wheel:

$v = r\,\omega = (0.2\text{ meters})(12.56\text{ radians/second}) = 2.5\text{ meters/second}$

2.5 meters / second means a point on the edge of wheel travels 2.5 meters each 1 second. After 10 seconds, the point travels 25 meters.

So the distance is 25 meters.

Lesson 5. Acceleration in circular motion: Constant and tangential acceleration

a) Learning objective

Derive equations of circular motion

b) Teaching resources

Projector, computer, flip chart, manila paper

c) Prerequisites/Revision/Introduction

Student teacher should have prerequisite on calculation for some trigonometric functions and review on calculation of angular velocity, angular acceleration, linear velocity, centripetal acceleration.

d) Learning activity 21.5

- **Guidance**
  - Facilitate student teachers for developing their critical thinking through analyzing on the activity.
  - Let student teacher go in smart classroom to search for other information related to the activity.
  - Invite student teacher to write their research in their notebook
  - Ask them what they find out on internet with references
- **Answers to activity 21.5**

1. Because frictional force between the tyres and the ground is at a maximum and hence centripetal force is a maximum.

e) Answers to application activity 21.5

1. Formula

$$a = \frac{v^2}{r}$$

We were given *r* in the problem statement (radius will be equal to the length of the string), so we only need to find the velocity of the ball. We are told that it travels in a circle with radius 1.5m and completes two full rotations per second. The length of each rotation is just the circumference of the circle:

$C=2\pi r=2\pi(1.5)=3\pi$

The velocity can be found by multiplying that distance by the frequency:

$v = Cf = 3\pi \cdot 2 = 6\pi m/s$

Now we have all of our variables and can plug into our first equation:

$$a = \frac{(6\pi)^2}{1.5} = \frac{36\pi^2}{1.5} = 237 \text{ m/s}^2$$

2. If we imagine the hill as a semi-circle, it appears that the car is moving along a circle. At the apex of the hill, the car's acceleration points downwards as this point towards the center of the circle. If an object travels in a circular fashion, at a constant speed, the direction of acceleration is always towards the center of the circle. This type of acceleration arises do to the change in velocity. Although the speed is constant, the direction changes.

Lesson 6. Centripetal force

a) Learning objective

- Describe and determine centripetal force
- Appreciate centripetal force acts to towards the centre circular motion.

b) Teaching resources

Ropes, computer, projector

c) Prerequisites/Revision/Introduction

Student teacher review on calculation of centripetal acceleration, prerequisite on Newton's law.

d) Learning activity 21.6

- **Guidance**
  - With a help of a tutor, student teacher search on internet what will happen in that activity.
  - Move around the class guiding student teacher as they are performing the activity.
- **Answers to activity 21.6**

1) When a ball is attached to a string and is swung round in horizontal circle, the centripetal force which keeps it in a circular orbit arises from the tension in the string.

e) Answers to application activity 21.6

1. $F = m\gamma = \dfrac{mv^2}{r}$

$$F_c = m\frac{v^2}{r} = \frac{3.0\times(4.0)^2}{0.75} = 64N$$

$$a_c = \frac{F_c}{m} = \frac{64N}{3.0kg} = 21.3m/s^2$$

2. Known :

Object's <u>mass</u> (m) = 200 gr = 200/1000 kg = 2/10 kg = 0.2 kg

Angular speed (ω) = 5 rad/s

Cord's length = radius (r) = 60 cm = 60/100 m = 0.6 m

Wanted : The centripetal force

Solution :

The centripetal force is the resultant force that causes the centripetal acceleration.

The equation of the centripetal force :

$\sum F = m\ a_s$

$\sum F = m\ v^2/r = m\ \omega^2\ r$

$\sum F$ = Centripetal force, m = object's mass, v = linear velocity, ω = angular velocity, r = radius.

$\sum F = m\ \omega^2\ r = (0.2)(5)^2(0.6) = (0.2)(25)(0.6) = 3\ N$

3. This force will be equal to the weight of the student; the student's weight will pull downward, while the friction of the wall pushes upward.

$fs = mg = 50kg.10m/s^2 = 500N$

Now we can calculate the normal force required to reach that magnitude of frictional force. Note that the vector for the normal force will be perpendicular to the wal, directed toward the center of the circlel.

$fs = 500N = \mu N$

$N = \frac{500N}{0.8} = 625N$

This normal force is the minimum centripital force required to keep the student pinned to the wall. We can convert this to centripital acceleration:

$N=Fc=mac$

$ac=\frac{625N}{050\text{kg}}$ $=12.5m/s^2$

We can now convert centripetal acceleration to a translational velocity using the equation: $ac=\frac{v^2}{r}$

Rearranging for velocity, we get:

$v=\sqrt{ac.r}=\sqrt{\left(12.5m/s^2\right)\left(5m\right)}=\sqrt{62.5m^2/s^2}=7.9\text{m/s}$

This is the velocity that the outer wall of the ride must be spinning at. Since we know the radius of the ride, we can convert this velocity into a maximum period, the final answer:

$Period=\frac{Circumference}{velocity}$

$Period=\frac{C}{v}=\frac{\pi D}{v}=\frac{\pi 10m}{\frac{7.9m}{s}}$

Period = 3.97s

Lesson 7. Applications of circular motion

a) Learning objective

- Discuss different applications of circular motion and solve problems involving circular motion.
- Show concern of the effects of gravity on body projected at an angle to the horizontal

b) Teaching resources

Ball, Conical pendulum (bob, thread and fixed point)

c) Prerequisites/Revision/Introduction

Student teacher review on calculation of centripetal acceleration, prerequisite on Newton's law.

d) Learning activity 21.7

- **Guidance**
  - Move around the class guiding student teacher as they are performing the activity. In case of any assistance you can make bright student teacher to assist the weak ones.
  - Let the student teacher discuss their findings in their groups and finally present to the whole class.

- Consolidate the lesson by developing and giving your ideas basing on student teachers' ideas.
- Guide the student teacher to work through the exercises in the student teacher's book.

▪ **Answers to activity 21.7**

Task1:

1) In horizontal circular motion, the weight force is always perpendicular to the centripetal force, whereas, in vertical circular motion, the weight force is sometimes parallel, sometimes perpendicular and most of the time at an arbitrary angle to the centripetal force.

2) A force perpendicular to the direction of motion may change the direction of the object but will have no effect on the velocity in the given direction. The velocity caused by gravity (v_g) is the velocity in the y-direction (v_y). The Earth is considered flat for short displacements.

Task 2:

- Base of retort stand should be facing away from pendulum
- Excess string should not be in the way of the pendulum's swing

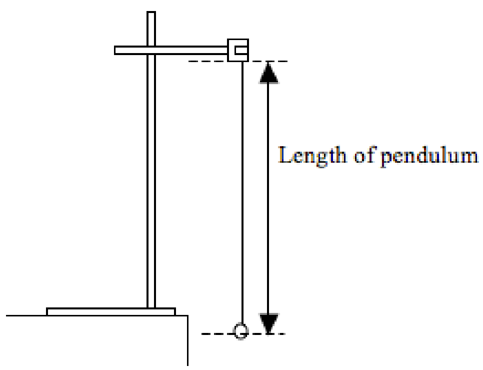
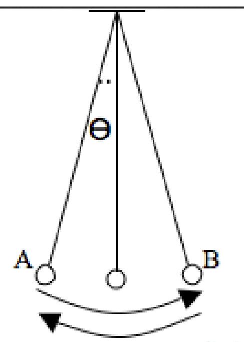


Diagram 1



Back-and-Forth Swing
(From A to B and back to A)

Diagram 2

a. Tie the pendulum bob on one end of a thread.
b. Clamp the other end firmly between two pieces of split cork to make a pendulum.
c. Measure the length of the string L between the middle of the bob and the edge of the split cork clamping the thread, for L = 50.0 cm.
d. Give the pendulum bob a slight displacement and allow it to oscillate steadily. An example of a complete oscillation is when the bob moves from A to B and back to A (see diagram 2).

- When displacing the pendulum, make sure it is in a plane parallel to you (not swinging diagonally, orbiting etc.)
- Place your eyes at the same level as the pendulum to reduce parallax error

Task 3:

a) The direction of friction the maximum velocity was toward the center. If the minimum is the opposite, should it be toward the bank.

b) The techniques for driving around curves and corners are basically the same. In a curve or corner, the vehicle will want to go straight ahead while you want to turn. If you are going too fast, or if the road is slippery, the vehicle will win and you will not get around the corner or curve. Any speed or steering adjustments required while in the curve should be very gradual to avoid losing control of your vehicle.

The most important part of driving a curve or corner is to slow down before you get to it.

To drive around a sharp curve or corner, follow this procedure:

i. Slow down. Take your foot off the accelerator and, if necessary, brake. It is important to brake in a straight line.

ii. In a manual transmission vehicle, shift to a lower gear so that you have enough power to accelerate through the curve or corner.

iii. Use the vision techniques for driving on a curve.

iv. Use your accelerator gently until you reach the mid-point of the curve, pushing down on the accelerator if you want the vehicle to go to the outside of the curve. Ease up on the accelerator if you want the vehicle to go to the inside of the curve or corner.

v. Once you reach the mid-point of the curve, unwind the steering wheel and accelerate out of the curve

e) Answers to application activity 21.7

1) Curved roads are banked in order to avoid the chances of toppling the vehicles. When a vehicle moves on curved road centripetal force acts on the vehicle and it has tendency to pull the vehicle towards it so in order to avoid this effect banking is provided.

2) a) Centripetal force is not constant. Centripetal force directly proportional to square of speed and speed is increasing uniformly

b) Tangential acceleration is constant because speed along the circular path increases uniformly. Only constant acceleration will give uniform increase of speed.

c) Angular acceleration is also constant. Tangential acceleration is the product of angular acceleration and radius of circular path. If the particle is restricted to move in the circular path of constant radius, then Angular acceleration is constant.

3.

$$F_c = T = m\frac{v^2}{r} = \frac{0.075\times(7.0)^2}{0.5} = 7.35N$$

21.6. Summary of the unit

- Projectile motion is a predictable path traveled by an object that is influenced only by the initial launch speed, launch angle, and the acceleration due to gravity.
- The best angle to kick the football, If I am kicking the ball really slow, a 45° would be close to the best angle. At an angle of 45°, you get the best of both horizontal velocity and time for the ball to be in the air.
- The magnitude of the velocity at the moment t is

$$v = \sqrt{v_x^2 + v_y^2} \qquad v = \sqrt{v_0^2 + 2gtv_0\sin\theta + g^2(t-t_0)^2}$$

Projectile equation parabola

$$y(x) = -\frac{g}{2v_0^2}x^2 + y_0$$

Projectile to reach the maximum height:

$$t_m = -\frac{v_0\sin\theta}{g}$$

We can find how far away the projectile hits the ground as we know that $x_f = x(t_f)$:

$$x_f = xt_f = v_0\cos\theta t_f = v_0\cos\theta\left(\frac{2v_0\sin\theta}{g}\right) = v_0^2\left(\frac{2\sin\theta\cos\theta}{g}\right)$$

Circular motion: Movement of an object along the circumference of a circle, or rotation along a *circular* path.

$a_N = \omega v$

As $v = r\omega$, we also find that $a_N = \frac{v^2}{r} = r\omega^2$

21.7. Additional information for tutors

21.8. End unit assessment (answers)

1. They strike the ground at the same time. The same force of gravity is acting on both balls. Since both balls started falling (from the force of gravity) from the same height, they will fall towards the ground with the same acceleration. Consequently, they hit the ground at the same time. The fact that one ball has horizontal motion has nothing to do with its 'vertical' motion.

2. Neglecting air resistance, if you throw a ball straight up with a speed of 20m/s, it will be moving with 20m/s when you catch it.

3.

$$a_c = \frac{v^2}{r} = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 = 4r\frac{\pi^2}{T^2} = \frac{4\times 2\times 9.86}{9} m/s = 8.764 m/s^2$$

4. $\omega = \sqrt{\frac{a}{r}} = \sqrt{\frac{9}{25}} rad/s = \frac{3}{5} rad/s$

$$T = \frac{2\pi r}{v} = \frac{2\pi\times 1.6}{16} s = 0.20\pi \sec$$

5. $T = \frac{t}{n} \Rightarrow n = \frac{t}{T} = \frac{60}{0.2\pi} rotations = \frac{300}{\pi} rotations$

6. $a = r\omega^2 = 1.15\times 16\pi^2 m/s^2$

7. $a) v = \frac{90\times 4\pi}{60} m/s$

$b) \omega = \frac{1}{r} v = \frac{45\times 4\pi}{60} rad/s$

$c) a = r\omega^2 = 2\left(\frac{45\times 4\pi}{60}\right)^2 m/s^2$

8. What is the angular velocity of the earth around its axis? What is the linear velocity of a point situated at the equator? The radius of the earth is supposed to be 6400km.

$$\omega = \frac{2\pi}{24} rad / h$$

$$v = r\omega = \frac{6400}{2} \times \frac{2\pi}{24} km \times rad / h = \frac{6400}{2} \times \frac{\pi}{12} km \times rad / h$$

21.9. Additional activities (Questions and answers)

21.9.1 Remedial activities

1. A car with tires 50 cm in diameter travels 10 meters in 1 second. What is the angular speed?

Answer:

Known :

Radius (r) = 0.25 meter

The linear speed of a point on the edge of tires (v) = 10 meters/second

Wanted: The angular speed

ω = v / r = 10 / 0.25 = 40 radians/second

2. A 25*kg* boy is riding a merry-go-round with a radius of 5*m*. What is the centripetal force on the boy if his velocity is 6*ms*?

Answer

For this problem, we use the centripetal force equation:

$$Fc = \frac{mv^2}{r}$$

We are given the mass, radius or rotation, and the linear velocity. Using these values, we can find the centripetal force.

$$Fc = \frac{(25kg)\text{x}(6\text{m}/\text{s})^2}{5m}$$

$$Fc = \frac{900kgm^2 / s^2}{5m}$$

Fc=180N

3. What force acts on a projectile in the horizontal direction?

Answer:

A projectile is an object upon which the only force is gravity. Gravity acts to influence the vertical motion of the projectile, thus causing a vertical acceleration.

The horizontal motion of the projectile is the result of the tendency of any object in motion to remain in motion at constant velocity.

4. A force of 250 N is required to keep an 8.0 kg object moving in a circle whose radius is 15m. What are the speed, period and frequency of the object?

Answer

$$F_{net} = m\left(v^2 / r\right) \Rightarrow v = \sqrt{\frac{F_{net} \times r}{m}} = 21.65 m/s$$

Next, we find the period of the object's motion $v = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v} = 4.35 s$

And finally, we find its frequency $f = \frac{1}{T} = 0.23 Hz$

21.9.2. Consolidation activities

1. A car is travelling with a velocity of $17.0 ms^{-1}$ on a straight horizontal highway. The wheels of the car has a radius of 48.0cm. If the car then speeds up with an acceleration of $2.00 ms^{-2}$ for 5.00s, calculate
   a. the number of revolutions of the wheels during this period,
   b. the angular speed on the wheels after 5.00s.

Answer:

u= 17.0m/s r= 0.48m a= $2.00 m/s^2$ t= 5.00s

a. $u = rw_o$ $17.0 = 0.48\ w_o$ $\Rightarrow w_o = 35.4$ rad/s

b. The angular acceleration of the wheel is given by:

$a = r\alpha$ $2.00 = 0.48\alpha$ $\alpha = 4.17\ rad/s^2$

3. What force acts on a projectile in the horizontal direction?

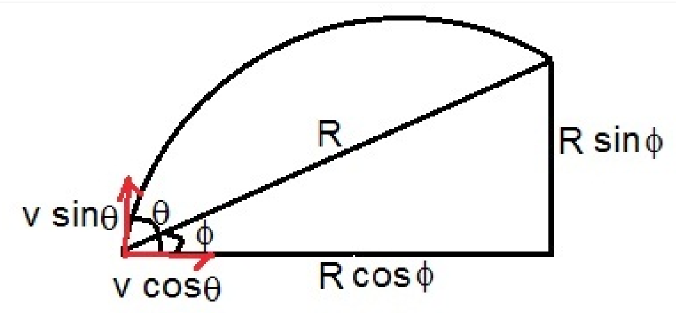
Answer:

A projectile is an object upon which the only force is gravity. Gravity acts to influence the vertical motion of the projectile, thus causing a vertical acceleration. The horizontal motion of the projectile is the result of the tendency of any object in motion to remain in motion at constant velocity.

21.9.3. Extended activities

1. A particle is projected with speed V_o at angle θ to the horizontal on an inclined surface making an angle Φ(Φ<θ) to the horizontal. Find an expression of its range on inclined surface.

Answer



If R is the range in inclined plane, the horizontal distance travelled is RcosΦ and vertical distance travelled is Rsin Φ.

Time taken t for travelling RcosΦ is $= \dfrac{R\cos\Phi}{V\cos\Phi}$

Using the equation for t we can write for vertical distance.

$$R\sin\Phi = V\sin\theta\left(\frac{R\cos\Phi}{V\cos\theta}\right) - \frac{1}{2}g\left(\frac{R\cos\Phi}{V\cos\theta}\right)^2$$

Cancelling out the common R throughout all the terms and multiplying all the terms by:

$$\frac{2V^2Cos^2\varnothing}{g}$$

We get:

$$\frac{2V^2}{g}\cos^2\theta\sin\Phi = \frac{2V^2}{g}\sin\theta\cos\theta\cos\Phi\text{-}R\cos^2\Phi$$

By rearranging the terms

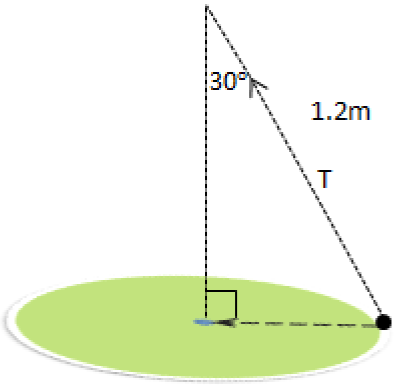
$$R\cos^2\Phi = \frac{2V^2}{g}\cos\theta\left(\sin\theta\cos\Phi - \cos\theta\sin\Phi\right)$$

$$= \frac{2V^2}{g}\cos\theta\sin\left(\theta - \Phi\right)$$

Hence

$$R = \frac{2V^2}{g} cos\theta \frac{\sin(\theta - \Phi)}{cos^2\theta}$$

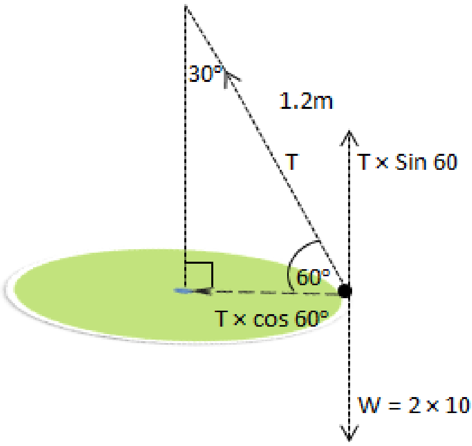
2. The pendulum below has a mass of 2kg. The pendulum is moving in a horizontal circle. The string is inclined at 30^0 to the vertical.



a. Calculate the tension in the string
b. Calculate the centripetal force.
c. Calculate the centripetal acceleration.
d. Calculate Scalar & angular velocities.
e. Calculate period & frequency of centripetal motion.

Answer:

First before we begin answering the question we need to make some additions to the drawing above. We want to work with an angle besides the 30 degrees if you look at the diagram you'll realize there's a triangle but one of the angles are missing, this is the angle we want to use. You can easily find this angle because you are already given one angle (30 degrees) and since it is a right angled triangle (indicated by the box formed between the vertical and horizontal line)it also has 90 degrees, therefore the remaining angle must be 60 degrees, if we were to add them all up we would get a total of 180 degrees. So place the 60 degrees in the missing position. The question also stated that you would need to calculate tension, so you would need to split the "T" in its horizontal and vertical components. This would give "T × sin $60^0$for the vertical component and "T × cos 60^0 for the horizontal component. Now place these components in the diagram. The next thing to note is that the pendulum has a mass 2kg therefore a downward force of weight must be acting on the body, add this as well to the diagram.



For the tension in the string we use the vertical component but if you look closely you will see that there is weight also acting downward against the vertical component so we use the rule:

Upward forces =Downward forces

$T \times \sin 60^0 = \text{weight}$

$$T = \frac{20}{\sin 60^0}$$

$$T = \frac{20}{0.8660} = 23.09N$$

3. An object is attached to a string which is supplying a Tension that helps keeps it moving in a vertical circle of radius

0.50m. The object has a mass of 2.0 kg and is traveling at a constant speed of 5.0 m/s (impractical to do, but let's use that as an assumption). What is the tension in the string in the following situations?

a. When the object is at the top of the circle.

b. When the object is at the bottom of the circle.

a. At the top of a circle, both the weight and the tension point downwards. So does the acceleration of the object, since the acceleration of an object in uniform circle motion is always directed at the centre of the circle. If we down define as negative:

$$\sum F = ma$$

$$-T - W = -ma$$

but since all signs are negative, we can multiply by (-) on both sides and make them all positive

$$T + W = ma \Rightarrow T = ma - W \Rightarrow T = \frac{mv^2}{r} - mg$$

$$T = m\left(\frac{v^2}{r} - g\right) \Rightarrow T = 2(5/0.50 - 9.8)N = 80.4N downwards$$

b. At the bottom of the circle, the weight points downward and the tension points upwards, towards the centre of the circle. The acceleration of the object also point upwards the centre of the circle, since the acceleration of an object in uniform circular motion is always directed at the centre of the circle. If we define down as negative:

$$\sum F = ma \Rightarrow T - W = ma \Rightarrow T = ma + w$$

$$T = m(a + g) = m\left(\frac{v^2}{r} + g\right) = 119.6N upwards$$

UNIT 22

GENERAL STRUCTURE OF THE SOLAR SYSTEM

22.1. Key Unit competence

Illustrate and describe the general structure of the solar system

22.2. Prerequisite (knowledge, skills, attitudes and values)

- Solar system formation covered in ordinary level.
- Eclipse and its formation covered in ordinary level.
- Existence of the universe covered in ordinary level.

22.3. Cross cutting issues to be addressed

- **Standardization culture**: Emphasize the need to use appropriate instruments in observation of different phenomena in solar system and occurrence of eclipse.
- **Financial education:** Emphasize the need to compare price against measuring instrument while buying based on its functionality.
- **Environment and sustainability:** Recognize the nature of astronomical bodies and geographical formation of solar system.
- **Peace and values education:** Cooperation and teamwork spirit should be encouraged in learning process.

22.4. Guidance on introductory activity

- Ask student-teachers to look at the illustration of the unit and let them discuss what they see.
- Let them brain in five minutes to discover what is observed in the illustration of the unit.
- Let sample student-teacher expose their ideas in five minutes to discover more details in the illustration of the unit.
- Ask them to suggest what topics do they think this unit will focus on based on the illustration?
- Give time for some brainstorming and try to introduce the unit based on the discussion done.

22.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Astronomical scales	Identify and explain scales for estimate astronomical distances.	2
2	Sun-earth-moon system: eclipses and phases of the moon	Illustrate the phenomenon of eclipse by considering the relative positions of the sun-moon-earth system.	2
		Explain the phenomenon of eclipse and explain phases of the moon.	
		Value the importance of orbital motion of the earth to human life and activities.	
3	The Solar system	Differentiate inner, outer planets, comets, meteorites and asteroids.	3
4	Kepler's laws	State Kepler's laws and use them to describe the positions of the eight planets with the sun.	2
5	Existence of constellations.	Explain the existence of constellations	2
	End unit assessment	Evaluate the achievement of the objectives.	2

Lesson 1. Astronomical scales

a) Learning objective

- Identify and explain scales for estimate astronomical distances.

b) Teaching resources

- Flipchart papers, Markers of different colors, Scotch/Masking tape, memory stick, videos, computer and projector.

c) Prerequisites/Revision/Introduction

- Refraction and refraction of light
- Optical instruments especially camera and telescopes.
- Solar system concepts covered in ordinary level.
- Rotation of the earth covered in ordinary level

d) Learning activity 22.1

Technical guidance

- This activity introduces the student-teacher to know more about the origin of the solar system and astronomical scale.
- Divide your class into small groups, and let them read and interpret the activity based on their understanding and corresponding concepts about solar system and astronomical scale.
- Let the student-teachers perform the activity using their prior knowledge about the provided concepts and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts of the origin of the solar system and astronomical scale in the student-teacher book and use the information while guiding the towards expected feedback.

Activity 22.1:

a) It is, for example, difficult for most learners to conceive that a deep valley could have been carved out over many millions of years by the small river at the bottom. Similarly the universe is so large that it is almost impossible to imagine and we even use a new unit of distance to describe the vast distances in the universe. This unit is the light year. Students often find it confusing to express a distance with the term 'year' as we usually use this term to describe a period of time. This unit of distance is poorly understood by most adults.

b) It has important implications because it supports us in measuring long distances in the astraunomical observations.

e) Answers to application activity 22.1

1. The time line to be constructed should depend on the origins of the solar system and life on earth to provide a helpful scale.

2. The scale model of the solar system should be constructed based on the distances and size of the planets. We can assume the orange to represent the size of the sun

Lesson 2. Sun-earth-moon system: eclipses and phases of the moon

a) Learning objectives

- Explain the phenomenon of eclipse and explain phases of the moon.
- Illustrate the phenomenon of eclipse by considering the relative positions of the sun-moon-earth system.
- Value the importance of orbital motion of the earth to human life and activities.

b) Teaching resources

- Flipchart papers, Markers of different colors, Scotch/Masking tape, memory stick, videos, computer and projector.

c) Prerequisites/Revision/Introduction

- Solar system concepts covered in ordinary level.
- Rotation of the earth covered in ordinary level.

d) Learning activity 22.2

Technical guidance

- This activity introduces the student-teacher to know how eclipse is formed and the phases of the moon.
- Divide your class into small groups, and let them read and interpret the activity based on their understanding about the illustration of eclipse formation and phases of the moon.
- Let the student-teachers perform the activity using their prior knowledge about geographical positioning of the Sun-Earth- Moon and write their ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.

- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in the eclipse formation and phases of the moon in the student-teacher book and use the information while reviewing the questions together in order to give the feedback.

Answers to Activity 22.2:

Answers to questions from a) to d) are directly given in the notes under activity 22.2 in student teacher's book

e) Answers to application activity

Refer to notes under activity 22.2

Lesson 3. The solar system

a) Learning objective

Differentiate inner, outer planets, comets, meteorites and asteroids.

b) Teaching resources

- Flipchart papers, Markers of different colors, Scotch/Masking tape, memory stick, videos, computer and projector.

c) Prerequisites/Revision/Introduction

Circular motions

d) Learning activity 22.3

Technical guidance

- This activity introduces the student-teacher to know more about the general structure of the solar system based on the nature of inner and outer planets.
- Divide your class into small groups not more than five student-teacher, and let them read and interpret the activity based on their understanding and corresponding concepts about the general structure of the solar system.
- Let the student-teachers perform the activity using their prior knowledge about the provided solar system and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.

- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in general structure of solar system in the student-teacher book and use the information in providing the feedback based on their ideas.

Answers to Activity 22.3:

Use concepts and illustrations under activity 22.3 from student teacher' s book to explain the general structure of the solar system based on the inner and outer planets

e) Answers to application activity 22.3

Refer to notes under subheading 22.3

Lesson 4. Kepler's laws

a) Learning objective

- State Kepler's laws and use them to describe the positions of the eight planets with the sun.

b) Teaching resources

- Flipchart papers, Markers of different colors, Scotch/Masking tape, memory stick, videos, computer and projector.

c) Prerequisites/Revision/Introduction

Solar system Earth Moon and Sun

Circular motion learned in year one

Previous lessons of this unit 22

d) Learning activity 22.4

- This activity introduces the student-teacher to know more about the general motion of planets based on their locations and size.
- Divide your class into small groups not more than five student-teacher, and let them read and interpret the activity based and search for the information from internet web engines.

- Let the student-teachers perform the activity using their prior knowledge about the provided solar system and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in general structure of solar system in the student-teacher book and use the information in providing the feedback based on their ideas.

Answers to Activity 22.4

From the research student teachers should come up with this statements like:

1. "The path of the planets about the sun is elliptical in shape, with the center of the sun being located at one focus." (The Law of Ellipses) "A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time."

   "The Square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit".
2. Planets move faster in their orbits when close to the Sun. Some students may predict the opposite, as a common misconception exists that the farther away you are from something, the GREATER the gravity. As an example, students often believe that the Earth's gravity on the top of a mountain is greater than its gravity in the bottom of a valley. In reality, the opposite is true.

e) Answers to application activity 22.4

1. $$\frac{T^2}{r^3} = cte$$
2. Area If A1 = A_2 = A_3 then T_1=T_2=T_3

3. Consider Figure 22.14 from student teacher' s book , The time it takes a planet to move from position A to B, sweeping out area A1, is exactly the time taken to move from position C to D, sweeping area A2, and to move from E to F, sweeping out area A3. These areas are the same: A1 = A2 = A3.

Lesson 5. Star Patterns: Constellations

a) Learning objective

- Explain the existence of constellations.

b) Teaching resources

- Flipchart papers, Markers of different colors, Scotch/Masking tape, memory stick, videos, computer and projector.

c) Prerequisites/Revision/Introduction

Solar system Earth Moon and Sun

Circular motion learned in year one

Previous lessons of this unit 22

d) Learning activity 22.5

Technical guidance

- This activity introduces the student-teacher to know more about the Constellations and their importance.
- Divide your class into small groups not more than five student-teacher, and let them read and interpret the activity based and search for the information from internet web engines.
- Let the student-teachers perform the activity using their prior knowledge about the provided solar system and write the ideas in the notebook.
- Schedule the discussion and let the student-teacher brainstorm on the tasks in order to gain more.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the concepts using student-teachers' work and provided concepts.
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts.

- Remember that the responses from the discussions may differ but you can refer to the key concepts in general structure of solar system in the student-teacher book and use the information in providing the feedback based on their ideas.

Answers to activity 22.5:

From the research student teachers should come up with these statements like:

1. A constellation is a group of visible stars that form a pattern when viewed from Earth. The pattern they form may take the shape of an animal, a mythological creature, a man, a woman, or an inanimate object such as a microscope, a compass, or a crown.
2. Constellations can help people to recognize stars in the sky. By looking for patterns, the stars and locations can be much easier to spot

e) Answers to application activity 22.5

1. c) A group of visible stars that make a pattern when viewed from Earth.
2. d) 88
3. d) Draco
4. b) Ursa Minor
5. a) Orion
6. c) Ursa Major
7. False
8. a) Ursa constellations
9. e) All of the above

22.6. Summary of the unit

- The word “eclipse” comes from the Greek word “ekleipsis” which means “abandonment” or “downfall.” The longest that a solar eclipse will last is seven and a half minutes.The most solar eclipses of any type that can occur on Earth within a year is five.
- A total solar eclipse occurs about every 1.5 years. Animals sometimes become confused and behave strangely during a total eclipse of the Sun.
- As the Earth rotates on its axis and revolves around the Sun, day and night and seasons result.

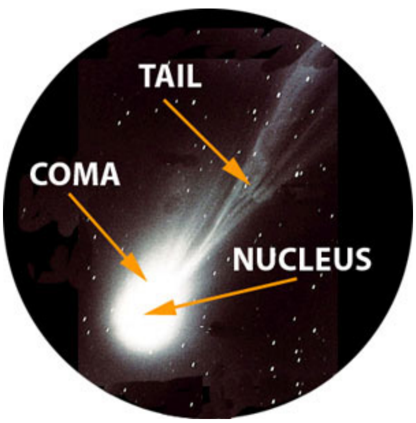
- When the new moon comes between the Earth and the Sun along the ecliptic, a solar eclipse is produced.
- When the Earth comes between the full moon and the Sun along the ecliptic, a lunar eclipse occurs.
- Observing the Moon from Earth, there is a sequence of phases as the side facing us goes from completely darkened to completely illuminated and back again every 29.5 days.
- As the Moon orbits Earth, tides align with its gravitational pull.
- The Sun produces a smaller tide. When the solar and lunar tides align, at new and full moons, higher than normal tidal ranges called spring tides occur.
- At first and last quarter moons, the solar tide and lunar tide interfere with each other, producing lower than normal tidal ranges called neap tides.
- Because Uranus and Neptune contain many "ices" such as water, methane, and ammonia they are often referred to as the "ice giants."
- Scientists estimate there are around 200 billion stars in the Milky Way galaxy.
- Pluto was once considered a full planet, but was redefined as a dwarf planet in 2006.
- About 99.85% of the mass of the Solar System is the Sun. All the other planets, asteroids, moon, etc. together make up less than 0.15% of the Solar System's mass.
- The area around the Sun where the Sun's solar wind has an influence is called the heliosphere.
- All of the planets orbit the Sun in the same counterclockwise direction.
- Scientists who study the solar system and outer space are called astronomers.
- The Oort cloud is located about one light year from the Sun.
- One of the most famous comets is Halley's Comet. Halley's Comet has an orbit of 76 years and is visible from Earth as it passes by.
- During ancient times, people believed that the passing of a comet was an omen of doom.
- Eventually the ice will burn off of a comet and it will just be a

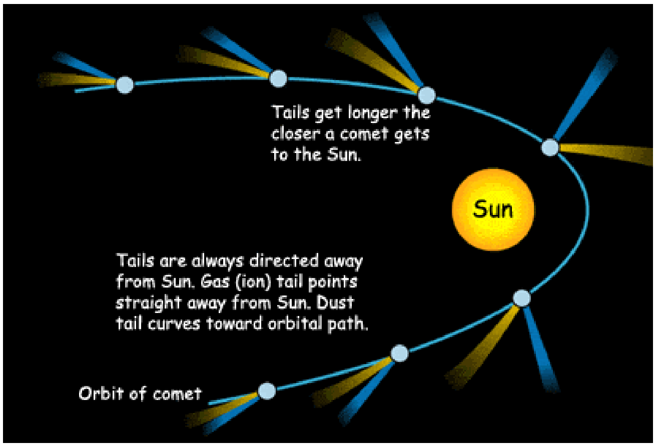
metallic rock with no coma or tail. These comets are said to have gone "extinct".

- Millions of meteors enter the Earth's atmosphere every day. Most of them are about the size of a pebble.
- Italian astronomer Giuseppe Piazzi discovered the first asteroid, Ceres, in 1801.
- The word asteroid comes from a Greek word meaning "star shaped."
- Scientists estimate that there are over one million asteroids larger than 1km in diameter within the asteroid belt.
- The five largest asteroids make up more than 50% of the total mass of the asteroid belt.
- Some scientists have theorized that the extinction of the dinosaurs was caused by a large asteroid colliding with the Earth.
- The largest constellation by area is Hydra which is 3.16% of the sky.
- The smallest is Crux which only takes up 0.17 percent of the sky.
- Small patterns of stars within a constellation are called asterisms. These include the Big Dipper and Little Dipper.
- The word "constellation" comes from a Latin term meaning "set with stars."
- Twenty two different constellation names start with the letter "C."

22.7. Additional information for tutors

A **comet** is an icy small Solar System body that, when passing close to the Sun, heats up and begins to out gas, displaying a visible atmosphere or coma, and sometimes also a tail. The tail of the comet always points away from the sun.





A **meteor** is a bright streak of light in the sky (a "shooting star" or a "falling star") produced by the entry of a small meteoroid into the Earth's atmosphere. A **meteorite** is a fragment of rock or iron from outer space, usually a meteoroid or asteroid, which survives passage through the atmosphere as a meteor to impact the surface of the Earth. A **meteoroid** is a small body moving in the solar system that would become a meteor if it entered the earth›s atmosphere.

22.8. End Unit Assessment 22 (Answers)

1. The answer to both question is the same. It's that the moon is a world in space, just as earth is. Like earth, the moon is always half illuminated by the Sun; the round globe of the moon has a day side and the night side. And like the Earth , the moon is always moving in space . For our earthly vantage point, as the moon orbits around the Earth, we see varying fractions of its day and night sides.These are the changing phases of the Moon. And the moon is in the daytime sky about half the time. It is just that it's sometimes it's so near the sun we don't notice it.
2. New Moon, Waxing Crescent, First quarter, waxing gibbous, full Moon, Waning Gibbous, Last quarter and finally waning crescent.

3. The largest known meteorite, estimated to weigh about 60 metric tons, is situated at Hoba West near Grootfontein, Namibia.
4. Constellations can help people to recognize stars in the sky. By looking for patterns, the stars and locations can be much easier to spot.The constellations were used to help keep track of the calendar. This was very important so that people knew when to plant and harvest crops. Another important use for constellations was navigation. By finding Ursa Minor it is fairly easy to spot the North Star (Polaris). Using the height of the North Star in the sky, navigators could figure out their latitude helping ships to travel across the oceans.
5. Angular momentum is conserved in the case of law of areas.
6. See student teacher's paragraphs below figure 22.2

22.9. Additional activities

22.9.1. Remedial activities

1. Write the dimensional formula for gravitational constant.
2. Define orbital speed of a satellite around the earth.
3. Name the force that provides the necessary centripetal force for the earth around the sun in an approximately circular orbit.
4. How does the escape velocity of a body varies with the mass of the earth?
5. How does speed of the earth changes when it is nearer to the sun?
6. What are central forces?

Answers to remedial activities:

1. The dimensional formula for G is [M-1 L3 T -2].
2. Orbital speed of a satellite around the earth is the speed required to put a satellite into its orbit.
3. Gravitational force between earth and the sun provides the necessary centripetal force for the earth around the sun in an approximately circular orbit.
4. The escape speed of a body is proportional to the square root of the mass of the earth.
5. The speed of the earth increases when it is nearer to the sun.
6. Central forces are always directed towards or away from a fixed point, that is along the position vector of the point of application of the force with respect to the fixed point.

22.9.2. Consolidation activities

1. Select the best answer

A. The following is (are) example(s) of celestial body(ies)

i) Sun ii) Moon iii) Stars iv) All of the above

B. The flowing is (are) true about the Sun

i) It is made up of gases ii) It has its own heat and light iii)Sun is a star iv) All of the above.

C. The different group of stars is known as

i) Constellations ii) celestial bodies iii) asteroids iv) comet

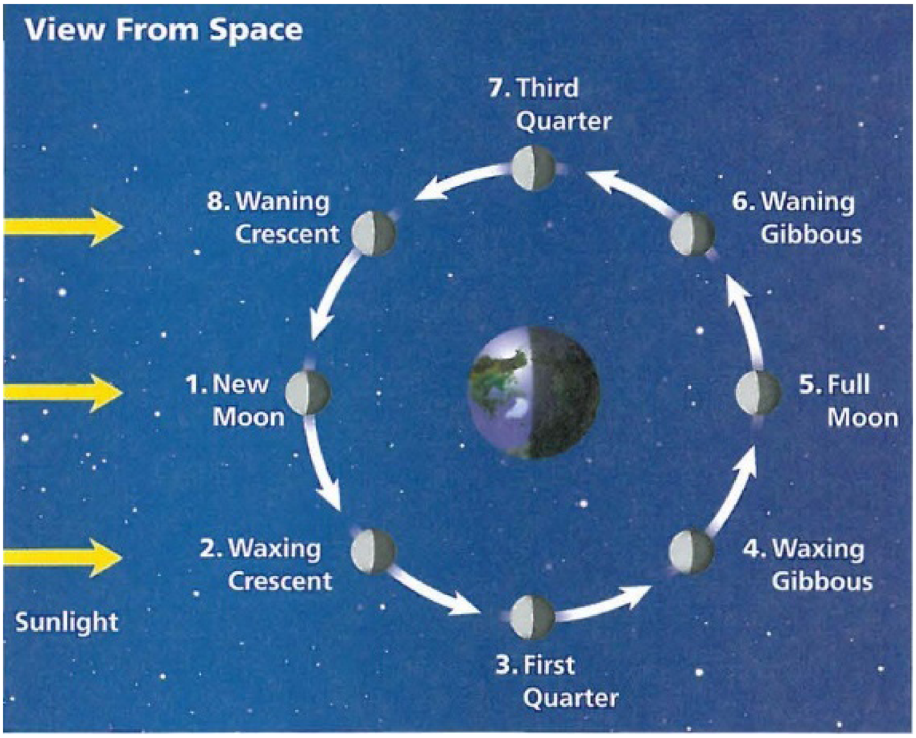
D. The following constellations consists of seven main stars

i) Ursa major ii) Ursa minor iii) Hercules iv) Lyra

E. The Sun is .....million km away from the Earth

i) 100 ii) 150 iii)200 iv) 250

2. With a help of diagram draw Moon phases, Sun rays and the Earth.



(Source: Boston, Massachusetts Glenview)

22.9.3. Extended Activities

1. "Cavendish weighed the earth". Why this statement is popular? Justify with the expression for the mass of the earth.

Answer: The acceleration experienced by the mass m due to the earth is called acceleration due to gravity g, which is related to the force F by Newton's 2nd law from the relation F = mg.

Therefore $g = \frac{F}{m} = \frac{GM_E}{R_E^{\ 2}}$

Acceleration g is measurable. R_E is a known quantity. The measurement of G by Cavendish's experiment and with the knowledge of g and R_E , the mass of the earth M_E can be estimated. Because of this reason there is a popular statement regarding Cavendish, "Cavendish weighed the earth".

2. Who proposed 'Geocentric theory'? Give the brief account of the theory.

Answer: Geocentric theory was proposed by Ptolemy about 2000 years ago. According to this theory, all celestial objects, stars, the sun and the planets all revolved around the Earth. The only motion that was thought to be possible for celestial objects was motion in a circle. Complicated schemes of motion were put forward by Ptolemy in order to describe the observed motion of the planets. The planets were described as moving in circles with the centre of the circles themselves moving in larger circles.

3. Derive $g=(GM_E)/R_E^{\ 2}$, where the symbols have their usual meaning.

Answer: Let m be the mass of the body on the surface of the Earth of radius R_E . The entire mass M_E of the earth is concentrated at the centre of the Earth. The magnitude of the force acting on the mass m is

$$F = \frac{GmM_E}{R^2{}_E} \text{.....(1)}$$

If the entire earth is assumed to be of uniform density φ, its mass is

$$M_E = \frac{4}{3}\pi R_E^{\ 3}\varphi\text{.....(2)}$$

Therefore from (1) and (2)

$$F = \frac{Gm\left(\frac{4}{3}\right)\pi\varphi R_E^{\ 3}}{R_e^{\ 2}} \left[but\left(\frac{4}{3}\right)\pi\varphi = \frac{M_E}{R_E^{\ 3}}\right]$$

$$Therefore: F = G\ m\left(\frac{M_E}{R_E^{\ 3}}\right)\frac{R_E^{\ 3}}{R_E^{\ 2}}$$

That is

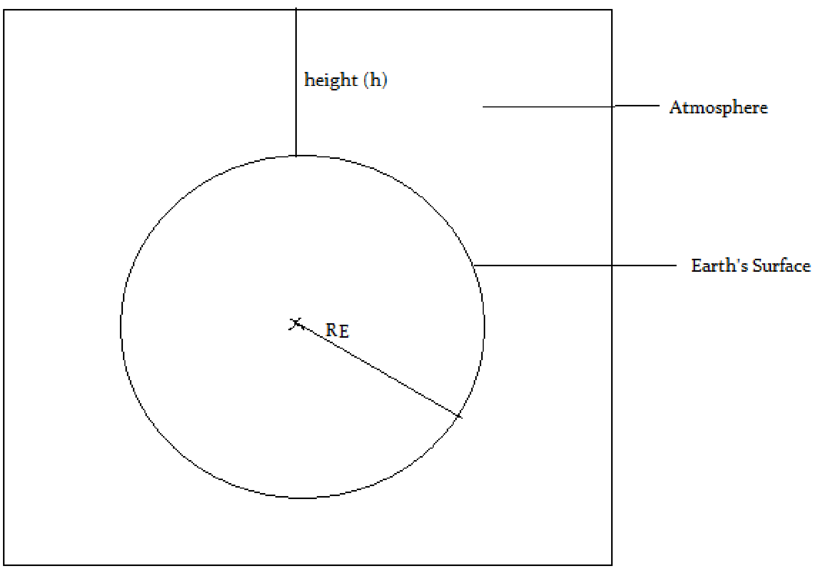
$$Therefore: F = Gm\frac{M_E}{R_E{}^2}...(3)$$

By Newton's second of motion, $F = mg.....(4)$ is the force on the mass m and g is the acceleration experienced by the mass m. Therefore, from (3) and (4)

$$= \frac{F}{m} = \frac{GmM_E}{R_E{}^2 m} = \frac{GM_E}{R_E{}^2}$$

4. Derive the expression for acceleration due to gravity at a point above the surface of the earth.

Answer: Consider a point mass m at a height h above the surface of the earth as shown in figure.



The radius of the earth is R_E . Since this point is outside the earth, its distance from the centre of the earth is (R E + h). If F (h) is the magnitude of the force on the point mass m,

Then $F(h) = GM_E m/(R_E+h)^2$................................(1)

The acceleration experienced by the point mass is F(h)/m = g(h) and we get $g(h) = F(h)/m = GM_E/(R_E+h)2$.................................(2)

This is clearly less than the value of g on the surface of earth,
$g = GM_E / R_E{}^2$

For $h << R_E$ we can expand the Right Hand Side of equation (2), $g(h) = GM_E/[R_E^2(1+h/R_E)^2] = g(1+h/R_E)^{-2}$

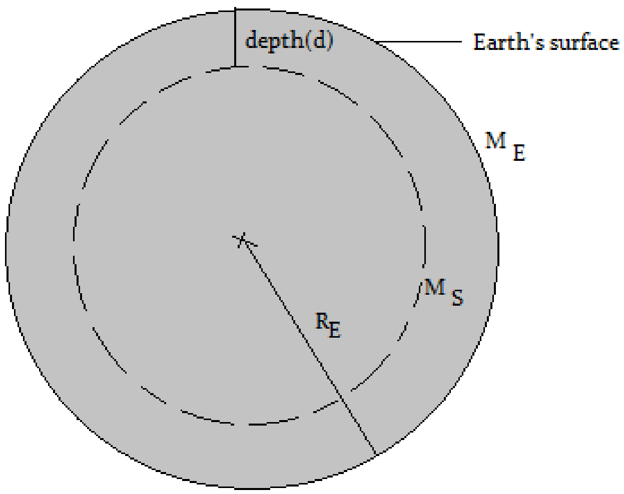
For $h/R_E << 1$, using binomial expression, $g(h) = g(1-2h/R_E)$................(3)

Equation (3) tells that for small heights h above the surface of the earth, the value of g decreases by a factor $(1-2h/R_E)$.

5. Derive the expression for acceleration due to gravity at a point below the surface of the earth.

Answer:

Consider a point mass m at a depth(d) below the surface of the earth as shown in figure.



Its distance from the centre of the earth is (R_E-d). The earth can be thought of as being composed of a smaller sphere of radius $(R_E - d)$ and a spherical shell of thickness d. The force on m due to the outer shell of thickness d is zero. The point mass m is outside the smaller sphere of radius $(R_E - d)$. The force due to this smaller sphere is just as if the entire mass of the smaller sphere is concentrated at the centre. If M_S is the mass of the smaller sphere, then $M_S/M_E = (R_E - d)^3/R_E^3$..(1) (Since mass of a sphere is proportional to the cube of its radius).

Therefore the force on the point mass is $F(d) = GM_S m/(R_E - d)^2$ ....(2)

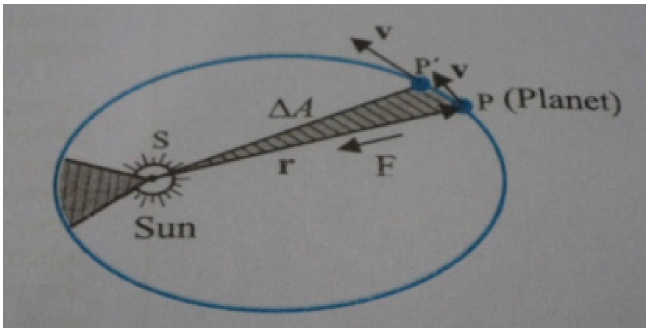
Substituting for M_S we get $F(d) = GM_E m(R_E - d)/R_E^3$..........................(3)

Therefore, the acceleration due to gravity at a depth d is, $g(d) = F(d)/m$ that is $g(d) = [GM_E/R_E^3](RE - d) = g(R_E - d)/R_E$; $g(d) = g(1 - d/R_E)$......(4)

Therefore, as we go down below earth's surface, the acceleration due to gravity decreases by a factor $(1 - d/R_E)$.

6. Show that the law of areas follows from the law of conservation of angular momentum.

Answer: Law of areas: The line that joins any planet to the sun sweeps equal areas in equal intervals of time.



The law of areas can be understood as a consequence of conservation of angular momentum which is valid for any central force. A central force is such that the force on the planet is along the vector joining the sun and the planet. Let the sun be at the origin and let the position and momentum of the planet be denoted by $\vec{r}$ and $\vec{p}$ respectively. Then the area swept out by the planet of mass m in time interval Δt is $\Delta\vec{A}$ given by

$$\Delta\vec{A} = 1/2\left(\vec{r} \times \vec{v}\Delta t\right) \ldots(1)$$

$$\frac{\Delta\vec{A}}{\Delta t} = 1/2\left(\vec{r} \times \vec{p}\right)/m = \frac{\vec{L}}{2m} \ldots.(2)$$

Since $\vec{v} = \frac{\vec{p}}{m}$ where $\vec{v}$ is the velocity, $\vec{L} = \vec{r} \times \vec{p}$, is the angular momentum

For a central force, which is directed along $\vec{r}, \vec{L}$, is a constant as the planet goes around.

$\frac{\Delta\vec{A}}{\Delta t}$ is a constant according to the last equation. This is the law of areas.

Gravitation is a central force and hence the law of areas follows.

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