INTEGRATED SCIENCE

FOR TTC

YEAR ONE

TUTOR'S GUIDE

OPTIONS: ECLPE

FOREWORD

Dear tutor,

Rwanda Basic Education Board is honoured to present tutor's guide for Integrated Science Year One of TTC 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's 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

ACKNOWLEDGEMENT

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. It would not have been successful without active participation of different education stakeholders.

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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

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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 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 activity**

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

- **Exercises/application activities**

This provides questions and answers for 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 activity disseminated in learner-centered rather than the traditional didactic approach. The student-teachers are 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-teacherswith 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-teachercan 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 teacher 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 student teachers 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 activity.

Some active techniques that can be used in Integrated sciences

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 student teachers 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. Orstudent-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.

SAMPLE LESSON PLAN

School Name: ……………………… **Teacher's name**: ………………………

Term	Date	Subject	Class	Unit Nº	Lesson Nº	Duration	Class size
Term II	19/09/ 2019	Integrated Science	Year 1	13	1 of 6	80 min	45

Type of Special Educational Needs to be catered for in this lesson and number of learners in each category	None
Unit title	Kirchhoff's laws in electric circuits
Key Unit Competence	By the end of the unit, the student-teachers should be able to analyze complex electric circuits using Kirchhoff's laws.
Title of the lesson	Simple electric circuit and its construction.
Instructional Objective	Provided different electric components, Student-teachers manipulate and construct appropriate simple electric circuits in series and parallel.
Plan for this Class (location: in / outside)	Laboratory
Learning Materials (for all learners)	Two batteries; Two bulb holders; 7 pieces of copper wires; 3 bulbs, chalk board; answer sheets and rough papers.
References	Integrated Science Textbook (Year 1).

Timing for each step	**Description of teaching and learning activity**		**Generic competences** and **Cross cutting issues** to be addressed **+ a short explanation**
	Description of teaching and learning activity Through reading and interpretation activity 8.1, student-teachers manipulate electric components and try to construct simple electric circuits with teacher's guidance to gain more skills in electric circuit construction and answer problems related to it.		
	Teacher activities	**Learner activities**	

Introduction 10min	Motivate the learners by asking them the use of different electric components provided? Form small groups and let them brainstorm on the question. **Possible answers:** Bulb is a device that gives light but switch is a device used to switch on and off. Facilitate the learners to think about the unit objective.	Recall the electric components and their arrangement in circuits. Brainstorm on the question and take position by writing down the functions of distinguished electrical components. **Possible predictions:** Battery uses as source of electrical energy, Wires are components used in joining other electrical components; Switch is a device that gives light, bulb is a device used to switch on and off.	Communication, cooperation, critical thinking through responding to questions. Gender is addressed in forming groups.
Development of the lesson 50min	Lead the process of examining learners' predictions Give the opportunity to the learner to suggest how to verify their predictions	Suggest that they can perform the activity 8.1given in the textbook using the provided materials. Suggest some of the risks which may arise when manipulating the provided materials.	Peace and value education through co-operation in discussions.

	Give the student-teachers the apparatus in their respective groups, brainstorm on how to handle them carefully and let them perform the activity following given guidelines. Schedule the presentations in sample groups to discuss on the observations and difficulties involved in circuit construction.	Compare the results with different predictions Present the results and write on the chalk board.	Standardization culture is addressed through using appropriate electrical components. Through group discussions, each student teacher develops critical thinking skills. Creativity is developed through performing tasks.
Conclusion 20 min	**Summary** Correct, conclude and then generalize with the real life ***Assessment*** Verify using different methods the level of gained skills of the learning outcomes	Correct their reports and write the home work in their note books. Apply the gained skills to answer questions below and other problems related to arrangement of electric components: Explain why it is very important to use parallel circuit arrangement in an electric circuit installation. Suggest two disadvantages of using parallel arrangement in electric circuit installation?	Critical thinking, analytical skills
Teacher self-evaluation	Done after the lesson (Done successfully or partially done).		

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 appropriate instruments to measure different physical quantities

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

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

1.3. Cross-cutting issues to be addressed:

a) Standardization culture:

- Emphasize the need to use appropriate instruments and correct SI Units when measuring physical quantities for purposes of standards in everyday life.

b) Financial education:

- Emphasize the need to compare price against measuring instrument while buying based on its functionality.

c) Environment and sustainability:

- Recognize the safety measures taken for the sake of environmental protection.

d) 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 brain in five minutes to discover what is taking place in the illustration of the unit.

- 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/sub-heading

#	Lesson title	Learning objectives	Periods
1	Introduction to integrated science	Explain the meaning of Integrated science.	2
		Relate integrated science with other subjects.	
		Explain the role of integrated science in their everyday life situations.	
2	Measurement of physical quantities	Classify physical quantities and tools used in measuring physical quantities.	2
		Use different measuring instruments to measure fundamental physical quantities.	
3	Dimension of physical quantities	Use physical quantities' units to determine the dimension of physical quantities.	1
4	End unit assessment	Evaluation of the achievement of the objectives.	1

Lesson 1: Introduction to integrated science

a) Learning objectives

- Explain the meaning of integrated science.
- Relate integrated science with other subjects.
- Explain the role of integrated science in their everyday life situations.

b) Prerequisites/ Revision/ Introduction

Arithmetic's operations and scientific notation

c) Teaching resources

Textbooks, charts

d) Learning activity 1.1

Guidance in 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.

Answers for activity 1.1

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.

Answers for application activity 1.1

Refer to student teacher book paragraphs above application activity 1.1 to answer all the tasks.

- **Lets take an example of science and language:** Although science is a practical subject, but it is very important for it's 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.

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 objectives.

- Classify physical quantities and tools used in measuring physical quantities.
- Use different measuring instruments to measure fundamental physical quantities.

b) 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).

c) Teaching resources

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

d) Learning activity 1.2

Guidance on 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.

Answers for activity 1.2

Task 1:

- 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.

Answers for 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 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 = 5.00 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. S I Units stands for international system of units.
2. Yes it true because SI Units helps in comparing distinguished quantities in various measurements.
3. It is proved that tape measure can give measurements very quick because itself contains 3 m.
4. 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

Question 7

a). 250 m = 25000 cm.

b). 320 mg = 0.320 g.

c). $5\mu g = 0.000005$ g.

d). 7200 cm = 72.00 m.

e). 3 kg = 3000 g.

Lesson 3: Dimension of physical quantities

a) Learning objective.

- Use physical quantities' units to determine the dimension of physical quantities.

b) 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).

c) Teaching resources

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

d) Learning activity 1.3

Guidance on activity 1.3

- This activity introduces the student -teacher to know more about dimensions of physical quantities and their importance.
- Divide your class into small groups, and let them interpret the activity based on their understanding and try to find out what is needed to assign dimensions to physical quantities.
- Let the student-teachers perform the activity using their prior knowledge of the formulas of distinguished physical quantities and dimensional symbols for basic fundamental quantities to calculate the dimensions of given physical quantities.
- Schedule the discussion and let the student-teachers brainstorm on the tasks and their observations in order to find out more details about dimensions of physical quantities.
- Monitor the discussions for the student-teachers' comments to support them in order to continue the discussion with a brief brainstorming of the rules followed in assigning dimensions to physical quantities using student-teachers' work .
- Comment on student-teachers' discussion and give them the summary of expected deep understanding of the concepts and feedback.
- Remember that the responses from the discussions may differ but you can refer to the key concepts in dimensions of physical quantities in the student-teacher book and use the information in giving feedback.

Answers for activity 1.3

a). $[LT^{-1}]$;

b). $[LT^{-2}]$;

c). $[MLT^{-1}]$;

d). $[MLT^{-2}]$;

a). e). $[ML^2T^{-2}]$.

Answers for application activity 1.3

1. i)

- Describing dimensions help in understanding the relation between physical quantities and its dependence on base or fundamental quantities, that is, how dimensions of a body rely on mass, time, length, temperature and others.

- Dimensions are used in dimension analysis, where we use them to convert and interchange units.
- Dimensions are used in predicting unknown formulae by just studying how a certain body depends on base quantities and up to which extent.
- It makes measurement and study of physical quantities easier.
- We are able to identify or observe a quantity just because of its dimensions.

ii.)

- Dimensions never define exact form of a relation.
- We can't find values of certain constants in physical relations with the help of dimensions.
- A dimensionally correct equation may not be the correct equation always

2. $\frac{1}{2}[LT^{-2}][T^2] = [LT^{-1}]$. Therefore, $\frac{1}{2}gt^2$ has the same dimension as distance.

3. a. The dimensions of velocity are $[LT^{-1}]$

   b. The dimensions of force are $[MLT^{-2}]$

4. a) The dimension of a physical quantity **is defined as the powers to which the fundamental quantities are raised in order to represent that quantity.**

b) Start by giving the dimension of each quantity as given in the learning process and then finally give the final dimension of requested quantity:

i). [Velocity] = $[LT^{-1}]$

ii). [Acceleration] = $[LT^{-2}]$

iii). [Momentum] = $[MLT^{-1}]$

iv). [Force] = $[MLT^{-2}]$

v). [Work] = $[ML^2T^{-2}]$

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.
- The dimension of physical quantity is defined as the powers to which the fundamental quantities are raised in order to represent the quantity.

1.7. Additional information for the tutor

- **International system of units (S I)**
  - The *International System of Units* (abbreviated as *SI Units* from its French name, Système International d›unités) is an internationally agreed metric system of units of measurement that has been in existence since 1960.
  - The history of the metre and the kilogram, two of the fundamental units on which the system is based, goes back to the French Revolution.
  - The system itself is based on the concept of seven fundamental base units of quantity, from which all other units of quantity can be derived.
  - Following the end of the Second World War, it became increasingly apparent that a worldwide system of measurement was needed to replace the numerous and diverse systems of measurements in use at that time.

- **Measuring instruments**
  - Instruments should be handled carefully to reduce accidents and used well to give true results (observations).
  - Pay special attention to any safety symbols and caution statements that appear in the investigation.
  - We cannot measure the thickness of a piece of a paper or the distance from the city to another directly with a ruler.
  - A metre rule whose scale was accurately marked will give readings close to the exact value it is measuring.
  - **Stop clocks and watches:** All living things have an inbuilt biological clock which seems to control the rhythm of their life cycle.
  - **Error** refers to the difference between a measured value and the true value of a physical quantity being measured.
  - Whenever possible we try to correct for any known errors: for example, by applying corrections from calibration certificates.
  - But any error whose value we do not know is a source of uncertainty.
  - Measurement errors can arise from two sources: **a random component**, where repeating the measurement gives an unpredictably different result; and **a systematic component,** where the same influence affects the result for each of the repeated measurements.
  - Measurement can greatly support in overall goal to improve plant health and yield, to preserve valuable resources, to use inputs more effectively, and to minimize the overall impact on the environment.
  - **Standard form**: It is a convenient and widely used method in science for abbreviating large and small numbers.
  - Whenever possible we try to correct for any known errors: for example, by applying corrections from calibration certificates.
  - Measurement errors can arise from two sources:
    - a random component, where repeating the measurement gives an unpredictably different result;
    - a systematic component, where the same influence affects the result for each of the repeated measurements.
  - Measurement can greatly aid in this overall goal to improve plant health and yields, to preserve valuable resources, to use inputs more effectively, and to minimize the overall impact on the environment.

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 ρ read as Rho, while mass and volume are abbreviated (m) and (v) respectively. Using these symbols, the formula for density is** $\rho = \frac{m}{v}$

- 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 carry 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 for end unit assessment 1

1. **Fundamental quantities** are those quantities that are not defined in terms of other quantities [Sample example: **mass** its SI unit is **kilogram (kg)] w**hereas **derived quantities** are ones that are defined in terms of the fundamental quantities [Sample example: v**olume** its SI unit is m^3].

2. (a) $2.7\text{m} = 2.7 \times 1000\text{mm} = 2700\text{mm}$

(b) $26.9\text{cm} = 26.9 \times 100 = 2.69\text{mm}$

(c) $35\mu\text{m}=356 \times 0.000001 \times 1000 = 0.356$ mm

3. The length of the glass block is 3.3 cm

4. a) Observable property

b) Fundamental and derived physical quantities.

c) Fundamental physical quantities.

d) A unit and a number

e) International system of units

5.

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

b). Data types were not controlled effectively.

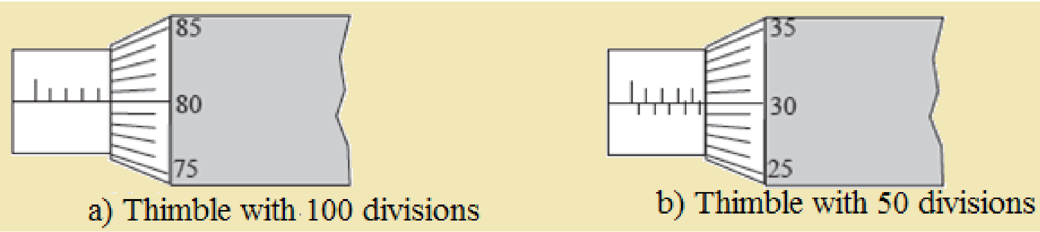
c). He was not fair in frequency of fertilizer because all types of plant are not treated in the same way.

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

1.9. Additional activities

1.9.1. Remedial activities

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



a) Thimble with 100 divisions

b) Thimble with 50 divisions

Fig: Thimble divisions.

Answer:

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 × LC)

= 4.5 + (30 × 0.01) mm

= 4.80 mm.

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

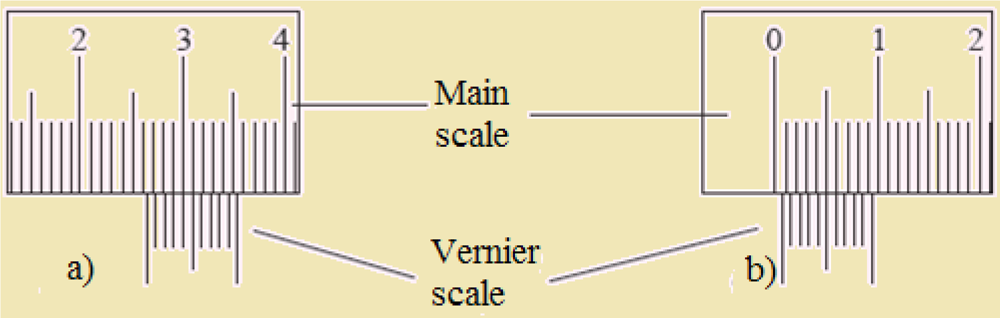


Fig: Vernier caliper readings

Response:	
a	b
Main scale reading = 2.6 cm Vernier scale reading = 0.04 cm Reading = 2.64 cm	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?

Answer:

1 week = 7 days

1 day = 24 h

1 h = 60 min

1 min = 60 s

1 week = 7 × 24 ×60 × 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	……

Answer:

Fill in the blankspace 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

   a). Insert the inside jaws of a vernier callipers into the test tube.

   b). Move the sliding jaws until the jaws just touch the inside walls of the test tube as shown in the figure below.

2. 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.

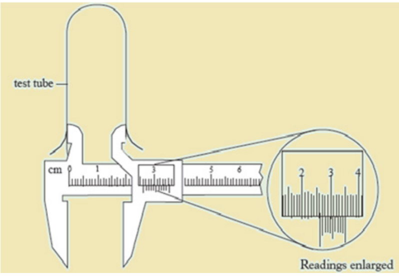


Fig: Measurement of internal diameter using vernier calipers.

Answer

Let the student teachers perform the experiment and guide them to get the answer

3. 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.

Answer:

a). Fundamental quantities: mass, length, and time

b). Derived quantities: force, volume, density and area

c). Fundamental quantities cannot be defined in terms of other quantities, but Derived quantities are defined in terms of fundamental quantities.

d). We obtain the value of a certain physical quantity by using measuring instruments. For example a beam balance is used to measure mass, tape measures is used to measure length, and stopwatch measures time.

1.9.3. Extended activities

1. If an equation is dimensionally correct, does this mean that the equation must be true? Justify your answer using real example based on the situation.

   Answer:

   No, for example $K_E = \frac{1}{2}mv^2$, if the someone else says that $K_E = \frac{3}{2}mv^2$

   Both people will get the same dimension but second formula is wrong.

   .

2. a) Do all tests of physical quantities always involve measuring? Explain your reasoning to justify your decision.

   b) Explain why it is very important to have quality measurements of physical quantities?

Answer

a). No just because some of the tests will require direct answer by saying yes or no.

b). To increase standardization culture in the society.

UNIT 2: COMMON DISEASES AND HYGIENE

2.1. Key Unit competence

Implement ways of preventing and controlling common diseases and hygiene related issues.

2.2. 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 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.

2.3. 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 tutor 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.
- Tutors 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.

2.4. Guidance on introductory activity

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-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-teachers to make summary of the group discussions.

The Answers may include 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.

2.5. 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	3
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	2
3	Human immune system (Immunity, structure and role of antibodies), immunization and vaccine	– Describe the human immune system and ways to keep it healthy – Explain the Immunity, structure and role of antibodies in human immune system as well as immunization and vaccine.	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
	End unit assessment		1

Lesson 1: Common diseases (Infectious diseases, STDs, deficiency diseases, and worm diseases)

a) Learning objectives

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
- Describe the challenges encountered to eradicate some common infectious diseases
- Explain what is meant by health and disease.
- Identify different categories of disease and give an example of each.
- Explain the theory of the disease and the causes, sources, transmission, symptoms and controls of the disease.
- Discuss how global patterns of disease are studied.
- Analyze and interpret records from a given hospital to identify diseases as endemic, epidemic or pandemic.
- Apply knowledge gained to classify common diseases.
- Appreciate the importance of germ theory of disease by showing that the death rate related to infections is greater than those caused by accidents.
- Explain the effect of tobacco, alcohol and drug abuse on human health.
- Identify importance of practicing hygiene

b) Teaching resources

Different student teacher's books, graph charts, simulations (videos) and computer animations, projector, Manila paper with diagrams showing different people suffering from deficiency diseases, drug, for improvisation.

c) Prerequisites/Revision/Introduction

For succeeding well in this lesson student-teachers should know and remember, the mode of transmission and symptoms, modes of prevention and treatment of different diseases, 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 2.1

- **Guidance on activity 2.1**

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 2.1.a 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 teacher'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 for activity 2.1

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%.

d). The infectious diseases are: Cholera, typhoid, tetanus, tuberculosis, polio, measles, Ebola, malaria, sleeping sickness, trichomoniasis, candidiasis, athlete's foot, ring worms, elephantiasis, bilharzias, syphilis, gonorrhoea.

The above diseases are infectious ones because:

- They are caused by germs
- They are transmitted from one person to another

Answers for application activity 2.1

1. Bacteria pass out in faeces of infected person; carried in, water / food, consumed by uninfected person.
2. Cholera is a serious disease; death can occur very quickly after infection; spreads quickly in population (especially after a disaster); deaths are avoidable.
3. There is a high death rate from TB in countries with a high proportion of the population who are HIV-positive because:
   - TB linked with HIV infection
   - HIV weakens immune system
   - TB is an opportunistic disease
4. TB is an opportunistic infection because it strikes many people with a depressed immunity.
5. A female Anopheles (mosquito) takes a blood meal from an infected person; transfers parasite / pathogen / Plasmodium, in saliva when takes a blood meal from an uninfected person.
6. Biological factors that make malaria a difficult disease to control.
   - The vectors multiply quickly
   - Lack of vaccine
   - Malaria is transmitted by mosquitoes
7. Reference Student-teacher's books   page……..

8. Answer is C

9. The answers are:

   a). *Mycobacterium tuberculosis*; accept Mycobacterium bovis.

   b). Infected person, coughs / sneezes / spits; aerosol / droplets, containing bacteria, breathed in by uninfected person.

   c). Sub-Saharan Africa; South-East Asia; countries of India / Pakistan / Afghanistan; South America / Bolivia; Papua New Guinea.

   d). TB linked with HIV infection; HIV weakens immune system; TB is an opportunistic disease; as many people are infected although show no symptoms; transmission where there is, overcrowding / poor housing; poverty; poor ventilation of housing; poor nutrition; poor access to health care; poorly organized treatment for people with TB.

10. Answers are:

   a). Bacteria pass out in faeces of infected person; carried in, water / food, consumed by uninfected person.

   b).

      i). 2.22

      ii). Treatment for cholera involves supply of oral rehydration therapy (ORT); and provision of safe drinking water; better response to emergencies (in some countries); effectiveness of response may depend on number of cases; ref to very high number of cases in Haiti; may depend on remoteness of regions affected by cholera; or ways in which, emergency supplies / personnel, can reach affected areas; ref to high case fatality rates in, Nigeria / Cameroon; use of data to compare case fatality rates in individual country with global rate.

      iii). Cholera is a serious disease; death can occur very quickly after infection; spreads quickly in population (especially after a disaster); deaths are avoidable; if ORT is available immediately; data is useful to predict, situations / places, where cholera may occur; WHO can coordinate responses to outbreaks.

c). Water supply is not contaminated with (human), sewage / faeces; piped water / water supply is treated to kill bacteria; *V. cholera* destroyed in sewage treatment.

Lesson 2: Importance and Hygiene practices

a) Learning objectives

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 showing different activities necessary for hygiene promotion.

c) Prerequisites/Revision/Introduction

This is the second lesson of the 2th 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.

- **Guidance on activity 2.2**

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 2.2 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 teacher'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 for activity 2.2

a). To answer the question (a) student-teachers will answer depending activity the always perform every morning. It is your turn to compile ideas from them, harmonize and give short summary

b). Confer to student-teacher books, lesson two, you will find answers.

Answers for application activity 2.2

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 ensures proper growth and development of children.
- It helps to prevent diseases especially hygiene related diseases.
- It prevents 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), immunization and vaccine

a) Learning objectives

By the end of this lesson, I 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 showing the structure of antibody, simulations(videos) and computer animations, projector, Manila paper with diagrams illustrating different modes of action of human body defence mechanism for improvisation.

c) Prerequisites/Revision/Introduction

This is the third lesson of the 2nd unit. In this lesson you will be dealing with how the human body defence mechanism. The first thing is to remind Student-teachers 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 2.3**

- **Guidance on activity 2.3**

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 2.3 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 teacher'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 for activity 2.3

Yes, it is possible that the human body can resist an infection from environment full of pathogens due to its lines of defence such as:

a). **Body's first line of defence** which line of defence prevents harmful micro-organisms from entering the body. It is the external defence system of the body.

Example of the body defence 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 defence: This is the body defence mechanism that fights the pathogens already entered the body. It uses white blood cells to destroy pathogens

Answers for application activity 2.3

I. Multiple choice questions:

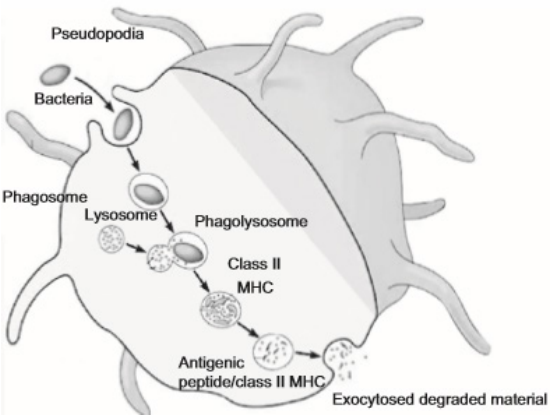
1. (d); recognition of antigen by receptors on B-lymphocytes.
2. (b); as IgG type of antibodies can cross placenta
3. (a); as B-lymphocytes grow in size, acquire Golgi apparatus and transform into actively secreting plasma cells.
4. (c); as histamine causes decrease in blood pressure and respiratory 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.
9. (c); as by employing various strategies bacteria have evolved resistance to a number of antibiotics leaving many diseases untreatable.

II. 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 objectives

- 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 forth lesson of the 2nd 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 2.4

- **Guidance on activity 2.4**

As facilitator, help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 2.4 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 teacher'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 for activity 2.4

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 cause serious negative effects.
2. All except water
3. Confer to Student-teacher book

Answers for application activity 2.4

I. Answers

1. False
2. True
3. True
4. True
5. True
6. False
7. True
8. False
9. True
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……

2.6. Summary of the unit

Infectious diseases are caused by microorganisms known as pathogens which may include viruses, bacteria, fungi and protozoa. One of infectious disease is cholera caused by *Vibrio cholerae* the pathogens which multiply in the intestine, releasing a powerful toxin which results in violent inflammation of the intestine and production of the watery diarrhoea. Another disease is 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. Malaria is spread by Female anopheles mosquitoes.

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).

Apart from AIDS which is mainly transmitted through unprotected sexual intercourse there are other diseases called Sexually transmitted diseases (STDs) that are transmitted by infected persons to healthy persons during sexual intercourse. Examples of these diseases are **chlamydia, gonorrhoea, syphilis and, HIV and AIDS.**

There are many diseases caused by malnutrition, and are known as common deficiency diseases or nutritional disorders. These include Kwashiorkor, Marasmus, obesity and Vitamin deficiencies (Scurvy, rickets), anaemia,

In our Africa countries many people are facing worms causing infection the parasites that live and breed mostly in the intestine. Infection is caused by worms such as roundworms, hookworms and tapeworms.

Our body is always exposed to different kinds of pathogens, but they do not affect always the body due to the ability of the body to defend itself against pathogens. **The immune system** is a protective system that is made of a series of defences 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 which 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.

People are nowadays using Tobacco, Alcohol and drugs which are **common addictive substances** that show signs and symptoms of drug addiction.

2.7 Additional Information for the tutors

On infectious diseases you have to know different kind of infection such as:

Measles 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 faeces 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.

2.8. Answers for end unit assessment

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.

a). *Mycobacterium tuberculosis*; **accept** *Mycobacterium bovis*.

b). Infected person, coughs/ sneezes/ spits**;** aerosol/ droplets, containing bacteria, breathed in by uninfected person**.**

c). Sub-Saharan Africa**;** South-East Asia**;** countries of India / Pakistan/ Afghanistan**;** South America/ Bolivia**;** Papua New Guinea**.**

d). TB linked with HIV infection**;** HIV weakens immune system**;** TB is an opportunistic disease**;** as many people are infected although show no symptoms**;** transmission where there is, overcrowding / poor housing**;** poverty**;** poor ventilation of housing**;** poor nutrition**;** poor access to health care**;** poorly organized treatment for people with TB**.**

2. 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.

3. Confer to student-teacher text book, lesson 2.4

4.

	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

2.9. Additional activities

2.9.1. 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

Answers:

1. Two categories of diseases are
   - Infectious diseases
   - Non-infectious diseases
2. Vibrio cholerae.
3. A balanced diet helps to:
   - Make you strong
   - Make you more productive
   - Provide better health
   - Ensure strong immune system

2.9.2. 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.

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.

2.9.3. 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 thing are factors that cause the failure to eradicate tuberculosis?

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 bronchiols.

   iv). .... occurs upon inhaling certain allergens in the air leading to sneezing and coughing.

v). Penicillin is produced by ....

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 3: STRUCTURE OF AN ATOM

3.1. Key Unit competence

Calculate relative atomic mass (R.A.M) of different elements

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

Components of an atom and their properties, definition of an atomic number, mass number and isotopes as they learnt them from ordinary level senior one chemistry unit 5.

3.3. Cross-cutting issues to be addressed

a) Gender inequality

General need of people to complement one each over without conflict in order to be peaceful.

The nature of atoms can be related to relationship in human beings. There is a serious issue of misunderstanding of gender equality in our society. When introducing this unit, it would be an opportunity to guide student teachers on understanding the importance of gender equality and how the issues related to gender inequality may be addressed.

Help student teacher to:

a). Understand that complementarities are very important. *Atoms constituents such as protons and neutrons coexist in the atomic nuclei for playing the specific role. There are no conflicts between protons and neutrons in the nucleus of the atom even though their masses are quite equal.* Student teachers should know that female and male are both human beings and no one should say that he/she is more indispensable than another.

b). Understand that gender equality plays a big role in the development of the country.

c). Understand that female needs male and vice-versa in different ways for their future achievement.

d). Underlining the necessity of cooperation and working in mixed group rather than working in single group)

You can do this in a short whole class discussion. This may be an opportunity for you as chemistry tutor to confront the individual student teachers who need advice on relationship matter.

b) Inclusive education

This unit involves a number of activities on the properties and discovery of atoms, and calculations involving mass spectrometer; the activities require reading and writing. This may be challenging to student teacher 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 grouped with others and assigned roles basing on individual student teacher's abilities.
- Providing procedure earlier before the activity 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 or in Braille.
- 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.

3.4. Guidance on introductory activity

Before introducing the first lesson (outline of the discovery of the atom constituents and their properties) of this unit, let student teachers attempt the introductory activity.

Answers for 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 blue spheres 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

3.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	The constituents of an atom, their properties and the outline of their discovery.	Outline the discovery of the sub-atomic particles.	2
2	Concept of atomic number, mass number, isotopic mass and relative atomic mass.	Compare the properties of sub-atomic particles.	1
3	Calculations of the relative atomic masses of elements.	Calculate the relative atomic mass of an element, given isotopic masses and abundances.	2
	End unit assessment		1

Lesson 1: The constituents of an atom, their properties and the outline of their discovery.

a) Prerequisites/ Revision/ Introduction

This is the first lesson of unit 3. It is a single lesson, but it also covers the introduction of the whole unit, it has two periods (80 minutes).

b) Teaching resources

Illustrations in the student teachers' book, reference books

c) Learning activity 3.1

- **Guidance on activity 3.1**

Before introducing the lesson, you will have to introduce the whole unit. Let student teachers therefore attempt the introductory activity first then learning activity 3.1 which leads student teachers to the first lesson of the unit.

- Form groups of 3 to 5 student teachers and ask them to choose a group leader
- Provide the activity 3.1 from the student teacher book (when the books are not enough, he/she can write the activity on the chalkboard) to the student teachers in their groups and ask every group to discuss questions 1 – 5, and provide answers.
- Let student teachers to work together in their groups without intervene directly.
- Monitor how the student teachers are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
- Invite group leaders to present the student teachers' findings, but manage your time well.
- Record the key points for each presentation in order to harmonize later.
- Evaluate the student teachers' findings and emphasize on which are correct, incomplete or false
- Ask student teachers 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 do application activity 3.1. Student teachers should do the application activity in any method you wish to use

Answers for activity 3.1

1. a)Matter is anything that has mass and takes up space.

   b) Light is not matter: it doesn't have measurable mass and can't be contained in a volume.

   Energy is not matter: energy does not have size, shape or occupy space

   Gold is matter; it has measurable mass and can be contained in a volume.

   Sound is not matter: it doesn't have measurable mass

   Ideas not matter: do not have measurable mass and can't be contained in a volume.

Smoke is matter: smoke is a collection of tiny solid, liquid and gas particles that may occupy the space and the volume

Peanuts: matter, have measurable mass and can be contained in a volume.

2. Matter is made up of what atoms and molecules are made of, meaning anything made of positively charged protons, neutral neutrons, and negatively charged electrons.

3. 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 “intermingle” 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 behaviour.

4. J. J. Thomson’s study of cathode-ray tubes led him to postulate the existence of negatively charged particles that we now call electrons.

   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 center 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.

5. 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.

6. Protons in an atom determine 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.

Answers for application activity 3.1

1. $5.93 \times 10^{-18}\,C \times \frac{1 \text{ electron charge}}{1.602 \times 10^{-19}\text{ C}}$ = 37 negative (electron) charges on the oil drop

2. False. Hydrogen contains only 2 (1 proton and 1 electron)

   An atom is composed by 3 fundamental particles but its mass depends only to 2 of them. The 2 particles are protons and neutrons. The third type particle which is electron is much lighter therefore its mass is negligible.

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.
   a). Thomson found that under the same conditions of his experiment, atoms of different elements produced the particles with the same properties.

   b). Most alpha particles pass straight through tin metal foil because there are many spaces in between the nuclei of atoms

   c). Some alpha particles are scattered because the charge of nucleus is also positive as the charge of alpha.

Lesson 2: Concept of atomic number, mass number, isotopic mass and relative atomic mass

a) Prerequisites/ Revision/ Introduction

Student teachers 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)

b) Teaching resources

- The periodic table of chemical elements.
- Charts illustrating isotopes of some elements.

c) **Learning activity 3.2**

- **Guidance on activity 3.2**
  - Form groups of 3 to 5 student teachers and ask them to choose a group leader
  - Provide the activity 3.2 from the student teacher book (when the books are not enough, you can write the activity on the chalkboard) to the student teachers in their groups and ask every group to do questions, and provide their answers.
  - Let student teachers to work together in their groups without intervene directly.
  - Monitor how the student teachers are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
  - Invite group leaders to presents the student teachers' findings, but manage your time well.
  - Record the key points for each presentation in order to harmonize later.
  - Evaluate the student teachers' findings and emphasize on which are correct, incomplete or false
  - Ask student teachers 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 do application activity 3.2.
  - Student teachers should do the checking up activity in any methodology you wish to use.

Answers for activity 3.2

1. Isotope 1: A= 23, Z = 11 . Isotope 2: A= 24, Z= 11
2. Isotopes are atoms of the same element with sameZ but different A.
3. Mass number A is determined by the addition of the number of protons and the number of neutrons.
4. Atomic number provides information regarding the number of protons in the atomic nucleus.

5. In the atom the number of protons are equal to the number of electrons.
6. Protons and neutrons are located in the nucleus of an atom; electrons are distributed within the sphere surrounding the nucleus
7. If the mass of an atom is concentrated in the centre, the particles in the centre/nucleus are the heaviest subatomic particles ones.
8.
   i). Wrong
   ii). Correct
   iii). Wrong
   iv). Correct
   v). Wrong

Answers for application activity 3.2

1. a) For $^{35}_{17}Cl$: Atomic number =17. There are therefore 17 protons per nucleus.

   Mass number = 35. There are therefore 35 protons plus neutrons or, because we know that there are 17 protons, there are 18 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, or 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. $^{9}_{4}Be$

b. $^{51}_{23}V$

c. $^{124}_{54}Xe$

d. $^{69}_{31}Ga$

3.

a). Protons, electrons

b). Atomic number

c). Mass number

d). Isotope

e). Neutrons

Lesson 3: Calculations involving relative atomic mass

a) Prerequisites/ Revision/ Introduction

Before beginning this lesson, student teachers should be able to recall the definition of isotopes, give their masses and some examples.

b) Teaching resources

- The periodic table of chemical elements
- Charts illustrating isotopes of some elements and their relative abundances.

c) Learning activity 3.3

- **Guidance on activity 3.3**

  - Learning activity 3.3 is suggested in student teachers' book. However the tutor is free to add more.
  - Form groups of 3-5 student teachers. The number of groups and members will depend on your class size.
  - In the groups student teachers attempt activity 3.3, discuss and record their answers.
  - Each group representative presents their answers to the whole 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.
  - Make a summary of the lesson (short notes) and assess your lesson.

    Let student teachers do application activity 3.3. Student teachers should do the application activity in any method you wish to use.

Answers for activity 3.3

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) + (0.2785× 86.9092amu) /100 =

   61.263amu + 24.204amu = 85.467amu

   From the periodic table, X is Rubidium (Rb)

3. [10x + 11(100-x)]/100 = 10.8

   10x + 1100 – 11x = 1080

   ∴ x = 1100 – 1080 = 20%

Answers for application activity 3.3

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 amu) + $(1 - x)$ (70.9249 amu) = 69.72 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%

3.6. Summary of the Unit

- The nucleus contains protons (positively charged) and neutrons (neural).
- The atomic 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 they are charged.
- 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 average relative atomic mass is equal to the sum of each isotope's mass for an element times its relative abundance.
- The relative formula mass of a compound is equal to the sum of the individual relative atomic masses.

3.7. Additional Information for the tutor

The History of the Atom

1) **Timeline: 400 BC**

Scientist: Democritus (Greek Philosopher)

Democritus was a Greek philosopher who was the first person to use the term atom (*atomos*: meaning indivisible). He thought that if you take a piece of matter and divide it and continue to divide it you will eventually come to a point where you could not divide it any more. This fundamental or basic unit was what Democritus called an atom.

He called this the theory of the universe:

- All matter consists of atoms, which are bits of matter too small to be seen.

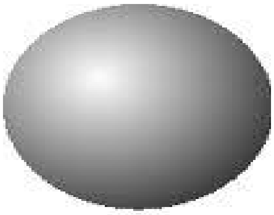
- There is an empty space between atoms
- Atoms are completely solid
- Atoms have no internal structure
- Each atom (of a different substance) is different in size, weight and shape.

2) Timeline: 1800's

Scientist: John Dalton

John Dalton was the first to adapt Democritus' theory into the first modern atomic model.

John Dalton's Atomic Model:



Dalton

i). All matter consists of tiny particles called atoms

ii). Atoms are indestructible and unchangeable

iii). Elements are characterized by the weight of their atoms

iv). When elements react, it is their atoms that have combined to form new compounds

3) Timeline: 1890's

Scientist: J.J Thomson

J.J Thomson was a physicist who is credited for discovering the electron. He used his research on cathode ray tube technology in this discovery.

i). Nearly Empty tube (Air has been sucked out)

ii). An electric charge is passed through the tube. Travels from cathode to anode

iii). The charge is invisible, so to see where it travelled a fluorescent screen is placed at back of tube. Where the beam hits, a dot will appear on the screen. You could also use a fluorescent gas and the whole tube will light up.

iv). This beam will always travel straight if not interfered with.

v). The deflection coils each have a specific charge. One is positive and the other is negative.

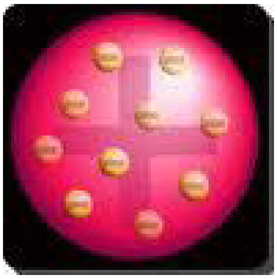
vi). Thomson showed (as in the diagram above) that the charge would deflect away from the negative coil. He then stated that this charge was thus a negative charge. J.J Thomson was an excellent physicist and thus did not stop when he had found this negative charge. Through a series of clever experiments he was able to predict the mass of this charge.

Scientific Interpretation at its Best

He then found out that this charge was 1000 times lighter that a hydrogen atom. He made a bold statement saying that this negative charge must be inside an atom. This negative charge (he called corpuscles) later became known as the electron.

Thomson's Atomic Model

Using what he had discovered, Thomson predicted what an atom should look like. These are the key points to Thomson's Atomic Model:



1. Because of its design this model is known as the plum pudding model
2. Each atom is a sphere filled with positively charged 'fluid'. This resembles the sticky jam part of a pudding.
3. Corpuscles (later called electrons), are the negatively charged particles suspended in this 'fluid'. This resembles the plums in the pudding.
4. He did not predict the movement of these electrons

4) Timeline: 1910's

Scientist: Ernest Rutherford

Ernest Rutherford was not convinced about the model of the atom proposed by Thomson. He thus set up his now famous Gold Foil Experiment.

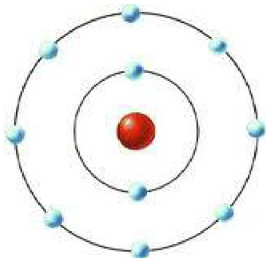
i). He fired alpha particles (positively charged) at a gold foil.

ii). He measured the deflection as the particles came out the other side.

iii). Most of the particles did not deflect at all. Every now and then a particle would deflect all the way back.

iv). He said that there must be a positive centre of the foil. He called this centre the nucleus.

Rutherford's Atomic Model



a). The nucleus of the atom is a dense mass of positively charged particles.

b). The electrons orbit the nucleus

c). A problem raised was: Why are the negatively charged particles not attracted by the positively charged nucleus

d). Rutherford stated that the atom was like a mini solar system and that the electrons orbited the nucleus in a wide orbit. That is why it is known as the planetary model.

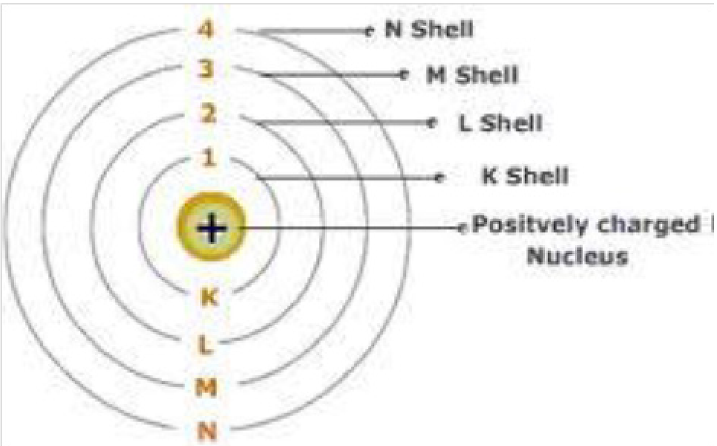
5) Timeline: 1910's

Scientist: Niels Bohr

Niels Bohr agreed with the planetary model of the atom, but also knew that it had a few flaws. Using his knowledge of energy and quantum physics he was able to perfect Rutherford's model. He was able to answer why the electrons did not collapse into the nucleus.

Bohr's Atomic Model

i). Electrons orbit the nucleus in orbits that have a set size and energy.



ii). The lower the energy of the electron, the lower the orbit.

iii). This means that as electrons fill up the orbitals, they will fill the lower energy level first.

iv). If that energy level is fill (or at capacity), a new energy level will begin.

v). Radiation is when an electron moves from one level to another.

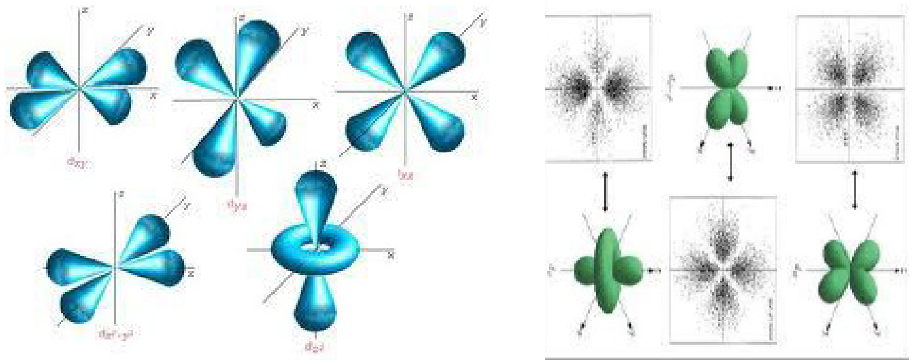
Problems with this theory: Electrons do not travel on a specific orbit or path.

6) Timeline: 1920's

Scientist: Erwin Schrödinger

Erwin Schrödinger was a revolutionary physicist who used Heisenberg's uncertainty principle to come up with the atomic model that we still use today.

Schrödinger's Atomic Model (The Cloud Model)



i). An electron does not travel in an exact orbit

ii). We can predict where it will probably be iii). We cannot say for certain where it is, but only where it ought to be.

iv). The type of probability orbit is dependent on the energy level described by Bohr

3.8. Answers for end unit assessment

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.

Answers for end unit assessment

I. 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 which does not influence chemical properties).

II. Short and long answer questions

4. 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 constitute nucleus are protons and neutrons.

5. $RAM = \frac{(6.015121 \times 7.50) + (7.016003 \times 92.50)}{100} = 6.94093685$ Writing the answer with two decimal places we prove that the RAM of lithium is 6.94

6. $\% = \frac{6.x + 7(100 - x)}{100} = 6.94$

   6x+700-7x=694

   -X=694-700

   X=6

   % of Li-7=100-6=94

7.

Atoms	A	z	protons	neutrons	electrons
R	20	**8**	8	**12**	**8**
X^{2-}	**20**	18	**18**	20	**20**
Y^{3+}	45	21	**21**	**24**	**18**

3.9. Additional activities

3.9.1. Remedial activity

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

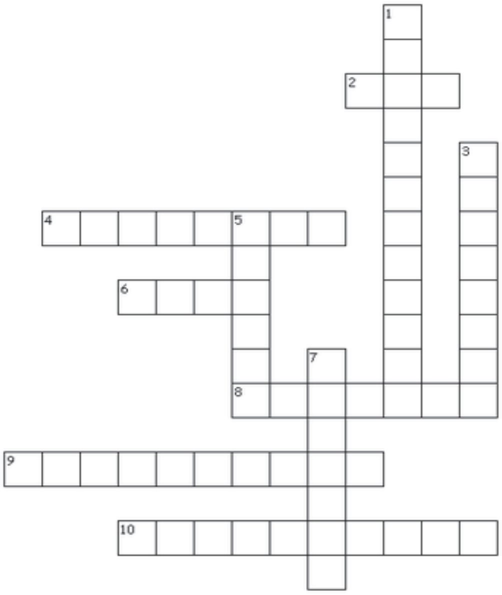
Down

1. 1. Number of protons

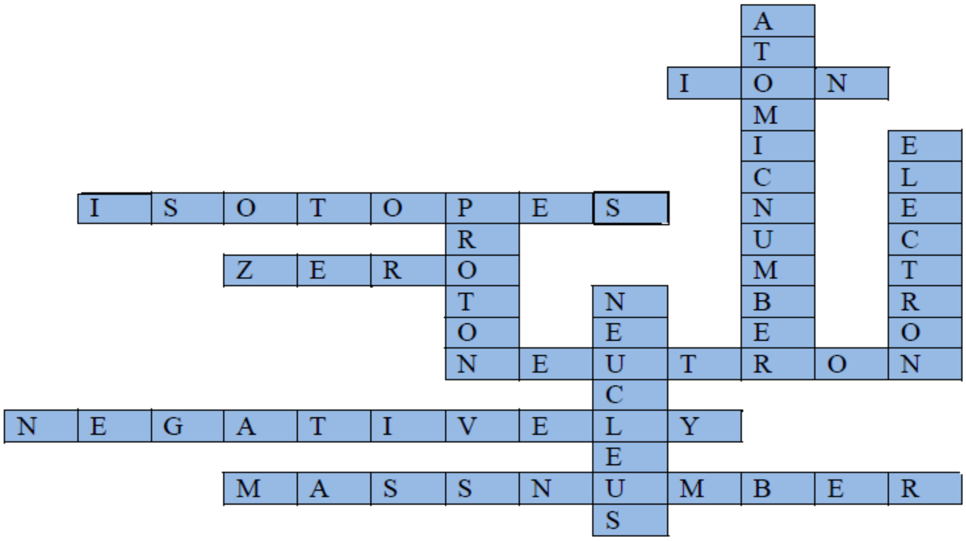
3. I move around the nucleus

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.

3.9.2. Consolidation activity

5. 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 sulphur analogue?

Answer:

Sulphur is in the same group as oxygen, and its most common ion is S^{2-}. Therefore, the formula of the sulphur analogue would be Ta_2S_5.

Total number of protons in Ta_2O_5:

Ta, Z = 73, so 73 protons × 2 = 146 protons; O, Z = 8, so 8 protons × 5 = 40 protons

Total protons = 186 protons

Total number of protons in Ta_2S_5:

Ta, Z = 73, so 73 protons × 2 = 146 protons; S, Z = 16, so 16 protons × 5 = 80 protons

Total protons = 226 protons

Proton difference between Ta_2S_5 and Ta_2O_5: 226 protons – 186 protons = 40 protons

6. 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.

3.9.3. Extended activity

7. Natural silicon in silicon-containing ores contains 92% silicon -28. 4.7 % silicon -29 and 3.1% silicon-30.
   a). What is the atomic number of silicon?
   b). What are the relative isotopic masses of the three isotopes of silicon?

c). What is the relative atomic mass of silicon?

Answers:

a). Si: Z = 14

b). The relative isotopic masses of silicon: 28, 29 and 30

c). The relative atomic mass of silicon

$=[(28 \times 92) + (29 \times 4.7) + (30 \times 3.1)]/100$

$= (2576 + 136.3 + 93)/100 = 28.05$

8. Explain each assertion that follow:

a). Atoms of every element are neutral;

b). The mass of every atom is concentrated in the nucleus.

c). The number of neutrons can be obtained by subtracting the atomic number from the mass number.

d). The nature of an atom is defined by the number of protons not defined by the number of electrons.

Answers:

a). The number of electrons (negatively charged particles) is equal the number of protons (negatively charged particles).

b). The heaviest particles (protons and neutrons) of atoms are localised in the nucleus

c). The mass number is the number of neutrons + the number of protons (atomic number)

d). The number of protons of a given atom cannot chemically change while electrons can change when atom gains or loses some or all of them

UNIT 4: UNIFORM CIRCULAR MOTION

4.1. Key unit competence

Analyse and solve problems related to circular motion.

4.2. 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, and able to use ICT tools like computer, XO laptop.

4.3. Cross-cutting issues to be addressed

a) 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).

b) 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.

c) 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.

d) Environmental and sustainability:

Are integrated through different activities in circular motion in different examples for our environment.

4.4. 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 introductory activity let student teacher observe the image and think critically what happen for the bicyclist and guide them for writing their findings.

Answers for introductory activity

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.

4.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Period
1	Definition of key terms in circular motion	Describe angular velocity; linear velocity, periodic time; frequency	1
2	Relationship between angular and linear parameters.	Discuss different applications of circular motion.	2
3	Acceleration in circular motion	Adapt scientific skills in estimating the speed of approaching cars to avoid road accidents.	3
4	Centripetal force.	– Solve problems involving circular motion. – Apply concepts of circular motion to different real life	1
5	End unit assessment		1

Lesson 1: Definition of key terms in circular motion

a) Learning objective

Describe angular velocity; linear velocity, periodic time; frequency

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

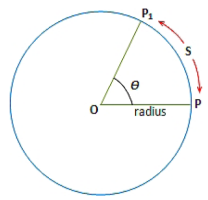
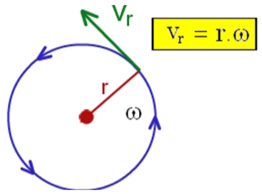
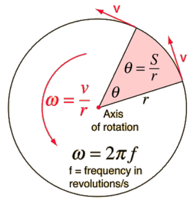
d) Learning activity 4.1

- **Guidance on activity 41**
  - Facilitate student teacher to observe the figure represented in the activity 4.1
  - Let them think deeply and write their observation
  - Put them into groups and tell them to share their observation
  - Guide them for relating the activity within their daily life
  - Invite one in each group to share their findings
  - Help them to conclude the activity

Answers for activity 4.1

The student teachers will explain that the body changes the velocity direction, keep the radius by keeping the magnitude 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 for application activity 4.1

			
Angular and linear coordinates	Linear velocity	Angular velocity	Angular acceleration

Lesson 2: Relationship between angular and linear parameters

a) Learning objective

Discuss different applications of circular motion.

b) Teaching resources

Stop watch, Protractor, ball, thread, tape measure, projector, and computer

c) Prerequisites/ Revision/ Introduction

Review on terms used in circular motion and its application

d) Learning activity 4.2

- **Guidance on activity 4.2**
  - 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.

Answers for activity 4.2

The variables **v, r** and **w** means:

- **V** means the linear velocity of a circular motion
- **r** means radius of a circular motion
- ω : means angular velocity of a circular motion

1. In the movement of the wheel, ω shows the angles of the wheel changing.

e) Answers for application activity 4.2

1. **Solution**

Known:

Radius (r) = 0.5 meters, 1 meter, 3 meters

The angular speed = 10 radians/second

Wanted: 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 rad/ s

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 m)(523.3 rad/s) = 26 m/s

b). The magnitude of the linear velocity of a point located 0,1 m from the center

$v = r\,\omega$ = (0.1 m)(523.3 rad/s) = 52 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 meters)(12.56 radians/second) = 2.5 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 3: Acceleration in circular motion

a) Learning objective

Adapt scientific skills in estimating the speed of approaching cars to avoid road accidents.

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 4.3

- **Guidance on activity 4.3**

- 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 for activity 4.3

1. Because frictional force between the tyres and the ground is at a maximum and hence centripetal force is a maximum.

Answers for application activity 4.3

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:

   $$a = \frac{(6\pi)^2}{1.5} = 237\, m/s^2$$

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 4: Centripetal force.

a) Learning objectives

- Solve problems involving circular motion.
- Apply concepts of circular motion to different real life

b) Teaching resources

Ropes, computer, projector

c) Prerequisites/ Revision/ Introduction

Student teacher review on calculation of centripetal acceleration, pre-requisite on Newton's law

d) Learning activity 4.4

- **Guidance on activity 4.4**
  - 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 for activity 4.4

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.

Answers for application activity 4.4

1. Centripetal force, F_c= 64 N

   Centripetal acceleration, a_c = 21 m/s^2

2. Known:

   Object's mass (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:

   $$\sum F = m\,a, \quad \sum F = m\,v^2/r = m\,\omega^2 r$$

$\sum F$ = 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 teacher; the student teacher's weight will pull downward, while the friction of the wall pushes upward.

$$fs = mg = 50kg \times 10m/s^2 = 500N$$

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 wall, directed toward the center of the circle.

$$fs = 500N = \mu N$$

$$N = \frac{500N}{0.8} = 625N$$

This normal force is the minimum centripetal force required to keep the student teacher pinned to the wall. We can convert this to centripetal acceleration:

$$N = F_c = ma_c$$

$$a_c = \frac{625\,N}{50kg} = 12.5\,m/s^2$$

We can now convert centripetal acceleration to a translational velocity using the equation:

$$a_c = \frac{v^2}{r}$$

Rearranging for velocity, we get:

$$v = \sqrt{a_c.r} = \sqrt{(12.5m/s^2)(5m)} = \sqrt{62.5m^2/s^2} = 7.9\,m/s$$

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:

$$period = \frac{circumference}{velocity}$$

$$Period = \frac{C}{v} = \frac{\pi D}{v} = \frac{\pi 10m}{\frac{7.9m}{s}} = 3.97s$$

4.6. Summary of the Unit

The analysis of uniform circular motion is important because there are many situations in the world around us which approximate to this kind of motion. The mathematics of uniform circular motion is relatively straightforward.

To keep an object in uniform circular motion, there must be a centripetal force which is constant in magnitude and always perpendicular to the direction of motion, directed radially inwards towards the centre of the circle.

The angular speed, $\omega = \frac{2\pi}{T}$, of an object in uniform circular motion is equal to the angle swept out in unit time by the position vector from the centre of the circle to the object.

The speed v and angular speed ω of an object in uniform circular motion are constant and related by the equation $v = r\omega$ (ω in $rads^{-1}$), where r is the radius of the circle

The period T of uniform circular motion is related to the angular speed by the equation

$$T = \frac{2\pi}{\omega}$$

The acceleration which is necessary to keep an object in uniform circular motion is known as the centripetal acceleration. It is directed radially inwards and has a magnitude given by the following equivalent expressions

$a = v\omega$

or $a = \frac{v^2}{r}$ or $a = r\omega^2$

The centripetal force is the force which gives rise to the centripetal acceleration. It is directed radially inwards with magnitude given by the following equivalent expressions

$F = m\frac{v^2}{r}$ or $F = mr\omega^2$

The analysis of uniform circular motion can be applied to many practical problems such as the radius of curvature for 'safe' bends on roads, and the orbits of geostationary and geosynchronous satellites.

4.7. Additional information for the tutor

Uniform circular motion can be described as the motion of an object in a circle at a constant speed. As an object moves in a circle, it is constantly changing its direction of motion. At all instances, the object is moving tangent to the circle. This happens because of a centripetal force, a force pointing towards the center of a circle, an acceleration vector towards the center of a circle and a velocity tangent to the circle. The speed of an object in uniform circular motion is constant because after all that's what makes it uniform. But the velocity is always changing.

Examples of uniform circular motion in everyday life:

1. Amusement park ride
2. Satellites orbiting the Earth and our natural satellite Moon's motion around the earth.
3. Movement of a windmill.
4. An athlete running on a circular track
5. Merry go round
6. The motion of electron around the nucleus
7. The motion of toy car on the circular track
8. The motion of planets around the sun

4.8. Answers for end unit assessment

1. We need a force to beep a body moving uniformly along a circular path because it changes it's direction at every instant of time when it is made to rotate. It acts towards the centre of the circular path and the corresponding acceleration is known as centripetal force.
2. Any object in circular motion is constantly changing direction. The unbalanced force that causes objects to move in a circular path is called a centripetal force. Gravity provides the centripetal force that keeps objects in orbit, the word centripetal means "toward the center."
3. An object is said to be moving in uniform circular motion when it maintains a constant speed while travelling in a circle. Since acceleration is a vector quantity comprised of both magnitude and direction, objects can accelerate in any of these three ways: Constant direction, changing speed (linear acceleration)

4. In uniform circular motion, velocity changes due to change in direction, even though magnitude remains constant (displacement is vector quantity). Consequently, acceleration (a quantity dependent on velocity) changes. So, YES! Linear acceleration does change for an object in uniform circular motion.

5.

a). $$\sum F = ma \Rightarrow F_{gravity} + F_{normal} = m\frac{v^2}{r}$$

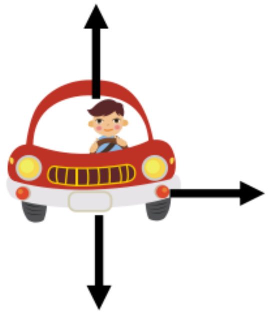
(At minimum speed $F_{normaldrops}$ to zero)

$$mg = m\frac{v^2}{r} \Rightarrow v = \sqrt{gr} = 1.4m/s$$

b). $$\sum F = ma \Rightarrow F_{gravity} + F_{normal} = m\frac{v^2}{r}$$

$$F_{normal} = m\frac{v^2}{r} - mg = 0.124N$$

6.

$F_{net} = ma = m\frac{v^2}{r} = 2940N$	Car experiences a centripetal acceleration	
Friction provides the force	Without friction the car could not turn	
$F_{fs} < \mu_s F_N \rightarrow F_{f\max} = 3600N$	The normal force is balancing gravity pulling down	
At 14 m/s the car won't slide	The force needed (2940N) is less than max friction	
$\mu_s mg = m\frac{v^2}{r}$	Set maximum frictional force equal to $ma_{centripetal}$	
$v = \sqrt{\mu_s gr} = 15.5m/s$	Solve for v	

8. The centripetal force that the tension provides is given by $F_R = m\frac{v^2}{r}$.

   Solve that for the speed

   $$\Rightarrow v = \sqrt{\frac{F_R r}{m}} = \sqrt{\frac{75\times 1.3}{0.45}}\, m/s = 15\, m/s$$

4.9. Additional activities

4.9.1. 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 speedω = 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:

   $$F_c = \frac{mv^2}{r}$$

   We are given the mass, radius or rotation, and the linear velocity. Using these values, we can find the centripetal force.

   $$F_c = \frac{(25kg)\,\mathrm{x}\,(6\mathrm{m/s})^2}{5m} = 180N$$

4.9.2. Consolidation activities

1. 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

2. A car is travelling with a velocity of 17.0ms^{-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 2.00ms^{-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 = 2.00m/s2, t = 5.00s

a). $u = r\omega_o$, $17.0 = 0.48\ \omega_o$

$\Rightarrow \omega_o = 35.4\,rad/s$

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. 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

$$F_{net} = m\left(v^2/r\right) \Rightarrow v = \sqrt{\frac{F_{net} \times r}{m}} = 21.65m/s$$

Next, we find the period of the object's motion

$$v = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v} = 4.35s$$

And finally, we find its frequency $f = \frac{1}{T} = 0.23Hz$

4.9.3 Extended activities

1. A ball of mass 1*kg* is on a string of length 2*m*. If the ball is being spun in vertical circles at a constant velocity and with a period of 2*s*, what is the maximum tension in the string? g=10ms^{-2}

First, we need to identify at which point in the cSircle the string is experiencing the most tension. There are two total forces in the system: gravity and tension. It is important to note that the tension isn't only resulting from gravity; it also includes the centripetal force required to keep the ball in circular motion. Thinking practically, we can say that the greatest tension will be when the ball is at its lowest point (gravity and tension are in opposite directions). At this point we can write:

$$T = F_c + F_g$$

Expand our terms for force:

$$T = ma_c + ma_g = m\left(a_c + a_g\right)$$

We know the acceleration due to gravity, but we need to determine the centripetal acceleration. The formula for that is:

$$a_c = \frac{v^2}{r}$$

We know the radius (length of the string), so we need to develop an expression for velocity. We can use the period and circumference of circle:

$$velocity = \frac{circumference}{time} = \frac{2\pi r}{P}$$

Here, we use *P* to denote period.

Substituting this into the expression for centripetal acceleration:

$$a_c = \frac{\left(\frac{2\pi r}{P}\right)^2}{r} = \frac{4\pi^2 r}{P^2}$$

Substituting this back into the equation for tension, we get:

$$T = m(\frac{4\pi^2 r}{P^2} + a_g)$$

We have all of these values, allowing us to solve:

$$T = \left(1kg\right)\left(\frac{4\pi^2\left(2m\right)}{\left(2s\right)^2} + \frac{10m}{s^2}\right) = 29.7N$$

UNIT 5: MICROSCOPE AND CELL STRUCTURE

5.1. Key Unit competence

Describe the structure and function of cells in an organism

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

To understand well this unit 5, Student-teachers should 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.

5.3. 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 activity, 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 activity, 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 teacher and other student-teachers should help them to achieve the competences as required in all teaching-Learning activity.

5.4. Guidance on introductory activity

- In groups or pairs, help student-teachers to choose group representatives.
- Help student-teachers to brainstorm the structure of microscope and work on the introductory activity 5
- Supervise the work on how it is conducted and give the student-teachers' 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.

5.5 List of lessons

#	Lesson title	Learning objectives	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.	3
2	Eukaryotic and prokaryotic cell	State differences between eukaryotic and prokaryotic cells	2

3	Description of cells (Structure of animal and plant cells and functions of cell organelles)	– Describe the cell structure – Explain the difference between animal cell and plant cell, – Functions of cell organelles	4
4	Specialized cells	– Explain and interpret cell specialization and functions of specialized cells – Appreciate the importance of cell specialization in multicellular organisms.	2
5	End unit assessment		1

Lesson 1: Cell theory and microscopes (Compound Light Microscope, its magnification and resolution, Electron microscopes)

a) Learning objectives

- 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.

d) Learning activity 4.5.1

Guide student-teachers to use internet and textbooks and work on the activity 5.1

The probable answers to the learning activity 5.1 may be:

The cell theory states that all living organisms are made up of *cells, and cells are* the basic unit of structure function in all living organisms. The main principles of cell theory is that all known living organisms are made up of one or more cells, all cells come from pre-existing cells by division and cells contain the hereditary information that is passed from cell to cell during cell division.Information about the functions of the components of the compound light microscope and the difference between the compound-light microscope and electron microscope is well discussed in the content summary of the lesson 5.1.

e) Answers for application activity 5.1

1. 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.
2. Help and follow how the learner applies 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 technician.
   - You are responsible for the microscope while using it— treat it with care!

3. 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.

4. 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.

5. 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 showing different types of bacteria, projector, microscope, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

For student-teachers to understand this lesson 5.2, they must 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 5.2

Guide student-teachers to manipulate the microscopes and work on the activity 5.2. The probable answers should be correlated with information discussed in the content summary of the lesson 5.

e) Answers for application activity 5.2

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.

6. **Table for Comparison between prokaryote and eukaryote**

Criterion	Prokaryote	Eukaryotic Plant cell	Eukaryotic Animal cell
Cell membrane	Present	Present	Present
Cell wall	Present	Present	Absent
Nuclear envelope	Absent	Present	Present
Chromosome	Circular	Threadlike	Threadlike
Mitochondria	Absent	Present	Present
Chloroplast	Absent	Present	Absent

Endoplasmic reticulum	Absent	Present	Present
Golgi body	Absent	Present	Present
Ribosomes	Small (70S)	Big (80S)	Big (80S)
Vacuole	Absent	Big	Absent
Lysosomes	Absent	Present	Present
Centrioles	Absent	Absent	Always present

Lesson 3: Plant and animal cell

a) Learning objectives

- 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 they 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 5.3

Provide clearer electronic micrographs to student-teachers, and guide them to work on the learning activity 5.3. Probable answers should be correlated with the information discussed in the content summary of the lesson 5.3 from the student-teachers' text books.

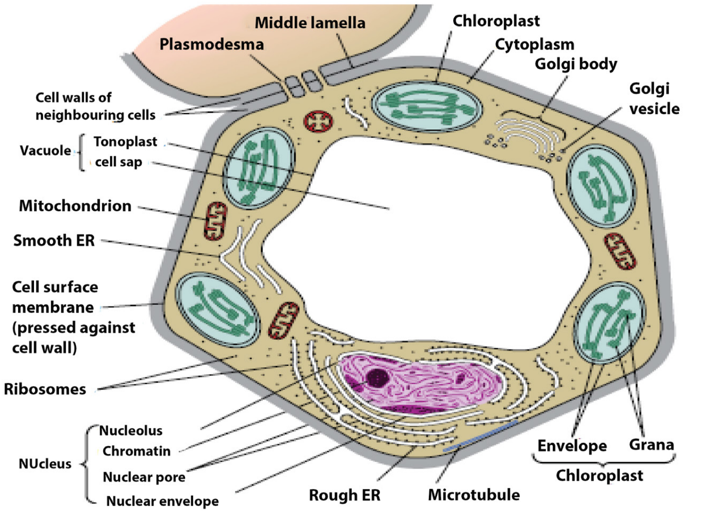
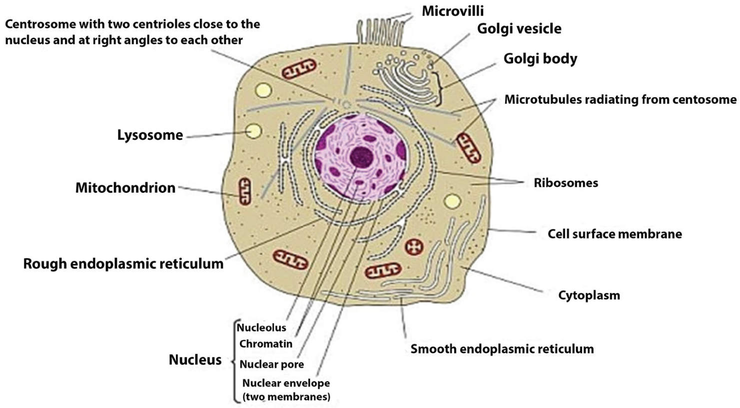


Figure 5.1: for the Structure of a plant cell



The figure 5.2: for the structure of a plant cell

e) Answers for application activity 5.3

1. The structures of both animal cell and plant cell are described in the content summary of the lesson 5.3.

2. 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 and it is also involved in in movement.

3. To answer the question, confer to student-teacher book, lesson 5.3
4. a) false b) false c) false
5. To answer the question, confer to student-teacher text book, lesson 5.3

Lesson 4: Specialized cells

a) Learning objectives

- 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 showing different kinds of special cells' movement, projector, microscope, Manila paper with diagrams illustrating different special cells for improvisation.

c) Prerequisites/Revision/Introduction

To understand this lesson, student-teachers should have 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 5.4

Guide Student teacher to observe the figure in the student teacher's text books and guide them to work on the activity 5.4. 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 for application activity 5.4

1. Because their nucleus is lost, Erythrocytes are specialized by having a **biconcave** shape which enable them to carry out their function (to transport Oxygen) sufficiently.

2. Cell division, protein synthesis, aerobic respiration.

3. 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.

5.6. Summary of the unit

The unit **"Cell structure"** is divided into four sub-headings: Cell theory and microscopes, Eukaryotic and prokaryotic cell, the description of cells (Structure of animal and plant cells and functions of cell organelles), 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.

5.7. Additional Information for the 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

5.8. End unit assessment

Answers for end unit assessment

Section A: Multiple choice questions

1. d
2. c
3. a
4. b
5. b

Section B: Questions with short answers

1. To answer the questions, confer to student-teacher book, point 5.3
2. 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.
3. 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.
4. 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.

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.

Section C: Essay questions

1. To answer the question, confer to the student teacher text book, lesson 5.3

2. To answer the question, confer to the student teacher text book, lesson 5.3

3. To answer the question, confer to the student teacher text book, lesson 5.3

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:

   $A = \frac{I}{M}$ 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

5.9. Additional activities

5.9.1 Remedial activities

1. Match each part of the cell to its correct statement:

Nucleus	controls movement of substances in and out of the cell
Mitochondrion	where photosynthesis takes place
Chloroplast	where aerobic respiration takes place
Smooth ER	controls the activity of the cell
Cell membrane	where lipids including steroids are made

Expected answer

Nucleus	controls the activity of the cell
Mitochondrion	where aerobic respiration takes place
Chloroplast	where photosynthesis takes place
Smooth ER	where lipids including steroids are made
Cell membrane	controls movement of substances in and out of the cell

2. Complete the table below:

Parts of microscope	**Functions**
Base	……………………………
…………	rotates to allow use of different power objectives
Coarse focus adjustment	……………………………
……………	focuses and magnifies light coming through the slide
Eye piece / ocular lens:	………………………………………

Expected answer

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

5.9.2. Consolidation activities

1. Identify each cell structure or organelle from its description below.
   - a). Manufactures lysosomes and ribosomes
   - b). Site of protein synthesis
   - c). Can transport newly synthesized protein round the cell
   - d). Manufactures ATP in animal and plant cells
   - e). Controls the activity of the cell, because it contains the DNA
   - f). Carries out photosynthesis
   - g). Can act as a starting point for the growth of spindle microtubules during cell division
   - h). Contains chromatin
   - i). Partially permeable barrier only about 7 nm thick
   - j). Which two organelles other than the nucleus contain their own DNA?

   Expected answer

   a) Nucleus
   b) Ribosome
   c) Endoplasmic reticulum
   d) Mitochondria
   e) nucleus
   f) Chloroplast
   g) Centriole
   h) nucleus
   i) cell membrane
   j) mitochondria and chloroplast

2. Describe how the following are specialized for their roles:
   - a). Neutrophil
   - b). Sperm cell
   - c). Root hair cell

   Expected answer

   - 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 ATP 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.

5.9.3. Extended activities

1. Calculate the magnification of an image measuring 50mm, while the object measures 5μm.
2. If a nucleus measures 100mm on a diagram, with a magnification of X10 000, what is the actual size of the nucleus?
3. Many hospitals in Rwanda use light microscope instead of electron microscope. Discuss the credibility of the results found by the end of the study.

Expected answer

1. 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.

2. 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

3. 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.

UNIT 6: CELL AND NUCLEAR DIVISION

6.1. Key Unit competence

Describe the stages of the cell cycle and explain the significance of cell and nuclear division in organisms.

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

To succeed well this lesson 6.1, Student-teachers should 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.

6.3. Cross cutting issues to be addressed

a) Peace and value

Tell student teachers 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 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 activity, 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 activity, 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 activity.

6.4. Guidance on introductory activity

Guide Student-teachers to use the text books and work on the introductory activity 6. 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.

6.5. List of lessons

#	Lesson title	Learning objectives	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	5
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 – Show concern to individuals with physical disabilities like Down's syndrome	4
4	End unit assessment		1

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 6.1

Guide Student-teachers to use text books and work on the learning activity 6.1 to describe the phases of cell cycle.

Answers for learning activity 6.1

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),
- Cytokinesis.

e) Answer for application activity 6.1

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 6.1.
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

a) Learning objectives

- 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

To understand this lesson 6.2, Student-teachers should 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 6.2

Provide Student-teachers with manila papers, markers, and other possible resources. Guide them to work on the activity 6.2. Their graphical presentation should be similar to those found in content summary of the lesson 6.2.

e) Answers for application activity 6.2

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. Its volume

3. The answer is summarised under subheading 6.2

4. During interphase the cell grows and replicate its DNA. Student-teachers should describe what happens during G1, S and G2 phases.

5. 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.

6. a) the number is 46 b) in gonads c) prophase I.

Lesson 3: Mitosis and Meiosis roles in living organisms

a) Learning objectives

- 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

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 6.3

Guide Student-teachers to observe the figure and work on the activity 6.3. The answer should appreciate mitosis which allows growth (figure A) and tissue repair (figure B).

e) Answers for application activity 6.3

1. Significance 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. There are three types of tumours: **benign tumours, malignant tumours and metastasis**.
   i). **Benign tumour:** it is a lump of the abnormal cells that remains at the original site**.** Most benign tumours do not cause serious problems and can be removed by surgery.
   ii). **Malignant tumours**: 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 tumour 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**.
4. 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).

6.6. 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.

6.7. Additional information for the 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.

6.8. End unit assessment

Answers for end unit assessment

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 6.2.
5. And
6. See the answers in the content summary of the lesson 6.3
7. To maintain the number of chromosomes in species after fertilisation of gametes to form a zygote.
8. And
9. And
10. see answers in the content summary of the lesson 6.3
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 penetrate in the nucleus of the host cell, so that when the host cell divides, at the same time the HIV is multiplied.

6.9. Additional activities

6.9.1. 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 6.3

6.9.2. 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 6.2.

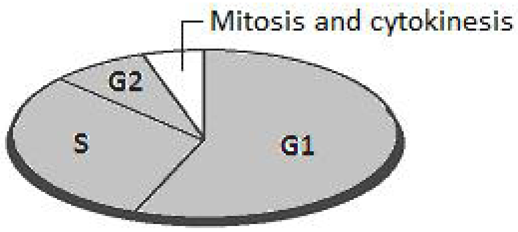
   a). 64 chromosomes
   b). 32 chromosomes.

3.

- **Spindle fibres:** are microtubules that move chromosomes during cell division. They are found in eukaryotic cells. Spindle fibres 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.

6.9.3. 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 7: ELECTRON CONFIGURATIONS OF ATOMS

7.1. Key unit competence

To relate Bohr's model of the atom with hydrogen spectrum and energy levels, practice writing electronic configurations using s, p, d, f orbitals.

7.2. 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.

7.3. Cross-cutting issues to be addressed

a) Inclusive education

Provide print with adequate size and speak aloud every important point for learners with low vision. Write every important point for learners with hearing impairment.

b) Standardization culture

Allow the student teachers to appreciate the way electrons are well arranged in their orbits. This can be linked to the culture of standardization where, for example, some objects that are packed in industries must be done as required without jumping any row or for the liquids that must be filled to the mark.

7.4. Guidance on introductory activity

- Establish a relationship between the unit and student teachers' daily life so as to capture their attention.
- Assess the prior knowledge of the student teachers on the atom and its structure, components (subatomic particles) and their respective properties.
- Make the student teachers try to create the abbreviated way to represent the electrons arranged in an atom, without drawing.
- Ask them to read and observe attentively the introductory activity and answer the questions asked (in the Introductory Activity).

Answers for the questions in the Introductory activity

1. Energy levels or shells
2. Energy content
3. Bohr suggested that each electron occupies its energy level, no one will be placed half way, between two shells. Each is characterized by the shell it occupies.
4. Quantum numbers
5. For example, 1 shelf (23), 2 shelf (21), 3 shelf (17)

7.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Bohr's atomic model: Concept of energy levels.	– Explain the achievements and limitations of Bohr's atomic model. – Describe the existence of energy levels in atoms bond together.	2
2	Absorption and emission of spectra and energy associated, $\Delta E = h\nu$.	– Explain the evidence of energy levels using the data from emission spectra. – Explain the types of spectra and the nature of light.	2
3	Hydrogen spectrum and spectral line series	– Describe Hydrogen spectral lines and spectral line series.	3
4	Concept of orbitals and Quantum numbers	– Explain the quantum theory of the atom using the quantum numbers. – Determine the number and shapes of orbitals.	1
5	Rules governing the electronic configurations: Aufbau principle, Pauli Exclusion Principle and Hund's rule.	– Explain the Rules governing the electronic configuration. – Describe the methods of writing electronic configuration for atoms and ions.	3
	End unit assessment		1

Lesson 1: Bohr's Atomic Model and Concept of Energy Levels

a) Learning objectives

- Explain the achievements and limitations of Bohr's atomic model.
- Describe the existence of energy levels in 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 *Bohr's atomic model and concept of energy levels* they need to have prerequisites on the electronic configuration of elements using dot-and-cross diagrams.

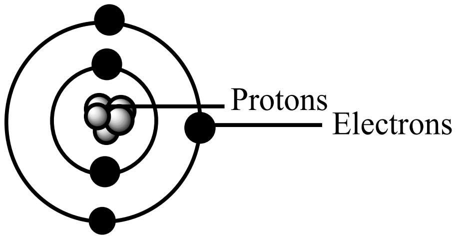
d) Learning activity 7.1

- **Guidance on activity 7.1**
  - Before introducing the lesson, you will have to introduce the whole unit by allowing learners to do introductory activity and thereafter proceed to *Activity 7.1*which is specific to lesson 1.
  - As you enter the class, inform the student teachers on the activity taking place.
  - Ask learners to sit in groups of 4 to 5 student teachers and choose a group leader.
  - Ask student teachers to read carefully the introductory activity, discuss on it and answer the related questions.
  - Ask student teachers to move forward to the activity 7.1 and answer the related questions.
  - Monitor the progress of the group discussion and assist 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.
- Confirm the correct answers, eliminate the wrong ones or complete the incomplete statements
- Give feedback on the works done in order to improve the understanding.

Answers for activity 7.1

1. Electrons, protons and neutrons
2. Proton
3. Suggested structure of boron atom.



4. Because there are fixed places in each level, so when one is full, the next starts to be filled.
5. It must absorb or emit energy.

e) Answers for application activity 7.1

1. It does not work for more complex atoms.
2. See Student teacher's Book, lesson 7.1,Bohr's atomic model and concept of emergency levels
3. Energy level
4. Because the Bohr Model is a modification of the earlier Rutherford Model
5. Give the meaning of each of the following terms:
   a). Electromagnetic spectrum: The term used by scientists to describe the entire range of light that exists.
   b). Quantized: Having real number values /A description of the discrete or individual values by which the energy of an electron can vary.

c). Photon: A packet of light or electromagnetic radiation. It is also called “quantum of light”. Its energy is given by $E = h\nu$

6. According to Bohr, the atom is made by a small positively charged nucleus surrounded by revolving negatively charged electrons in fixed orbits; where electron will have more energy if it is located away from the nucleus whereas the electrons will have less energy if it located near the nucleus.

Lesson 2: Absorption and emission of spectra and energy associated, $\Delta E = h\nu$

a) Learning objectives

- Explain the evidence of energy levels using the data from emission spectra.
- Explain the types of spectra and the nature of light.

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 7.2

- **Guidance on activity 7.2**
  - Refer to Learning activity 7.2 which is suggested in the student teacher’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 7.2 and record their answers.

- Each group representative presents the Answers for his/her group to his/her classmates.

Answers for activity 7.2

1. An arch of different colours visible in the sky/A rainbow
2. Refraction and reflection of the sun's rays in raindrops, spray, or mist
3. Passing the light through the prism.
4. Light is composed by different colours

e) Answers for application activity 7.2

1. Spectrum: Display of component wavelengths (colours) of electromagnetic radiation.
2. It consists of waves of all wavelengths in the visible range where each colour blends into the next with no discontinuity.
3. Some differences between emission and absorption spectra.

Criteria	Emission spectrum	Absorption spectrum
Definition	A spectrum of the electromagnetic radiation emitted by a substance	A spectrum obtained by transmitting electromagnetic radiation through a substance
Look	*Light colored*, with dark bands that run through it	*Dark colored*, with light bands that run through it.
Wavelengths recorded	Records wavelengths emitted by materials, which had been stimulated by energy before.	Records the wavelengths absorbed by the material.
What is figured out	*The type of elements* that the substance is formed of.	*How much quantity* of a substance is present in the sample

Lesson 3: 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

Refer to lesson 2 above and use the concept of quantization of energy and radius to meet the above expectations.

d) Learning activity 7.3

- **Guidance on activity 7.3**
  - Refer to Learning activity 7.3 which was suggested in the student teacher'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 7.3 and record their answers.
  - Each group representative presents the Answers for 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 Activity 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 for activity 7.3

1. Line spectrum
2. Emission spectrum
3. It is light colored, with dark lines that run through it
4. The way fingerprints are used to identify people; the characteristic lines in an atomic spectrum are used to identify unknown atoms of the element beca*use no one will have the same pattern as the other.*

e) Answers for application activity 7.3

1. The infinity level in the hydrogen spectral lines means the far level, once reached, the electron is removed completely from the atom, i.e. there will be ionisation.
2. Given a transition of an electron from n=5 to n=2. Calculate

$$\frac{1}{\lambda} = R(\frac{1}{n_1^2 - n_2^2})$$

$$= 1.09667\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$= 1.09667\left(\frac{1}{4} - \frac{1}{25}\right)$$

$$= 1.09667 \times \frac{21}{100}$$

$$\frac{1}{\lambda} = 0.2303007$$

$\lambda = 4.34215 \times 10^{-7}$ m

$\upsilon = \frac{C}{\lambda}$, $\nu = \frac{3 \times 10^8 m}{4.34215 \times 10^{-7} m} =$ 6.909×10^{14} ms^{-1}

E = hv

= 6.626×10^{-34}Js x 6.909 x 1014s^{-1} = 4.578×10^{-19} J

3. Atomic emission spectra arise from electrons dropping from higher energy levels to lower energy levels within the atom; photons (light packets) with specific wavelengths are released. The energy levels in an atom are specific/unique to each element on the periodic table therefore the wavelength of light emitted can be used to determine which element the light came from.

4. The lines on the atomic spectrum relate to electron transitions between energy levels, if the electron drops an energy level a photon is released resulting in an emission line and if the electron absorbs a photon and rises an energy level an absorption line is observed on the spectrum.

5. The difference between absorption and emission spectra are that absorption lines are where light has been absorbed by the atom thus you see a dip in the spectrum whereas emission spectra have spikes in the spectra due to atoms releasing photons at those wavelengths.

6. The following needs to be in your answer: In what wavelength range the sunlight reaches the earth, the absorption of the sunlight and the re-radiation as infrared light, and finally the scattering of the infrared light by the carbon-dioxide and how this scattering contributes to the Greenhouse Effect.

7. Use the figure to answer the questions.
   a). The colour of light emitted at 423 nm is violet. (Use calculations)
   b). This energy interval corresponds to a transition from energy level 4 to energy level 2. (Use calculations)

8. $\Delta E = hv = E_f - E_i = -4.086 \times 10^{-19}$ J

$$v = \frac{\Delta E}{h} = \frac{-4.086 \times 10^{-19}\,\text{J}}{6.626 \times 10^{-34}\,\text{Js}} = 6.167 \times 10^{14}\, s^{-1}$$

$$\text{Wavelength} = \frac{c}{v} = \frac{3 \times 10^{8}\, ms^{-1}}{6.167 \times 10^{14}\, s^{-1}} = 4.8646 \times 10^{-7}\, m$$

Lesson 4: Concept of orbitals and quantum numbers

a) Learning objectives

- Explain the quantum theory of the atom using the quantum numbers.
- Determine the number and shapes of orbitals.

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 7.4

- **Guidance on activity 7.4**
  - Refer to Learning activity 7.4 which is suggested in the student teacher'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 7.4 and record their answers.
  - Each group representative presents the Answers for his/her group to his/her classmates.

Answers for activity 7.4

1. It does not work for more complex atoms.
2. Orbit: Space where the probability of finding electrons is maximum
3. A specific part within one of orbits of an atom where an electron can be found.
4. There are numbers used to locate the orbitals. These are of four types. One usually encountered is qualified to be "principal".
   a). Quantum numbers
   b). Principal, Secondary, Magnetic and Spin (quantum numbers)

c). ■ Size of the shell ■ Energy of electron in an atom
■ Average distance of the orbital from the nucleus

e) Answers for application activity 7.4

1. Definitions of the terms
   a). Orbital: The region where the probability of finding electron is high
   b). Quantum number: a set of numbers that describe the state of an electron in an atom.
2. Types of orbitals: s-orbital (spherical), p-orbital (dome shaped), d-orbital (complex shape) and f-orbital (very complex shape)
3. Quantum numbers

Quantum number	**What it reveals**
Spin	The direction the electron is spinning in a magnetic field
Magnetic	Different orientations of the orbitals
Principal	Size of the shell
Azimutal	The shape of the orbital
	Energy of electron in an atom

4. Quantum Number that are not allowed and the reason.
   a). For n=3 l lies in the range $0 \leq n \leq (n-1)$ cannot be higher than 2.

   d). m_s is $m_s = +\frac{1}{2}$ or $m_s = -\frac{1}{2}$ and cannot take any other value.
   e). ***l*** cannot have negative values.

   f). The value of m_l should lie in the range $-l \leq m_l \leq +l$. No value outside this range is acceptable.

Lesson 5: Rules governing the electronic configurations

a) Learning objectives

- Explain the Rules governing the electronic configuration.
- Describe the methods of writing electronic configuration for atoms and ions.

b) Teaching resources

Student teacher's Book, periodic table of elements, reference books

c) Prerequisites/ Revision/ Introduction

For better understanding the rules that govern the electronic configurations, it is better to remember the atomic structure studied in previous lessons (ordinary and previous unit in this year), the subatomic particles and the orbitals.

d) Learning activity 7.5

Guidance on activity 7.5

- Put your student teachers in groups of 4 - 6.
- Provide them with the activity 7.5 (you can use the chalkboard, books, and worksheets or even use the projector).
- Give them time between 15 and 20 minutes to answer the questions of this activity.
- Invite 3 groups chosen randomly to present their findings.
- Allow some student teachers to comment about the findings of their colleagues presented.
- Take this time to give additional information (missing in what found by all groups) and use some questions to draw the conclusion.
- Give them the Application Activity 7.5 in pairs to be completed in 10 min and collect worksheets to be corrected, once you return in the class with corrected copies, remember to give feedback.

Answers for activity 7.5

1. Write electronic configuration of the following atoms using K, L, M, N orbit representations: Ca (Z = 20), Cl (Z= 17), Sr (Z=38)

   Ca: K: 2 electrons

   L: 8 electrons

M: 8 electrons

N: 2 electrons

Cl: K: 2 electrons

L: 8 electrons

M: 5 electrons

Sr: K: 2 electrons

L: 8 electrons

M: 18 electrons

N: 8 electrons

O: 2 electrons

2. This question is about potassium and sulphur.
   a). In the formation of potassium ion, its atom loses its valence electron (19 – 1 = 18 electrons) and sulphide ion will be formed when sulphur atom gains two electrons (16 + 2 = 18 electrons)
   b). This is Argon which belongs to group 18 (Noble gases)

3. Differences between atom and its ion.
   a). Calcium atom is uncharged while calcium ion is charged, Ca has 4 shells while Ca^{2+}has only 3, Ca has 20 electrons while Ca^{2+} has only 18, Ca has larger size (radius) than Ca^{2+} ion, etc.
   b). Nitrogen atom (N) is uncharged while nitrogen ion (N^{3-}) is charged; N has 7 electrons while N^{3-} has 10 electrons.

e) Answers for application activity 7.5

1. Given: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^4$
   a). The atomic number = 2 + 2 + 6 + 2 + 4 = 16
   b). Sulphur

2. a). Nitride ion: N^{3-}
   b). Q^- which has 10 electrons is from an atom with 9 protons. Q is fluorine, so this ion is fluoride ion *(N^{3-})*

3. Electronic configurations
   a). Ge (Z=32): [Ar] $4s^2 3d^{10} 4p^2$
   b). S (Z=16): [Ne] $3s^2 3p^4$
   c). Co^{2+} (Z=27): [Ar] $3d^7$
   d). Br^- (Z=35): [Kr]
   e). Sr (Z=38): [Kr] $5s^2$

7.6. Summary of the Unit

The Bohr Model is a planetary model in which *the negatively-charged electrons orbit a small, positively-charged nucleus similar to the planets orbiting the Sun* (except that the orbits are not planar). The main points of the Bohr Model are the following:

- Electrons orbit the nucleus in orbits that have a set size and energy.
- The energy of the orbit is related to its size. The lowest energy is found in the smallest orbit.
- Radiation is absorbed or emitted when an electron moves from one orbit to another.

When white light passes through a prism, a *series of coloured bands are seen* called *spectrum*. Since the colours merge into each other, we call it a "*continuous spectrum*". There 2 types of spectra:

- The emission spectrum is the spectrum of radiation emitted by a substance that has absorbed energy. Atoms, molecules, and ions that have absorbed radiation are called 'excited'.
- Absorption spectrum is the plotting of the energy that is absorbed by an element or substance. It is the spectrum formed by electromagnetic radiation that has passed through a medium, in which radiation of some frequencies is absorbed.

Hydrogen molecules dissociate when we pass electric discharge through gaseous hydrogen. Subsequently, the energetically excited H_2 atoms *emit electromagnetic radiation of discrete frequencies giving rise to a spectrum* emitted light is analyzed with a spectrometer and discrete bright lines in a dark background are observed. The well-defined separation of lines is experimental evidence for the existence of *separate*, *discrete* or '*quantized*' energy levels in the atom. No two gases give the same exact line spectrum. These lines that correspond to n_1 = 1, 2, 3, 4, 5 are called Lyman, Balmer, Paschen, Brackett and Pfund series, respectively.

The orbital is the volume or the space around the nucleus where there is a high probability of finding the electron. The orbitals are of 4 types. They are named s, p, d, f .The s, p, d, and f stand for sharp, principal, diffuse and fundamental, respectively. *"s"* **sublevels are spherically shaped** and *"p"* **orbitals are often described as dumb-bell shaped** *"d"* **and "***f"* **orbitals are not easily visualized**

Quantum numbers are *a set of numbers that describe the state of an electron in an atom* (and they are derived from quantum mechanical treatment). Four numbers, called *quantum numbers*, were introduced to describe the characteristics of electrons and their orbitals:

- Principal quantum number: n *the average distance of the orbital from the nucleus (the size of the shell) — and the energy of the electron in an atom*.
- Angular momentum quantum number: l describes *the shape of the orbital*
- Magnetic quantum number: describes *how the various orbitals are oriented in space*.
- Spin quantum number: describes *the direction the electron is spinning in a magnetic field* — either *clockwise* or *counter-clockwise.*

Rules governing the electron configuration:

- *Aufbau Principle:* Orbitals with the lowest energy are filled first.
- *Hund's Rule:* Orbitals within the same sub-shell are filled singly first (for example, one electron is put into each separate 2p-orbital first so that they are each half-full instead of filling one of the 2p-orbitals with 2 electrons and then moving onto the next 2p-orbital).
- *Pauli Exclusion Principle:* No 2 electrons can have the same 4 quantum numbers (the 2 electrons in each full orbital would have to have opposite directions of spin, as spin is one of the quantum numbers.

When writing an electron configuration, first write the **energy level** (the period), then the **sub-shell** to be filled and the **superscript**, which is *the number of electrons in that sub-shell*. The total number of electrons is the atomic number, Z.

The rules above allow one to write the electron configurations for all the elements in the periodic table. Three methods that are commonly used to write electron configurations:

- Spdf notation

- Orbital diagrams
- Noble gas notation

Each method has its own purpose and each has its own drawbacks.

7.7. Additional information for the tutor

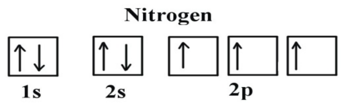
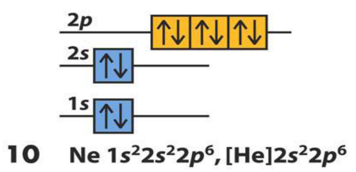
"***Stability of completely filled and half-filled orbitals***"

Almost all the elements follow the same trend for writing electronic configuration. Sometimes when two sub-shells differ in the energies, an electron from the lower energy moves to higher energy. This is because of ***two reasons***:

1. **Symmetrical distribution:** As everyone knows that symmetry leads to stability. The orbitals in which the sub-shell is exactly half filled or completely filled are more stable because of symmetrical distribution of electrons.

2. **Exchange energy:** The electrons which are there in degenerate orbitals have parallel spin and tend to exchange their position. Exchange energy is nothing but the energy is released during this process. When the orbitals are *half-filled* or *completely filled* then the number of exchanges is maximum. Therefore, its stability is maximum.

   The nitrogen and the neon electronic configuration are examples of what are called *half-filled* (three electrons in a six electron subshell) and *filled* (eight electrons in the n = 2 shell) electronic configurations. It will turn out that filled and half-filled shells and sub- shells have added stability. As a consequence, all kinds of physical and chemical consequences are realized. You know, for example, that Neon is unreactive. The reason is that it has a filled shell configuration. There is much more to come on this concept since it is at the root of just about everything to come in this course.

The nitrogen electronic configuration—a stable atom (because its electronic configuration is half-filled).	
The neutral neon electronic configuration—a VERY stable atom (because its electronic configuration is filled).	

7.8 Answers for end unit assessment

1. For each of the following, choose the letter corresponding to the best answer.

   a). (iii) The shape of the orbital

   b). (iii) Magmatic

   c). (ii) [Ar] $4s^2 3d^{10} 4p^1$

   d). (iv) Planck

2. According to the Aufbau principle, which orbital is filled immediately before each of the following?

   a). 3s

   b). 3d

   c). 6s

   d). 4f

3. Hafnium: *1s2 2s2 2p6 3s2 3p6 4s2 3d10 4p6 5s2 4d10 5p6 6s2 4f14 5d2*

4. Because the outer-most electrons are the only ones involving in (covalent) bonding and electron dot diagram came as the theory developed by Lewis to explain the covalent bond formation.

5. They indicate the direction the electron is spinning in a magnetic field; either clockwise or counterclockwise.

6. The emission spectrum of hydrogen consists of several series of lines.

   a). A to G

   b). A to G

   c). Because it shows different transitions of electrons in orbits.

   d). They all have the same lower energy level. Each emission transition reaches the same orbital.

7. a) Electronic configuration of atoms/ions:

   Na (11): **1***s2 2s2 2p6 3s1*

   Mg^{2+} (10): *1s2 2s2 2p6*

   Al (13): *1s2 2s2 2p6 3s2 3p1*

   Al^{3+}(10): *1s2 2s2 2p6*

   O^{2-} (10): *1s2 2s2 2p6*

b). The have the same number of electrons (they are isoelectronic). Some accept electrons and others lose them and they finally have the same number of electrons.

c). Aluminium atom loses three electrons and becomes aluminium ion (Al^{3+}), it is positively charged because the number of positively charged protons becomes higher than that of negatively charged electrons.

d). Identification of groups and periods.

- Aluminium: *1s2 2s2 2p6 3s2 3p1, Group: 2+1= 3* and *Period = 3*
- Sodium: *1s2 2s2 2p6 3s1, Group: 1* and *Period = 3*
- Oxygen:*1s2 2s2 2p4, Group: 2+4=6* and *Period = 2*

8. Given four possible electron configurations for a nitrogen atom:

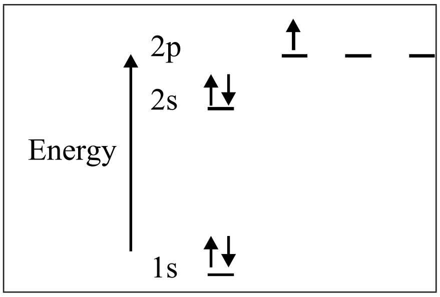
a). B

c). A and C

b). C and D

9. S(16)=1s22s22p63s23p4 *and S2-(18)=*1s22s22p63s23p6. *Block is "***p***" because the last orbital is "p" according to the electron configuration.*

10. The diagram below shows the electronic structure of boron.



a). They represent that two electrons in the same orbital rotate in different directions (clockwise and anticlockwise), they spin.

b). 2s electrons are close to the nucleus, they are close to the ground state. They occupy different sub-energy levels where 2p electrons are in higher than that occupied by 2s.

7.9. Additional activities

7.9.1. Remedial activities

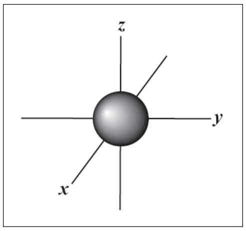
1. Sketch the shape and orientation of the following types of orbitals:

a). s

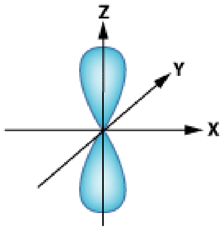
b). p_z

Answer:

a). s orbital



b). p_z orbital



2. 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.*

3. The maximum number of electrons a single d orbital can hold is:

a). 10
b). 6
c). 2
d). 14

Answer: *(a)*

4. How many d electrons can the second energy level hold?

a). 0
b). 2
c). 6
d). 10

Answer: *(a)*

5. What is the total number of orbitals containing electrons in a nitrogen atom?

a). 5
b). 3
c). 4
d). 6

Answer: *(b)*

6. Of the orbitals shown, the one with the lowest energy is:

a). 2s
b). 3s
c). 3d
d). 2p

Answer: *(a)*

7. The maximum number of electrons that can occupy a 3p sublevel is:

a). 1
b). 2
c). 3
d). 6

Answer: *(d)*

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 sub-level is

a). 2
b). 6
c). 8
d). 10

Answer: *(d)*

11. What is the frequency (in 1/s) of light with wavelength equal to 5×10^{-6} cm?

a). 6×10^{15}
b). 6×10^{14}
c). 1.5×10^{15}
d). 1.5×10^{3}

Answer: *(a)*

12. What is the wavelength of photons of light of frequency = 1150 kilocycles/sec

a).	26 m	c).	261 m
b).	3.4×10^{11} m	d).	3.4×10^{14} m

Answer: *(c)*

13. What is the wavelength of a wave having a frequency of 3.76×10^{14} s^{-1}?

Answer: $$\lambda = \frac{c}{\nu} = \frac{3.00\times10^{8}\,ms^{-1}}{3.76\times10^{14}\,s} = 7.98\times10^{-7}\,m$$

14. What is the frequency of a wave carrying energy of 8.35×10^{-18} J?

Answer: $$\nu = \frac{E}{h} = \frac{8.35\times10^{-18}\,J}{6.626\times10^{-34}\,J.s} = 1.26\times10^{16}\,Hz$$

15. What is meant by first ionization energy?

Answer: First ionization energy is the energy required to remove the first electron from a gaseous atom.

7.9.2. Consolidation activities

1. What electron transition in a hydrogen atom, ending in the orbit n=3 will produce light of wavelength 1090 nm?

Answer:

Data: $\lambda = 1090nm = 1.090\times10^{-6}\,m, n_f = 3$

Unknown: $n_i = ?$

The wavelength of the radiation is calculated using Balmer's relation.

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

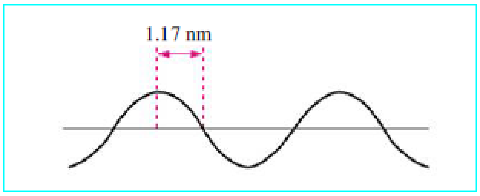
Rearranging the equation yields

$$n_i = \sqrt{\frac{n_f^2 R_H \lambda}{R_H \lambda - n_f^2}}$$

$$n_f = \sqrt{\frac{3^2 \times 1.097 \times 10^7 m^{-1} \times 1.090 \times 10^{-6} m}{1.097 \times 10^7 m^{-1} \times 1.090 \times 10^{-6} m - 3^2}} = \sqrt{\frac{98.73}{89.73}} = \sqrt{1.100} = 1$$

The electron transition corresponding to λ =1090nm in hydrogen atom is from n=3 to n=1.

2. 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,

$$\lambda = 4 \times 1.17 nm = 4.68 nm = 4.68 \times 10^{-9} m$$

7.9.3. Extended activities

1. 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***

2. 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?

Answer:

a). *For 5f, n=5 and l=3*

For 3d, n=3 and l=2

b). $Data: n_i = 5, n_f = 3$

$R_H = 1.097 \times 10^7 m$

$h = 6.6262 \times 10^{-34} J.s$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = R_H\left(\frac{1}{3^2} - \frac{1}{5^2}\right) = \frac{16R_H}{225}$$

$$\lambda = \frac{225}{16R_H} = \frac{225}{16 \times 1.097 \times 10^7 m^{-1}} = 1.28 \times 10^{-6} m = 1.28 \mu m$$

c). $$E = hc = h\frac{c}{\lambda} = 6.626 \times 10^{-34} J.s \times \frac{3 \times 10^8 ms^{-1}}{1.28 \times 10^{-6} m} = 1.552 \times 10^{-19} J$$

The energy in kilojoule per mole is given as

$$IE = \frac{E \times N_A}{1000} = \frac{1.552 \times 10^{-19} \times 6.022 \times 10^{23}}{1 \times 10^3} kJmol^{-1} = 93.4 kJmol^{-1}$$

($N_A = 6.022 \times 10^{23}$ *is the Avogadro number. It expresses quantity of matter in terms of the number of particles contained in one mole.*

UNIT 8: KIRCHHOFF'S LAWS IN ELECTRIC CIRCUITS

8.1. Key unit competence

Analyse complex electric circuits using Kirchhoff's laws.

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

Current electricity in ordinary level.

8.3. Cross-cutting issues to be addressed

a) Standardization culture:

Emphasize the need to use appropriate electrical components.

b) Financial education:

Emphasize the need to compare price against electric components while buying based on its functionality.

c) Environment and sustainability:

Recognize the safety measures taken for the sake of environmental protection.

d) Peace and values education:

Cooperation and teamwork spirit should be encouraged in learning process.

8.4. 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 taking place in the illustration of the unit.
- 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.

8.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Simple electric circuit and its construction.	Use different electric components to construct simple electric circuits.	2
2	Voltage or terminal potential and electromotive force in electric circuits.	Interpret and determine terminal potential and electromotive force in electric circuits.	2
3	Sources of electric current and electric receptors	Identify the sources of electric current.	1
4	Connection of electrical current source and resistors either in series or parallel or mix-up.	Construct and interpret circuits with resistors connected in series, parallel and mixture.	3
5	Kirchhoff's laws and its applications in solving problems in complex electric circuits.	Demonstrate Kirchhoff's laws using loop and junction rule.	3
		Apply Kirchhoff's laws to interpret and solve problems in electric circuits.	3
6	End unit assessment	Evaluate the achievement of the objectives.	2

Lesson 1: Simple electric circuit and its construction

a) Learning objective

Use different electric components to construct simple electric circuits.

b) Teaching resources

Batteries, wires, bulbs, switches and integrated science textbook.

c) Prerequisites/ Revision/ Introduction

Manipulation and construction of electric circuits covered in ordinary level.

d) Learning activity 8.1

Guidance on activity 8.1

- 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 for activity 8.1

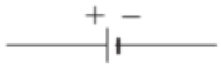
Task1: Facilitate the student teachers to go through all steps and bulb lights because of energy transformation from electrical energy to light and heat.

Task 2 and Task 3: Let student teachers go through all procedures as shown by the activity 8.1 and discuss with them their findings

Answers for application activity 8.1

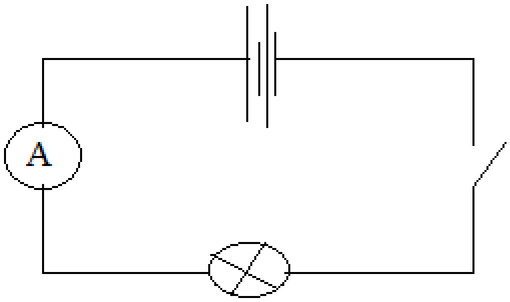
1. An electric circuit is a path in which electrons from a voltage or current source flow.
2. See student teacher's book figure 8.4

3. An open circuit is one where the continuity has been broken by an interruption in the path for current to flow.

4. 

5. a) Electric source, ammeter, bulb/lamp, wire, switch

   b)



Lesson 2: Voltage or terminal potential and electromotive force in electric circuits

a) Learning objective

Interpret and determine terminal potential and electromotive force in electric circuits.

b) Teaching resources

Dry cells, batteries, wires, ammeters and voltmeters

c) Prerequisites/ Revision/ Introduction

Current electricity in O level

d) Learning activity 8.2

Guidance on activity 8.2

- 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 for activity 8.2

The student teacher's uses the activity 8.2 to show that terminal voltage is less that e.m.f because of internal loses due to internal Resistance

Dry cell	Labeled voltage	Measured terminal voltage	Observation
1	1.5V	1.49V	Labeled voltage is greater than measured voltage due to internal resistance of cells.
2	1.5V	1.48V	
3	1.5V	1.4V	
4	1.5V	1.39V	

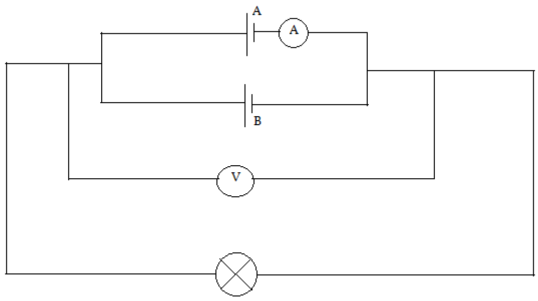
e) Answers for application activity 8.2

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.



7. $r = \frac{e.m.f - V}{I} = \frac{1.52}{25}\Omega$

Lesson 3: Sources of electric current and electric receptors

a) Learning objectives

- 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 8.3**

Guidance on activity 8.3

- 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 for activity 8.3

1. An source of electric current is any device that change any form of energy into electrical energy.
2. An electric source of energy is also known as generator.
3. List some of electric source include battery, dry cell, solar cell, alternator, dynamo, engine. All these devices generate electrical current.
4. 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 for application activity 8.3

1. The load resistance in a circuit is the effective resistance of all of the circuit elements excluding the emf source. In energy terms, it can be used to determine the energy delivered to the load by electrical transmission and there appearing as internal energy to raise the temperature of the resistor. The internal resistance of a battery represents the limitation on the efficiency of the chemical reaction that takes place in the battery to supply current to the load. The emf of the battery represents its conversion of chemical energy into energy which it puts out by electric transmission; the battery also creates internal energy within itself, in an amount that can be computed from its internal resistance. We model the internal resistance as constant for a given battery, but it may increase greatly as the battery ages. It may increase somewhat with increasing current demand by the load. For a load described by Ohm's law, the load resistance is a precisely fixed value.

2. No. If there is one battery in a circuit, the current inside it will be from its negative terminal to its positive terminal. Whenever a battery is delivering energy to a circuit, it will carry current in this direction. On the other hand, when another source of emf is charging the battery in question, it will have a current pushed through it from its positive terminal to its negative terminal.

3. a) $r = \dfrac{\varepsilon - \Delta V}{I} = 0.520\,\Omega$

   b) $R = 0.207\,\Omega$ or $1.3\,\Omega$

4. $\sum R_{ext} = \left(\dfrac{1}{4+2} + \dfrac{1}{1+6+3}\right)^{-1} = 3.75\,\Omega$

   $V_{ext} = RI = 7.5 \times 3.75 = 28.125\,V$

Which actually makes this question impossible because the current is too high for the resistance supplied to the circuit

5. The current in the circuit is $i = \dfrac{P}{V} = \dfrac{20.0}{11.6} = 1.72\ A$

From $V = \varepsilon - ri$ we get $r = \dfrac{(\varepsilon - V)V}{P} = \dfrac{(15.0 - 11.6)(11.6)}{20.0} = 1.97\,\Omega$

From $R = \dfrac{P}{i^2} = \dfrac{V^2}{P} = \dfrac{11.6^2}{20.0} = 6.72\,\Omega$

Lesson 4: Connection of electrical current source and resistors either in series or parallel or mix-up

a) Learning objectives

- 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) Learning activity 8.4

Guidance on activity 8.4

This activity introduces the student-teacher to gain more skills about manipulation of electrical components and electric circuit construction.

- Let the student teachers perform this activity in laboratory.
- 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 for activity 8.4

Guide and facilitate the activity based on procedures shown by activity 8.4. See student teachers book.

Task 1

a). When bulbs are connected in series and one is removed from the circuit others stop to shine.

b). And (c) Two bulbs brightness is less than that of one bulb.

Task 2

a). When bulbs are connected in parallel and one is removed from the circuit other continues to shine.

b). And (c) Two bulbs brightness is the same that of one bulb.

d) Answers for application activity 8.4

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

$$R_{eq} = 4.00\,\Omega + \frac{70}{17}\Omega + 9.00\Omega = 17.12\,\Omega$$

$$I = \frac{V}{R_{eq}} = \frac{34V}{\left(\frac{7\times10}{7+10}+4+9\right)\Omega} \approx 2A$$

$$I_{4\Omega} = I_{9\Omega} = I_{4.12\Omega} = 2\,A$$

$$V_{4.12\Omega} = 2A \times 4.12\Omega = 8.24V$$

$$I_{7\Omega} = \frac{8.24V}{7\Omega} = 1.18A$$

$$I_{9\Omega} = \frac{8.24V}{9\Omega} = 0.92A$$

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 and its applications 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 8.5

Guidance on activity 8.5

- Instruct learners to carry out activity 8.5
- 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 flowing 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 for activity 8.5

$$I = \frac{12-6}{8+10} A = \frac{6}{18} A = \frac{1}{3} A, \quad P = RI^2$$

$$P_1 = \left(\frac{1}{3}\right)^2 \times 8w = 0.89\,w, P_2 = \left(\frac{1}{3}\right)^2 \times 10w = 1.11w$$

$$P_{12V} = 12 \times \frac{1}{3} = 4w$$

e) Answers for application activity 8.5

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

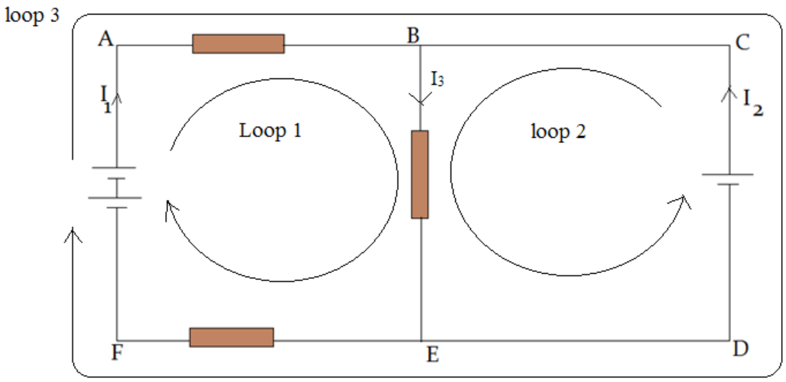
$$I_3 = I_1 + I_2$$

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):

$$1.5V - (10\Omega) I_3 = 0$$



8.6. 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

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

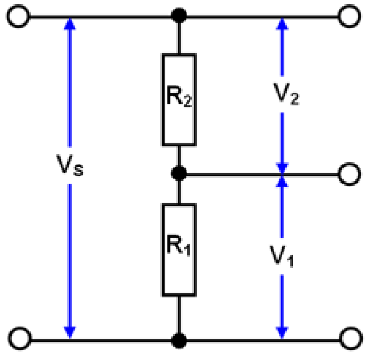
- A junction in a circuit is a point where three or more conductors meet. Junctions are also called nodes of branch points. A loop is any closed conducting path.

- Kirchhoff's junction rule: the algebraic sum of the currents into any junction is zero. That is, 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,

8.7. Additional Information for the tutor

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

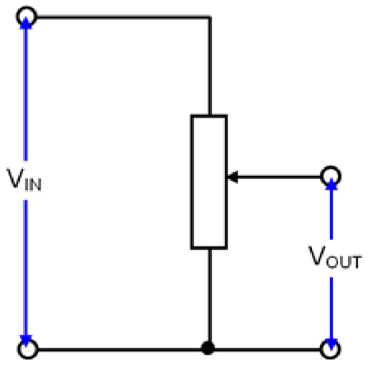
For an unloaded potential divider the current through each resistor is the same so the voltage is proportional to the resistance. This means that the pd across the pair of resistors is divided in the same ratio as the resistors themselves:

i.e. $V_1 / V_2 = I R_1 / I R_2$ or $V_1 / V_2 = R_1 / R_2$

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.

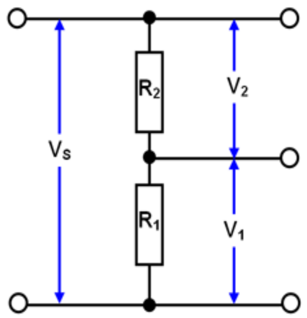
This can, of course be done continuously using a rheostat or potentiometer shown below:



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.

8.8. 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.

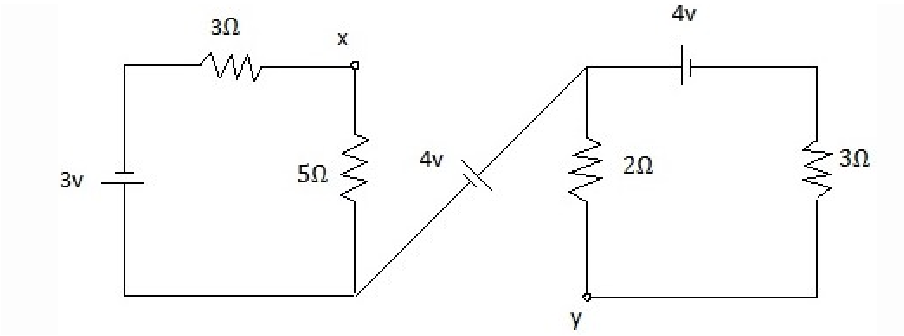
8.9. Additional activities

8.9.1. 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.

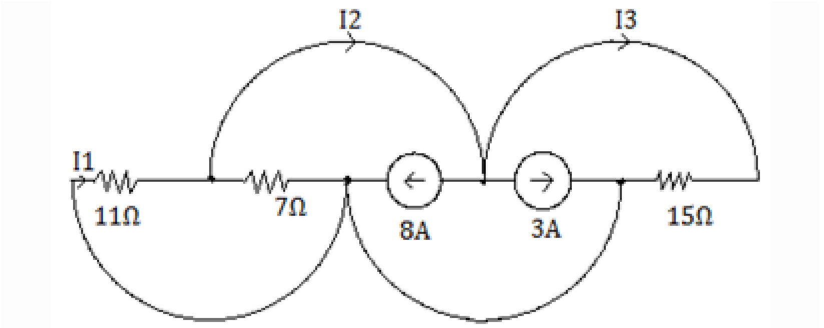
2. **Choose the correct answer.** The algebraic sum of voltages around any closed path in a network is equal to
   a). Infinity
   b). 1
   c). 0
   d). Negative polarity

3. **Choose the correct answer.** Potential difference between X and Y is



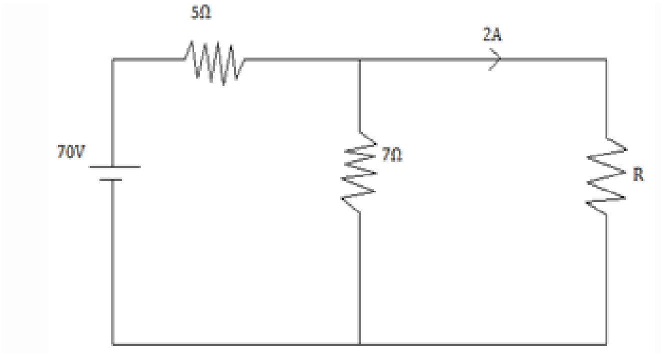
a). 4.275V
b). -4.275 V
c). 4.527V
d). -4.527V

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

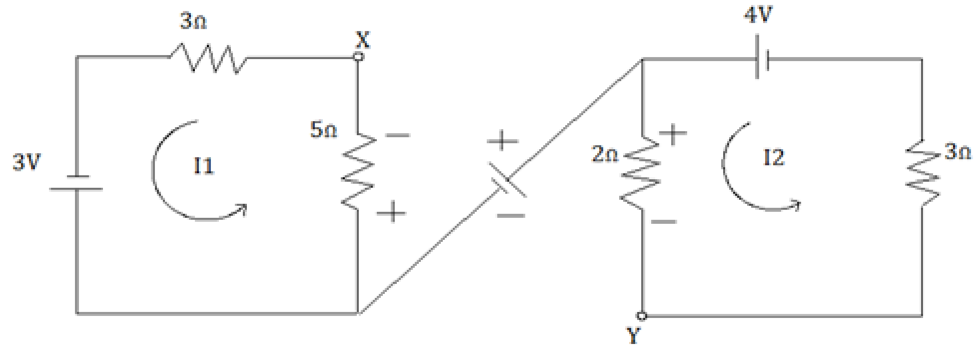


a) 17.5 Ω
b) 17.2 Ω
c) 17.4 Ω
d) 17.8 Ω

Answers for remedial activities

1. b)
2. c)
3. Answer: b

   Explanation:



$$I_1 = \frac{3V}{3\Omega + 5\Omega} = \frac{3V}{8\Omega} = 0.375A$$

$$I_2 = \frac{4V}{5\Omega} = 0.8A$$

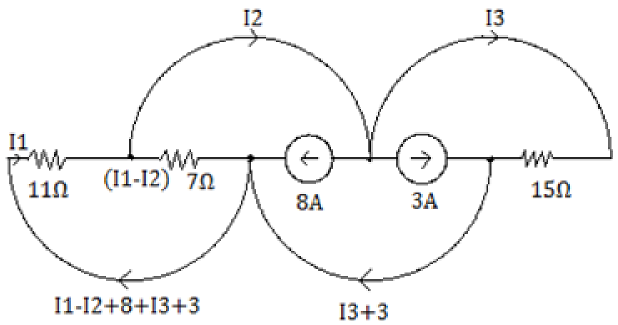
$$V_{xy} = V_x - V_y$$

$$V_x + 5I_1 + 4 - 2I_2 - V_y = 0$$

$$V_x - V_y = 2I_2 - 4 - 5I_1 = -4.275V$$

4. Answer: c

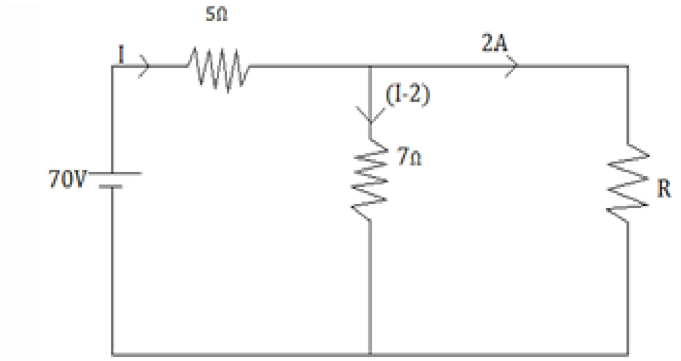
   Explanation:



$$I_1 = I_1 - I_2 + 8 + I_3 + 3$$
$$I_2 - I_3 = 11$$
$$and -11I_1 - 7(I_1 - I_2) = 0$$
$$-18I_1 + 7I_2 = 0$$
$$and\ -11I_1 - 15I_3 = 0$$
$$solving\ I_1 = 3.32\ A, I_2 = 8.5A,\ I_3 = -2.4A$$

5. Answer: a

   Explanation:



KVL: $70 - 5I - 7(I-2) = 0$

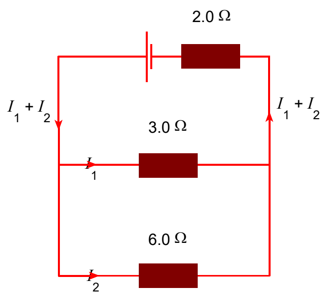
$I = 7A$

KVL to 2nd loop: $7(I-2) - 2R = 0$

$R = 17.5\Omega$

8.9.2. 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 3.0Ω resistor.



Answer:

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:

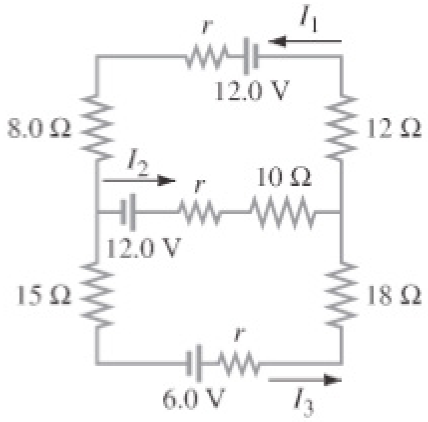
$$1.6V = 12I_2 \rightarrow I_2 = 0.13A \ and \ I_1 = 0.27A$$
$$Current\,through\ cell = I_1 + I_2 = 0.40A$$

pd across 3.0 Ω resistor

$$V = I_1 \times 3.0\Omega = I_2 \times 6.0\Omega = 0.8V$$

8.9.3. 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.

   $$12.0V - I_2(1.0\Omega) - I_2(10\Omega) - I_1(12\Omega) + 12.0\,\mathrm{V} - I_2(1.0\Omega) - I_1(8.0\Omega) = 0 \rightarrow$$
   $$24 = 11I_2 + 21I_1$$

   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.

   $$\text{üüüüVüüüü} - I_2(\text{üüü}\ \Omega) - I_2(\quad\Omega) + I_3(\quad\Omega) - \qquad + I_3(\quad\Omega) = \quad \rightarrow$$
   $$6 = 11I_2 - 34I_3$$

   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 9: AUTOTROPHIC NUTRITION

9.1. Key unit competence

Explain photosynthesis as an energy transfer process, its limiting factors and adaptations

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

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 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) Gender education

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.

c) Inclusive education.

This cross-cutting issue should be integrated in all sub-headings. When forming groups for Learning activity, 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 teacher and other Student-teachers should help them to achieve the competences as required in all teaching-Learning activity.

9.4. Guidance on introductory activity

Engage Student-teachers in their groups to use text books and work on the introductory activity 9. After making analysis, Student-teachers 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,

9.5 List of lessons/sub-heading

#	Lesson title	Periods
1	Types of autotrophic nutrition.	1
2	Structural adaptation and role of chloroplast in the process of photosynthesis)	3
3	Rate of photosynthesis: limiting factors of photosynthesis and importance of autotrophic nutrition.	1
	End unit assessment	1

Lesson 9.1: 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 unit.

d) Learning activity 9.1

Engage Student-teachers in their groups to use text books or internet in computer lab and work on the learning activity 9.1.

Their answer should be correlated with the types discussed in the summary content of the lesson 9.1

e) Answers for application activity 9.1

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 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 adaptation and role of chloroplast in the process of 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

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 unit.

d) Learning activity 9.2

- **Guidance on activity 9.2**

1. Put learners into groups and guide them to carry out the research Activity the discussion corner and a class debate.
2. Let the learners find out the adaptations of leaves for photosynthesis. Then they should also discuss the importance of different mineral salts in plants. Let each group explain to others what they have found out.
3. Moderate the discussions and correct where learners have gone wrong and add to where they have not given enough.
4. Conclude the lesson with questions.
5. Let learners:
   - Outline different adaptations of leaves
   - Mention uses of minerals to plants
   - Explain symptoms of mineral deficiencies in plants, etc
6. Engage Student-teachers in their groups to use text books or internet in computer lab and work on the learning activity 9.2. Their answer should be correlated with the types discussed in the summary content of the lesson 9.1.

Answers for activity 9.2

a). Providing carbon dioxide for photosynthesis

b). It relights, so the evolved gas during photosynthesis is oxygen

c). Controlling experiment

d). Chloroplast

Answers for activity 9.2.2

The answer is found in student-teacher text book lesson 9.2, sub-lesson 9.2.2

e) Answer for application activity 9.2

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 9.2.

Application activity 9.2

Answers are found in student-teacher text book lesson 9.2 and for question 2, student-teachers should make research in different text books and discuss in groups

Lesson 3: Rate of photosynthesis: limiting factors of photosynthesis and importance of autotrophic nutrition.

a) Learning objectives

- Discuss and investigate factors of photosynthesis
- 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 9.3

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 9.3

Answers for activity 9.3.

$NaHCO_3$hasbeenadded for carbon dioxide necessary for photosynthesis

e) Answer for application activity 9.3

1. See the answer in the content summary found in the lesson 9.3.

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.

3. Without autotrophs, no photosynthesis, without photosynthesis no food production and oxygen, without food and oxygen, no life.

9.6. 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
- Rate of photosynthesis: limiting factors of photosynthesis**,** Importance of autotrophic nutrition

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.

Heterotrophs depend on autotrophs. Aututrophism 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.

- Organisms that are autotrophic can make their own food from inorganic substances with help of energy.
- Photosynthesis is the process where the source of energy is light. It is carried out by green plants, algae and some bacteria.
- Photosynthesis takes place in green parts of a plant, mainly leaves. Within leaves, chloroplasts in mesophyll cells are the site of photosynthesis.
- Photosynthesis has two stages: light reaction and dark reaction. Light reaction is a photochemical reaction, in which light energy is absorbed by the pigments present in antenna molecules of light harvesting complex. While, in dark reaction carbon is reduced in the stroma of chloroplast.
- Chlorophyll, a molecule is the reaction centre which has two special forms PSI and PSII with absorbance maxima at 700 nm and 680 nm, respectively.
- Various environmental factors such as light, temperature, carbon dioxide concentration, oxygen concentration and air pollutants are responsible for the plant productivity on account of photosynthesis.

9.7. Additional Information for the tutor

For more information refer to SME student teacher books unit 11, integrated science

9.8. End unit assessment

I. Choose whether the given statements are True (T) or false (F):

1. False
2. True
3. False
4. True
5. True
6. False

II. Multiple choice questions:

1. (a), (b), (d)
2. (c); Sugarcane is the tropical plant
3. (b)
4. (b); Bundle sheath cells show different chloroplast in C-4 plants
5. (d); During assimilation six molecules of carbon dioxide, 18 ATP are required and one molecule of glucose is produced
6. (c); they produce sugars from chemical energy which is used by other organisms. They produce food for all organisms.

III. Long answer type questions:

1. Types of Autotrophic Nutrition

Chemoautotrophic: An autotrophic nutrition where organisms get energy from oxidation of chemicals, mainly inorganic substances like hydrogen sulphide and ammonia.

Photoautotrophic: An autotrophic nutrition where organisms get energy from sunlight and convert it into usable form like sugars. Green plants and some bacteria like, green sulphur bacteria can make their own food from simple inorganic substances by a process called photosynthesis.

$$6CO_2 + 6H_2S \xrightarrow[\text{bacteriochlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 6S \quad \text{(green sulfur bacteria)}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{} C_6H_{12}O_6 + 6O_2 \quad \text{(green plants)}$$

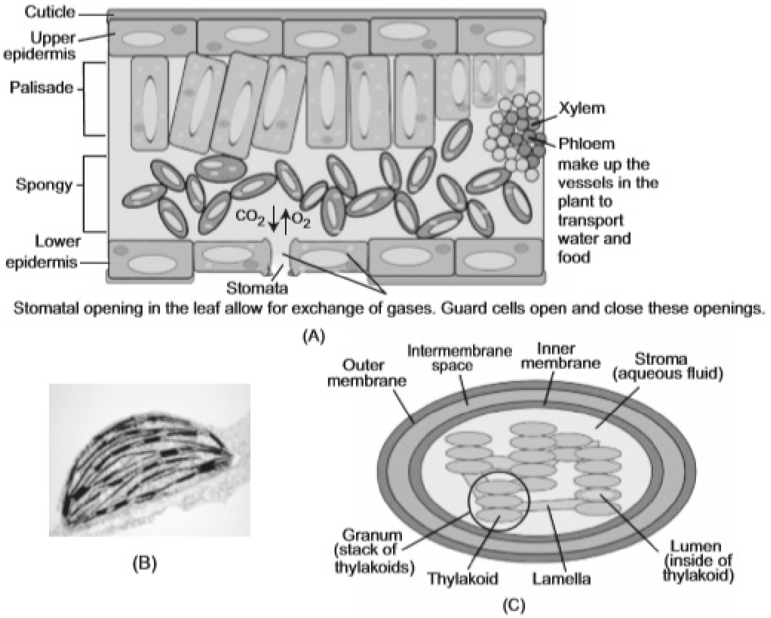
Role of Light

1. Light has two components: wave and particle. A wave is characterized by a wavelength, denoted by a Greek letter lambda (·), which is the distance between two successive wave crests, and the number of

wave crests that pass an observer in given time is called frequency (·). Light is also a particle called photon. Sunlight is like rain of photons with different frequencies. The energy content of light photon is not continuous, rather delivered in discrete packets, the quanta. When a light photon is absorbed, an electron is excited from pigment molecule to a higher energy level (triplet state). It remains there for 10–9 s and then falls to ground state. Sometimes, it can emit the energy in the form of light and heat as it reaches the ground state. This process is called fluorescence. When electron remains at triplet state for more than 10–9 s and then comes back to ground state, the energy is lost in the form of heat and light. This happens even after the source is put off. Such a process is called phosphorescence.

2. Photosynthesis is a process by which plants and other organisms, such as algae and bacteria synthesize their own food using the energy of light for their growth and development. The food produced by plants is in the form of carbohydrates. In preliminary studies, Julius von Sachs proposed that glucose is the first product of photosynthesis. It is stored in chloroplasts within plant cells. It provides energy in the form of food to organisms that feed on plants. It has been rightly said "ALL FLESH IS GRASS", as all organisms (herbivores, carnivores and omnivores) are directly or indirectly dependent on plants as source of energy. It is the means by which solar energy is captured by plants for use by all organisms. In 1782, Jean Senebier proved that green plants can produce oxygen in presence of light and carbon dioxide. It is the single most important biological process that can replenish oxygen which is required for existence of all other organisms. Have you ever thought what will happen if there is no photosynthesis? This chapter focuses on the photosynthetic machinery, the reactions in this physiochemical process and the factors affecting photosynthesis.

3. Photosynthesis occurs not only in eukaryotic organisms such as green plants but also in prokaryotic organisms like blue green algae and green sulphur bacteria. In higher plants, photosynthesis occurs in green part of the plant. Leaves are adapted to carry photosynthesis efficiently. Most leaves are broad and flat to capture maximum light. Also, the bifacial nature of leaf allows it to collect incident light on the upper surface and diffuse light on lower surface. The photosynthetic tissue is located between upper and lower epidermis. It consists of one to three layers of compactly arranged, elongated and cylindrical palisade mesophyll cells, and loosely arranged, irregular and isodiametric spongy mesophyll cells. In monocotyledonous leaf there is no distinction of palisade and spongy parenchyma. The mesophyll cells in leaves contain large number of chloroplasts that transform light energy into ATP and NADPH which are then used to convert CO2 into sugars.



(A) Structure of leaf showing photosynthetic cells;

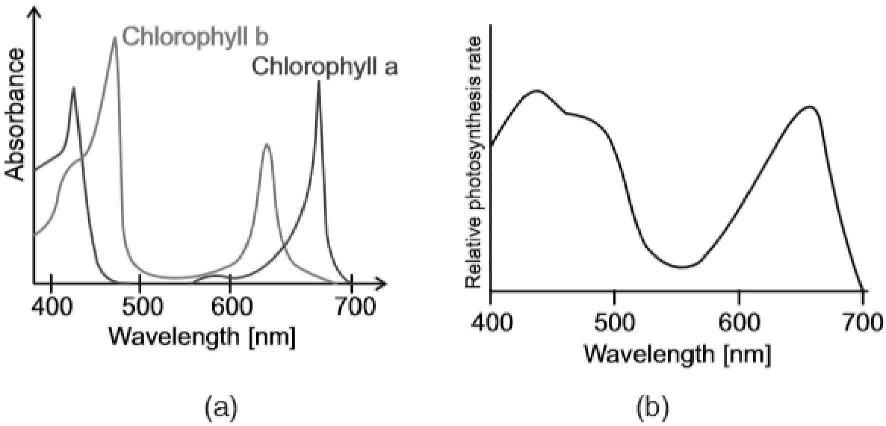
(B) EM of chloroplast cells;

(C) Sectional view of chloroplast.

Chloroplast is the photosynthetic machinery. It is a double membrane organelle that contains series of parallel membranes called thylakoids or lamellae, suspended in fluid like matrix called stroma. The thylakoids are flattened discs arranged in stacks called grana. In a typical chloroplast as many as 40–60 grana may be present and each granum may contain 2–100 thylakoids. The stroma contains DNA, ribosomes, soluble proteins and enzymes, while pigments are confined to thylakoids. Thylakoids have large surface for absorption of light and the space within them 'lumen' allows rapid accumulation of protons.

4. A pigment is a substance that absorbs light of different wavelengths. Pigments are involved in absorption of light of certain wavelength. While some wavelengths are absorbed, other are reflected or scattered, which imparts them colour. The absorbed wavelength of light has the correct energy to excite specific transitions of electrons in the pigments. Photosynthesis depends on light absorption by pigments in leaves. However, it can be carried out in isolated chloroplast but not in isolated pigments. Chlorophyll a is the major pigment involved in trapping light energy. It is the principal pigment involved in photosynthesis. It is of universal occurrence. It is a large molecule composed of four pyrrole rings with Mg at centre, and a long hydrocarbon phytol chain. It absorbs maximum wavelengths of 430 nm and 660 nm. Chlorophyll b constitutes

one-fourth of the total chlorophyll content. It has a similar structure as that of Chlorophyll a, except that the –CH3 group in chlorophyll a is replaced by –CHO group in chlorophyll b. It absorbs maximum wavelengths of 460 nm and 680 nm. Carotenes are tetraterpenes or polyunsaturated hydrocarbons containing 40 carbon atoms and variable number of hydrogen atoms and no other elements. -carotene is the common form found abundantly in orange, yellow and green fruits and vegetables. Carotenes protect plant against photo-oxidation. Xanthophylls are yellow coloured pigments. They are structurally similar to carotenes, but contain oxygen atoms. These are more common in young and etiolated leaves. Absorption and Action Spectra A plot showing absorption of light of different wavelengths of a pigment is called absorption spectrum.



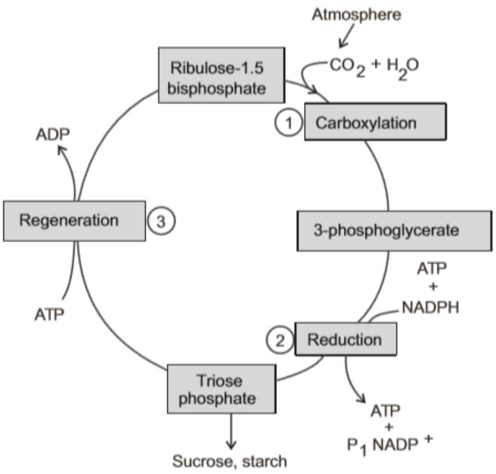
(a) Absorption spectrum of chloroplast pigments;
(b) Action spectrum of green plants.

Each pigment absorbs a specific wavelength. We can plot an absorption spectrum showing the ability of pigments to absorb lights of different wavelengths. From Figure A, it can be concluded that Chlorophyll a and b show absorption peaks at blue and red light. On the other hand, action spectrum is the plot of graph depicting the rate of a light sensitive process at different wavelength of light. The action spectrum of photosynthesis shows that most of the photosynthesis also takes place in blue and red light. The absorption spectrum of a pigment when compared with action spectrum of photosynthesis, gives the function of the pigment. Therefore, it can be concluded that chlorophyll a is the chief photosynthetic pigment. The other pigments like chlorophyll b, carotenes and xanthophylls are called accessory pigments and form the antenna complex.

They collect the light of different wavelength and transfer it to reaction centre (basic model of energy transfer). This is called Light Harvesting Complex. LHC is made up of hundreds of pigment molecules bound to proteins.

5. **Calvin Cycle**

It is carbon assimilation process which utilizes assimilatory power generated from light reaction to produce sugars. It occurs in stroma of chloroplasts. Melvin Calvin got Nobel Prize for his outstanding work on carbon assimilation. Melvin Calvin, Andrew Benson and James Bassham gave the Calvin cycle of dark reaction. They used autoradiography to detect path of cycle, and chromatography to separate constituents. The first product that showed radioactivity was a three carbon (3-C) compound Phosphoglyceric acid (PGA) and hence the cycle is also called C-3 cycle.



The process of carbon assimilation can be described under three stages: carboxylation, reduction and regeneration.

Carboxylation: It is the process of fixation of carbon in stable organic intermediate, phosphoglyceric acid. This reaction is catalyzed by called RuBPcarboxylase-oxygenase (RUBISCO). Rubisco-bis-phospahte (RuBP) is the initial acceptor or substrate for dark reaction.

$$6RuBP + 6CO_2 + 6H_2O \xrightarrow{\text{RUBISCO}} 12 \text{ Phosphoglyceric acid}$$

Reduction or Glycolytic Reversal: It is the process involving reduction of carbon. It is a multistep process that utilizes 12 ATP molecules and 12 NADPH for release of one molecule of glucose. The glucose can further be converted into starch for storage or sucrose for transport.

12 Phosphoglyceric acid + 12ATP $\longrightarrow$ 12 Di-phosphoglyceric acid + ADP

12 Di-phosphoglyceric acid + 12 NADPH $\longrightarrow$ 12 Phosphoglyceraldehyde + 12 NADP + H_3PO_4

5 Phosphoglyceraldehyde (PGAL) $\rightleftharpoons$ 5 Dihydroxy acetone phosphate (DHAP)

3 PGAL + 3 DHAP $\longrightarrow$ 3 Fructose 1,6-diphosphate

Fructose 1,6-diphosphate $\longrightarrow$ Fructose 6-phosphate

Fructose 6-diphosphate $\longrightarrow$ Glucose 6-phosphate

Regeneration: This process requires 6 ATP molecules to regenerate 6 molecules of RuBP, which is crucial for continuity of Calvin cycle.

2 Fructose 1,6-diphosphate + 2 PGAL + 2 DHAP + 6ATP 6 RuBP + 6ADP

During complete cycle, ATP, NADPH and CO_2 are used up. For one molecule of glucose six molecules of carbon dioxide, 18 ATP and 12 NADPH are required. The dark reaction is therefore dependent on light for the production of high amount of ATP and NADPH.

In	Out
Six CO_2	One glucose
18 ATP	18 ADP
12 NADPH	12 NADP

Another important requirement is high concentration of CO_2. The efficiency of photosynthesis declines at low concentration of CO_2. This is because the enzyme RUBISCO has low affinity with carbon dioxide as compared to oxygen. At low CO_2 concentration RUBISCO catalyzes the reaction between RuBP and oxygen. The oxygenation of RuBP in presence of light and oxygen is called Photorespiration. It occurs in chloroplast, peroxisome and mitochondria. It is a wasteful process as during this process carbon dioxide is released and efficiency of photosynthesis decreases.

6. The rate of photosynthesis can be influenced by many factors like number, size, orientation and age of leaf, sunlight, temperature, carbon dioxide and water. However, when several factors can affect a process, the rate of reaction is governed by the factor which is limiting. This is called Blackman’s (1905) law of limiting factor.

External Factors

CO_2 concentration: Carbon dioxide is the inorganic substrate for photosynthesis. Increase in concentration up to 0.05% in atmosphere can cause an increase in CO_2 fixation. Carbon dioxide is the major limiting factor, especially in C-3 plants; C-4 plants are more productive even at low concentration of CO_2. Nevertheless, both C-3 and C-4 plants show increase in rate of photosynthesis at high CO2 concentration and high light intensities. The fact that C-3 plants respond to higher CO2 concentration by showing increased rates of photosynthesis leading to higher productivity has been used for some greenhouse crops such as tomatoes and bell pepper. They are allowed to grow in carbon dioxide enriched atmosphere as in glasshouses leading to higher yields.

Light: Light is an important factor to carry out photosynthesis. It is rarely a limiting factor in nature as photosynthesis can occur even at low light intensities. There is a direct relation between light and CO2 fixation. With increase in light intensity, the rate of photosynthesis increases. However, at higher light intensities, rate does not increase linearly but light saturation occurs. At very high light intensity, there is breakdown of chlorophyll molecules called photooxidation and the rate of photosynthesis decreases. The quality of light and time of exposure also governs photosynthesis. Green plants show high rate of photosynthesis at red and blue light.

Temperature: The dark reactions are dependent on temperature as they are enzymatic. Rate of photosynthesis is best at optimum temperature. Different plants have different temperature optima that also depend on their habitats.

Water: Only about 1% of water absorbed by plants is used in photosynthesis. It is an important factor for various metabolic processes in plant. Water may not have direct effect on photosynthesis even though it is one of the reactants in light reaction. In water, stress plants wilt and their stomata close. Thus, reducing availability of carbon dioxide and decreasing the rate of photosynthesis. Water stress will also alter the hydration of enzymatic proteins, affecting their activities.

Oxygen concentration: Atmospheric oxygen content affects photosynthesis directly or indirectly. The decrease in the rate of respiration at high oxygen concentration was first observed by O. Warburg in 1920 in Chlorella. The phenomenon is called Warburg effect.

Chemical pollutants: Plant growth has been adversely affected by accumulation of various undesirable chemicals. Heavy metals such as lead, mercury, cadmium seem to be affecting photosynthesis through stomata closure. Air pollutants like SO_2, NO_2 and O_3 are also known to affect photosynthesis at higher concentrations.

Internal Factors

Adaptation of leaf: Leaves are arranged on plants to minimize overlapping. The shape, size, age and orientation of leaf influences the absorption of light and thus, affects photosynthesis. Most leaves are broad for more absorption of light. The anatomy of leaf is also highly specialized for absorption of light. The epidermis is transparent and also acts as convex lens to focus and intensify the light reaching mesophyll cells for maximum absorption. The palisade layer also helps in absorption of more light. Presence of hairs, salt glands and epicuticular wax increase the reflection of light and thereby reducing the absorption. Absorption of carbon dioxide is also dependent on leaf surface area and number of stomata. Spongy parenchyma has large intercellular space so that carbon dioxide can easily diffuse. Opening and closing of stomata is yet another factor that governs photosynthesis as the exchange of gases is affected when stomata close. In some succulent plants such as Bryophyllum, Kalanchoe, stomata open during night and close during day to reduce the rate of transpiration. Such plants have special mechanism for photosynthesis called Crassulacean Acid Metabolism (CAM), where CO_2 fixation takes place in different time (day and night) as per availability of carbon dioxide and light.

7.

Feature/ Characteristic	C4 Plants	CAM Plants
Distribution in the plant kingdom (% of plant species)	~3% (Simpson 2010), all angiospermous including most troublesome weeds; mostly monocots (C4 grasses and sedges about 79% of all C4 plants)	~8% {Simpson 2010), mostly succulent plants but not all succulents are CAM plants
Type of photosynthesis	C4 photosynthesis	CAM photosynthesis

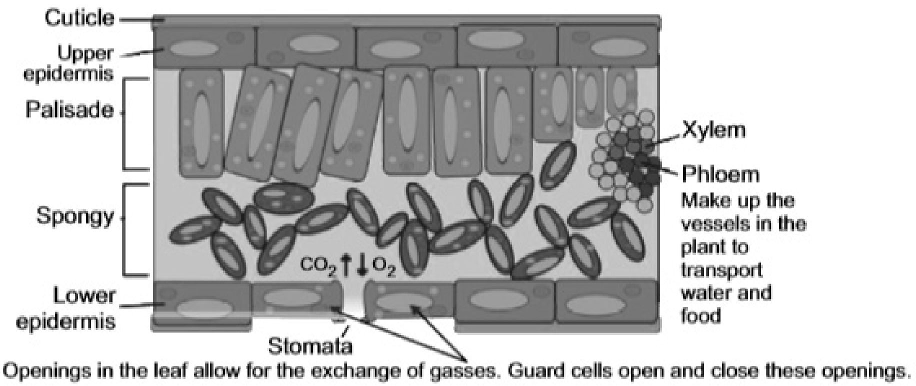
CO_2 fixation pathway	via C3 and C4 cycles, spatially (C4 in the mesophyll cell then C3 in the bundle' sheath cell) Generally thinner leaves closer arrangement of vascular bundles, smaller air spaces than C3; veins surrounded by thick-walled BSC further surrounded by thin-walled mesophyll cells (wreath-like arrangement of BSC is called Kranz anatomy); mesophyll cells and BSC contain chloroplasts, those of the BSC much larger	via C3 and C4 cycles, both spatially (in different parts of same cell) and temporally (C4 at night, C3 at day time) Thick and fleshy leaves, mesophyll cells having large, water-filled vacuoles
Stomatal movement	Stomata open at daytime, close at night	Inverted stomatal cycle (open at night, close in the day
Typical Environmental/ Geographical adaptation (where most common)	Tropical or semitropical,high light intensity, high temperature, drought conditions	Desert or arid (xeric) habitats

8. Comparison of C3, C4 and CAM plants

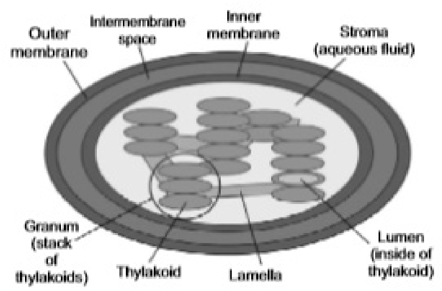
C3 plants	C4 plants	CAM plants
Most plants	Tropical grasses like corn, sugarcane	Succulents, pineapple, agave
Fix carbon in Calvin cycleattach CO_2 to RuBP	Fix carbon in cytoplasmattach CO_2 to PEP	Fix carbon at night only, fix it to organic molecules
Enzyme-Rubisco	Enzyme–PEP-ase	Enzyme–PEP-ase
Most energy efficient method	1/2 way between these two	Best water conservation
Loses water through photore spiration	Loses less water	Loses least water

9. **Light:** Light is an important factor to carry out photosynthesis. It is rarely a limiting factor in nature as photosynthesis can occur even at low light intensities. There is a direct relation between light and CO_2 fixation. With increase in light intensity, the rate of photosynthesis increases. However, at higher light intensities, rate does not increase linearly but light saturation occurs. At very high light intensity, there is breakdown of chlorophyll molecules called photo oxidation and the rate of photosynthesis decreases. The quality of light and time of exposure also governs photosynthesis. Green plants show high rate of photosynthesis at red and blue light

10. Photosynthesis occurs not only in eukaryotic organisms such as green plants but also in prokaryotic organisms like blue green algae and green sulphur bacteria. In higher plants, photosynthesis occur in green part of the plant (Figure (i)). Leaves are adapted to carry photosynthesis efficiently. Most leaves are broad and flat to capture maximum light. Also, the bifacial nature of leaf allows it to collect incident light on the upper surface and diffuse light on lower surface. The photosynthetic tissue is located between upper and lower epidermis. It consists of one to three layers of compactly arranged, elongated and cylindrical palisade mesophyll cells, and loosely arranged, irregular and isodiametric spongy mesophyll cells. In monocotyledonous leaf there is no distinction of palisade and spongy parenchyma.



(i) Structure of leaf showing Photosynthetic cells



(ii) Em of Chloroplast cells

The mesophyll cells in leaves contain a large number of chloroplasts that transform light energy into ATP and NADPH which are then used to convert CO_2 into sugars. Chloroplast is the photosynthetic machinery. It is a double membrane organelle that contains a series of parallel membranes called thylakoids or lamellae, suspended in fluid like matrix called stroma. The thylakoids are flattened discs arranged in stacks called grana. In a typical chloroplast as many as 40-60 grana may be present and each granum may contain 2-100 thylakoids. The stroma contains DNA, ribosomes, soluble proteins and enzymes, while pigments are confined to thylakoids. Thylakoids have large surface for absorption of light and the space within them 'lumen' allows rapid accumulation of protons.

11. Autotrophic nutrition is very important. Autotrophic nutrition means that simple inorganic substances are taken in and used to synthesise organic molecules. Most producers use this nutritional method. By far, the greatest energy supply to support food chains and webs is obtained from photo-autotrophic nutrition. As is clear, a food chain is an essential part of sustenance of life on earth with one organism being eaten by another correlating to sustainability. Food chain starts with producers and producers use autotrophic nutrition to synthesise energy. Environment can be sustained if we:

    i). **Use energy saving products**: One of the biggest impacts on our environment is energy consumption – with workplaces consuming large amounts of resources to operate buildings, including lighting, workstations, kitchen appliances and office equipment. As an eco-conscious workplace standard, we encourage employees to conserve computer energy by switching to sleep mode when possible and shutting the device down at the end of each day.

    ii). **Provide eco-conscious products** across your workplace, there are many products that can be swapped for eco-friendly, recyclable varieties. For instance, eco-conscious kitchen essentials such as tea and coffee products, paper towels and cups can be supplied as well as cleaning products and eco-stationery products.

    iii). **Participate in recycling programmes:** Most workplaces require printing service which is commonly produced by printers with ink toner cartridges. By engaging in a recycling programme such as Cart Collect, your business can sustain the environment by having the cartridges recycled up to eight times. Once the cartridges are no longer recyclable, Staples 100% recycle them into our award-winning Sustainable Earth by Staples. Calculator and Stapler products.

iv). **Use our own transportation:** Encourage your employees to travel to and from work by foot or nonmotorised transportation such as a bicycle, rollerblades or scooter if they live within a feasible distance from your workplace location. Not only is this an eco-conscious Earth Day practice – it can also add to your employee's daily exercise.

v). **Keep our workstation clean:** In addition to maintaining cleanliness to avoid the spread of germs in the workplace, it's important to monitor workstation appliances for dust and build-up that can occur in the filters which can result in running less efficiently. As a sustainable best practice, we recommend employees maintain a clean workstation and any other facilities that are utilised throughout the workplace. It is photosynthesis that produces the carbohydrates that you eat and thus, provides the energy you need to live. Another way to say this is that this carb-making process allows you to obtain the energy from the sun for use as energy in your body. When you eat a green salad, your body is able to metabolize the carbs by breaking the bonds between the atoms that make up each carb molecule. In this way, the stored energy is released for use by your cells. Without the energy from the foods you eat, you would not be able to move, breathe, or have a beating heart. Whether you eat the green part of the plant, such as the stems and leaves of celery or spinach, or the fruit or roots of tomato and carrot plants, you are taking advantage of photosynthesis. It is a miraculous process that we mostly take for granted as we enjoy all of the delicious and nutritious foods it produces.

12. a) A= Photosystem II, B= photosystem A

b). Photolysis of water.

c). ATP, $NADPH_2$ and O_2

d). A= water, B= Oxygen, C= CO_2, D= glucose.

13. 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.

9.9. Additional activities

9.9.1. 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) $6CO_2+$
3. Refer to the content summary of the lesson 9.2

9.9.2. Consolidation activities

1. Explain the involvement of the plant parts bellow in the process of photosynthesis

a). Stomata	c). Leaf stalk	e). Xylem
b) Lamina	d). Leaf cuticle	f). Phloem.

2. 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 9.2
2. Refer to the content summary of the lesson 9.3
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.

9.9.3. 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.

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 10: THE CHEMICAL BASIS OF LIFE

10.1. Key unit competence

Explain the use of biological molecules in living organism

10.2. 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.

10.3. 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 tutor 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 importance 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.

10.4. Guidance on introductory activity

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 three student-teachers to present their findings while others are following

e). Help the student-teachers to make summary of the group discussions.

The answers should be relating to chemicals of life they obtain from different types of food given in the figure such as carbohydrates, lipids, proteins, mineral salts, vitamins, etc.

10.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	**Biological molecules** (The chemical elements, sub-units, structure, function of carbohydrates, lipids and proteins,	– 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	5
2	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	6

		substrate concentration, and inhibitors on enzyme activity. – Understand the roles of enzymes in industry and medicine. – Apply enzymes actions in living organisms	
	End unit assessment		1

Lesson 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.)

a) Learning objectives

- 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

b) Prerequisites/ Revision/ Introduction

To understand well this lesson student-teachers should have knowledge on 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 unit 5, 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.

c) Teaching resources

Different student teacher's books, laboratory chemicals like enzymes, experimental materials, graph charts, simulations (videos) and computer animations, projector, Manila paper with diagrams for improvisation.

d) **Learning activity 10.1**

- **Guidance on activity 10.1**

As facilitator help the student-teachers to develop competences in the following:

- Ask student-teachers to do in groups activity 10.1 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 teacher’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 for activity 10.1

All chemicals of life are made up with carbon, hydrogen, oxygen, except proteins that sometimes contain Sulphur, Nitrogen… and water which lack carbon

For more information read the student-teacher book.

Answers for activity 10.1.3

1. Protein polymers 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.

e) Answers for application activity 10.1

1.

Biological molecules	Food sources	Functions
Carbohydrates	They are mainly found in fruits, cassava, potatoes, sugar cane, honey and 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 teacher book).

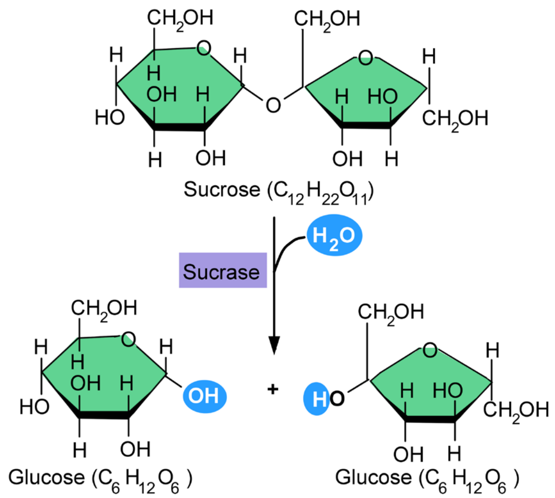
3. The peptide bond formation: A condensation reaction occurs between the amino group of one amino acid and the carboxyl group of another, to form a dipeptide

4. In student teacher book

5. In preparing food, we have to consider many plant food staff.

6. Addition of water molecules to sucrose to obtain two unit of glucose

7. By Chemical bond.



8. 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: Water and enzymes

a) Learning objectives

- 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
- Analyse 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, computer and projector for showing mode of enzymes activity.

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 10.1.

d) **Learning activity 10.2**

- **Guidance on activity 10.2**

  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 for activity 10.2 a

- Maltase hydrolyses maltose into glucose
- Lactase hydrolyses lactose into glucose and galactose
- Dehydrogenase catalyses the removal of hydrogen from a functional group
- Oxidase catalyses the oxidation of molecules
- Pepsin hydrolyse the proteins into polypeptides in the acidic medium in the stomach
- Renin promotes the coagulation of liquid and soluble casein.
- Enzymes are named based on substrate catalyse, type of reaction they catalyse of by using specific name.

Answers for activity 10.2 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 for activity 10.2.2 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 catalyses the oxidation of molecules
- Pepsin hydrolyse the proteins into polypeptides in the acidic medium in the stomach
- Renin 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 for activity 10.2.2 b

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

$$2)\ H_2O_2(l)\ H_2O(l) + O_2(g) \longrightarrow 2H_2O_2(l) \xrightarrow{MnO_2} 2H_2O(l) + O_2(g)$$

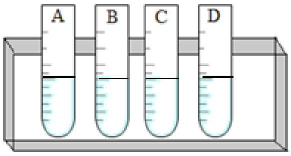
Properties of enzymes

- 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 for activity 10.2.2 c

To help student-teachers to come up with learning outcomes, you are advised to do the following:

- Make different groups and provide the printed hand-out 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 for activity 10.2.2 d

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 for activity 10.2.2 e

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) Answers for application activity 10.2

1. Missing terms: catalysts – living – Activation – proteins –
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 collision between reactant molecules.

10.6. 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.

10.7. Additional Information for the tutor

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 1-3cm^3 (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.

Functions of lipids

- 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.
- Fat in foods provides texture and flavour in foods and it helps to make it palatable.

Food containing fat provides a feeling of satiety or fullness after a meal as fat is digested slowly.

Proteins: are polymers 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.

Protein denaturation

Protein denaturation is a mechanism by which quaternary, tertiary and secondary structure of protein changes their shape due to external stress called agent or factor of denaturation. Protein denaturation may be temporary or permanent due to a variety of factors. The agent of denaturation may include heat, changes in pH, Ultra Violet (UV°) rays, high salt concentration and heavy metals. Cooked egg is an example of a denatured protein due to the heat. This also explains why excessively high fever disease is fatal to the organism because protein in the blood denature at high temperature. The agents of denaturation will denature protein causing the loose of its shape and hence its ability to function.

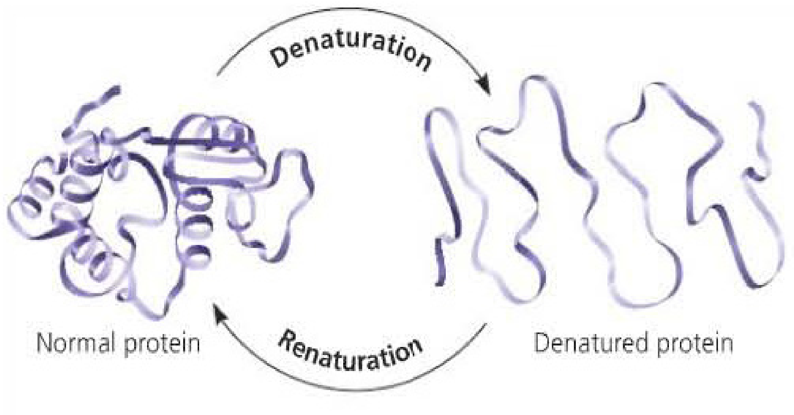


Figure 10.24: Denaturation and renaturation of a protein.

Functions of water

- Turgidity of plant cell which increase their size is due to the availability of water.
- The transport of substances (minerals, nutrients in plant and animals) is done in water.
- Excretion of waste product
- Support for hydrostatic skeleton.
- Temperature regulation in plant and animals(transpiration)
- Seed germination by breaking down the seed coat
- Medium for biochemical reaction.

10.8. End unit assessment

1. a
2. $C_3H_6O_3$
3. 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

4. They are used by the body to produce energy.

   They are used in hormone production
5. a) Triose=$C_3H_6O_3$ b) Pentose=$C_5H_{10}O_5$
6. **Answers:**

   a). **Alpha glucose is the β glucose**. Ring monosaccharide are said to be alpha (α) 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 α-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 α glucose the only difference it is that Amylose is unbranched while Amylopectin is highly branched.
7. a) Latent heat of vaporization

   b) Solvent property of water

   c) High heat capacity

8. **Notice:** Explanation student teacher book

Monomers	Bond	Polymer
Nucleotides	Phosphodiester linkages	Triacylglycerol
Monosaccharide	Glycosidic linkages	Polysaccharide
fatty acids	Ester linkages	Triacylglycerol
Amino acids	Peptide bonds	Polypeptides

9. During denaturation there the braking down peptide bond

10. The following are the answers:
    a). The following are the explanations:
        i). 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.
        ii). 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.
        iii). Activation energy is the energy required by molecules to start a reaction.
        iv). 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.

11. 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.

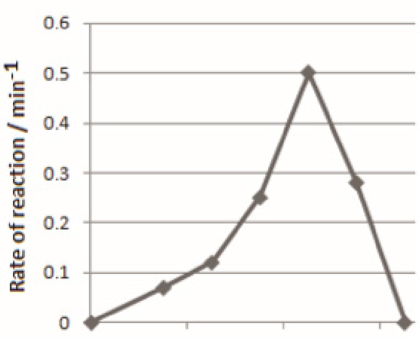
d). Enzymes catalyze different reactions and are found in different cellular environments; for example, extra-cellular digestive enzymes have to be able to work in acidic or alkaline conditions in the stomach or intestine respectively. In addition, each enzyme has a different combination of amino acid side chains.

e). Differences between reversible and irreversible enzyme inhibitors:

12. 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.

13. The following are the answers:

a). I plot the curve



b). The optimum temperature is 45^0C

c). The rate of the reaction is increasing with temperature / linear increase; rate doubles with every 10^0C increase in temperature; reference to Q_{10}.

d). Rate at 20^0C is 0.1, rate at 30^0C is 0.2; Rate of increase is $0.1/10^0C$ or 0.01 per ^0C

10.9. Additional activities

10.9.1 Remedial activities

1. On your choice give the food in which we can find the following substances

a). Starch b). Vitamin C c). Lipids

2. ……………is the reverse of a condensation reaction

3. How do we call a single sugar molecule?
   a). Monomers
   b). Monosaccharide
   c). Carbohydrates
   d). Proteins

4. How many numbers of hydroxyl groups in a glycerol molecule?

5. Name the bond in secondary structure of proteins.

6. What happen to the protein if is denatured?

Answers

1. a) Tubers such as potatoes, cassava, Seeds such as maize, rice and sorghum

   b) Orange and lemon fruits

   c) Oil, ground nuts, sunflower

2. Hydrolysis

3. (b) Monosaccharide.

4. There 3 OH group in Glycerol molecule

5. Secondary structure bond: peptide bond, hydrogen bond.

6. When a protein is denatured the proteins change the shape.

10.9.2. Consolidation activities

1. The empirical formula of a compound is $C_{51}H_{98}O_6$. Such compound is a:
   a) Protein b) Lipid c) Vitamin d) Carbohydrate

   Answer: (b)

10.9.3. Extended activities

1. 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?

2. Explain why it is an advantage of storing energy in large molecules?

Answers

1. The following are the answers:

a) Similarities

- Long chain of alpha glucose
- Branching chain
- Long chain linked by glycosidic links / bonds.

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

2. 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 11: COVALENT BONDS

11.1. Key unit competence

Demonstrate how the nature of the bonding is related to the properties of covalent compounds.

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

Before learning this unit, student teachers should have a prior knowledge ionic bonding. This will help them relate the information about formation of why atoms bond to achieve the stability. Student teachers also should be helped to recall the formation of covalent bonds also seen in senior two unit1 in ordinary level chemistry. It is also important for student teachers to recall how electronic configuration of different elements is written.

11.3. Cross-cutting issues to be addressed

Comprehensive Sexuality Education

Refer to the unit 3 teacher guide. However, you can still emphasise this cross cutting issue though mentioned in the previous unit 3.

a) 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 for the success of human race.

b) Inclusive education

This unit involves number of structures that require drawing. It is therefore imperative to note that student teachers with visual impairment are helped by drawing big enough pictures or find them spaces near the chalk board.

11.4. Guidance on Introductory activity

Before introducing the first lesson of this unit (**Overlap of atomic orbitals to form covalent bonds**), let student teachers attempt introductory activity. This activity intends to:

- Relate the unit with student teachers' real daily life to capture their attention and enhance their curiosity towards the unit.
- Assess student teachers understanding of the concept of covalent bonding by using the activity 11.1

Answers for 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).

11.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Overlap of atomic orbitals to form covalent bonds.	Explain the formation of covalent bonds using orbital concept	1
2	Lewis structures using octet rule (dot and cross structures).	Enjoy Lewis structures using octet rule (dot and cross structures	1
3	Coordinate or dative covalent bond (e.g. hydronium ion, ammonium ion, aluminium chloride and the combination of boron trifluoride and ammonia).	Compare the formation of dative covalent to normal covalent bonding and describe how the properties of covalent compounds depend on their bonding.	1

4	Polarity of the covalent bond in relation to difference in electronegativity	Predict whether the bonding between specified elements will be polar covalent, non-polar covalent or ionic.	1
5	Physical properties of covalent compounds: simple molecular structure (e.g: Melting and boiling points, solubility in polar and non-polar solvents and conductivity of electricity).	Recognise physical properties of covalent compounds	1
	End unit assessment		1

Lesson 1: Overlap of atomic orbital to form covalent bonds

This is the first lesson of unit 4 and is made up of suggested three periods. The first lesson also covers the introduction of the whole unit (introductory activity). You are advised not to spend a lot of time on this introductory activity. This is only intended to raise the curiosity of student teachers and relate the lesson to real/daily life.

a) Prerequisites/Revision/Introduction

Student teachers will learn better the Overlap of atomic orbitals to form covalent bonds if they have understanding on: The concept of bonding and the stability of atoms as the sole reason why covalent bonding take place, the arrangement of elements in the periodic table and writing the electronic configuration of elements, (refer to unit 2).

b) Teaching resources:

- Periodic table of elements
- Use the illustrations in the student teachers' book for lesson 1 or draw them on a manila paper.
- Use downloaded videos from you tube if the internet is not sufficient.
- Other relevant chemistry text books if available in the library.

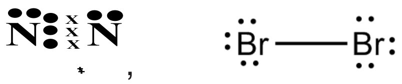
c) Learning activity 11.1:

Guidance on activity 11.1

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 4.1 which is specific to lesson 1.

- Form groups of 4-5 depending on the size of the class.
- Distribute the introductory activity and estimate the time for it.
- Let the student teachers proceed and do activity 11.1 of lesson 1.
- Allows the student teachers to work together in groups.
- Invite group leaders to present their findings.
- Instead of groups you can also use “**pair-think and share**”.
- In this step you can guide the student teachers to evaluate the findings by confirming the correct answers, eliminating the wrong ones or completing some statements.
- You summarise the learned knowledge and gives examples which illustrate the learned content. Here you can also give other necessary examples that could have not indicated in step 2.
- Integrate crosscutting and real life experiences by linking them with the lesson learned.

Answers for activity 11.1

1. They are called orbitals.
2. Types of overlapping: s-s, s-p, p-p. It leads to the formation of bonds.
3. 

Answers for application activity 11.1

1. Formation of sigma bonds and pi bonds in:
   a). N_2: 2 pi bonds are formed by lateral overlapping 2 p orbitals (py-py, pz-pz) and 1 sigma bond formed by axial overlapping of p orbitals (px-px). One lone pair of electrons are also present.
   b). Br_2: 1 pi bonds formed by axial overlapping of s orbitals (s-s). 3 lone pairs of electrons are also present.
   c). NH_3: 3 sigma bonds formed from overlapping of px-s, py-s and pz-s. p orbitals from N and 3 orbitals from 3 H. There is also a lone bond pair.

2. CH_3- $CH_3$is less reactive than CH_2=CH_2because ethane is formed only by sigma bonds which are stronger than pi bond which is found in ethene.

3. In propene CH_2=CH-CH=CH_2they are 2 pi bonds and 8 sigma bonds. In oxygen there are 1 pi and 1 sigma bonds.

Property	**Covalent molecules**	**Ionic compounds**
Formation	A covalent bond is formed between two non-metals that have similar electro negativities. Neither atom is "strong" enough to attract electrons from the other. For stabilization, they share their some valence electrons.	An ionic bond is formed between a metal and a non-metal. Non-metals can get electrons very easily from the metal. The non-metal becomes an anion and a metal becomes a cation. These two opposite ions attract each other and form the ionic bond
Polarity	Low	High
Shape	Definite shape	No definite shape
What is it?	Covalent bonding is a form of chemical bonding between two non-metallic atoms which is characterized by the sharing of pairs of electrons between atoms and other covalent bonds.	Ionic bond, also known as electrovalent bond is a type of bond formed from the electrostatic attraction between oppositely charged ions in a chemical compound. These kinds of bonds occur mainly between a metallic and a non-metallic atom.
Melting point	Low	High
Occurs between	Two non-metals Note**:** it is possible between metal and non- metal. Remember polarization	One metal and one non-metal Remember :Polarization
Boiling point	Low	High
State at room temperature	Liquid or gaseous **Note: few are solids**	Solid

Examples	Methane (CH_4), Hydrochloric acid (HCl), water (H_2O)	Sodium chloride (NaCl), Sulphuric acid (H_2SO_4)

Lesson 2: Lewis structures using octet rule (dot and cross structures).

This is the second lesson under covalent bonding Formation it consists of three periods. Student teachers are expected to explain how Lewis structures are drawn and muster the rules followed to write Lewis structures through practicing as many examples of molecules as possible.

a) Prerequisites/Revision/Introduction

Refer to lesson 1 above but mainly here the concept of valence electrons and electronic configuration is much more needed.

b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating formation of Lewis structures and rules may be pinned in class for some time for student teachers to familiarize with them and practice.
- Where possible use manila papers, flipcharts and you-tube videos with computers and projectors. (If there is no internet you can download and keep the videos on memory sticks)

c) Learning activity 11.2

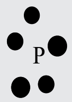
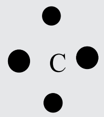
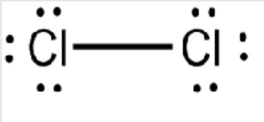
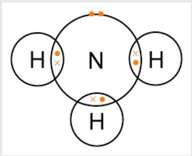
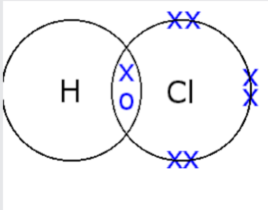
Guidance on activity 11.2

- The teacher form groups of 3-4. The number of groups and members will depend on your class size.
- In groups, student teachers do activity 11.2 indicated in learner's book, discuss and record their answers.
- Allow the student teachers to concentrate and use their time appropriately.
- student teachers do the activity 11.2.1 (this includes the exceptions of the octet rule) to avoid confusion
- During the presentation ask some questions that lead to discovery of new concepts. use student teachers examples to guide them discover some of the rules that were applied to draw correct Lewis structures

and some exceptions octet rule

- The teacher summarises the learned knowledge and gives examples which illustrate the learned content.
- Your purpose here to confirm the correct information, correct the ambiguity among the findings presented.
- Emphasise about rules of writing the Lewis structures and give some examples among the exceptions of the octet rule.

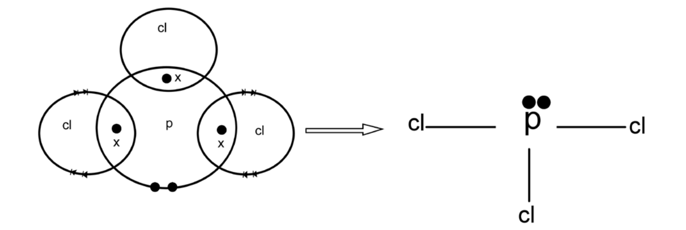
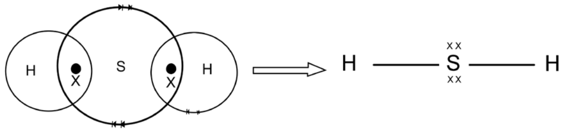
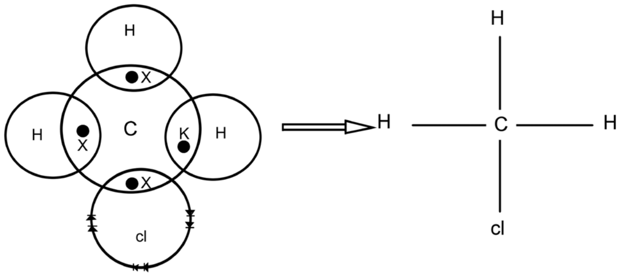
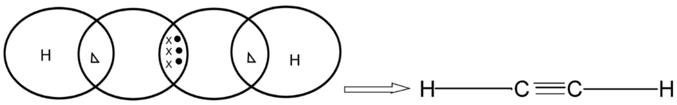
Answers for activity 11.2

#	Compound /element	Chemical formula	Structure
1	Phosphorous	P	
	Carbon	C	
	Chlorine	Cl_2	
2 (i)	Ammonia	NH_3	
(ii)	Hydrogen chloride	HCl	
(iii)	Nitrogen molecule	N_2	

3. No more single electron (all electrons are paired)

Answers for application activity 11.2

1. A covalent bond is a chemical bond that involves the sharing of electron pairs between two atoms.
2.

a	
b	
c	
d	

Lesson 3: Coordinate or Dative covalent bonding

This lesson consists of three periods; during these you can split the lesson according to the nature of your student teachers. It is about formation of dative covalent bond, properties and resonance structures.

a) Prerequisites

Before beginning this lesson, you can ask a few questions about the formation of covalent bonds either orally or set a simple exercise for revision. You can also use the activity 4.3. This activity is only intended to remind student teachers and link the information with the previous lesson and other lessons learnt in S.2 chemistry unit 1.

b) Teaching resources

- Periodic table
- flip charts, videos downloaded from you tube (if internet is available) ,
- Student teachers' text books or other relevant chemistry books can be used if available.

c) Learning activity 11.3

Guidance on activity 11.3

- Form groups or pairs of learner and distribute the activity 11.3 in student teachers' book.
- Remember to give student teachers activity 11.3 for resonance structures.
- Allow the student teachers to work in their respective groups.
- You can invite the representatives of groups to presents their findings.
- Learner evaluate their findings through discussion with the assistance of the teacher to correct, the incomplete or false
- You can use the examples given by the student teachers to link the lesson to the content being learned.
- You summarise the learned knowledge and gives examples which illustrate the learned content.
- Emphasise on the difference between covalent bond formation and co-ordinate bond.

Answers for activity 11.3

- The structure of ozone formed by three oxygen atoms bonded by sharing electrons. 2 atoms bonded by 1 sigma and 1pi where 1 atom constributes for 1 electron.One other bond is special it is formed by 2 electrons from 1 atom of oxygen.
- The structure of $NH_4^+$is formed by three normal covalent bonds and another special bond formed by shared electrons all from nitrogen.
- H_3O^+ is formed by 3 normal covalent bonds, the third is special called cordinate bond where 2 electrons shared are given by oxygen only.

Answers for application activity 11.3

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 covalence.

   a)

   - Covalence: 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 4: Polarity of covalent bonds

a) Prerequisites/Revision/Introduction

Before beginning this lesson, you have to make sure that student teachers understood how to know the concept of electronegativity and their effects on formation of bonding.

b) Teaching resources

- Periodic table of chemical elements (make sure it contains electronegative values)
- Flip charts or manila papers.

c) Learning activity 11.4

Guidance on activity 11.4

- Discovery activity
- Distribute the periodic that contains electronegative values.
- Let the student teachers pair think and share on activity 11.4

- Ask the student teachers to do number 1 of activity 11.4 in pairs or groups
- Allow them to continue with the activity.
- Student teachers present the findings of the activity 11.
- Guide the student teachers by helping them to evaluate their findings by commenting and making contributions or subtractions or criticising each other.
- Summarise by confirming or eliminating the false information and link their examples to the learned content. You can give more examples if necessary.
- Make sure student teachers are able to explain the purpose of difference in electronegativity.

Answers for activity 11.4

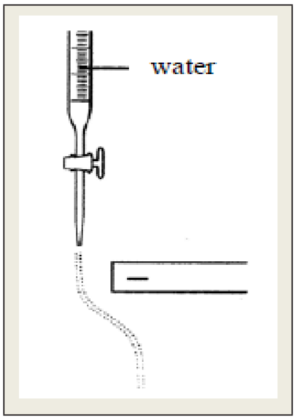
1. Covalent bond is formed between two atoms with similar or close ability to attract electrons towards themselves, and this is the reason why they share electrons without being transferred.

   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 respect0ively.



Answers for application activity 11.4

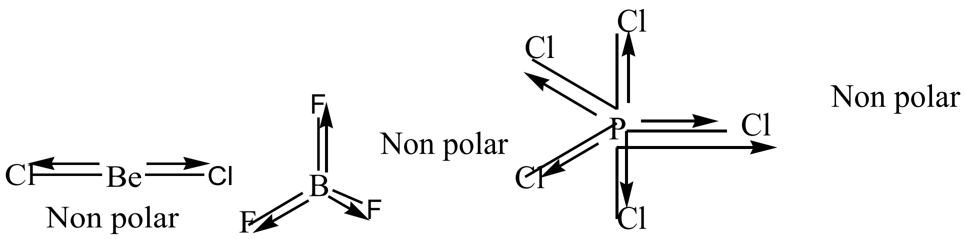
1. a)

   i). $BeCl_2$ (polar bonds)
   ii). BF_3 (polar bonds)
   iii). CH_4 (non polar bonds
   iv). PCl_3 (polar bonds)
   v). H_2S (polar bonds)
   vi). CO_2(polar bonds)
   vii). SO_2 (polar bond)
   viii). SO_3 (polar bonds)
   ix). SF6 (polar bonds)
   x). PCl_5 (polar bonds)
   xi). Cl_2 (non polar)

   b). Non polar molecules form between them very weak intermolecular forces, their boiling and melting points are very low. Polar compounds form between their molecules relatively strong intermolecular forces so that their B.P and M.P are high. Ionic bonding being very strong the ionic compounds have very high M.P and B.P.

   c) Methane is non polar while water is polar

2.



Lesson 5: Physical properties of covalent compounds: simple molecular structure

a) Prerequisites/Revision/Introduction

The previous lessons can be used here, make sure it was well understood. The activity indicated in 4.4 can be used to introduce the lesson.

b) Teaching resources

- Periodic table of elements
- Textbooks and internet resources
- Balloons to represent the p-orbitals.
- Downloaded videos from you tube.

c) **Learning activity 11.4**

Guidance on activity 11.4

- Student teachers are asked to do research or read it from student teacher's book on valence bond theory and try to answer questions in activity 4.4 in student teacher's book.
- The teacher may guide the student teachers by giving them a list of important reference books available in the school library. If the internet is available you can give exact URL for proper researching.
- You can allow presentations of the summarised work
- Correct the mistakes and eliminate false or unnecessary information.
- Give the summary of the lesson and other examples(description of valence bond theory must be emphasised)

Answers for activity 11.5

1.
   a). Carbon dioxide gas, Bromine (Br_2): liquid and SiO_2: solid
   b). Decreasing order of melting and boiling points: SiO_2, Br_2, CO_2
   c). B.P and M.P for solids are greater than of liquids also greater than those of gas due to the molecular forces which are stronger from solids to gas.
2. Refers to the student teacher book, lesson11.5.Physical properties of covalent compounds: simple molecular structure

Answers for application activity 11.5

1. Explain why:
   a). Simple molecules have low melting points;
   b). Simple molecules have poor conductivity of electricity;
2. The more polar the molecules, the more water molecules will be attracted to them examples: hydrogen fluoride (HF), hydrogen chloride (HCl) and ammonia (NH_3)

11.6. Unit Summary

Covalent bonding is the sharing of electron pair(s) between nuclei of atoms.

The covalent bond and ionic bond are both very strong chemical bonds.

A covalent bond is formed by the overlapping of two half-filled valence atomic orbitals of two different atoms

The electrons on in the overlapping orbitals get paired and confirmed between the nuclei of two atoms.

The electron density between two bonded atoms increases due to overlapping. This confirms stability to the molecule.

A dative covalent bond is one formed in which both electrons are donated from the same atom.

The covalent bond formed by sidewise overlapping of atomic orbitals is called π- bond.

The covalent bond formed due to overlapping of atomic orbital along the inter nucleus axis is called σ-bond. It is a stronger bond and cylindrically symmetrical.

The shape of a molecule is determined by the repulsion between bonded electrons and non-bonded electrons (lone pairs).

Lone electron pairs repel more than bonded pairs of electrons and give rise to distorted shapes.

By reducing the number of bonded electron pairs and lone pairs of electrons, the shape of a molecule may be predicted.

Type of hybridization of atomic orbital sp sp^2 sp^3, sp^3d, sp^3d^3

BF_3 is Trigonal planar; CH_4 and NH_4^+ are tetrahedral; SF_6 is octahedral; H_2O is non-linear (V-shaped/bent); CO_2 is linear and ammonia, NH_3, as pyramidal

An intermolecular force exists between molecules and may include hydrogen bonding, dipole-dipole or van der Waals' forces.

Electronegativity is the ability of an atom in a covalent bond to attract a bonded pair of electrons towards itself.

Hydrogen bonding arises in molecules in which a hydrogen atom is bonded to either an N or O atom.

Water molecules, and other substances consisting of hydrogen bonding, have anomalous properties as a result.

11.7. Answers for end unit assessment

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 one period reserved.

1.

Substance	δ^-	Insoluble in water
Nitrogen N_2	No	Yes
Formic acid HCOOH	Yes	No
Methane CH_4	No	Yes
Octane C_8H_{18}	No	Yes
Ethanol CH_3CH_2OH	Yes	No

2. 3 N-Cl bonds and 10 lone pairs of electrons.

3. The boiling point of water is much bigger that of methane while their masses are not very different because intermolecular forces between molecules of water are bigger than those of methane due to molecules of water are polar while molecules of methane are non polar.

4. (d) Sidewise overlap of two parallel p orbitals.

5. a) δ^-on C and δ^+on H in C-H, δ^+ on C and δ^-on Cl in C-Cl

   b). δ^+on C and δ^-on O, δ^-on O and δ^+on H

   c). δ^+on C and δ^-on N, δ^-on N and δ^+on H

6. Propane: CH_3-CH_2-CH_3 Propene: CH_3-CH=CH_2

   Propane is less reactive than propene because it is formed only by very strong bonds which are sigma bonds while in propene there is pi bond which is a weak bond.

7. B

8. a) Electronegativity

   b) H-Cl, H-I, H-F, H-Br. Range from the most polar to the least

   HF, HCl, HBr, HI

9. Lewis structures:

   a). H_2O_2 c). C_2H_2 e). Al_2S_3

   b). HCN d). SF_6

10. $H_2C = CH- CH_3$: 8 sigma bonds then 16 sigma electrons, 1 pi bond then 2 pi electrons

11.8. Additional information for the tutor

A. Hybridisation and its types

1. Definition of hybridisation

The concept hybridization involves the "*cross breeding*" of atomic orbitals to create "*new*" orbitals. Hence the use of the term "hybrid": Think of a *hybrid* animal which is a cross breed of two species.

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*.

During hybridization, the atomic orbitals with different characteristics are mixed with each other. Hence there is no meaning of hybridization between same type of orbitals i.e., mixing of two '**s**' orbitals or two '**p**' orbitals is not called hybridization. However orbital of '**s**' type can mix with the orbitals of '**p**' type or of '**d**' type.

Keep in mind that ***only the orbitals of nearer energy values can participate in the hybridization***. Based on the type and number of orbitals, the hybridization can be subdivided into following types.

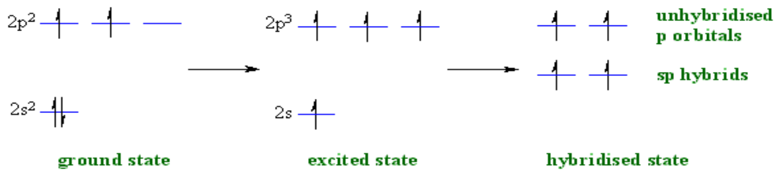
2. Types of hybridization

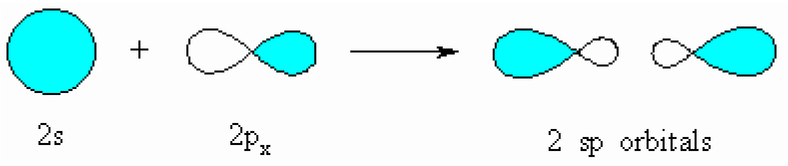
a) sp-Hybridization

*Intermixing of one '**s**' and one '**p**' orbitals of almost equal energy to give two identical and degenerate hybrid orbitals is called **'sp' hybridization**.*

These two sp-hybrid orbitals are arranged ***linearly*** at by making **180°** of angle.

They possess 50% '**s**' and 50% '**p**' character.



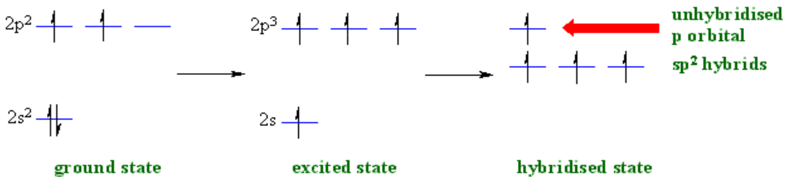


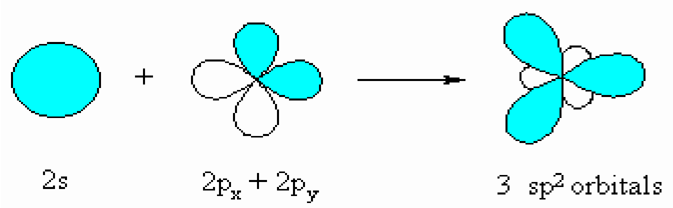
b) sp^2-Hybridization

*Intermixing of **one** 's' and **two** 'p' orbitals of almost equal energy to give three identical and degenerate hybrid orbitals is known as **sp^2 hybridization**.*

The three sp^2 hybrid orbitals are oriented in ***trigonal planar*** symmetry at angles of **120°** to each other.

The sp^2 hybrid orbitals have 33.3% 's' character and 66.6% 'p' character.



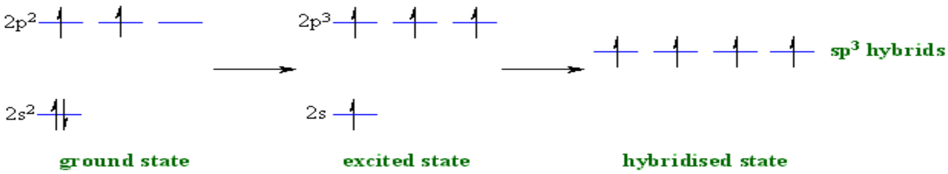


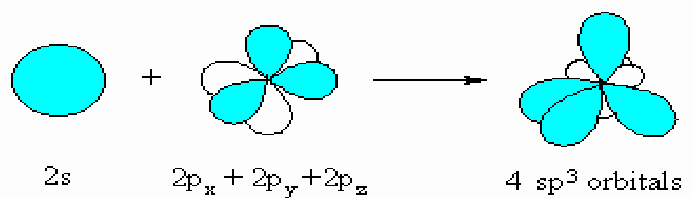
c) sp^3-Hybridization

*In sp^3 hybridization, **one 's'** and **three 'p'** orbitals of almost equal energy intermix to give four identical and degenerate hybrid orbitals.*

These four sp^3 hybrid orbitals are oriented in ***tetrahedral***symmetry with **109°28'** angle with each other.

The sp^3 hybrid orbitals have 25% '**s**' character and 75% '**p**' character.



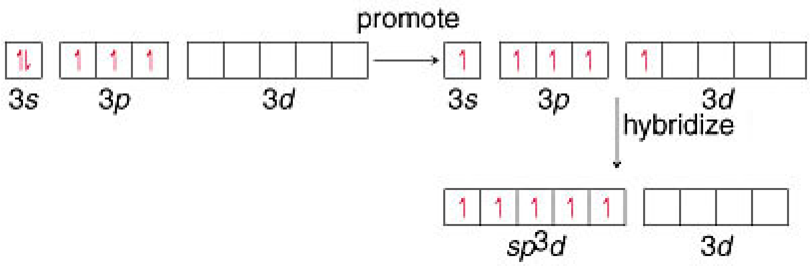


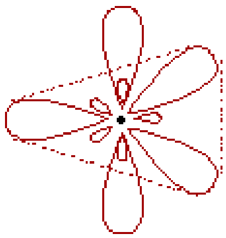
d) *sp³d-Hybridization*

In sp³d hybridization, ***one 's'****,* ***three 'p'*** *and* ***one 'd'****orbitals of almost equal energy intermix to give five identical* and degenerate hybrid orbitals, which are arranged in ***trigonal bipyramidal*** symmetry.

Among them, three are arranged in trigonal plane and the remaining two orbitals are present above and below the trigonal plane at right angles.

The five sp³d hybrid orbitals have 20% 's', 60% 'p' and 20% 'd' characters.



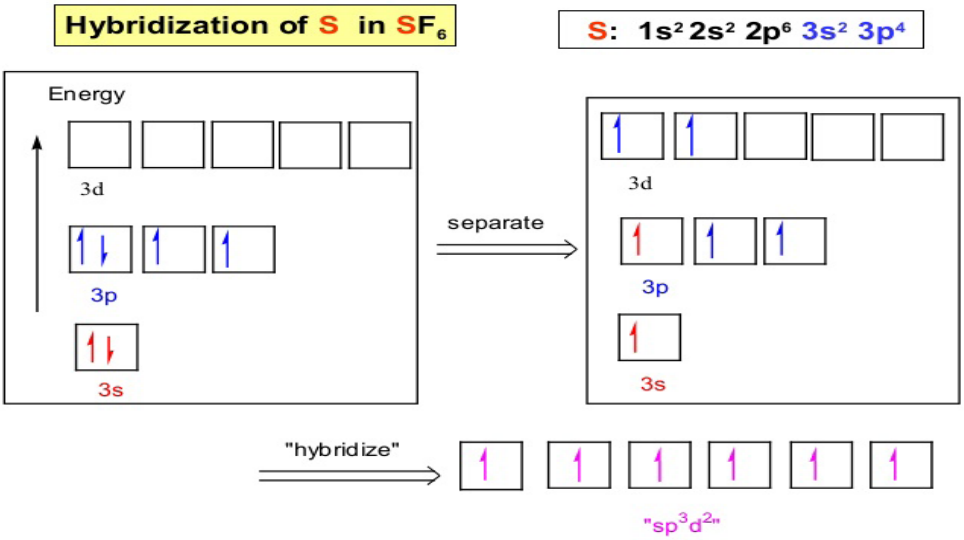


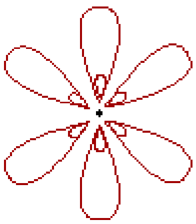
sp³d hybrid orbitals

e) *sp³d²-Hybridization*

Intermixing of ***one 's'****,* ***three 'p'*** *and* ***two 'd' orbitals*** *of almost same energy by giving six identical and degenerate hybrid orbitals is called* ***sp³d² hybridization***.

These six sp³d² orbitals are arranged in ***octahedral*** symmetry by making **90°** angles to each other. This arrangement can be visualized as four orbitals arranged in a square plane and the remaining two are oriented above and below this plane perpendicularly.





sp^{3}d^2 hybrid orbitals

Conditions for the hybridization:

- Orbitals of same element should take part in the hybridization.
- There should be minimum difference between the orbitals undergoing hybridization.

Characteristics of Hybridization:

- During hybridization the number of hybrid orbitals formed is equal to the number of atomic orbitals involved in hybridization.
- Hybrid orbitals form more stable and stronger bonds than pure atomic orbitals.
- Hybridization does not take place in isolated atoms and possible in those atoms which are prior to participate in chemical bonding.

B. VSEPR theory to explain the formation of shapes of covalent molecules (geometry) and bond angles

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). The basic assumptions of this theory are summarized below.

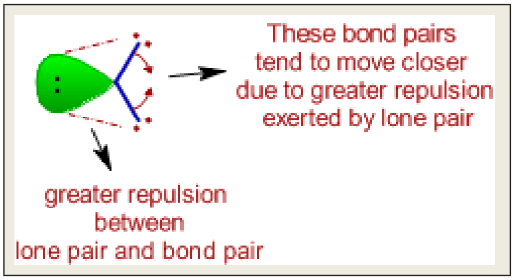
1. The electron pairs in the valence shell around the central atom of a molecule repel each other and tend to orient in space so as to minimize the repulsions and maximize the distance between them.
2. There are two types of valence shell electron pairs namely, **(i)** Bond pairs and **(ii)** Lone pairs.
   - Bond pairs are shared by two atoms and are attracted by two nuclei. Hence they occupy less space and cause less repulsion. It is also called "*sharing pair*".
   - Lone pairs are not involved in bond formation and are in attraction with only one nucleus. Hence they occupy more space. As a result, the lone pairs cause more repulsion.

   The *order of repulsion* between different types of electron pairs is as follows:

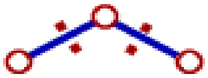
   Lone pair - Lone pair > Lone Pair - Bond pair > Bond pair - Bond pair

   Note: The bond pairs are usually represented by a ***solid line***, whereas the lone pairs are represented by a ***lobe with two electrons***.
3. In VSEPR theory, the multiple bonds are treated as if they were single bonds. The electron pairs in multiple bonds are treated collectively as a single super pair. The repulsion caused by bonds increases with increase in the number of bonded pairs between two atoms i.e., a triple bond causes more repulsion than a double bond which in turn causes more repulsion than a single bond.
4. The shape of a molecule can be predicted from the ***number*** and ***type of valence shell electron pairs*** around the central atom. When the valence shell of central atom contains only bond pairs, the molecule assumes symmetrical geometry due to even repulsions between them. However the symmetry is distorted when there are also lone pairs along with bond pairs due to uneven repulsion forces.
5. ***Primary & Secondary effects on bond angle and shape***:

   i). The bond angle decreases due to the presence of lone pairs, which cause more repulsion on the bond pairs and as a result the bond pairs tend to come closer.

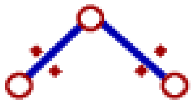


ii). The repulsion between electron pairs increases with increase in electronegativity of central atom and hence the bond angle increases. The bond pairs are closer and thus by shortening the distance between them, which in turn increases the repulsion. Hence the bonds tend to move away from each other.



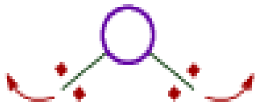
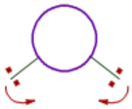
The bond pairs tend to move away from each other since the distance between them is shortened as they are more localized on more electronegative central atom.

However the bond angle decreases when the electro negativities of ligand atoms are more than that of central atom. There is increase in the distance between bond pairs since they are now closer to ligand atoms. Due to this, they tend to move closer resulting in the decrease in bond angle.

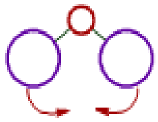
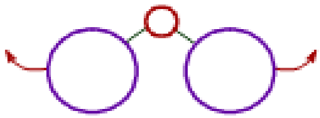


The bond pairs tend to come closer since the distance between them is increased as they are more localized on more electronegative ligand atoms.

iii). The bond angle decreases with increase in the size of central atom.

	
On smaller central atoms the bond pairs are closer and hence tend to move away from each other so as to minimize repulsion. Hence bond angle will be more.	On bigger central atoms, the bond pairs are more distant from each other and hence there is less repulsion. Hence they tend to move closer and thus by decreasing the bond angle.

However the bond angle increases with increase in the size of ligand atoms, which surround the central atom.

	
There is less repulsion between smaller ligand atoms and they can move closer to each other and thus decrease the bond angle.	There is more repulsion between bigger ligand atoms and hence they tend to move away from each other. Thus bond angle increases.

iv). The bond angles are also changed when multiple bonds are present. It is due to uneven repulsions.

6. When there are two or more resonance structures, the VSEPR theory is applicable to any of such contributing structure.

The shape of molecule and also the approximate bond angles can be predicted from the **number** and **type** of electron pairs in the valence shell of central atom as tabulated below.

In the following table the molecule is represented by "**AXE**" notation, where

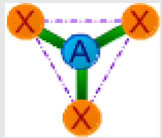
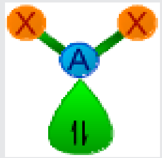
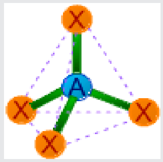
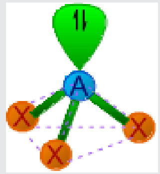
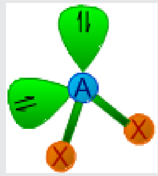
A = Central atom

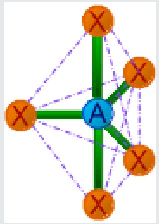
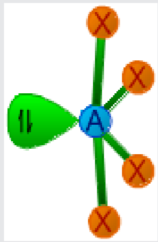
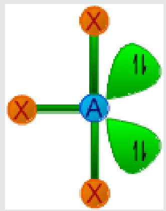
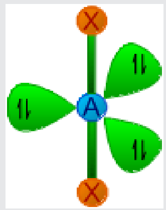
X = Ligand atom bonded to the central atom either by a single bond or by multiple bond; indicating a bond pair.

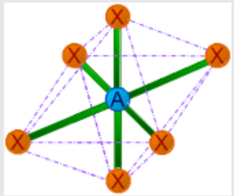
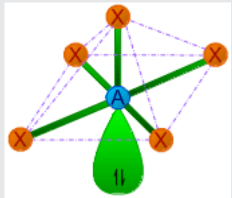
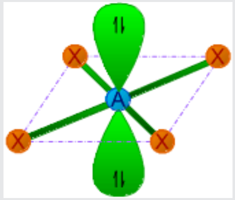
E = Lone pair

Note:

- The sum of number of ligand atoms (**X**) and number of lone pairs (**E**) is also known as **steric number.**
- The bond pairs are shown as green colored thick lines, whereas the lone pairs are shown as point charges using green colored lobes.

Electron Arrangement	Formula	Hybridization	Bonding Pairs	Lone Pairs	Name of the Shape	Shape	Bond Angle
Linear	AX or AX_2	Sp	1 or 2	0	Linear		180°
Trigonal Planar	AX_3	sp^2	3	0	Trigonal planar		120°
			2	1	Bent		116.8°
Tetra-hedral	AX_4	sp^3	4	0	Tetra-hedral		109.5°
			3	1	Trigonal pyra-midal		107°
			2	2	Bent		104.5°

Electron Arrangement	Formula	Hybridization	Bonding Pairs	Lone Pairs	Name of the Shape	Shape	Bond Angle
Trigonal Bipyramidal	AX_5	sp^3d	5	0	Trigonal Bipyramidal		120° and 90°
			4	1	See-saw		<120° and 90°
			3	2	T-shaped		90° and 180°
			2	3	Linear		180°

Electron Arrangement	Formula	Hybridization	Bonding Pairs	Lone Pairs	Name of the Shape	Shape	Bond Angle
Octa-hedral	**AX_6**	**sp^3d^2**	6	0	Octa-hedral		90°
			5	1	Square pyra-midal		90° and 180°
			4	2	Square planar		90° and 180°

Determination of shape of a molecule

- 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*.

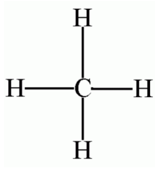
The following table shows some examples for each type of shapes:

Steric No.	No. of Bond pairs	No. of Lone pairs	Formula	Examples
1	1	0	AX	ClF, BrF, BrCl, HF, O_2
2	2	0	AX_2	$BeCl_2$, $HgCl_2$, CO_2
3	3	0	AX_3	BF_3, CO_3^{2-}, NO_3^-, SO_3
	2	1	AX_2E	SO_2, $SnCl_2$, O_3, NSF, NO_2^-
4	4	0	AX_4	CH_4, $SiCl_4$, NH_4^+, PO_4^{3-}, SO_4^{2-}, ClO_4^-
	3	1	AX_3E	NH_3, PCl_3, XeO_3
	2	2	AX_2E_2	H_2O, SCl_2, Cl_2O, OF_2
5	5	0	AX_5	PCl_5, SOF_4
	4	1	AX_4E	SF_4, $TeCl_4$
	3	2	AX_3E_2	ClF_3, BrF_3, $BrCl_3$
	2	3	AX_2E_3	XeF_2, I_3^-
6	6	0	AX_6	SF_6
	5	1	AX_5E	ClF_5, BrF_5, ICl_5
	4	2	AX_4E_2	XeF_4

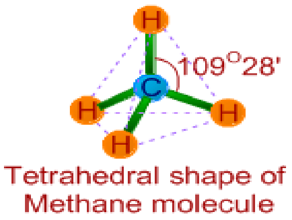
Worked examples:

1. Methane (CH_4):

- The Lewis structure of methane molecule is:



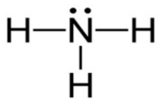
- There are 4 bond pairs around the central carbon atom in its valence shell. Hence it has tetrahedral shape with **109°28'** of bond angles.



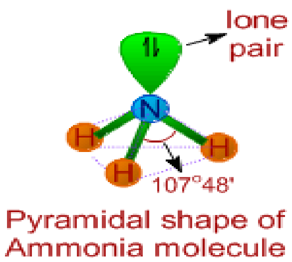
Tetrahedral shape of methane molecule

2. Ammonia (PCl_3):

- The Lewis structure of ammonia indicates there are three bond pairs and one lone pair around the central nitrogen atom.



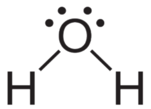
- Since the steric number is 4, its structure is based on tetrahedral geometry. However, its shape is pyramidal with a lone pair on nitrogen atom.
- The bond angle is decreased from 109°28' to **107°48'** due to repulsion caused by lone pair on the bond pairs.

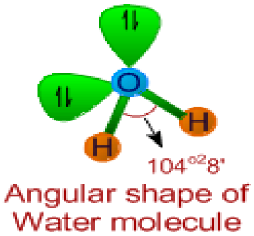


Tetrahedral shape of ammonia molecule

3. Water (H_2O):

- It is evident from the Lewis structure of water molecule; there are two bond pairs and two lone pairs in the valence shell of oxygen. Hence its structure is based on tetrahedral geometry. However its shape is angular with two lone pairs on oxygen.





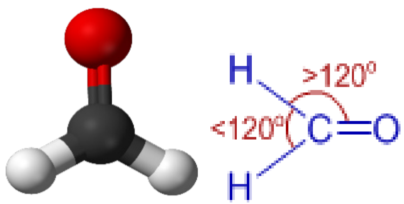
Tetrahedral shape of water molecule

- The bond angle is decreased to **104°28'** due to repulsions caused by lone pairs on bond pairs. It can be noted that the bond angle decreases with increase in the number of lone pairs on the central atom.

4. Formaldehyde (HCHO):

There are three bond pairs around the central carbon atom. The double bond between C and O is considered as a single super pair. Hence the shape of the molecule is trigonal planar and the bond angles are expected to be equal to 120°.

However, the C=O exerts more repulsion on the C-H bond pairs. Hence the ∠H-C-H bond angle will be less than 120° and the ∠H-C-O is greater than 120°.



C. Intermolecular forces

Now let us talk about the intermolecular forces that exist between molecules. Intermolecular forces are *much weaker* than the intramolecular forces of attraction but are important because they determine the physical properties of molecules like *their boiling point*, *melting point*, *density*, and *enthalpies of fusion* and *vaporization*.

1. Definition, types and origin of intermolecular forces

Intermolecular forces are the forces between molecules forces between molecules that bind them together. Intermolecular forces are like the glue that holds molecules together. There are strong and weak forces; the stronger the force, the more energy is required to break those molecules apart from each other.

Intermolecular forces include (listed from weakest to strongest):

- Van der Waals dispersion forces
- Van der Waals dipole-dipole interactions
- Hydrogen bonding

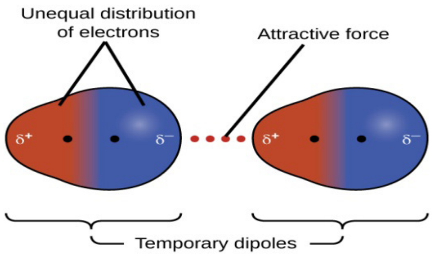
So, if two molecules are only connected using van der Waals dispersion forces, then it would require very little energy to break those molecules apart from each other. On the other hand, if two molecules are connected using ionic bonds, it takes a whole lot more energy to break those two apart.

a) Van der Waals Dispersion Forces

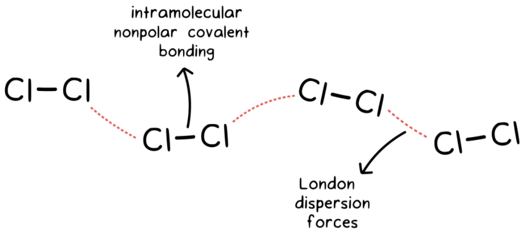
Van der Waals dispersion forces, also called ***London forces***, occur due to instantaneous dipoles. At any given moment the electrons in a molecule or atom may not be evenly distributed around the molecule. If more electrons are on the left side of the molecule than on the right side, then there will be a slight (partial) negative charge on the left side of the molecule. The side with fewer electrons will have a slight (partial) positive charge.

These momentary, partial, positive and negative charges are attracted to each other (like the positive and negative ends on a magnet). This causes *momentary bonds* between molecules. We can already see why these bonds would be so weak, because *they only last for a little while*.

Van der Waals dispersion forces ***increase as the atomic size increases***. This means that larger molecules will feel more force, thus increasing the intermolecular forces. So if we have two molecules that are exactly the same except that one is bigger than the other (such as methane and ethane), then the intermolecular forces of the bigger one will be stronger than for the smaller one.



Dispersion forces result from the temporary dipoles for two non-polar diatomic molecules.



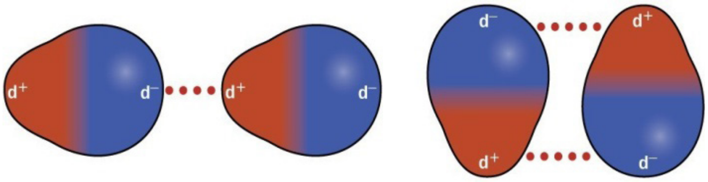
Intramolecular non-polar covalent bonding between Cl-atoms and London dispersion forces between Cl-Cl molecules

b) Van der Waals Dipole-Dipole Interactions

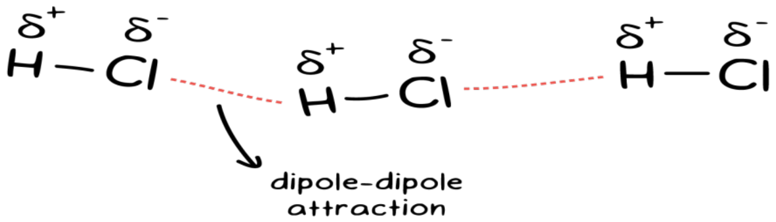
A partial positive charge and a partial negative charge can be created between two atoms when there is a difference in electronegativity. These interactions are called ***van der Waals dipole-dipole interactions.***

For example, carbon is less electronegative than oxygen, creating a partial positive on carbon and a partial negative on oxygen. The dipole interactions are stronger than the dispersion forces because the oxygen will almost always have slightly more electrons than the carbon, instead of constantly changing. There still is not a full negative charge on the oxygen, or a full positive charge on the carbon. But the partial positive and negative charges are still enough to attract opposite charges together.

The ***higher the difference in electronegativity, the strong the dipole-dipole interactions will be***. So compounds with a higher electronegativity difference will have strong intermolecular forces.



This image shows two arrangements of polar molecules, such as HCl, that allow an attraction between the partial negative end of one molecule and the partial positive end of another.

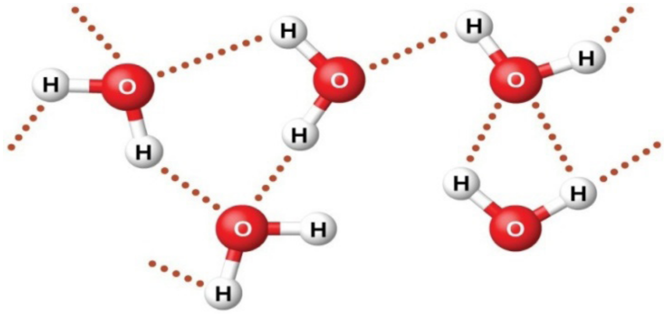


H-Cl to H-Cl dipole-dipole attraction

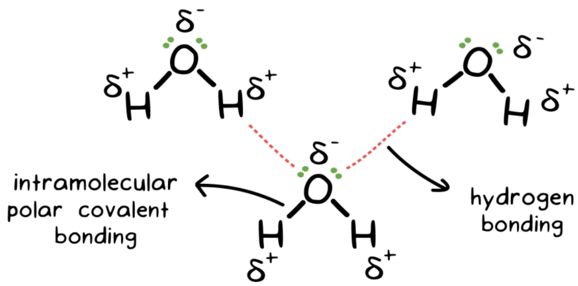
c) Hydrogen bonding

This is***a special kind of dipole-dipole interaction that occurs between a hydrogen atom bonded to a high electronegative atom***, specifically either an oxygen, nitrogen, or fluorine atom. The partially positive end of hydrogen is attracted to the partially negative end of the oxygen, nitrogen, or fluorine of another molecule. A hydrogen bond is usually represented as a dotted line between the hydrogen and the unshared electron pair of the other electronegative atom.

Hydrogen bonding is a relatively strong force of attraction between molecules, and considerable energy is required to break hydrogen bonds. This explains the exceptionally high boiling points and melting points of compounds like water and hydrogen fluoride.



Water molecules participate in multiple hydrogen-bonding interactions with nearby water molecules.



Intramolecular polar covalent bonding within H_2O molecules and hydrogen bonding between O and H atoms

2. Effect of intramolecular forces on physical properties of certain molecules

Intermolecular forces control how well molecules stick together. This affects many of the measurable physical properties of substances:

Melting and Boiling Points

- If molecules stick together more, they will be tougher to break apart
- Stronger intermolecular forces □ higher melting and boiling points

Viscosity

- Viscosity is a measure of how well substances flow.
- Stronger intermolecular forces □ higher viscosity.

Surface Tension

- Surface tension is a measure of the toughness of the surface of a liquid
- Stronger intermolecular forces □ higher surface tension.

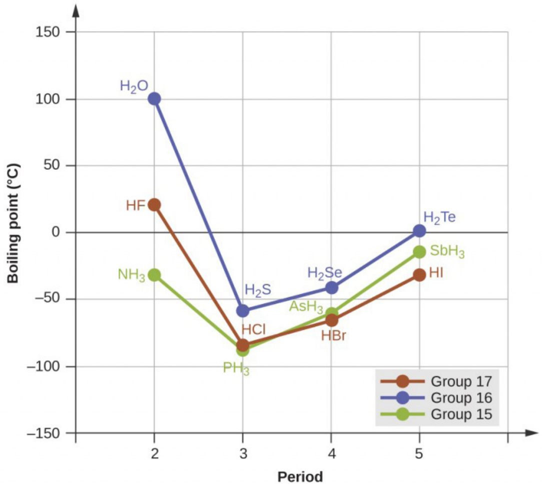
Vapour Pressure

- This is a small amount of gas that is found above all liquids.
- Stronger intermolecular forces □ Lower vapour pressure.

Note: 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). Here is the strategy for this:

- Look for molecules with ***hydrogen bonding***. They will have the strongest intermolecular forces.
- Look for molecules with ***dipoles***. These will have the next strongest intermolecular forces.
- Larger molecules will ***have stronger London dispersion forces***. These are the weakest intermolecular forces but will often be the deciding factor in multiple choice questions.

If we use this trend to predict the boiling points for the ***lightest hydride for each group***, we would expect NH_3 to boil at about –120 °C, H_2O to boil at about –80 °C, and HF to boil at about –110 °C. However, when we measure the boiling points for these compounds, we find that they are dramatically higher than the trends would predict, as shown in the figure below. The stark contrast between our naïve predictions and reality provides compelling evidence for the strength of hydrogen bonding.



Comparison of the melting points of some hydrides of groups 17, 16 and 15

These exhibit anomalously high boiling points due to hydrogen bonding. Hydrogen bonding is important in many chemical and biological processes. It is responsible for water's unique solvent capabilities. Hydrogen bonds hold complementary strands of DNA together, and they are responsible for determining the three-dimensional structure of folded proteins including enzymes and antibodies.

(1) An Example: Water

Since oxygen is more electronegative than hydrogen, oxygen pulls the shared electrons more closely to itself. This gives the oxygen atom a slightly more negative charge than either of the hydrogen atoms. This imbalance is called a dipole, causing the water molecule to have a positive and negative side, almost like a tiny magnet. Water molecules align so the hydrogen on one molecule will face the oxygen on another molecule. This gives water a greater viscosity and also allows water to dissolve other molecules that have either a slightly positive or negative charge.

(2) Protein Folding

Protein structure is partially determined by hydrogen bonding. Hydrogen bonds can occur between hydrogen on an amine and an electronegative element, such as oxygen on another residue. 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.

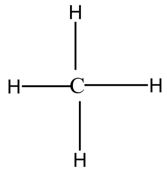
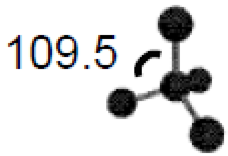
(3) DNA

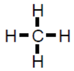
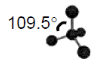
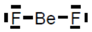
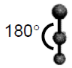
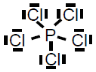
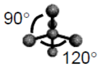
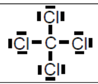
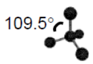
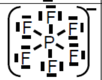
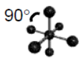
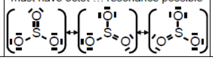
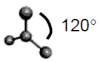
Hydrogen bonds hold complementary strands of DNA together. Nucleotides pair precisely based on the position of available hydrogen bond donors (available, slightly positive hydrogens) and hydrogen bond acceptors (electronegative oxygens). The nucleotide thymine has one donor and one acceptor site that pairs perfectly with the nucleotide adenine's complementary acceptor and donor site. Cytosine pairs perfectly with guanine through three hydrogen bonds.

11.9. Additional activities

11.9.1. Remedial activity

1. By applying rules, complete the table that follow the Lewis structure of compounds in the column A. Ignore columns C, D, E and F

A. Molecule	Show your working here	B. Lewis structure (use rules for drawing Lewis structures)	C. Build molecule sketch, & give bond angles	D. Number of peripheral atoms	E. Bond angles (list all)	F. Name
CH_4				4	109.5°	Tetrahedral
BeF_2						
PCl_5						
CCl_4						
PF_6^-						
SO_3						

1. CH_4			4	109.5°	Tetrahedral
2. BeF_2	$2 + 7 \times 2 = 16$, $16 - 4 - 12 = 0$ Note: Be is exception to octet rule 		2	180°	Linear
3. PCl_5	$5 + 7 \times 5 = 40$, $40 - 10 - 30 = 0$ 		5	120°, 90°	Trigonal bipyramidal
4. CCl_4	$4 + 7 \times 4 = 32$, $32 - 8 - 24 = 0$ 		4	109.5°	Tetrahedral
5. PF_6^-	$5 + 7 \times 6 + 1 = 48$, $48 - 12 - 36 = 0$ 		6	90°	Octahedral
6. SO_3	$6 + 6 \times 3 = 24$, $24 - 6 - 18 = 0$. S must have octet … resonance possible 		3	120°	Planar triangular

11.9.2. Consolidation activity

1. 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

   Answers:

   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).

   $\overset{\delta+}{C}—\overset{\delta-}{O}$ $\overset{\delta+}{C}—\overset{\delta-}{Cl}$ $\overset{\delta+}{C}—\overset{\delta-}{Br}$ $\overset{\delta+}{C}—\overset{\delta-}{N}$ $\overset{\delta+}{H}—\overset{\delta-}{Br}$

   $\overset{\delta-}{N}—\overset{\delta+}{H}$ $C—C$

2. a) The ammonium ion, NH_4^+, and the hydroxonium ion, H_3O^+ and CO 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.

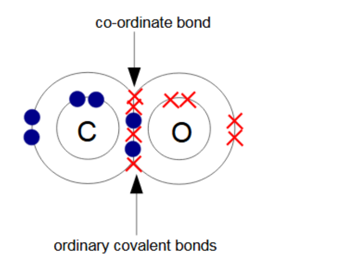
   b) Draw a dots-and-crosses diagram for the ion H_2F^+.

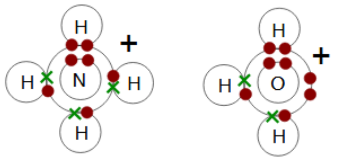
3. a) Aluminium chloride sublimes (turns directly from a solid to a gas) at about 180°C.Measurements of its relative molecular mass show that its formula is Al_2Cl_6 in the vapour at that temperature. Draw a dots-and-crosses diagram (showing outer electrons only) to show how the aluminium chloride is bonded in Al_2Cl_6.

   b) Ammonia, NH_3, and boron trifluoride, BF_3, combine to make a compound $NH_3.BF_3$. Draw a dots-and-crosses diagram (showing outer electrons only) to show the bonding in this new compound.

Answer

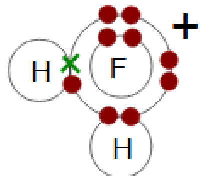
2. a)

	The question didn't allow you to just draw the outer electrons! In that case, if you don't put all the electrons in, you risk losing a mark. You have to read the question carefully

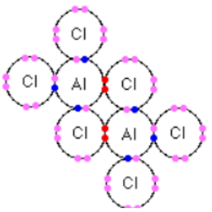
	In the diagrams below, the bonds consisting of two red dots are the co-ordinate bonds. The ordinary covalent bonds have a dot and a cross

In the first diagram, it doesn't matter which bond you show as the co-ordinate one. It doesn't matter where you attach the three hydrogens around the oxygen in the second diagram, as long as you show one co-ordinate and two simple covalent bonds.

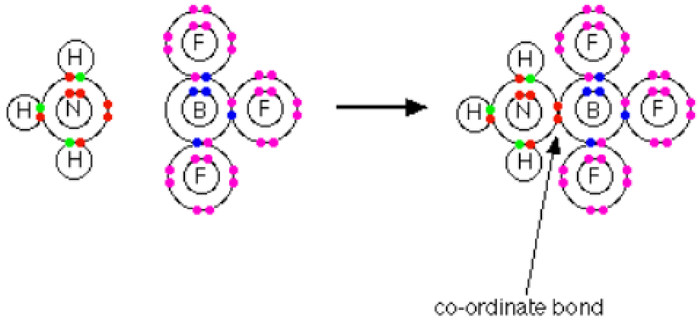
b)

	Again, it doesn't matter where you attach the two hydrogens around the fluorine, or which bond you show as the co-ordinate one.

3. a)

	It doesn't matter if you haven't colour-coded everything as long as it is obvious that the two bonds drawn here with red electrons are different from the other bonds.

b)



You only need the structure of the product, and you don't need to point out the co-ordinate bond, but it must be clear that both electrons in the bond are coming from the nitrogen. You don't need to draw the inner electrons.

11.9.3. Extended activities.

1. . Explain what it is about water that enables it to form co-ordinate bonds.
2. Write electronic structure of Mg and Mg^{2+}. Explain why Mg^{2+} is very stable.
3. Which one of the following compounds is soluble or insoluble in water and explain your answer: $CH_3CH_2CH_2CH_3$, CH_3NH_2, $MgCl_2$
4. How many bonds are formed side by sideorbitals overlapping or head to head orbitals overlapping in CH_2=CH-CH_3

Answers:

1. H_2O has lone pair electrons while H has an empty orbital.
2. Mg: $1s^22s^22p^63s^2$, Mg^{2+}: $1s^22s^22p^6$
3. $CH_3CH_2CH_2CH_3$is insoluble in water because it is non polar.

   CH_3NH_2 is soluble in water because it is polar

   $MgCl_2$ is soluble in water because it is ionic compound
4. 1 pi bond formed side by side orbitals overlapping and 8 sigma bonds formed head to head orbitals overlapping.

The table below gives Pauling Values for Electronegativity:

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 ….
Fr 0.7	Ra 0.9	Ac-Lr 1.1-															

UNIT 12: FORMATION OF IONIC AND METALLIC BONDS

12.1. Key unit competence

Describe how properties of ionic compounds and metals are related to the nature of their bonding.

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

Student teachers 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.

12.3. Cross-cutting issues to be addressed

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 how to make informed decisions in their relationships. In summary, 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. Student teachers should know that some relationships are 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.

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.

This can be done in a short whole class discussion but some points can be given to student teachers as an assignment to be done during their free time. This may be a good entry point for the Integrated Sciences Tutor to confront the individual student-teachers who need advice on relationship matter.

12.4. Guidance on introductory activity

Ionic and metallic bonds are the principal bonds studied since in 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 tutor and for student teachers.
- In the introductory activity, there is a figure that shows different materials used in daily life.
- Use the introductory activity figure and related questions to make student teachers have primary knowledge about ionic and covalent bonding and compounds.

Answers for introductory activity

From figure 12.1.

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 student teachers 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.

12.5. 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	– Explain the formation of ionic bonds using different examples. – Describe the properties of ionic compounds.	3
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 12.1

Guidance on activity 12.1

- 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 12.1* which is specific to the first lesson.
- As you enter the class, inform the student teachers on the activity taking place.
- Ask learners to sit in groups of 4 to 5 student teachers and ask them to choose their group leader.
- Ask student teachers to read carefully the introductory activity, discuss on it and answer the related questions.
- Ask student teachers to read carefully the *activity 12.1* 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 12.1* and go through the class correcting.
- Give feedback basing on the answers given.

Answers for activity 12.1

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) Answers for application activity 12.1

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 12.2**

Guidance on activity 12.2

Refer to Learning activity 12.2 which is suggested in the student teacher's book

- Welcome the class to the new lesson.
- Form working groups of 4 to 5 student teachers depending on the size of your class.
- In the groups learners discuss, attempt *activity 12.2* and record their answers.
- Each group representative presents the Answers for his/her group to his/her classmates.
- You can make any corrections if any and provide *application activity12.1*.
- Make corrections with student teachers to make sure there are no misconceptions

Answers for activity 12.2

1. Before, one needed one electron to make pairs; another had only one which is like a burden, it needs to lose it. After, the one which needed to lose one gave it to the one which needed the one to make all electrons paired. Each became stable.
2. "Little" and "Big" in answering:
   a). "Little" is a metal because it needs to lose, its outer shell contains few electrons..
   b). "Little" belongs to group 1 and "Big" belongs to group 17 as shown by the number of electrons in the outermost shell.
   c). This is because it has lost the electron which was like a burden to it. It is positive because it has lost the electron and the number of protons became higher than that of electrons, so becomes positive.
   d). Group 18 (Noble gases), the group of elements with the filled outermost shell.

e) Answers for application activity 12.2

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, and they obey Octet Rule.

Lesson 3: Ionic bonding

a) Learning objectives

- Explain the formation of ionic bonds using different examples.
- 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 12.3

Guidance on activity 12.3

Refer to *Learning activity 12.3* which was suggested in the student teacher'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 12.3* and record their answers.
- Each group representative presents the Answers for 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 Activity12.3 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 for activity 12.3

a). Ionic bond is the bond formed between the metal and the non-metal atoms.

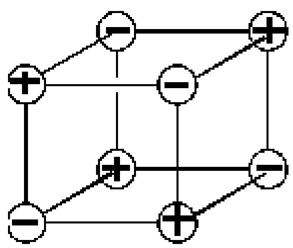
b). The properties of a table salt (of ionic compounds in general)

- Appearance: Crystalline solid
- Solubility: Soluble in water and insoluble in organic solvent
- Temperature required to melt: High (more than 100°C)
- Electrical conductivity: Solid does not conduct and its aqueous solution conducts.

e) Answers for application activity 12.3

1. Diagram of a part of the structure of sodium chloride.

   a). All charges marked

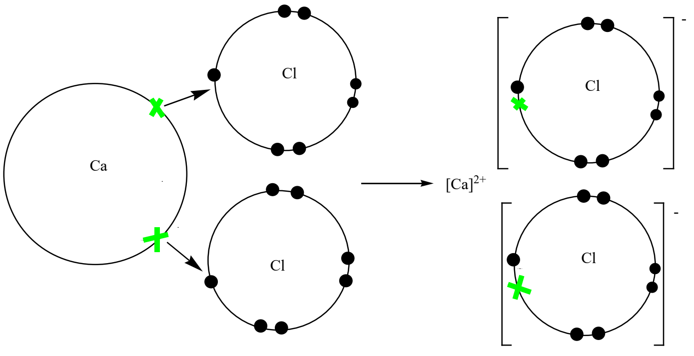


   b). The kinetic energy increases leading to the increase in motion of ions which go far apart between them and then the state changes from solid to liquid.

c). This electron comes from sodium.

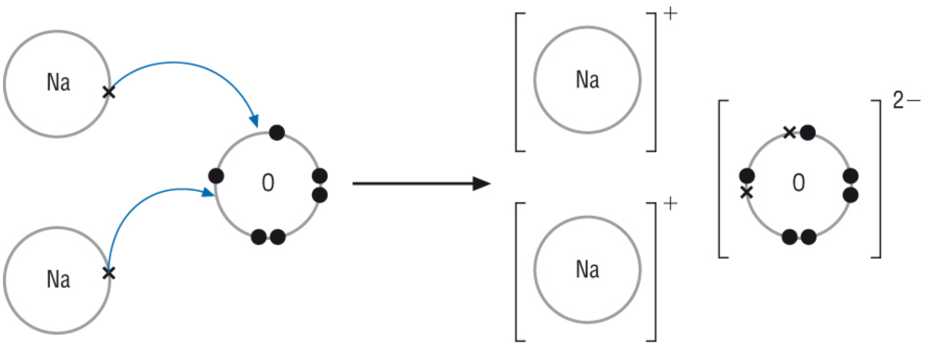
2. Diagrams illustrating the formation of ionic compounds some substances:

a). Magnesium chloride

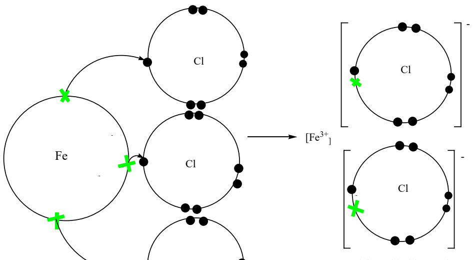


Calcium chloride ($CaCl_2$)

b). Sodium peroxide

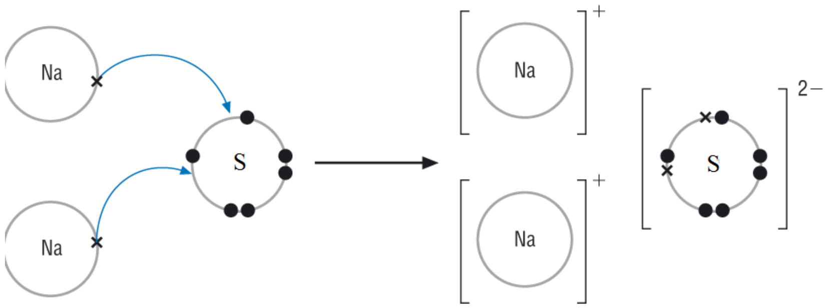


c). Iron (III) chloride



Calcium chloride ($FeCl_3$)

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 objectives

- 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 12.4

Guidance on activity 12.4

Refer to Learning activity 12.4 which is suggested in the student teacher's book.

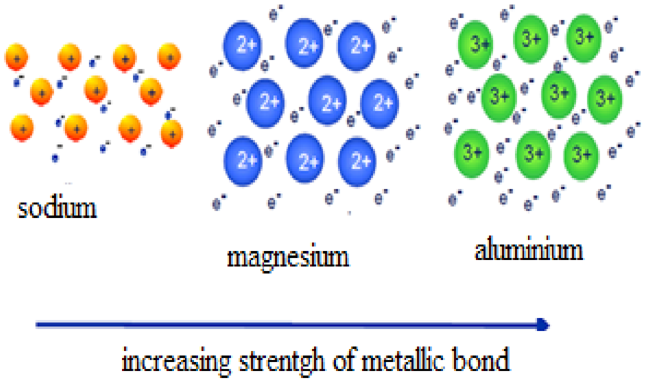
- Welcome the class to the new lesson.
- Form working groups of 4 to 5 learners depending on the size of your class.
- Assign the groups with tasks that can include group discussion or research.
- In the groups learners discuss, attempt *activity 12.4* and record their answers.
- Each group representative presents the Answers for 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 12.4.They should do the application activity in any method you wish to use.

Answers for activity 12.4

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 aluminum.



e) Answers for application activity 12.4

1. a) Magnesium has a higher melting and boiling point than sodium.

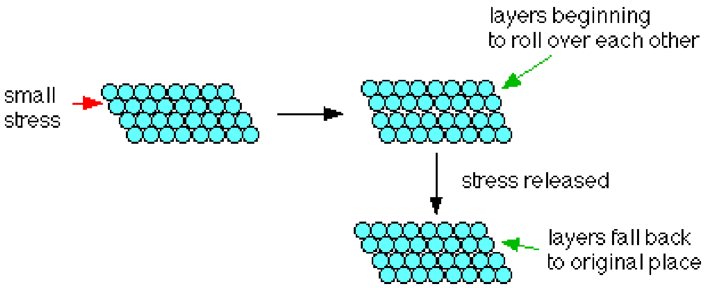
    - The electronic structures: Sodium has one outer electron which it can delocalize to form the metallic bond; magnesium has two. So with magnesium there will be a higher electron density in the bond. Magnesium also has an extra proton. There will therefore be stronger attractions between the nuclei and 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.

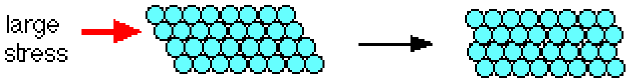
   c). Free electrons are able to transfer energy away from the heat source. This due to the presence of delocalized electrons that vibrate in fixed positions when heat energy is applied to one end of the metal hence allowing it to be conducted from one point to another.

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.

12.6. 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 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

12.7. Additional information for the tutor

“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.

12.8 Answers for 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 teacher Book to describe the nature and strength of the ionic bonding (in solid calcium oxide).

   b). *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.

   d). *At 25°C, CaO is a solid and the particles are in a regular lattice and only able to vibrate*

12.9. Additional activities

12.9.1. 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.

12.9.2. 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.

12.9.3. Extended activities

1. Sodium chloride and magnesium oxide have exactly the same structure. Their melting and boiling points are:

	NaCl	MgO
Melting point /K	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 13: THIN LENSES

13.1. Key unit competence

Explain the properties of lenses and image formation by lenses

13.2. 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.

13.3. Cross-cutting issues to be addressed

a) 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).

b) 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.

c) 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.

13.4. 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 13 in the student-teacher‘s book.
- Asks the groups to observe the pictures and answer the related questions.
- While student teachers 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 student teachers)
- Together with student teachers harmonize the points and make a summary on the board. Allow student teacher - teachers to write the main points in their notebooks

Linking to the summary and what have discussed in class, emphasize on thin lenses. You can take some minutes and explain them. 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 teacher - 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 student teachers 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 student teachers)

- Together with student teachers harmonize the points and make a summary on the board. Allow student teacher - teachers to write the main points in their notebooks
- Linking to the summary and what have discussed in class, emphasize on thin lenses. You can take some minutes and explain them.

13.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Types and characteristics of lenses	– Outline types of lenses and their properties. – Differentiate between lenses and curved mirrors	1
2	Refraction of light through lenses	– Explain the phenomenon of refraction of light by lenses	3
3	The thin lens equations	– Derive and apply the thin lens equations	2
4	Defects and corrections 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	– 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	3
6	Deviation by a prism and determination of refractive index	– 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 – Solve problems related to thin lenses and glass prism.	3
7	End unit assessment		1

Lesson 1: Types of lenses and their characteristics

a) Learning objectives

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

b) Prerequisites/ Revision/ Introduction

The student teachers will learn better this lesson if the tutor introduces it referring to light studied in O'level.

c) Teaching resources

Concave and convex lenses, bi-convex lens, plano-convex lens, bi-concave lens, plano-concave.

d) Learning activity 13.1

- **Guidance on activity 13.1**
  - 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 for activity 13.1

a). Concave, convex, biconcave and biconvex

b). Differ from their shapes and focal lengths

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

Answers for application activity 13.1

1. Refer to the summary of the activity 13.1
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.
   - Comments 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

Hand lens, convex and concave lenses

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 in previous lesson

d) Learning activity 13.2

- **Guidance on activity 13.2**
  - Help student teacher to work the experiment provided in activity
  - 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
- Together with student teachers harmonize the points and make a summary on the board. Allow student - teachers to write the main points in their notebooks
- Invite your student teacher to continue make a deep research on their practices.

Answers for activity 13.2

- 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

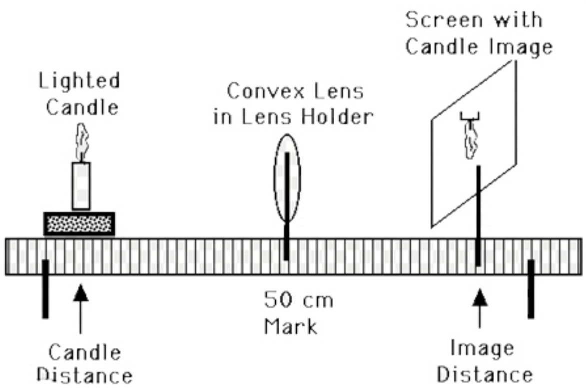
(ii) the objects are magnified

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

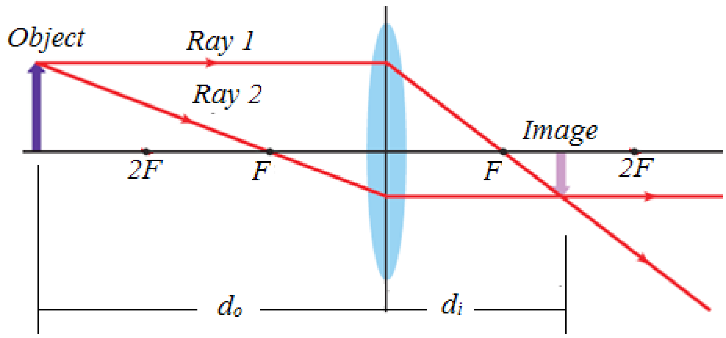
(iv) Rays come from all points on the objects. Where these rays meet or appear to meet after refraction by the lens is the position of the image.

e) Answers for application activity 13.2

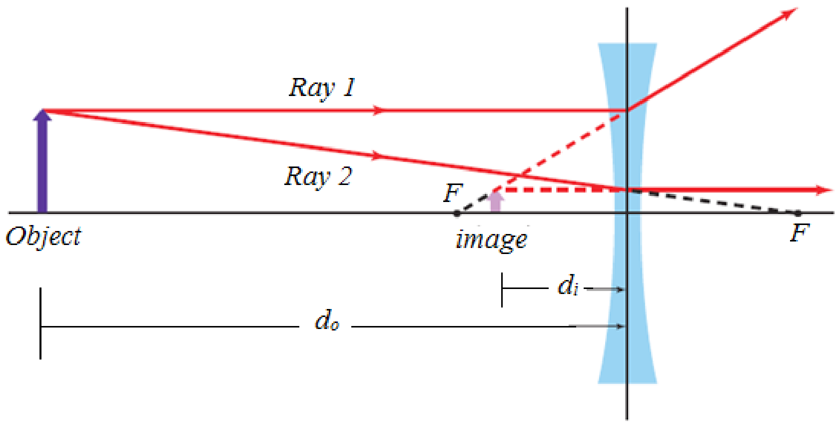
1. Refer to the summary of the activity 13.2 in student teacher text book
   - Guide student teacher to perform the experiment, remember to change focal length
   - Tell student teacher to write their observation



2. a). Converging or convex



b). Diverging or concave



Lesson 3: The thin lens equations

a) Learning objective

Derive and apply the thin lens equations

b) Teaching resources

Convex lenses, white screen, table

c) Prerequisites

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

d) Learning activity 13.3

- **Guidance on activity 13.3**
  - Let the student teacher - teachers carry out activity 13.3 in student teacher - teacher's book (if it is a mixed school, the number of boys and girls in each group should be balanced).
  - Arrange student teacher - teachers in groups (select any number of student teacher - teachers depending on the size of the class) make sure that they work in harmony.
  - Help them in selecting their group leaders.
  - Recognise student teacher - teachers with special needs in group making. Encourage them to actively participate in their respective groups.
  - Move around the class guiding student teacher - teachers as they are performing the activity. In case of any assistance you can make bright student teacher - teachers to assist the weak ones.
  - Let the student teacher - 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 teacher - teachers' ideas
  - 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 for activity 13.3

Task 1:

Facilitate student teachers to do the experiment provided in the **activity 13.3.**

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 13.2

e) Answers for application activity 13.3

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 and corrections of lenses

a) Learning objectives

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

b) Teaching resources

Glass ruler, computer, projector, convex lenses and a white sheet of paper

c) Prerequisites

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

d) Learning activity 13.4

- **Guidance on activity 13.4**
  - Provide the student teachers with a ruler and a white sheet of papers.
  - Instruct the student teachers to do activity 13.4 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 for activity 13.4

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) Answers for application activity 13.4

i). Refer to the summary of the activity 13.4

- 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

a) Learning objectives

- 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

b) Teaching resources

Prisms, flip chart, protractor, computer, projector, white sheet of paper, optical pins, drawing pins and soft board.

c) Prerequisites/Revision/Introduction

The student teacher will revise on reflection and refraction rays diagram, refraction of light

d) Learning activity 13.5

- **Guidance on activity 13.5**
  - Ask student teacher if they have ever seen a glass prism.
  - Facilitate the student teacher in group formation in physics laboratory.
  - Guide them in their discussions about the activity 13.5 in student teacher textbook
  - Provide the student teacher with an equilateral glass prism
  - Let student teacher 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 student teachers.

Answers for activity 13.5

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 for application activity 13.5

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.

Lesson 6: Deviation by a prism and determination of refractive index

a) Learning objectives

- 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
- Solve problems related to thin lenses and glass prism.

b) Teaching resources

Glass prism, optical pins, white sheet of paper, soft board and fixing pins

c) Prerequisites/Revision/Introduction

The student teachers revise on refraction through prisms and related calculations

d) Learning activity 13.6

- **Guidance on activity 13.6**
  - Help student teacher to work the experiment provided in activity 13.6 in student-teacher book**.**
  - Guide the experiment and distribute the TLMs according to the group formation

- 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
- Together with student teachers harmonize the points and make a summary on the board. Allow student teacher - teachers to write the main points in their notebooks
- Invite your student teacher to continue make a deep research on their practices.

Answers for activity 13.6

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;

   $$D = \left(i_1 + i_2\right) - A$$

e) Answers for application activity 13.6

1. When the ray is incident on the interface separating the two medium normally to the interface ie when the angle of incidence is zero. In this case there is no deviation from the original path. If angle of incidence is zero, then the angle of refraction is also zero.

2. 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,

   $$\sin i_1 = nSinr_1$$
   $$\sin 35^0 = 1.52 \sin r_1$$
   $$\sin r_1 = \frac{0.57}{1.52}$$
   $$r_1 = 23^0 \qquad (2)$$

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

Also relation between apex angle and angle of reflection is

$$A = r_1 + r_2 \rightarrow r_2 = 60^0 - 23^0 = 37^0 \qquad (3)$$

Applying Snell's law for emergent ray (i2) in prism,

$$\sin i_2 = nSinr_2$$

$$\sin i_2 = 1.52 \sin 37^0$$

$$i_2 = 66^0 \qquad (4)$$

Angle of deviation (D) is given by:

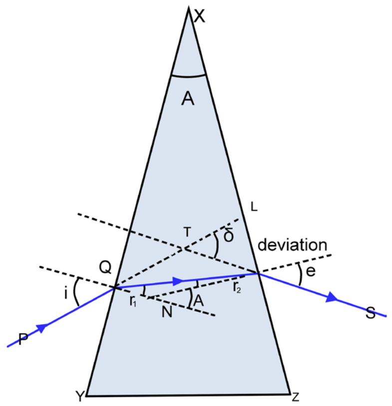
$$D = i_1 + i_2 - A$$

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

3. 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.

4. 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

$$D = (i - r_1) + (e - r_2) = (i + e) - (r_1 + r_2) \qquad (1)$$

At face AB,

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

Since angle of incident is small then,

Equation 2 becomes

$$n = \frac{i}{r_1} \rightarrow i = nr_1$$

Similarly at face AC,

$$e = nr_2$$

Substituting value of i and e in (1) we get

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

Where

$$(r_1 + r_2) = A$$

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

13.6. 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 moulded 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

As with everything in physics, the way to make more exact predictions is through an equation. In this case, the thin lens equation. It looks something like this:

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

And it works, unsurprisingly, for lenses that are thin. 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.

But to be able to use this equation properly, we need to understand the sign conventions for it. Negative and positive signs mean something specific with this equation. A positive focal length means that the lens is a converging lens (or in other words, it's convex), and a negative focal length means that the lens is a diverging lens (or concave). And if the image distance is positive, it means that the image is a **real image**, or in other words, the image is formed on the opposite side of the lens as the object, allowing you to project it onto a screen. On the other hand, if the image distance is negative, the image is a **virtual image**, meaning that the image is formed on the same side of the lens as the object, so that you can't project it onto a screen. These sign conventions are important both when plugging numbers into the equation and when interpreting the answers you get out of the equation.

Lens maker's equation

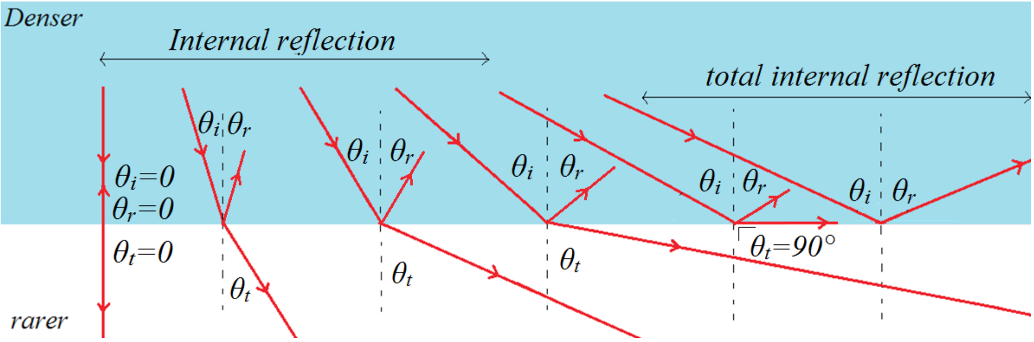
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

13.7. Additional Information for the 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"**.

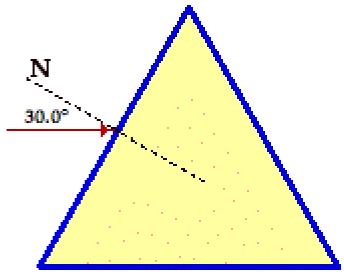


The angle of refraction may reach or approach 90° for some incident angle θ_c which is called **"critical angle"**. For incident angles greater than the critical angle there will be **"total internal reflection"** to mean that no part of light refracts. The critical angle can be calculated from Snell's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

$$n_i sin\theta_i = n_r sin\theta_r$$
$$n_1 sin\theta_c = n_2 sin90$$
$$n_1 sin\theta_c = n_2 x1$$

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

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.

13.8 Answers for end unit assessment

1. *concave→**virtual**→upright→**smaller***

   *convex→virtual→upright→**larger***

   *convex→real→**inverted**→**smaller***

2. The answer is found in **13.4** in student-teacher's book

3. Answer

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

4. Answer

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

The image is 30 cm in front of the lens

5. Answer

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

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

$$\frac{h_i}{h_0}=-\frac{d_i}{d_0}\rightarrow h_i=-\frac{d_i}{d_0}\times h_0=-\frac{(-8.33cm)(2cm)}{50cm}$$
$$h_i=0.33cm$$

6. Answer

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

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

The lens is converging

c). Power of the lens is

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

13.9. Additional activities

13.9.1 Remedial activities

1. Find the reflective index of the material of prism, if a thin prism of angle A is equal to 6 degree, produces a deviation is equal to 3 degree.

Answer:

For thin prism

D =A(n-1)

$$n=\frac{D}{A}+1=\frac{3}{6}+1=1.5$$

13.9.2. Consolidation activities

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

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

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

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

ii). The properties of the image:

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

3. A beam of monochromatic light is incident at i = 50° on one face of an equilateral prism, the angle of emergence is 40°.Calculate the angle of minimum deviation

Answer

The angle of deviation is given by:

$$i + e = A - D$$

For angle of minimum deviation , thus

$$2i = A - D_m \rightarrow 2(50)^0 = 60^0 - D_m$$

$$D_m = 40^0$$

13.9.3. Extended activities

1.

a). An object 34.5 cm in front of a certain lens is imaged 8.20 cm in front of that lens (on the same side as object). What type of lens is this, and what is its focal length? is the image real or virtual?

b). If the image were located, instead, 41.5 cm in front of the lens, what type of lens would it be and what focal length would it have?

c). We find the focal length of the lens from $\left(\frac{1}{d_0}\right) + \left(\frac{1}{d_0}\right) = \frac{1}{f}$

$$\left(\frac{1}{34.5cm}\right) + \left[\frac{1}{(-8.20cm)}\right] = \frac{1}{f}$$

which gives *f*=-10.8 cm

the lens is **diverging**

The image is in front of the lens, so it is **virtua**l

d). We find the focal length of the lens from $\left(\frac{1}{d_0}\right) + \left(\frac{1}{d_0}\right) = \frac{1}{f}$

$$\left(\frac{1}{34.5cm}\right) + \left[\frac{1}{(-41.5cm)}\right] = \frac{1}{f}$$

which gives

so, it is **converging lens**

The image is in front of the lens, so it is **virtua**l

2. A 60^0 prism has a refractive index of 1.5. Calculate the angle of incidence for minimum deviation, the angle of emergence of light at maximum deviation and angle of maximum deviation.

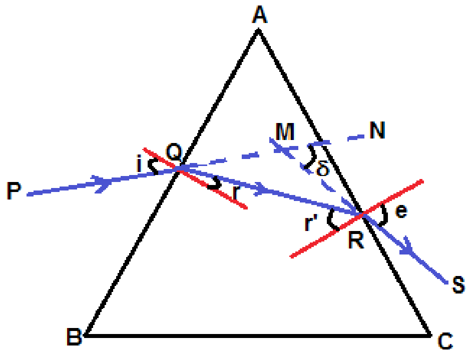
Answer

The formula relating refractive index, Angle of prism and angle of minimu deviation is

$$n = \frac{\sin\left[\left(A + D_{m)}\right)/2\right]}{\sin\left[A/2\right]}$$

where **n is the refractive index, A is angle of prism and** D_m **is minimum angle of deviation by substituting A = 60°, n =1.5 and solving for** D_m we get, $D_m = 37.2°$.

Maximum angle of deviation occurs when incident angle i is 90°.



As shown in figure, angle of deviation D is given by, **D =** i + e - A......(1)

also we have, r + r' = A .... (2)

$$n = \frac{1}{Sin\ r};\ \ sin\ r = \frac{1}{1.5};\ \ \ hence\ r = 41.8^0$$

for maximum angle of deviation, from eqn.(2), r' = A-r = 60 - 41.8 = 18.2° to get angle of emergence e, we have

$$n = \frac{\sin e}{\sin r'};$$

$$\sin e = n \sin r' = 1.5 \sin\left(18.2\right)^0 = 0.4685 \rightarrow e = 27.94^0$$

from eq.(1), we get maximum angle of deviation,

$$D = 90^0 + 27.94^0 - 60^0 = 57.94^0$$

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-teacher will learn better about asexual and sexual reproduction in plants if he/ she knows or remembers the following:

- The parts of the plants that intervene in reproduction(plant anatomy)
- The structure of flower and its adaptations for reproduction
- Draw a plant with all parts
- Manipulate 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 fertilisation, we also need each other.

a) Financial education

This cross-cutting issue should be integrated in the subheadings which require observing micrographs under microscope. 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.

b) 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 activity, 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.

c) **Inclusive education**

This cross-cutting issue should be integrated in all subheadings. When forming groups for Learning activity, 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 teacher without arms and legs; tutor and other student teacher-tutors should help them to achieve the competences as required in all teaching-Learning activity.

14.4. Guidance on introductory activity

- 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-tutors so that they may share their thoughts. Use student teacher-tutors' ideas and then introduce a whole unit.
- Provide the chart, books or micrographs with student teacher-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-teachers the time to present their findings.
- Receive answers and ideas from student-teachers and summarize them by valuing student teacher-tutors' contributions.
- Inform student teacher-tutors about the general knowledge, skills and values that they will get from this unit.
- Student teacher-tutors 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	Periods
1	**Asexual reproduction** (Application of Vegetative and artificial propagation in flowering plants and in growing improved varieties of plants)	– 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	1
2	**Sexual reproduction** (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 Fruit and seed dispersal with their adaptations	– 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	6
	End unit assessment		1

Lesson1. Application of artificial propagation in growing improved varieties of plants

a) Learning objectives

- Describe the characteristics of vegetative and artificial 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 14.1 given in student teacher textbook.

d) Learning activity 14.1

- **Guidance on activity 14.1**

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 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 student teachers' 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 student teachers to attempt all given application activities.

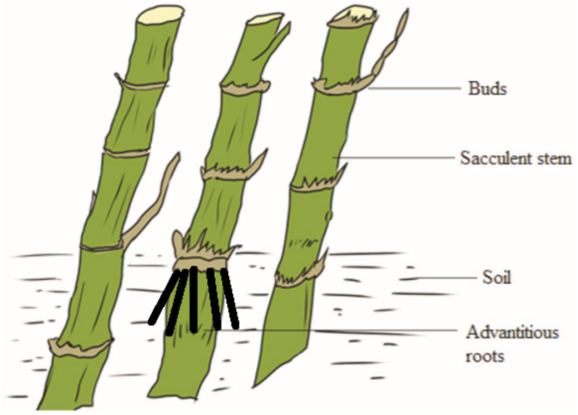
Answers for activity 14.1a

Answers are under the unit 14 (lesson one) in student-teacher book.

Answers for activity 14.1b

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.



e) Answers for application activity 14.1

1. Cutting, layering, and grafting.

2. It is an easier to get many plants in a short time, less expensive and a rapid method of propagation

3. External plant structures such as leaves, stems, roots, flowers, fruits, and seeds are known as plant organs. Each organ is an organized group of tissues that works together to perform a specific function. These structures can be divided into two groups: sexual reproductive and vegetative. Vegetative parts include roots, stems, shoot buds, and leaves; they are not directly involved in sexual reproduction. Vegetative parts often are used in asexual forms of reproduction such as cuttings, budding, or grafting

4. Artificial vegetative propagation is a type of plant reproduction that is accomplished through artificial means involving human intervention.

The most common types of artificial vegetative reproductive techniques involve cutting, layering, grafting, suckering, and tissue culture. These methods are employed by many farmers and horticulturists to produce healthier crops with more desirable qualities.

Lesson 2: Sexual reproduction in plants

a) Learning objectives

- Describe the types and structure of flowers
- Describe pollination and fertilization in flowering plants
- Explain the events that take 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 student teachers with disabilities. You can also use the student-teachers' text books.

c) Prerequisites/Revision/Introduction

For a successful teaching-learning process of this lesson, student teachers should have enough knowledge on plant anatomy and plant physiology.

d) Learning activity 14.2

- **Guidance on activity 14.2**
  - Ask student teachers to form groups, and provide learning-materials to be used in the activity.
  - Ask student teachers in their groups to work on the Activity 14.2 from the student teachers' text books,
  - Monitor how the student teachers 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 student teachers 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 for activity 14.2

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. Answers are under the unit 14 (lesson two) in student-teacher book.

Answers for activity 14.2.2

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 mega gametophyte 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 for activity 14.2.3

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 for activity 14.2.4

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.

b). 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) Answers for application activity 14.2.1

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 for application activity 14.2.2

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 for application activity 14.2.3

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 for application activity 14.2.4

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 the tutor

- This unit contains more practical activities you are advised to work on before you got to teach them the student teachers in order to avoid the failure of any activities before student teachers.
- The longevity of lifecycle 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.

14.8. Answers for end unit assessment

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). False   b). False

2. Answers are:

   a). iv (stem)   d). ii (anthers)

   b). ii (carpel)   e). ii (fruit)

   c). c) ii (fruit)

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. Student teachers' 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.
6. 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.
7. The bright-coloured parts of the flower might attract insects and other animals for pollination.
8. Endosperm is the stored food supply in angiosperm seeds that nourish the embryo plant.
9. Fruit could not form on flowers that lack carpels, because fruits develop from the ovary, which is the part of the carpel.
10. 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.
11. 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.
12. They all benefit. Bees obtain a food source, and flowers have a mean of pollination.
13. The main advantage of cross-pollination is to increase variation of offspring.
14. 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.

15. 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.

16. Answers are:
    a). Mediterranean squirting cucumber;
    b). Sycamore or European maple;
    c). Coconut;
    d). Mistletoe.

14.9. Additional activities

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. Differentiate dioecious plants from monoecious plants.

Answers for 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. a) Vegetative reproduction is the formation of a new individual from any vegetative part of the plant body.

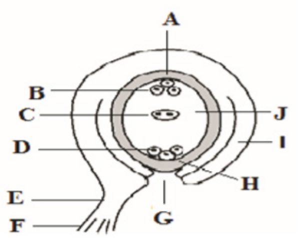
   b) Disadvantages of vegetative reproduction.

   - Year after year same variety is produced. New varieties cannot be produced by this method.
   - Since all the plants are genetically alike, they are susceptible to same diseases.
   - The plants when grown repeatedly may lose vigor.
   - Undesirable characters get transmitted from one generation to another.

4. 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).

14.9.2. Consolidation activities

1. State at least three differences between asexual and sexual reproduction.
2. Discuss the popular use of grafting.
3. Rose is propagated both by cutting and budding. What are the advantages of these methods?
4. Why do many angiosperms produce less pollen than conifers?
5. Name all parts labelled on the diagram below:



6. What is parthenocarpy?

Answers for consolidation activities

1.

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. 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.

3. 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.

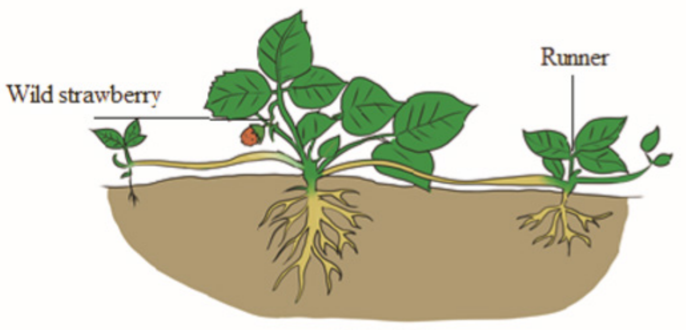
   ii). It can be easily practiced.

4. Many angiosperms are insect-pollinated whereas most conifers are wind-pollinated.

5. 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.
6. Parthenocarpy. It is when fruits mature without fertilization?
7. Answers are: a) A b) sporophyte.

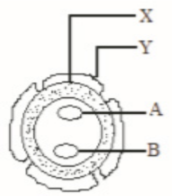
14.9.3. Extended activities

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 for 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.

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