INTEGRATED SCIENCE

FOR TTCs

YEAR ONE

TUTOR'S GUIDE

OPTIONS: Languages Education **(LE)**

&

Social Studies Education **(SSE)**

FOREWORD

Dear tutor,

Rwanda Basic Education Board is honoured to present tutor's guide for Integrated Science in Languages Education (LE) & Social Studies Education (SSE) options, 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' 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 of Rwanda Basic Education Board

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, Languages Education **(LE)** & Social Studies Education **(SSE)** options. It would not have been successful without active participation of different education stakeholders.

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

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

Joan MURUNGI,

Head of Curriculum, Teaching and Learning Resources Department

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PART I. GENERAL INTRODUCTION

1.0. About the tutor's guide

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

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

1.1. The structure of the guide

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

Overall structure

The whole guide has three main parts as follows:

- **Part I: General Introduction.**

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

- **Part II: Sample lesson plan**

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

- **Part III: Unit development**

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

Each unit is made of the following sections:

- **Unit title:** from the syllabus
- **Key unit competence**: from the syllabus

- **Prerequisites (knowledge, skills, attitudes and values)**

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

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

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

- **Guidance on the introductory activity**

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

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

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

- **End of each unit**

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

  - Summary of the unit which provides the key points of content developed in the student-teacher's book.
  - Additional information which provides additional content compared to the student-teacher's book for the tutor to have a deeper understanding of the topic.

- End unit assessment which provides answers to questions of the end unit assessment in the student-teacher's book and suggests additional questions and related answers to assess the key unit competence.
- Additional activities **:**(remedial, consolidation and extended activities)**.** The purpose of these activities is to accommodate each student-teacher (slow, average and gifted) based on end unit assessment results.

Structure of each sub heading

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

Lesson /Sub heading title 1: ……..

- **Prerequisites/Revision/Introduction:**

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

- **Teaching resources**

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

- **Learning activities**

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

- **Exercises/application activities**

  This provides questions and answers 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 activities disseminated in learner-centered rather than the traditional didactic approach. The student-teachers is evaluated against set standards to achieve before moving on.

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

Generic competence	**Examples of activities that develop generic competences**
Critical thinking	- Describe the relationship and interdependence of sciences - Observe, record, interpret data recorded during experiments - Identify and use the applications of integrated science concepts to solve problems of life and society
Research and Problem solving	- Research using internet or books from the library - Design a project for making bioplastics - Design a questionnaire for data collection during field visit

Innovation and creativity	- Create an experiment procedure to prove a point - Develop a graph to illustrate information - Design a data collection survey/questionnaire - Conduct experiments with objectives, methodology, observations, results, conclusions - Identify local problems and ways to resolve them
Cooperation, Personal and Interpersonal management and life skills	- Work in Pairs - Small group work - Large group work
Communication	- Organise and present in writing and verbally a complete and clear report of an experiment - Observe, record, interpret the results of a measurement accurately. - Select and use appropriate formats and presentations, such as tables, graphs and diagrams.
Lifelong learning	- Exploit all opportunities available to improve on knowledge and skills. Reading scientific journals to keep updated.

1.2.2. Addressing cross cutting issues

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

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

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

Cross-cutting issues	**Examples on how to integrate the cross-cutting issues**
Inclusive education	Involve all student-teachers in all activities without any bias. Eg: Allow a student-teacher with physical disability (using wheelchair) to take notes or lead the team during an experiment.
Gender	Involve both girls and boys in all activities: No activity is reserved only to girls or boys. Tutor should ensure equal participation of both girls and boys during experiments as well as during cleaning and tidying up related activities after experiments.
Peace and Values Education	During group activities, debates and presentations, the tutor will encourage student-teachers to help each other and to respect opinions of colleagues.
Standardization culture	- Some lessons involve carrying out experiments. Instruction should be clear for student-teachers to always check if they are not using expired chemicals or defective apparatus. - In addition, when performing experiments student-teachers have to record data accurately. - For tasks involving calculations, they have to always present accurate results.

Environment and sustainability	- In order to avoid the environment pollution, before, during or after experiments student-teachers avoid throwing away chemicals anywhere; special places or appropriate containers should be used. - Student-teachers also have to be aware of the impacts of the use of hydrocarbons as fuels, halogenoalkanes, and plastics on the environment.
Financial Education	When performing experiments, student-teachers are encouraged to avoid wasting chemicals by using the quantities that are just required. They are required to also avoid spoiling equipments and other materials…

1.2.3. Attention to special educational needs specific to each subject

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

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

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

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

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

Strategy to help student-teachers with developmental impairment:

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

Strategy to help student-teachers with visual impairment:

- Help student-teachers to use their other senses (hearing, touch, smell and taste) to play and carry out activities that will promote their learning and development.
- Use simple, clear and consistent language.
- Use tactile objects to help explain a concept.
- If the student-teachers has some sight, ask them what they can see. Get information from parents/caregivers on how the student-teacher manages their remaining sight at home.
- Make sure the student-teacher has a group of friends who are helpful and who allow the student-teachers to be as independent as possible.
- Plan activities so that student-teachers work in pairs or groups whenever possible.

Strategy to help student-teachers with hearing impairment:

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

Strategies to help children with physical disabilities or mobility difficulties:

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

- Encourage peer support friends can help friends.
- Get advice from parents or a health professional about assistive devices.

1.2.4. Guidance on assessment

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

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

Continuous/ formative assessment

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

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

Summative assessment

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

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

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

There are mainly four different learning styles as explained below:

a) Active and reflective learners

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

b) Sensing and intuitive learners

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

c) Visual and verbal learners

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

d) Sequential and global learners

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

1.2.6. Teaching methods and techniques that promote the active learning

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

What is Active learning?

Active learning is a pedagogical approach that engages student-teachers in doing things and thinking about the things they are doing. In active learning, learners are encouraged to bring their own experience and knowledge into the learning process.

The role of the tutor in active learning

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

The role of learners in active learning

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

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

- Draws conclusions based on the findings from the learning activities.

Some active techniques that can be used in Integrated 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 students the relationship between classroom science lessons and applied sciences. This helps them see the link between science principles and technological applications.

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

Before the visit, the tutor and student-teachers:

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

After the visit

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

Main steps for a lesson in active learning approach

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

1) Introduction

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

2) Development of the new lesson

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

- **Discovery activity**

  Step 1

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

Step 2

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

❖ **Presentation of student-teachers' productions**

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

❖ **Exploitation of student-teachers's productions**

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

❖ **Institutionalization (summary/conclusion/ and examples)**

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

❖ **Exercises/Application activities**

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

3) Assessment

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

PART II: SAMPLE LESSON PLAN

School Name: NYAMATA TTC **Tutor's name**: MUNYEMANA Emmanuel

Term	**Date**	**Subject**	**Class**	**Unit N°**	**Lesson N°**	**Duration**	**Class size**
xxxxxxxx	xxxxxx	Integrated Science	Y1SSE	3	3 of 5	80 min	52

Type of Special Educational Needs to be catered for in this lesson and number of learners in each category	None
Unit title	**Cell structure**
Key Unit Competence	To distinguish between the structure of animal and plant cell
Title of the lesson	Preparation of temporary slides and ultrastructure of a cell
Instructional Objective	Using onion bulb, iodine and a razor blade student-teacher prepare correctly a slide with onion specimen on it, and accurately observe under light microscope a real structure of plant cell.
Plan for this Class (location: in / outside)	In laboratory
Learning Materials (for all learners)	Microscopes, onion, razor blade, iodine and a chart of plant and animal cell, manila paper, pencil and rubber
References	1. Rwanda Education Board (2015). Advanced Level Biology Syllabus (S4-S6). Kigali 2. Kent M. (2000). Advanced Biology. Oxford University Press, Oxford, UK. 3. Campbell, N.A, et al. (2008). Biology, Pearson international Edition, San Francisco, USA, 8th edition

Timing for each step	**Description of teaching and learning activity**		**Generic competences** and **Cross cutting issues** to be addressed **+ a short explanation**
	Tutor guide student-teachers in microscope adjusting to view the onion specimen and student teacher draw the plant cell structure examined under low and high power objective of light microscope.		
	Tutor activities	**Student-teacher activities**	

1. Introduction	Tutor brainstorms on what is related to viewing of smallest unit of living things: ✓ What is the function of a microscope? ✓ What is lens effect in microscope?	Student-teachers answers to the questions: • The microscope is one of the tools that allows to magnify an object to look at it in details. • The ocular lens is to re magnify the image for to see.	- **Critical thinking** through answering the questions asked by tutor - **Peace and value education** through answering the question
2. Development of the lesson: in 45 minutes			
2.1. Discovery activity	– Ask students teachers to form groups of three student teachers. – Provide materials and instructions to student teachers. – Monitor how the students are progressing towards to obtain the slide with a specimen for viewing cell structure.	– Student teacher form groups with gender balance and start to share responsibilities. – Student-teachers work collaboratively on the task of preparing of slide with specimen on it. 	**Generic competences**: – **Communication** through discussing in groups on given task – **Cooperation**, through working in groups – **Critical thinking** through examining the animal and plant cells through observing them on microscope, – **Creativity** By preparing them self a slide for viewing cell structure

	– Tutor guides student teacher to adjust the microscope to view the specimen.	Student-teacher observe specimen under low power objective then turn to high power objective 	– **Cross cutting issue**: – Peace and value through working in their respective groups – - Financial education through using the microscope, they will take care of it.
2.2 Presentation and exploitation of student-teacher findings	Tutor invites representatives of groups to presents their findings. Tutor appreciates the drawings of plant cell from all the groups Ask students teachers to evaluate the productions: which ones are correct, incomplete or false Judge the logic of the students' products, corrects those which are false, completes those which are incomplete, and confirms those which correct.	Student teacher draw the image of specimen of onion observed under light microscope. Then present plant cell illustration. – Give comments on productions. – Follow to the correction of tutor.	**Communication** through commenting on the presented findings

2.4.Conclusion & Assessment 20minutes	- Summarize the learned knowledge, and give more clarification on the learned content Engage students teachers to work individually on questions of the application activities in students teachers text books	- Participate actively in summarizing the content. Making short notes. Do exercises as indicated in students teachers text books	**- Communication** through paying attention on what others are saying through summary and writing skills through taking some notes. **Creativity** through working on application activities found on student teachers book**.** **Critical thinking** through doing application activities
Tutor self-evaluation			

PART III: UNIT DEVELOPMENT

UNIT 1:

HEALTHY NUTRITION

1.1. Key unit competence:

To explain the concept of the integrated science, prepare and serve a healthy diet.

1.2. Prerequisites

The student teacher will learn better this unit if he/she has the Knowledge, skills, values and attitudes related different science subjects for ordinary level, and able to use ICT tools like computer, XO laptop.

For the proper teaching learning process of this unity, student teachers should have enough knowledge on the food nutrients, and well skilled on how to test the food nutrients as they learned in senior two. They also know the process of digestion as they learned in senior three. They should have good attitudes and values about digestion and food nutrients.

1.3. Cross-cutting issues to be addressed

a) Inclusive education

This unit involves preparation of a balanced diet, where student teachers should collect and manipulate materials during this process. So, tutor should organize this activity in a way that can facilitate even student teacher with disability so that they can also be involved in these activities.

- Individual differences should be taken into consideration in solving different activities for taking care on his/her ability.
- Tutor identify student teacher with special needs in group making and encourage them to actively participate during learning process.

b) Gender education

Emphasize to student teacher that anybody irrespective of their gender should participate actively during learning activities. Give examples of some persons as a role model who are successful in real life without considering their gender. Make sure that during experiments both boys and girls shares and participates equally in their activities.

c) Peace and Values Education

During learning process, the tutor will encourage student teacher to help each other and to respect opinions of colleagues.

1.4. Guidance on introductory activity

– The tutor engages student teachers to work on the introductory activity 1, page **5** teacher-student's book. In small group, student-teachers guided by tutor identify the main nutrients in different recipes and make a comparison of three families above about their diet.

– Tutor guides student teacher to analyze their diet at school and in respective families and compare with three families shown on page **8** student-teacher's book. Tutor asks student teacher to judge if the diet is balanced for all three families. Student teachers talk finally about guide lines required to cover this unit.

1.5. List of lessons/sub-heading

Unit 1: **Healthy nutrition**

Key unit competence: Explain the concept of the integrated science, prepare and serve a healthy diet

#	Lesson title	Learning objectives	Number of periods
1	Relationship between science subjects	- Define the concept of integrated science - Relate integrated science subjects	1
2	Macro nutrients	- List the principle sources of macro nutrients. - Classify macronutrients - State the importance of macro nutrients. - Justify the different functions of macro nutrients in the body	1

3	Micro nutrients	- List the principle sources of micro nutrients. - Classify micronutrients - State the importance of micro nutrients. - Justify the different functions of micronutrients in the body	1
4	Balanced diet and food service techniques	- Explain the importance of a balanced diet. - Explain how the condition factors affect the dietary needs of humans. - Organize the diet components in food groups. - Organize a list of foods that are good sources of specific food nutrients. - Prepare a balanced diet - Perform services techniques of healthy diet	2
	Assessment		1

Lesson 1: Relationship between science subjects

a) learning objectives:

- Define the concept of integrated science
- Relate integrated science subjects

b) Teaching resources

Charts on activity 1.1 in student teacher textbook, Computer, projector

c) Prerequisites/Revision/Introduction

The student teacher will have the prerequisite on the introduction of biology, chemistry, physics and other science subjects seen in ordinary level.

d) Learning activity 1.1

- Guidance

- The tutor invites the student teacher in formation of small group not more than four student teachers.
- The tutor presents to student teachers the chart indicated on **page 2** in student teacher textbook, or displays it using computer in smart classroom.
- Tutor lets student teachers, in their group work to brainstorm on the influences of the sun, NPK (manure), through the plant growth. Then, guides student teachers across respective group work.
- Student teachers provide and present findings from their respective groups
- Let student teacher consolidate through what their colleagues have presented
- Together with student teacher, conclude the lesson basing on the relationship between science subjects.

Answers to activity 1.1

1. The fertiliser NPK contains the major elements for plant growth and increase the fertility of the soil lacking nitrogen, phosphorus and potassium. Nitrogen as crucial component of chlorophyll helps in plant growth and development. It also positively affects the quality of leaves, seeds and fruits. Phosphorus helps plant in development (growth of roots and blooming, ect). Potassium helps plants growth, and is also active during photosynthesis. It is responsible of providing good quality of fruits as well.
2. Poor growth, short and spindly plant. You may also notice deaf of leaves and different patterns of damage to the leaves.
3. The plant uses the sun as the energy source for photosynthesis: **Sunlight** provides the energy **plants** need to convert carbon dioxide and water into carbohydrates and oxygen.
4. Farmer require knowledge from science subjects like physics, chemistry, biology, agriculture and geography

Answer to application activities 1.1

Science and languages: Student 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. Even though science is a practical subject, but it is very important to be able to express own views and ideas in clear and attractive form. For this purpose, it is necessary that students should have in- depth knowledge of language which they use.

Science with 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 or person intending to get advanced study of science subjects to have sound mathematical basis.

Lesson 2: Macro nutrients

a) Learning objectives:

- List the principle sources of macro nutrients
- Classify macronutrients
- State the importance of macro nutrients.
- Justify the different functions of macro nutrients in the body

b) Teaching resources

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

c) Prerequisites/Revision/Introduction

Students have knowledge about digested molecules of food, digestion process and testing biological molecules from the notion they got from ordinary level. These will help them to learn well this lesson.

d) Learning activity 1.2

- **Guidance**

Guided by the tutor, in small groups of 2 up to 4 student teacher will describe the components of food plates on the pictures from activity 1.2, **page 5** student teacher textbook.

- Facilitate student teacher in sharing about what their find out
- Invite one student teacher from each group to present to the whole class what they shared
- Together with student teacher consolidate on the results they got from their respective groups
- In their respective groups, let student teachers compare the food plate according to nutrients they have
- Tutor invite student teacher to make a deep analysis in identification of the main nutrients

Answer to activity 1.2

1. Early morning, 2.breakfast time, 3.lunch time, 4. Dinner time

2. Comparison of nutrients in recipes of a day:

① Vitamin C, Mineral salt (potassium) from lemon juice and mineral salt (sodium) from water;

② Vitamin A from vegetable juice; mineral (phosphorus, magnesium zinc,…) and vitamin B from 1 plate of vegetable oats; calories, cholesterol, fat, minerals (Na, K, Mg Ca,….),carbohydrates, proteins and vitamins (A,D,B-6) from egg; calories, fat, mineral (Ca, Mg, K), carbohydrates, proteins, vitamins (A, B-6, C) from avocado.

③ Calories, fat, cholesterol, mineral (Na, K and Mg), carbohydrates, proteins, vitamin B-6 from chicken soup; proteins and vitamins (B, thiamin,…) calories (fibers) , iron ect form cup of rice; proteins, minerals (Iron, Zinc, Na, Cu, Mn, k), vitamins (B3, V5,B6, B12, C, A, B complex from chicken/ protein, iodine, vitamins and minerals from chicken/ calories, cholesterol, fat, minerals (Na, K, Mg Ca,….),carbohydrates, proteins and vitamins (A,D,B-6) from egg and Calories and vitamin C from cup vegetables.

④ Calories and vitamin (C, A);proteins, carbohydrates, minerals (Na, K, Ca. iron) cholesterol and fat from cup raw vegetables salad; minerals (Ca, P, K, Iron,, Na,) calorie and protein from chapatti; proteins and vitamins (B, thiamin,…) calories (fibers) , iron ect form cup of rice; Calories and vitamin C from cup vegetables; Calories , proteins, fat, Vitamins B3, B5 and B6) from 1 cup dal; little fat, minerals (little Na, Mg, P, Zn, Iron and other minerals); Calories , fat and proteins from cup curd.

3. Three main food groups

- Energy food group,
- Body building food,
- Protective food.

4. Yes,

Emphasize put on vegetables, fruit, grains and low fat dairy product; little meats, poultry, fish, beans egg and nuts; limits saturated and fats, sodium and added sugar and control portion sizes considered.

Lesson 3: Micro nutrients

a) Learning objectives

- List the principle sources of micro nutrients.
- Classify micronutrients
- State the importance of micro nutrients.
- Justify the different functions of micronutrients in the body

b) Teaching resources

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

c) Prerequisites/Revision/Introduction

Students have knowledge, skills, attitudes and values about digestion and testing biological molecules from the notion they got from ordinary level. These will help them to learn well this lesson.

d) Learning activity 1.2

- **Guidance**

- Guided by the tutor, in small groups of 2 up to 4 student teachers will describe the components of four food plates on the pictures from activity 1.2, **page 5** student teacher textbook.
- Tutor facilitates student teacher in sharing about what their find out from respective group. Invite one student teacher from each group to present to the whole class what they shared
- Together tutor with student teacher consolidate on the results they got from their respective groups
- In their respective groups, tutor lets student teachers to compare the plates according to food components and portion size of food. Using search engine to discuss on standard of absorption quantities of each nutrient. He/she invites student teacher to make a deep analysis in identification of the main nutrients.

Answers to application activity 1.2, page 17-18 student teacher book

1. A variety of food is composed by energy giving food, protective food and Body building food
2. Food groups:

Energy giving food	**Protective food**	**Body building food**
Table sugar, sweet potatoes, Irish potatoes, cassava, milk, rice, groundnuts, maize, millet, avocado, green grams, sorghum, yam, strawberries	Pineapple, wheat, tomato, cabbage, honey, guavas, cassava, milk, orange, groundnuts, green banana, millet, carrot, avocado, apple, peas, leafy vegetables, pawpaw, mango, green grams watermelon, yams, strawberries	Beans, milk, fish, groundnuts, millet, meat, green gram

Answers to application activity 1.3, page 19, student teacher book

1. In picture a vegetables are being cooked in water
2. No, because all fat soluble are cooked in oil
3. **a. Calcium deficiency** can occur at any age. Chronic **calcium deficiency** can result in rickets, osteoporosis and osteopenia. It may also cause disruptions in the metabolic rate and other bodily dysfunctions such as chest pains, numbness in fingers and toes, muscle cramps, brittle nails, dry skin and tooth decay.

   The magnesium low d**eficiency** may cause fatigue, muscle cramps, mental problems, irregular heartbeat and osteoporosis.

   b. Yes, it is a calcium deficiency symptom.
4. Respect of a good (balanced) family eating plan.

Lesson 4: Balanced diet and food service techniques

a) Learning objectives:

- Explain the importance of a balanced diet.
- Explain how the condition factors affect the dietary needs of humans.
- Organize the diet components in food groups.
- Organize a list of foods that are good sources of specific food nutrients.
- Prepare a balanced diet
- Perform services techniques of healthy diet

b) Teaching resources

A variety of different foods or a chart (page 24-25 student-teacher textbook) that comprises different food (body building food, energy giving food and protective food) or use a computer to display them in front of the whole class, Manilla paper, Markers.

c) Prerequisites/Revision/Introduction

The student teacher is perform the concept of macro nutrients and micro nutrients.

d) Learning activity 1.3

- **Guidance**

– Guided by the tutor, in small groups of 2 up to 4 student teachers identify each types of food plates on the pictures from activity 1.3, **page 19** student teacher textbook.

– Facilitate student teacher in sharing about what their find out in respective groups

– Invite one student teacher from each group to present to the whole class what they shared

– Together with student teacher consolidate on the results they got from their respective groups

– In their respective groups, let student teachers brainstorm on the functions of taking the different foods which comprises all three categories for a balanced diet.

– Tutor invite student teacher to make a deep analysis on how they can prepare a balanced diet at their home place.

Answer to activity 1.3

1 a. Recipe A contains energy giving food (in grains), body build food (in chicken meat\) and protective food (in vegetables).Then, recipe B contains only body build food (in chicken meat\) and protective food (in vegetables).

b. Energy giving food is lacking in recipe B, therefore B is not balanced diet

1. In case of negative energy **balance** can lead to a decline in metabolism, decreases in bone mass, reductions in thyroid hormones, reductions in testosterone levels, an inability to concentrate, and a reduction in physical performance. Yet a negative **energy balance** does lead to weight loss.

2. A healthy Eating Plan respects the following:
   - Emphasizes vegetables, fruits, whole grains, and fat-free or low-fat dairy products.
   - Includes lean meats, poultry, fish, beans, eggs, and nuts.

- Limits saturated fats found in food such as meat and dairy, and trans-fat found in food such as frozen pizza, snack food, cakes, fast food, vegetable shortenings, ect ; sodium, and added sugars.
- Controls portion sizes.

3. The following is an example of good family eating plan

- ✓ 1glass of water with half a lemon squeezed in it
- ✓ Glass of vegetable juice + 1 plate vegetable oats+ 2 whole egg + ½ avocado
- ✓ Bowl chicken soup + 1 cup rice + 2-3 pc chicken/Fish/1 egg + 1 cup vegetable
- ✓ 1 cup raw vegetable salad + 2 chapatti + 1 cup rice + 1 cup vegetable + 1 cup dal + 1 cup pulses vegetable + 1 cup curd

Answers to application activities 1.4

1. Student teachers assiduously observe the style meal service through illustration on page 25, student teacher textbook,
2. The traditional table service provides service for family members who are seated at table.
3. The illustrated style of service is "The English service" comparable to Rwandan style. It is a type of service known as "family style service" in which the big dish is placed in front of the host along with serving plate and family members serve themselves.

1.6. Summary of the unit

A healthy diet includes a mix of energy of giving foods, protective foods and body building foods. Each of the food group provides a range of nutrients, and all have a specific role in helping the body function.

MyPlate is a reminder to find your healthy eating style and built it throughout your lifetime. It the food guide, to help parents to figure on how to feed their kinds nutritious, balanced meals. Half your plate should be covered with fruits and vegetables.

The body needs a variety of foods approximately 40 different nutrients. These are found in the foods a person eats. No single food item supplies all the nutrients needed by the human body. The greater the variety of food we eat, the less chance we have of developing a deficiency or excess of any single nutrient. Foods should be selected according to the food pyramid guidelines to assure a variety of food and a well-balanced diet.

Source: google food guide pyramid

1.7. Additional Information for teachers

1. Recommended daily dietary allowances for pregnant and lactating women

Nutrient	Non-Pregnant	Pregnant*	Lactation*
Vitamin A (µg/d)	700	770	1300
Vitamin D (µg/d)	5	15	15
Vitamin E (mg/d)	15	15	19
Vitamin K (µg/d)	90	90	90
Folate (µg/d)	400	600	500
Niacin (mg/d)	14	18	17
Riboflavin (mg/d)	1.1	1.4	1.6

Nutrient	Non-Pregnant	Pregnant*	Lactation*
Thiamin (mg/d)	1.1	1.4	1.4
Vitamin B_6 (mg/d)	1.3	1.9	2
Vitamin B_{12} (µg/d)	2.4	2.6	2.8
Vitamin C (mg/d)	75	85	120
Calcium (mg/d)	1,000	1,000	1,000
Iron (mg/d)	18	27	9
Phosphorus (mg/d)	700	700	700
Selenium (µg/d)	55	60	70
Zinc (mg/d)	8	11	12

2. The table below outlines the number of serves of foods from each food group that pregnant women need to make sure they have enough energy and nutrients for themselves and for the growing baby.

Food group	Serves required during pregnancy	Examples of one standard serve
Vegetables and legumes/ beans	18 years or under: 5 19–50 years: 5	½ cup cooked vegetables ½ cup cooked or canned* beans, peas or lentils 1 cup green leafy or raw salad vegetables ½ cup sweet corn ½ medium potato or other starchy vegetables 1 medium tomato

Fruit	18 years or under: 2 19–50 years: 2	1 medium fruit, such as apple, banana, orange 2 small fruits, such as apricots, kiwi fruits or plums 1 cup diced or canned fruit (no added sugar) **Or only occasionally** 125ml (½ cup) fruit juice (no added sugar) 30g dried fruit (such as 4 apricot halves, 1 ½ tablespoons sultanas)
Grain (cereal) foods, mostly wholegrain and/or high-fibre varieties	18 years or under: 8 19–50 years: 8 ½	1 slice bread, ½ medium roll or flat bread (40 g) ½ cup cooked rice, pasta, noodles, barley, buckwheat, semolina, polenta, burghul or quinoa ½ cup cooked porridge, 2/3 cup wheat cereal flakes, ¼ cup muesli 3 crispbreads 1 crumpet
Lean meats and poultry, fish, eggs, tofu, nuts and seeds and legumes/ beans	18 years or under: 3 ½ 19–50 years: 3 ½	65 g cooked lean meats, such as beef, lamb, veal, pork, goat or kangaroo (90–100 g raw) 80 g cooked lean poultry, such as chicken, turkey (100 g raw) 100 g cooked fish fillet (115 g raw) or one small can of fish 2 large eggs 1 cup cooked or canned* legumes/beans, such as lentils, chickpeas or split peas 170 g tofu 30 g nuts or seeds, nut/seed paste*
Milk, yoghurt, cheese and/or alternatives, mostly reduced fat	18 years or under: 3 ½ 19–50 years: 2 ½	1 cup (250 ml) fresh, UHT long life, reconstituted powdered milk or buttermilk ½ cup (120 ml) evaporated milk 2 slices (40 g) hard cheese, such as cheddar ¾ cup (200 g) yoghurt 1 cup (250 ml) soy, rice or other cereal drink, with at least 100 mg of added calcium per 100 ml

1.8. Answers to end unit assessment

1. Eating the right amounts and kinds of foods gives energy and stamina for active life-styles. A nutritious diet provides for growth and maintenance of a healthy body and helps keep you mentally alert.
2. At every stage in life, good nutrition is essential for health with a balanced diet your body is more prone to diseases, infection, fatigue and poor performance
3. Biological factors include age, gender, growth, disease state, and genetic makeup. Nutrition is important to teenagers because adolescence is the period of the fastest and most growth you will experience. Adolescence is also a time when your lifestyle is probably a very active one. Body goes through numerous physical and hormonal changes during pregnancy. The way a mom nourishes herself and his/her baby, therefore enough nutrients is needed. The breastfeeding use a lot of energy and nutrients. A mom tries to eat regularly and include a wide variety of healthy foods. Good nutrition is important to both your growth and the energy you need to maintain an active lifestyle.
4. Refer to the summary content of the **activity 1.1, page 2-4** student teacher textbook
5. Refer to the summary content of the activity 1.2, page 5-17 student teacher textbook
6. The diet components are organized in energy giving food, protective foods and body build food.
7. Refer to the summary content of the activity 1.3, **page 20-25 in** student teacher textbook
8. The integrated science is important influencing most aspects of everyday life, including food, energy, medicine, transportation, leisure activities and more. It improves human life at every level.

1.9. Additional activities

1.9.1. Remedial activities

1. How do you call a diet containing right amount of energy, carbohydrates, proteins, fats, fiber, vitamins, minerals and water to fulfill requirement of body?

   Answer: It is a balanced diet

2. What gives to body in suitable amounts of Vitamins, minerals and proteins?

   Answer: Nuts gives to body suitable amounts of Vitamins, minerals and proteins

3. In adulthood energy needs should balance with diet to prevent weight gain. Why is this?

   Answer: Because they have stopped growing

4. Why do we need to eat a balanced diet?

   Answer: In order to keep our bodies to function properly

5. **What do you understand by the term"** Malnutrition "?

   Answer: Malnutrition mean under nutrition or over nutrition

1.9.2. Consolidation activities

1) List out saturated and unsaturated food items?

Answer:

- **Saturated fat:** Cheese, butter, deep fried foods, processed oil, fatty meats
- **Unsaturated or good fat:** Fish, olives, nuts and peanuts, vegetable oil

2) If you don't drink milk because of lactose Intolerance where you can get calcium?

Answer: If you are not consuming milk due to lactose intolerance, you can get calcium from fat-free cheese and yogurt, canned sardines, orange juice and cereals

3) Provide any essential fatty acids that must be derived from the diet

Answer: The essential fatty acids that derived from diet are Linoleic and alpha-linoleic acid.

4) Explain what is good and bad fat?

Answer: Fat is classified in two categories, saturated and unsaturated. Un-saturated fat is healthy and reduces the risk of heart disease while saturated and trans fat are bad and increase the risk of the heart ailment.

5) People over the age of 65 may have a poor appetite what this may affect?

Answer: Their nutritional intake

1.9.3. Extended activities

1) Explain what is the intake of protein in diabetic?

Answer: About 15- 20% of your daily calorie should come from protein. However, a diabetic patient won't have any difference in their sugar level with high intake of protein, so they can consume food rich protein unless they have CKD (Chronic Kidney Disease) related to diabetes.

2) Explain which egg is more nutritious white or brown?

Answer: Both eggs has same nutritional value; they are rich in protein, vitamin and most important nutrient choline which is responsible for brain development and function. One egg may provide half of your daily requirement of choline.

3) When should a child take vitamins? Explain your reason

Both children and adults should always strive to eat a healthy diet, full of various different naturally colorful vegetables and fruits (it is the substances that give color to our food that often contain the greatest value!) A nutritional supplement should be taken to improve the overall value of the diet, not to replace the necessity of healthy dietary choices. But because in our hectic lifestyle many people cannot, or do not make the healthiest choices, a basic nutritional supplement targeted towards children's increased nutritional needs makes good nutritional "insurance."

UNIT 2:

STRUCTURE OF AN ATOM AND ELECTRONIC CONFIGURATION

2.1. Key unit competence:

To describe the structure of an atom, calculate relative atomic mass and practice writing of electronic configuration using s, p, d orbitals.

2.2. Prerequisites

Student-teachers will be able to learn the content of this unit if they understand the concept of Atoms, elements and compounds S1 Chemistry Unit 5 and appreciate the role of atoms in the physical and chemical behavior of the matter.

2.3. Cross-cutting issues to be addressed

a) Inclusive education

This unit involves a number of formulae and graphs, the writing of formulae and drawing of diagrams. This may be challenging to students with visual impairment or visual difficulties.

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

- Every important point is written in large font size.
- For learners with **hearing difficulties**, the teacher has to encourage them to sit where they can hear easily.
- When teaching, speak loudly and ensure that all the learners can hear your voice. Avoid speaking hurriedly as this will make it difficult for learners with hearing difficulties to make sense of what you are saying.

Learners with mobility difficulties

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

Learners with reading difficulties

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

b) Gender

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

c) Peace and values education

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

2.4. Guidance on introductory activity

For this activity, the tutor forms groups of four student-teachers that are as heterogeneous as possible.

The tutor helps student-teachers to observe that the spheres (A, B &C) differ from the number of red and blue particles, even though all red and blue particles are the same in each sphere.

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

After presentation, the tutor decides to engage the class into exploitation of the student-teachers' findings.

After presentation the tutor asks the student-teachers to judge findings from different groups and harmonize their work.

The tutor summarizes their findings and introduce the new unit.

2.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Number of periods
1	Discovery and properties of sub-atomic particles (protons, electrons and neutrons)	- Outline the discovery of and properties of the sub-atomic particles Compare the properties of sub-atomic particles	1
2	Atomic mass, mass number and isotopes and calculation of relative atomic mass.	- Calculate the relative atomic mass of an element using isotopic masses and abundances	1
	Rules governing the electronic configurations	- Explain the principles of electronic configuration.	1
4	Electronic configuration	- Make the electronic configuration of elements and ions using s, p, and d orbitals	1
5	Assessment		1

Lesson 1: Discovery and properties of protons, electrons and neutrons

a) Learning objective:

Outline the discovery of the sub-atomic particles.

b) Teaching resources

Textbooks, internet connection, computer and projector, videos on the discovery of sub-atomic particles (if possible)

c) Prerequisites/Revision/Introduction

Student-teachers will learn better the discovery of the atom constituents and their properties if they have understood the concept “Atoms, elements and compounds” (unit 5 of S1).

d) Learning activity 2.1

- Before introducing the lesson, let the student-teachers therefore attempt activity 2.1
- As facilitator you are expected to guide learners through the following steps:

✓ Form groups of four and let the learners perform the activity 2.1

✓ Tutor provides to the student-teachers the right resources (textbook or website) to perform the activity 2.1.

✓ Tutor monitors how the student teacher are progressing towards the findings to be presented and facilitates those who are still struggling.

✓ Tutor supervises the presentation of findings from respective groups.

✓ Allow the rest of the class to evaluate the work of their colleagues

✓ From the findings, highlight, the content which is correct, point out the one that is incomplete or false

- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Both, tutor and student-teachers consolidate and summarize the content based on the findings from respective groups.

Answers to activity 2.1

Refer to the content on **page 28-30,** student-teacher textbook: Joseph John Thomson discovered electrons and Ernest Rutherford discovered the nucleus.

f) Answer to application activity 2.1, page 31 student-teacher textbook.

1) Comparison between the Thomson's and Rutherford's models of the structure of an atom.

Thomson's model	Rutherford's model
Negatively charged electrons and positively charged protons are embedded; i.e it is a plum pudding model	Negatively charged electrons are moving around the nucleus; i.e. It is a nuclear model
Position of the nucleus not specified	The atom has a small and dens centre

2) Answer the following questions without referring to any table.

a) Electrons, protons and neutrons

b) -1, +1, 0

c) Neutron

d) electron

3) They have no electric charge

Lesson 2: Atomic mass, mass number and isotopes and calculation of relative atomic mass

a) Learning objective:

Calculate the relative atomic mass of an element using isotopic masses and abundances

b) Teaching resources:

The Periodic Table of Chemical Elements

Charts illustrating isotopes of some elements

c) Prerequisites/Revision/Introduction

Students will learn better a concept of atomic number, mass number, and isotopic mass if they have understanding on: Definition of atomic number, mass number and isotope (S1 chemistry: unit 5)

d) Learning activity 2.2

- Before introducing the lesson, let student-teachers therefore attempt activity 2.2 which leads students to the second lesson of the unit
- As facilitator you are expected to guide student-teachers through the following steps:
  - ✓ Form groups of four and let the student-teachers perform the activity 2.2
  - ✓ Monitor how the learners are progressing towards the knowledge to be learned and assist those who are still struggling (but without communicating to them the knowledge).
  - ✓ Let some groups present their work to the class
  - ✓ Allow the rest of the class to evaluate the work of their colleagues
  - ✓ From the findings, highlight, the content which is correct, point out the one that is incomplete or false
  - ✓ Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
  - ✓ Summarize the contents by giving more examples.

Note: *the time allocated to this activity must as short as possible since the concept has been dealt with in O'Level so that enough time can be availed to the following lessons where news concepts are introduced. Do not spend time on the functioning of the mass spectrometer.*

Expected Answers to activity 2.2

The statement is true. Atoms of the same element may exhibit some physical properties like mass, density, velocity because even if they contain the same number of protons, they may contain different numbers of protons. Such atoms are known as **isotopes.**

Expected answers for application activities

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

Mass number = 35. There are therefore (35 – 17) neutrons. Because no charge is indicated, there must be equal numbers of protons and electrons, or 17 electrons.

For $^{37}_{17}Cl$: There are 17 protons, 20 neutrons, and 17 electrons per atom. These are isotopes of the same element Cl. Both have 17 protons, but they differ in their numbers of neutrons: one has 18 neutrons and the other has 20.

b) For $^{63}_{29}Cu$: Atomic number = 29. There are 29 protons per nucleus. Mass number = 63. There are 29 protons plus 34 neutrons.

Because no charge is indicated, there must be equal numbers of protons and electrons that is there are 29 electrons.

For $^{65}_{29}Cu$: There are 29 protons, 36 neutrons, and 29 electrons per atom. These are isotopes. Both have 29 protons, but they differ in their numbers of neutrons: one isotope has 34 neutrons and the other has 36.

2. a) $^{9}_{4}Be$ 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) Neutron

4. $A_r = 54 \times \frac{5.84}{100} + 56 \times \frac{91.68}{100} + 57 \times \frac{2.17}{100} + 58 \times \frac{0.31}{100} = 55.9076 \approx 56$

X is iron.

Lesson 3: Rules governing electron configurations

a) Learning objective

- Explain the principles of electronic configuration.

b) Teaching resources

The Periodic Table of Chemical Elements

Charts illustrating isotopes of some elements

Flip charts or smart board or chalk board

c) Prerequisites/Revision/Introduction

Students will learn better a concept of atomic number, mass number, and isotopic mass if they have understanding on: atomic structure, lesson 1 of this unit

d) Learning activity 2.3

- Form group of four students and let them do activity 2.3
- Choose randomly three representatives of all groups to present their findings.
- Allow some other students to comment about the findings presented by their colleagues.
- Give your feedback highlighting the quantum numbers used to describe electrons in orbitals and the main principles that are behind.
- Through different small verbal questions, help the students to make the conclusion themselves.
- Check the understanding level of the student-teachers by letting them do the application activity 2.3

Answers to activity 2.3: See student-teacher book, page 35

e) Answers to application activities 2.3

1) a) m_l = -2, -1, 0, +1,+2 b) m_l = -4, -3, -2, -1, 0, +1,+2, +3, +4

2) a) 5 b) 9

3) The occupation of sub-shells follows three principles namely the Pauli exclusion principle, the Aufbau Principle, and the Hund's rule (See student book)

Lesson 4: Electronic configurations of elements using s, p, d, f orbitals

a) Learning objectives

Make the electronic configuration of elements and ions using s, p, and d orbitals.

b) Teaching resources:

The Periodic Table of Chemical Elements, charts illustrating isotopes of some elements

Flip charts or smart board or chalk board

c) Prerequisites/Revision/Introduction

Students will learn accurately predict electron configuration if they have o good understanding on the concept of atomic orbital and the rules that govern electronic configurations.

d) Learning activity 2.4

- Form group of four students and let them do activity 2.4
- Choose randomly three representatives of all groups to present their findings.
    - Allow some other students to comment about the findings presented by their colleagues.
    - Give your feedback highlighting the different ways of arrangement of electrons in sub-levels and orbitals.
    - Through different small verbal questions, help the students to make the conclusion themselves.
    - Check the understanding level of the student-teachers by letting them do the application activity 2.4

Answers to activity 2.4

1. See student-teacher' book.
2. Electronic configuration of:
   a) Hydrogen (Z = 1): $1s^1$
   b) Lithium (Z = 3) : $1s^22s^1$
   c) fluorine (Z = 9) : $1s^22s^22p^5$
   d) magnesium (Z= 12): $1s^22s^22p^63s^2$
   e) phosphorus (Z = 15): $1s^22s^22p^63s^23p^3$
   f) calcium (Z = 20): $1s^22s^22p^63s^23p^64s^2$
   g) vanadium (Z=23): $1s^22s^22p^63s^23p^64s^23d^3$

e) Answers to application activities 2.4

1. Electronic structures

   K (Z=19), $1s^22s^22p^63s^23p^64s^1$

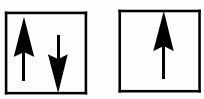
   Ne (Z=10), 1s22s22p6

   Al^{3+} (Z=13), 1s22s22p6

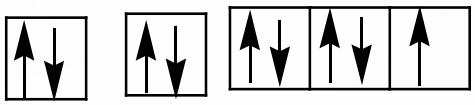
   Cl (Z=17), $1s^22s^22p^63s^23p^5$

   O^{2-} (Z=16), 1s22s22p63s23p2

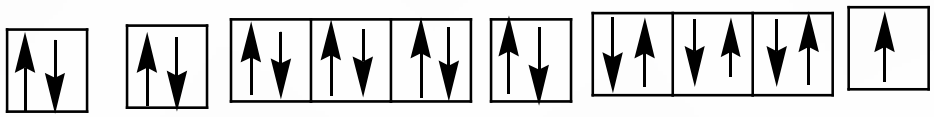
2. 2) Li (z= 3): Is^2 $2S^1$



F (z= 9): $1s^2$ $2s^2$ $2p^5$



K (z= 19): $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^1$



3) Mg^{2+} (z= 12): $1s^2\ 2s^2\ 2p^6$

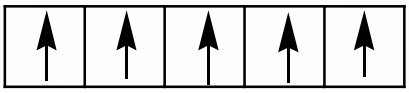
K^+ (z= 19): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

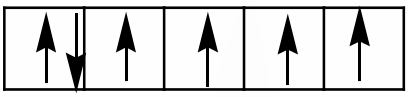
Al^{3+} (z= 13): $1s^2\ 2s^2\ 2p^6$

Cl^-(z= 17): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Br^-(z= 35): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 4s^2 3d^{10} 4p^6$

P^{3-}(z= 15): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

4) Fe^{3+}(z= 26): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0 3d^5$ 

Fe^{2+}(z= 26): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0 3d^6$ 

Fe^{3+} ion is more **stable** due to its half-filled $3d^5$ electron configuration. As half-filled and completely filled shells are more, **stable Fe^{3+} ion** is more **stable**. While **Fe^{2+}** is not **stable**.

Half-filled and full filled are more stable than others. **Fe^{3+}**has a half filled orbital and hence **Fe^{3+}**is more stable than **Fe^{2+}.**

Fe^{3+} is more stable than **Fe^{2+}**since **Fe^{3+}**has a half-filled 3d-orital whereas **Fe^{2+}**has neither full nor half-filled 3d-orbital.

2.6. Summary of the unit

Atoms are made up of protons, neutrons and electrons. Seeing that atoms are very small, the protons, neutrons and electrons are given relative atomic masses and charges.

The atomic number is the number of protons in the nucleus of an atom. The mass number is the total number of protons and neutrons in an atom.

Isotopes are atoms of the same element that have different numbers of neutrons. Isotopes of an element have identical chemical behaviour, but as they have different masses their physical properties are slightly different.

The **relative atomic mass (RAM)** of an element, $\mathbf{A_r}$, is the average of the relative isotopic masses of the different isotopes weighted in the proportions in which they occur.

Electrons are in principal energy levels. Each principal energy level is given a principal quantum number. Principal energy levels contain sub-levels that are of slightly different energies. Each different type of sub-level can hold a maximum number of electrons the sub-levels are assigned the letters s, p, d, f and so on. The shape of the periodic table depends upon the electronic structure of the elements. The blocks in the periodic table correspond to the filling of the different energy sub-levels.

The electrons are in the lowest available sub-level. The order of filling is 1s 2s 2p 3s 3p 4s 3s 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f 6d.

Sub-levels are split into orbitals, each of which contains a maximum of two electrons, the s, p, d and f orbitals have different shapes. Within a sub-level, electron-electron repulsion is reduced by having unpaired electrons in preference to paired electrons. When the transition metals form ions, it is the 4s electrons that are lost first.

2.7. Additional Information

- In 1913, physicist Niels Bohr described as an atom as a small, positively charged nucleus surrounded by electrons that travel in stationary circular orbits around the nucleus—similar in structure to the solar system, but with attraction provided by electrostatic forces rather than gravity. An electron must absorb or emit specific amounts of energy to transition between these fixed orbits.
- Despite its success in accounting for spectral lines of the H atom, the Bohr model failed to predict the spectrum of any other element. The model worked well for one-electron species, but not for atoms or ions with more than one electron.
- 1) According to Bohr, the circular orbits in which electrons revolve are planar.
- 2) Bohr's theory fails to account for Zeeman Effect and Stark Effect.
- 3) Bohr assumes that the electron revolves around the nucleus in circular orbits at fixed distance from the nucleus and with a fixed velocity.

- In 1926, Erwin Schrödinger used this idea to develop a mathematical model of the atom how electrons move in wave form, and developed the Schrodinger equation which describes how the quantum state of a system changes with time. This was the beginning of Quantum Mechanics (or Quantum Theory). A consequence of using waveforms to describe particles is that it is impossible to obtain precise values for both the position and velocity of a particle at the same time. This became known as the «uncertainty principle" formulated by Werner Heisenberg in 1926. This model was able to explain observations of atomic behaviour that previous models could not. Afterwards the planetary model of the atom was discarded in favour of one that described atomic orbital zones around the nucleus where a given electron is most likely to be observed.
- Thus, the quantum mechanical model is based on mathematics. Although it is more difficult to understand than the Bohr model, it can be used to explain observations made on complex atoms.
- Max Planck proposed that energy emitted is not done so in a continuous manner but is given off in small packets which he called quanta. He determined that an atom can emit only certain amounts of energy and therefore they must contain certain quantities of energy and that those are fixed. Thus, the energy of an atom is quantized. The change in the atom's energy results from the gain or loss of one or more packets of energy. Planck derived an equation to explain this quantized form of energy (as opposed to the idea that energy emitted was continuous)

$$E = hv$$

- where h = Planck's constant = 6.626×10^{-34} J•s and v = frequency (as above)
- According to quantum theory, energy is always emitted in integral multiples of hv; (hv, 2 hv, 3 hv . . .), but never, for example, 1.67 hv or 4.98 hv. At the time Planck presented his theory, he could not explain why energies should be fixed or quantized in this manner.
- Therefore, despite the fact that Planck thought that energy was quantized, physicists continued to think of energy as traveling in waves. Energy as waves, however, could not explain the photoelectric effect. The quantum mechanical model is based on *quantum theory*, which says matter also has properties associated with waves. According to quantum theory, it is impossible to know the exact position and momentum of an electron at the same time. This is known as the *Uncertainty Principle*.

- The quantum mechanical model of the atom uses complex shapes of *orbitals* (sometimes called *electron clouds*), volumes of space in which there is *likely* to be an electron. So, this model is based on probability rather than certainty.
- The existence of discrete atomic energy levels is retained from Bohr's model in the current atomic model.
- Four numbers, called *quantum numbers*, were introduced to describe the characteristics of electrons and their orbitals:
    - Principal quantum number: n
    - Angular momentum quantum number: ℓ
    - Magnetic quantum number:
    - Spin quantum number:

2.8. Answers to end unit assessment

1.
a) number of neutrons = 58-28 = 30

b) X= 100 - 26.23 -1.19 -3.66 -1.08= 67.84

c) Ar= $\frac{57.93 \times 67.84 + 59.9332 \times 26.23 + 61.9283 \times 3.66 + 63.9380 \times 1.08}{100} = 57.98$

2. Al: $1s^2 2s^2 2p^4 3s^2 3p^3$, it violate the buildup principle.

Correct electronic configuration: $1s^2 2s^2 2p^6 3s^2 3p^1$

B: $1s^2 2s^2 2p^5$, the total of the superscripts is greater than the atomic number of boron.

Correct electronic configuration: $1s^2 2s^2 2p^1$

F: $1s^2 2s^2 2p^6$, the total of the superscripts is greater than the atomic number of fluorine.

Correct electronic configuration: $1s^2 2s^2 2p^5$

3. a) There are 3 subshells in the n=3 level.

b) The subshells in the n=3 level are s, p and d.

c) There are 7 orbitals with n=4 and l=3

d) There are 1 orbital with n=3 and l=2 and m_l=-2

e) There are 16 orbitals in the level n=4

4. B is correct

A and D violate the Hund's rule

C violate both the Hund's rule and the Pauli Exclusion Principle

2.9. Additional activities

2.9.1 Remedial activities

1) Oxygen contains three isotopes ^{16}O, ^{17}O, and ^{18}O. Their respective relative abundances are 99.76%, 0.04%, and 0.20%. Calculate the relative atomic mass of oxygen.

Answer

Relative isotopic mass of ^{16}O is 16 and its relative abundance is 99.76%;

Relative isotopic mass of ^{17}O is 17, abundance 0.04%;

Relative isotopic mass of ^{18}O is 18, abundance 0.20%.

$$\text{Relative atomic mass of oxygen} = \frac{(99.76 \times 16) + (0.04 \times 17) + (0.20 \times 18)}{99.76 + 0.04 + 0.20} = 16.0044$$

2. Chlorine contains two isotopes ^{35}Cl and ^{37}Cl, what is the relative abundance of each isotope in a sample of chlorine if its relative atomic mass is 35.5?

Answer

$$35.5 = \left(\frac{A \times 35}{100}\right) + \left(\frac{100 - A}{100}\right) \times 37$$

Note that if the abundance of the isotope of atomic mass 35 is A%, the abundance of the isotope of mass 37 will be (100 – A) %.

$0.35A + (100 - A) \times 0.37 = 35.5$

$0.35A - 0.37A = 35.5 - 37$

$-0.02A = -1.5$

$A = 1.5/0.02 = 75$

Therefore, the abundance of the isotope of relative atomic mass 35.5 is 75% while that for the isotope ^{17}Cl is 100 – 75 = 25%.

3. Using the spdf notation, write the full electronic configuration of

a) Vanadium (Z = 23) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

b) Bromine (Z= 35): $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

Answer

a) Vanadium (Z = 23) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

b) Bromine (Z= 35): $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

2.9.2. Consolidation activities

1) Three isotopes of magnesium occur in nature. Their abundances and masses, determined by mass spectrometry, are listed in the following table. Use this information to calculate the relative atomic mass of magnesium.

Isotope	% abundance	Mass (amu)
^{24}Mg	78.99	23.98504
^{25}Mg	10.00	24.98584
^{26}Mg	11.01	25.98259

Answer:

Atomic weight = 0.7899 x 23.98504 + 0.1000 x 24.98584 + 0.1101x25.98259

= 18.946 + 2.4986 + 2.8607 = 24.30

2) The atomic weight of gallium is 69.72 amu. The masses of the naturally occurring Isotopes are 68.9257 amu for ^{69}Ga and 70.9249 amu for ^{71}Ga. Calculate the percent abundance of each isotope.

Answer:

. 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) Natural occurring lead contains 1.55% lead-204, 23.6% lead-206, 22.6% lead-205 and 52.3% lead -208. Calculate the relative atomic mass of lead.

$$Ar = 204 \times \frac{1.55}{100} + 206 \times \frac{23.6}{100} + 207 \times \frac{22.6}{100} + 208 \times \frac{52.3}{100} = 207.2$$

Or

$$Ar = \frac{(204 \times 1.55) + (206 \times 23.6) + (207 \times 22.6) \times (208 \times 52.3)}{(1.55 + 23.6 + 22.6 + 52.3)} = 207.2$$

4) Write the shorthand electron configurations for the following elements:

a. Aluminium (Al): _____

b. Zinc (Zn):_____

c. Tin (Sn):_____

d. Krypton (Kr):_____

Answers

a) Aluminium (Z = 13) : [Ne] $2s^2\ 2p^1$

b) Zinc (Z = 30): [Ar] $4s^2 3d^{10}$

c) Tin (Z = 50): [Kr] $5s^2 4d^{10} 5p^2$

d) Krypton (Z = 36) : [Ar) $4s^2 3d^{10}\ 4p^6$

2.9.3. 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) Hund's rule describes how electrons are distributed among orbitals of the same sublevel when there is more than one way to distribute them. Hund's rule consists of two important ideas. Based on your knowledge on the concept of electron configuration, circle the correct answer to each statement.

a) Electrons will pair up in an orbital only when _____

(i) there is an even number of electrons in the sublevel

(ii) all orbitals in the same sublevel have one electron

b). When single electrons occupy different orbitals of the same sublevel, _____.

(i) they all have the same spin

(ii) they all have different spins

(iii) their spins are random

Answers

a) (ii) b (i)

UNIT 3:

CELL STRUCTURE

3.1. Key unit competence:

To distinguish between the structure of animal and plant cells.

3.2. Prerequisites

For the successive teaching learning process of this unity, students should have enough knowledge of the parts of microscope and their functions. They have also to be well skilled on manipulating the microscope so that they can observe micrographs under the microscope. The knowledge and skills about how to prepare a slide that wear a specimen to observe under light microscope, how to use the light microscope will help you to guide students to observe prepared slides of cell structure under the microscope as they studied this in ordinary level.

3.3. 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 students 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 students on how to manipulate the microscope, you should give a caution of handling them carefully as they are very expensive, and that the country spends a lot of money to buy them.

c) Gender education

This cross-cutting issue should be integrated in all sub-headings which will involve formation and working in groups like. When forming groups for learning activities, when currying out practical activities with microscope and accessories, and when cleaning materials used during practical activities: both boys and girls should participate equally.

d) Inclusive education

This cross-cutting issue should be integrated in all sub-headings. When forming groups for learning activities, when currying out practical activities, and when cleaning materials that have been used during practical activities: students with disability should be considered and helped regarding their specific cases: hearing impairment, vision impairment, students with mobility difficulties; you the teacher and other students should help them to participate and achieve the competences as required in all teaching-learning activities.

3.4. Guidance on introductory activity

- Tutor lets learners to attempt the introductory activity 3. He/she facilitates student-teacher to think about various areas where the magnifying equipment are needed/used. Facilitator inculcates into student-teacher curiosity of knowing the components of magnifying tool like microscope.

- Help learners to conclude by predicting what they will learn in this unit.

3.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Number of periods
1	Preparation of temporary slide and Ultra-structure of cell	- Prepare temporary slides for: plants and cheek cells in animals. - Identify plant and animal cell structures visible under a light microscope. - Observe and draw plant and animal cells under a light microscope. - Explain the functions of cell structures as seen under an electron microscope. - List the functions of cell membranes. - Manipulate a compound light microscope to observe prepared slides of plant and animal cells. - Describe the structure of mitochondria and chloroplast	2
2	Comparison of the structure of an animal and a plant cell.	Distinguish between ultra-structures of plant cells and animal cells.	2
4	Assessment		1

Lesson 1: Preparation of temporary slides

a) Learning objectives:

- Prepare temporary slides for: plants and cheek cells in animals.
- Identify plant and animal cell structures visible under a light microscope.
- Observe and draw plant and animal cells under a light microscope.

b) Teaching resources

Onion tissues, razor blade, animal tissues, oil, slides, cover slips, microscopes and iodine.

c) Prerequisites/Revision/Introduction

The learners learnt about magnifying instruments and biological drawings (unit 4) in senior one. This will help them to observe the prepared slides under microscope.

d) Learning activity 3.1

Provide student-teachers with the textbooks, and guide them to work on the **learning activity 3.1** and **activity 3.2**

Answers to activity 3.1:

1) Student-teachers attentively observe the illustration of activity 3.1

2) The three basic, structural parts of a compound microscope are:

- Head/body houses the optical parts in the upper part of the microscope,
- Base of the microscope supports the microscope and houses the illuminator;
- Arm connects to the base and supports the microscope head

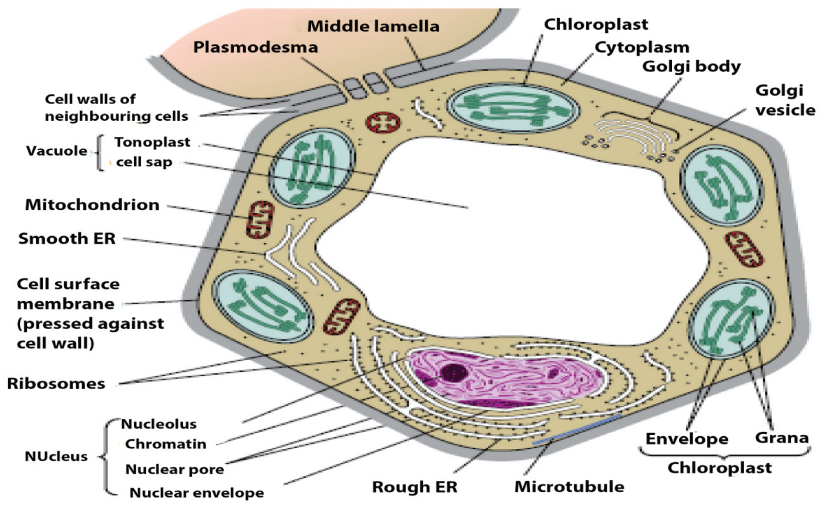
3) The different parts of light microscope are described below:

- **Base**: supports and stabilizes the microscope on the table or any other working place
- **Light source**: It is made by lamp or mirror which provides light for viewing the slide.

- **Stage**: is a platform used to hold the specimen in position during observation.
- **Stage clips**: are pliers used to fix and hold tightly the slide on stage.
- **Arm**: supports the body tube of microscope
- **Body tube**: maintains the proper distance between the objective and ocular lenses
- **Arm**: used for holding when carrying the microscope and it holds the body tube which bears the lenses.
- **Coarse focus adjustment** moves stage up and down a large amount for coarse focus
- **Fine focus adjustment** moves stage up and down a tiny amount for fine focus
- **Objective lenses**: focuses and magnifies light coming through the slide

The answers of the questions of activity 3.2:

Ultrastructure is the detailed of cell as revealed by the electron microscope.



3) Using a light microscope you can see a cell wall (for some types of cell), vacuoles, cytoplasm, chloroplasts, nucleus and cell membrane

Lesson 2: Comparison of the structure of an animal and a plant cell.

a) Learning objective:

Distinguish between ultrastructure of animal cell and plant cell.

b) Teaching resources

Tutor provides learners with microscopes and prepared slides. Guides them on how to manipulate the microscope, and work on the **activity 3.2**

c) Prerequisites/Revision/Introduction

Students have enough knowledge about the structure of both animal cell and plant cell.

d) Learning activity 3.2

Students in their groups work on the **activity 3.2** by observing the microphotographs (showing the structure of animal cell and plant cell) on prepared slides. Guide them to observe, discuss and draw what they see.

Their drawings may show some parts of cells which allow to differentiate animal cell from a plant cell like: cell wall in plant but not in animal cell, presence of chloroplast in plant cell but absent in animal cell.

e) Answers to activity 3.2

1) Student-teacher observe two slides (one with onion tissue another from a chicken) under the light microscope

2) Similarities between animal cell and plant

- Both animal and plant cells have a cell membrane, a cytoplasm and a nucleus.
- Both animal and plant cells have a true nucleus bounded by an envelope.
- Both animal and plant cells have mitochondria, Golgi apparatus, Reticulum endoplasmic, lysosome, big ribosomes (80S), peroxisome, microtubules.

- The protoplasm is enveloped by a bounding cell membrane called **plasmalemma.**
- The protoplasm is composed of a dense round structure called nucleus which is surrounded by a less dense jelly-like cytoplasm.
- The cytoplasm contains numerous organelles such as mitochondria, Golgi bodies, secretory vacuoles, endoplasmic reticulum.
- Mitochondria appear as very small darkly staining, rod-like structures.
- Golgi bodies are semi-transparent irregular, and membrane bound structures.
- Vacuoles contain secretions, food- particles, or decomposing organic substances.
- Chemically, both plant and animal cells are made up of water (80-90%), proteins (7-13%), lipids (1-2%), carbohydrates (1-1.5%) and inorganic salts.
- The cytoplasmic organelles are suspended in a semi-fluid jelly matrix called **cytosol**.

2) a) False, b) True

3) Difference between animal cell and plant cell:

Criterion	Animal Cell	Plant Cell
Shape	Ovoid or spherical	Polygon
Plastids	Absent	Present
Centrioles	Present	Absent
Vacuole	Small or absent	Big with a tonoplast
Cell wall	Absent	Present
Microvilli	Present	Absent
Plasmodesmata	Absent	Present

3.6. Summary of the unit

This unit: "**cell structure**" is divided into **subunits such as**: compound microscope and ultrastructure of animal and plant cells, Comparison between animal cell and plant cell.

- The unit deals with investigating the **ultrastructure** of animal and plant cells which allows to know similarities and differences between animal cell and plant cell. This ultrastructure of the cells, reveals different parts that are found in it.
- The cell has **many organelles** with different structures and different functions, but all work together for the good health of the cell.
- This unit shows the **structure of cell membranes**, the cell membranes and how they are adapted to perform their functions.

3.7. Additional Information for teachers

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:

a. **Lifespans 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

b. **Cell specialization:** 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. In animals, the first type of cells in the developing embryo is stem cells. These are unspecialized cells that go on to form all the different types of cells in adult. Cell can differentiate in many ways, with changes to the shape of the cell, the number of particular organelles and the content of the cell.

How do animal cells specialise?

In animals, the first type of cells in the developing embryo are stem cells. These are unspecialized cells that go on to form all the different cell types in the adult.

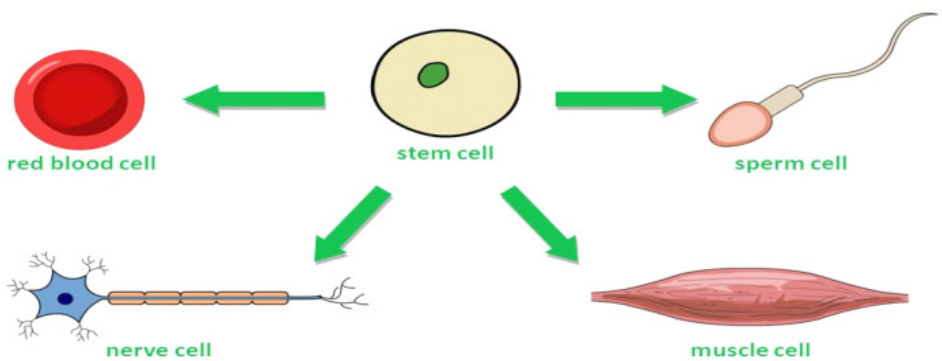


Table for Specialized animal cells and their functions.

The specialized cell	Specialization	function
erythrocytes	They don't have nucleus, mitochondria, Golgi apparatus, and rough ER. However, they have biconcave shape and possess hemoglobin	Transport of Oxygen in the body
sperm	They have many mitochondria, flagella, acrosome with enzymes, half number of chromosomes, being small, thin and long	Fertilization of the egg

Nerve cell	Have excitability and conductivity characteristics, acrosome, axon, node of Ranvier, Myelin sheaths, and dendrite	Conduction of nervous information.
Epithelial cells	Having different size and shape	Protection of the body, secretion of mucus, digestive enzymes, hormones and sweat. They reproduce to replace dead ones
Smooth muscle cells	Smooth muscle fibres do not have striation	Allow the motion
Pigment cells	They contain colouring substances which determine their colour. For example Melanocytes which secrete melamine for the skin colour	Determine the colour
Flame cells	They contain excretory structures. They are specialized excretory cells found in the simplest freshwater invertebrates, including flatworms.	They function like a kidney, removing waste materials by excretion.
Nematocysts	Nematocysts are specialized stinging cells specific to Coelenterates. They are also called Cnidae and hence the coelenterates are also called Cnidarians. The cells that produce nematocysts are called nematoblasts.	They act as organs of offence and defense. Their venomous coiled thread (bladder) can be projected in self-defense or to capture prey.

Specialized plant cells and their functions

a) Root hair cells

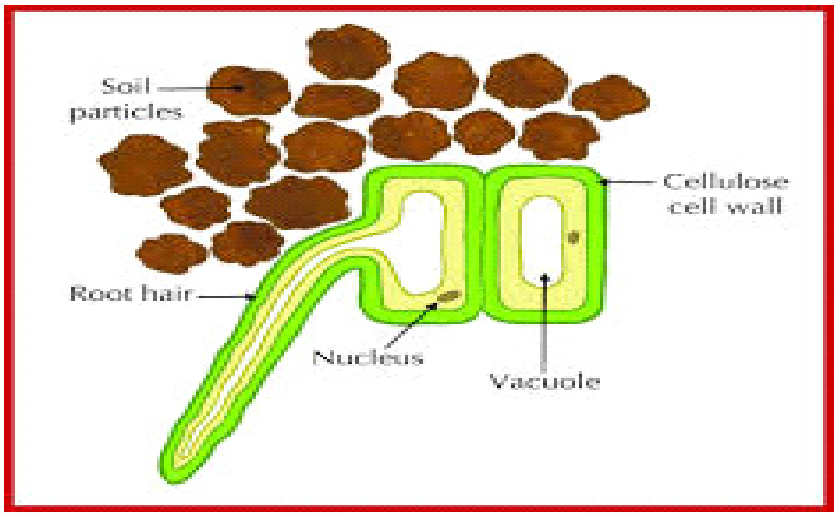
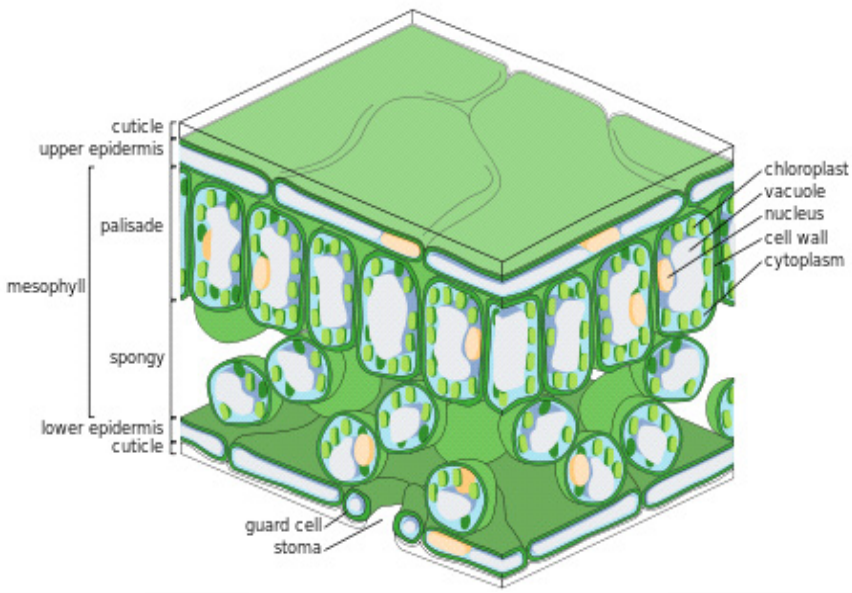


Figure 4.5.5: Root hair cell.

The root hair cells have hair-like projection from their surface out into the soil. This increase the surface area of root available to absorb water and minerals from the soil. Root hairs are tip-growing cells that originate from epidermal cells called trichoblasts. Their role is to extend the surface area of the root to facilitate absorption of mineral nutrients and water.

b) Palisade cells



Palisade cells are plant **cells** located in leaves, right below the epidermis and cuticle. They are vertically elongated, a different shape from the spongy mesophyll **cells** beneath them in the leaf. Their big number of chloroplasts allow them to absorb a major portion of the light energy used by the leaf in the process of photosynthesis.

c) **Parenchyma cells:**

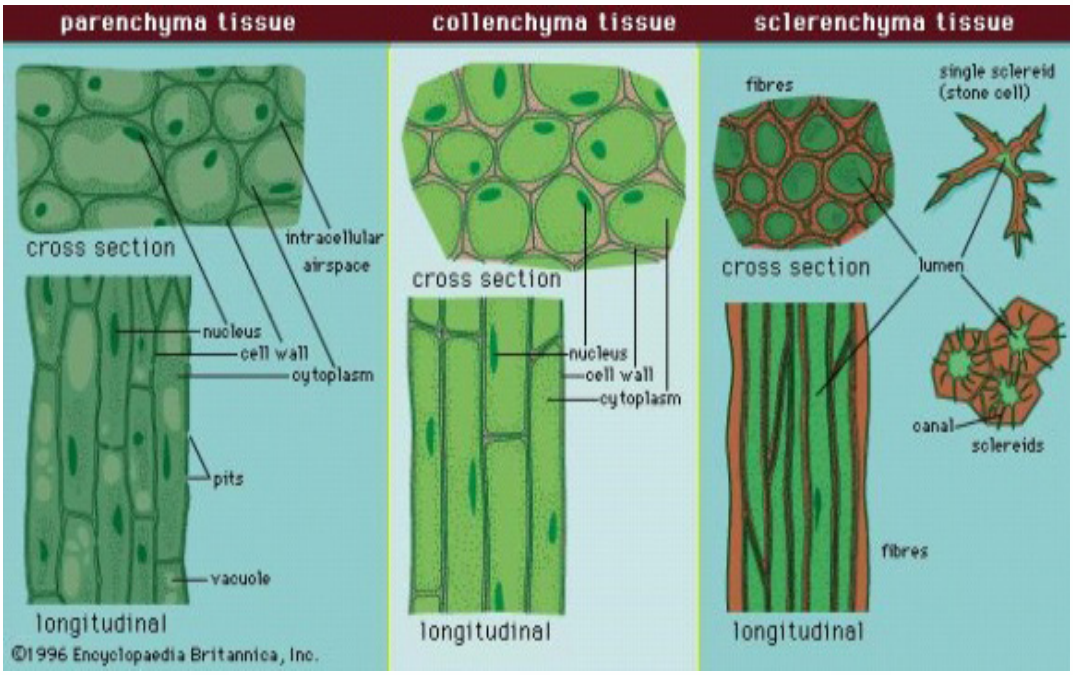


Figure: Parenchyma cells

Parenchyma cells are alive at maturity. They function in storage, photosynthesis, and as the bulk of ground and vascular tissues. Palisade **parenchyma cells** are elongated **cells** located in many leaves just below the epidermis. Parenchyma is composed of relatively simple, undifferentiated parenchyma cells. In most plants, metabolic activity such as respiration, digestion, and photosynthesis occurs in these cells because they retain their protoplasts (the cytoplasm, nucleus, and cell organelles) that carry out these functions. Parenchyma cells are capable of cell division, even after they have differentiated into the mature form.

d) **Guard cells**

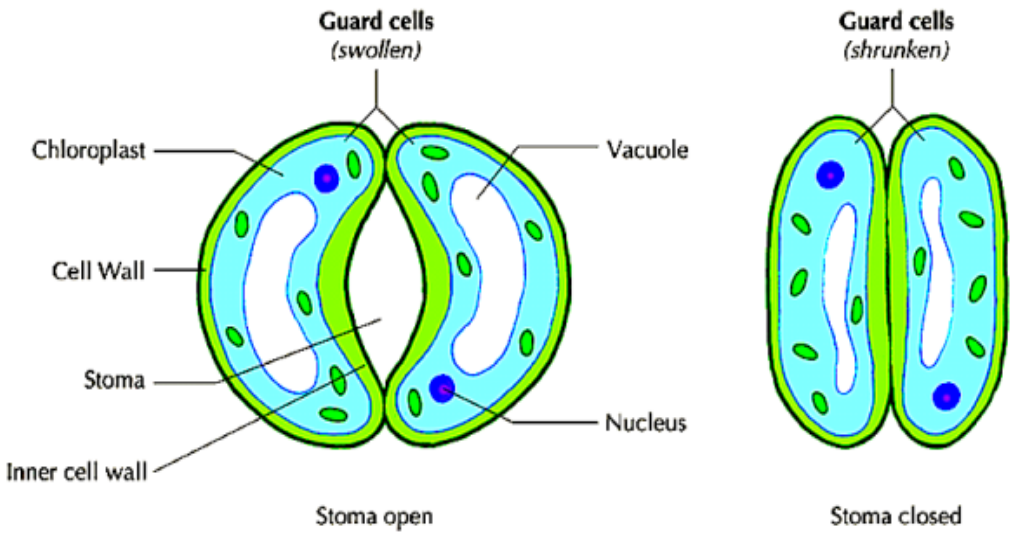


Figure Guard cells

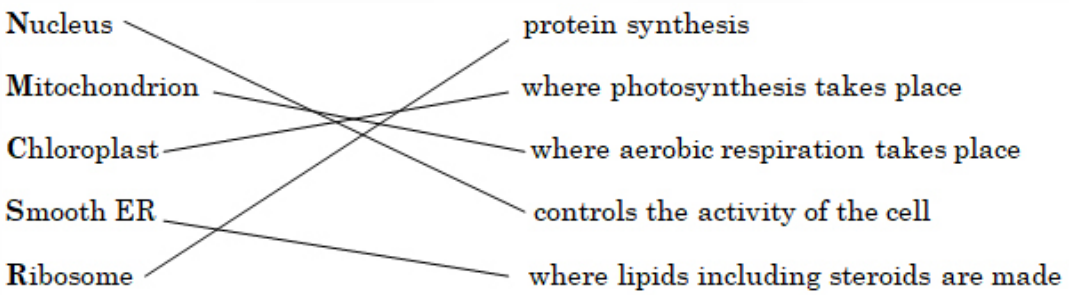
Guard cells are **cells** surrounding each stoma. They help to regulate the rate of transpiration by opening and closing the stomata. Guard cells are specialized cells in the epidermis of leaves, stems and other organs that are used to control gas exchange. They are produced in pairs with a gap between them that forms a stomatal pore.

3.8. Answers to end unit assessment

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

6) Match questions

Match each part of the cell to its correct statement:



7) A cell membrane is directly in contact with the plasma (cytoplasm) and is found in all cell, with a cell wall surrounds the cell membrane and is not found in animal cells.

8) The structures that animal and plant cells have in common are: **nucleus**, **cytoplasm**, **cell membrane**, **mitochondria** and **ribosomes.** Those found only in plant cells are: **cell wall**, permanent large central **vacuole**, c**hloroplasts** and other **specialized plastids**, and those found only in animal cells are **lysosomes** and **centromere.**

9) List:

   a) Centrosomes, centrioles, nucleolus, ribosomes, cytoskeleton, and flagella.

   b) Lysosomes, ER, Golgi bodies.

   c) Chloroplast, mitochondrion and nucleus.

10) 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 division of labor has its own advantages and disadvantages. The specialized cells are more efficient and since all the function and processes need resources and energy, such specialized cells do the job at a fraction of resources , as compared to more generalized cells

3.9. Additional activities

3.9.1. Remedial activities

1. What structures do all cells have?
2. Explain the role of a nucleus in the cell.
3. Appreciate the presence of the cytoskeleton in the cell.
4. Describe the functions of the cell membrane and the cell wall.
5. On your choice, list and give the functions of two organelles from animal cell and plant cell.
6. What is the adaptations of chloroplast for its function?
7. State the general function of the glycoproteins and glycolipids.

Answers of remedial activities

1) A cell membrane and DNA

2) It is the control center of the cell.

3) It helps the cell to maintain its shape, and it is involved in movement.

4) The cell membrane controls what enters or leaves the cell, and also provide protection and support. The cell wall provide support and protection to the cell.

5) From animal cell: mitochondria: site for energy production; nucleus: it controls all cell activities. From plant cell: chloroplasts: site for photosynthesis, Ribosomes: site for proteins synthesis.

6) Chloroplasts are adapted by: having thylakoids with chlorophyll where light-dependent reactions occur, stroma where light-independent reactions occur.

7) Both glycoproteins and glycolipids are involved in the cell protection, the process by which cell adhesions are brought about and also in the uptake and entry of selected substances.

3.9.2. Consolidation activities

1) Describe the basic structure of the cell membrane.

2) What part of the cell is involved in:

a) Protein synthesis?

b) Photosynthesis?

c) Cell respiration

3) Discuss two largest organelles of an animal cell and their functions.

4) A student was telling his colleagues that the lysosome is not important to the cell. Comment to his idea.

5) Why must cell membrane be partially permeable?

Answers of consolidation activities

8. The basic structure of the cell membrane is a double-layered sheet called a lipid bilayer in which proteins are embedded.
9. a) ribosomes, b) chloroplasts, c) mitochondria.
10. The nucleus: controls all activities of the cell, and ER: rough ER transports proteins made on attached ribosomes, while smooth ER does not have ribosomes, and it involves in making lipids that the cell needs.
11. His idea is wrong. Lysosomes are very important as they contain powerful **digestive enzymes** which can break down materials, and destroy invalid microorganisms. In acrosome, lysosomes help the sperm to penetrate the egg by breaking down the material surrounding the egg.
12. A cell membrane should be permeable in order to allow some materials to move through it.

3.9.3. Extended activities

1. How is a cell like a factory?
2. How the structure of the nuclear membrane enables it to carry out its function controlling what enters and leaves the nucleus?
3. Why didn't onion cells burst when they are in distilled water, while animal cells burst, in distilled water?

4. Would you expect the skin cells to contain more or fewer mitochondria than muscle cells? Explain your answer.

5. There are four categories of carbon compounds called molecules of life (protein, lipids, nucleic acids and carbohydrates). Explain where some of those compounds are in a typical cell.

Answers of the extended activities

1. Students may give various answers. One response may involve the comparison of ribosomes to machines in the factory. They may also compare other organelles to different parts of the factory.

2. The nuclear membrane contains many pores which enable it to carry out its function controlling what enters and leaves the nucleus?

3. The cell walls of the onion cells are strong to keep the cells from bursting. Animal cells do not have the cell wall, they may burst.

4. Because muscle cells are involved in movement, they require more energy than skin cells. Therefore, skin cells contain fewer mitochondria than muscle cells.

5. **Carbohydrates** are found in mitochondria where they are converted into high-energy compound (ATP). **Lipids** are found in the cell membrane made up of the lipid bilayer. **Proteins** are found in the ribosomes where they are manufactured. **Nucleic acids** are found in the cell's chromosomes, where genetic information is stored.

UNIT 4: INTRODUCTION TO BIODIVERSITY

4.1. Key unit competence:

To explain how biodiversity on the earth is threatened by climatic change and human activities.

4.2. Prerequisite

The students learnt biodiversity in ordinary level when they studied kingdoms of different living organisms. From there, they got basis which can conduct them to become environmental specialists.

4.3. Cross-cutting issues to be addressed:

a) Inclusive education

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

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

b) Gender education

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

c) Environment and sustainability

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

4.4 Guidance on introductory activity

This introductory activity helps you to engage learners in the introduction of biodiversity and invite the learners to follow the next lessons.

- Tutor ask students to work on the **introductory activity 4** from the students' text books and discuss the given questions. He/she facilitates student-teachers to appreciate the illustrations comparably with Rwanda's ecosystems
- Engage student-teachers in working collectively and ask randomly four students to present their findings from observation of illustrations toward to response to questions related to introductory activity 4.

4.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Number of periods
1	Various ecological terms	- Define the terms: species, ecosystem, niche, population, community and biodiversity.	1
2	Categories of biodiversity	- Categorizing Rwanda's biodiversity.	1
3	Importance and threats of biodiversity.	- Explain the importance of biodiversity - Evaluate the consequences of loss of biodiversity	2
4	Assessment		1

Lesson 1: Various ecological terms

a) **Learning objective:**

Define the terms: species, ecosystem, niche, population, community and biodiversity.

b) Teaching resources

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

c) Prerequisites/Revision/Introduction

The students learnt biodiversity in ordinary level when they studied kingdoms of different living organisms. From there, they got knowledge, skills and attitudes and values which can conduct them to study well this lesson.

d) Learning activity 4.1

Tutor provides student-teacher with biology student teacher's text books year one and facilitate them to work on the learning activity 4.1.

Answers to activity 4.1

Species is a group of closely related organisms which are capable of interbreeding to produce fertile offspring.

An ecological population is a group of individuals of the same species which live in a particular area at any given time.

An ecological community consists of populations of different species which live in the same place at the same time, and interact with each other.

A habitat is a specific area or place in which an individual organism lives. When a habitat is very small it is regarded as a **microhabitat.**

Within the habitat, **an ecological niche** is the status or the role of an organism in its habitat or the mode of life of an organism within its habitats. For example, insects are pollinating agents and preys of insectivores.

The **Biosphere** is the whole of the earth's surface, the sea and the air that is inhabited by living organisms. The biosphere is made up of all ecosystems.

An ecosystem is a collection of all the organisms that live together in a particular place, together with their nonliving, or physical environment.

Lesson 2: Categories of biodiversity

a) **learning objectives:**

To characterize the biotic and abiotic components that define Rwanda's ecosystems.

b) Teaching resources

Biology student-teacher's books year one, graph charts, simulations and computer animations, projector, Manila paper with diagrams for improvisation

c) Prerequisites/Revision/Introduction

Biology S1, Topic 1 "**biodiversity and classification**".

d) Learning activity 4.2

Tutor provides student-teacher with biology student-teacher's text books year one and facilitates them to work on the Learning activity 4.2.

Answers to activity 4.2

- **Genetic diversity:** the combination of different genes found within a population of a single species, and the patterns of variation found within different populations of the same species. These variations are caused by the gene mutations or chromosomal mutations which create differences in individuals of the same species.
- **Species diversity:** this is concerned with variation in number of species and their relative abundance in an area in which they inhabit. All species are different from each other. These could be structural differences, such as the difference between a mango tree and a cow. They could also be functional differences, such as the differences between bacteria that cause decay and those that help us to digest food.
- **Ecosystem diversity:** this is concerned with variations in ecosystems or habitats that occur within a region. Environmental factors like climate change may cause diversity of habitats or systems within a region.

Answers to activity 4.2

Biodiversity includes three main types: diversity within species (***genetic diversity***), between species (***species diversity***) and between ecosystem (***ecosystem diversity***).

1)

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

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

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

Lesson 3: Importance and threats of biodiversity

a) Learning objectives:

- Explain the importance of biodiversity
- Evaluate the consequences of loss of biodiversity

b) Teaching resources

Using internet, student-teacher's book year one, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

In ordinary level, students got knowledge, skills, attitudes and values when they learnt the classification of living things, biology S1- Topic 1. They also know some ecological terms, and the categories of biodiversity. This basic foundation will help them to learn successively this unit.

d) Learning activities:

- **Activity 4.3:**

Tutor guides student-teachers to move around in the school compound to identify all living things they see and to discuss possible functions for each living organism identified as required in the activity 4.3 from the students' text books.

- Allow them to work in groups and present to the whole class.

They may identify different living things such as: plants, mammals, birds, insects, replies, amphibian, and fungi. So they have to discuss the importances of the living things they identified, which may include:

- Provision of food, air, fire wood, medicines, energy, fresh water.
- Nutrient cycling such carbon, water and nitrogen cycles by microorganisms and primary production by photosynthesis.
- Cultural or aesthetic service recreation, ecotourism, cultural and religious inspiration.

▪ **Activity 4.4:**

Tutor guides student-teacher to read their text books, and work on the activity 4.4. They talk on how cutting and burning forests cause the loss of living organisms which live by depending on the forest like birds, snakes, lions, insects among others.

d) Answers of the application activities 4.3 and 4.4

1. Protection of our biodiversity (which is the source of income) for its long live will contribute highly to the growth of the economy of our country. The biodiversity found in national parks, livers and lakes, in forests and planes are the source of money for the country. For example, they may attract tourists.
2. The answers may vary according to which biodiversity they referred on. These may include:
   - Provision of food,
   - Provision of air,
   - Provision of fire wood,
   - Provision of medicines, energy, fresh water.
   - Nutrient cycling such carbon, water and nitrogen cycles by microorganisms and primary production by photosynthesis.
   - Cultural or aesthetic service recreation,
   - Attraction of tourists,
   - Creation of cultural and religious inspiration.
   - Cleaning of the atmosphere.
3. One of the roles of biodiversity is provision of food like: meat, milk, honey, fish, eggs, vegetables, fruit etc. The loss of these may cause the famine and malnutrition.
4. Extinction is when a species disappears, or is extinguished, from earth. Loss of habitat is the largest cause of extinction today.

5. The major factors leading to the degradation of ecosystems include:

a. Habitat loss and the degradation of the environment

The habitat loss and the degradation of the environment occur in different ways.

The most occurring, are tree cutting, agriculture and fires. These human activities lead to the alteration and loss of suitable habitats for biodiversity. As a consequence, there is a loss of plant species as well as the decrease in the animal species associated to this plant diversity.

b. Introduction of invasive species and genetically modified organisms

Species originating from a particular area are harmful to native species also called endemic species when they are introduced into new natural environments. They can lead to different forms of imbalance in the ecological equilibrium, so that endemic species may fail to compete with introduced species, and they may affect the abundance and distribution in natural habitat.

c. Pollution

Human activities such as excessive use of fertilizers, and increased pollutants from industries and domestic sewage affect biodiversity. They contribute to the alteration of the flow of energy, chemicals and physical constituents of the environment and hence species may die as a result of toxic accumulation.

d. Overexploitation of natural resources

Increased hunting, fishing, and farming in particular areas lead to the decrease and loss of biodiversity due to excessive and continuous harvesting without leaving enough time for the organisms to reproduce and stabilize in their natural habitat.

e. Climate change

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

4.6. Summary of the unit

The unit **"introduction to biodiversity"** is divided into three sub-headings: Definition of some ecological terms, categories of biodiversity and importance and threats of biodiversity.

It deals with:

- Defining some ecological terms,
- Categorizing biodiversity, and
- Discussing importances and threats of biodiversity.

4.7. Additional Information for teachers

The distribution and abundance of organisms of biodiversity can be measured by using sampling techniques such as: Random sampling method, Quadrat sampling method, Frame quadrats, Transect sampling, Belt transects method, Netting, The mark-release-recapture technique.

4.8. Answers to end unit assessment

1. A habitat is a specific area or place in which an individual organism lives.
2. Expected answers are:
   a) Water pollution is the contamination of water bodies
   b) Sedimentation, pollution, climate change, deforestation, landscape changes, and urban growth industrialization...
   c) It would be a death of aquatic animals. It means that the main problem caused by water pollution is that it kills organisms that depend on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat.
   d) Desertification is thought by scientists to be a consequence of climate change, has been considered to be related to deforestation. Disrupting water cycles and soil structure results into less rainfall in an area.

4.9. Additional activities

4.9.1 Remedial activities

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

Answers of the remedial activities

1) The true answer is no. But students will develop the reasons in different ways. As teacher, you guide them by basing on the effect of deforestation on life after mentioning the importance of forests.
2) Plants will not reproduce properly due to lack of pollination, and it will end by the plant extinction.
3) Biodiversity contributes to ecosystem goods and services. The ecosystem goods and services include:
   - **Provisioning** services (provision of food, air, fire wood, medicines, energy, fresh water),
   - **Regulating** services (climate regulation, water purification, waste treatment, natural hazard),
   - **Supporting** services (nutrient cycling, primary production) and
   - C**ultural** or **aesthetic** services (recreation, ecotourism).

4.9.2. Consolidation activities

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

Answers of the remedial activities

1. Cutting of forest should be regulated by adopting methods like Clear cutting, Selective cutting, and Shelter wood cutting.

- To avoid forest fire
- Reafforestation and afforestation
- Proper usage of forest products and forests.

2. Major factors leading to the degradation of ecosystems in Rwanda.
   - Habitat loss and the degradation of the environment
   - Introduction of invasive alien species and genetically modified organisms
   - Pollution
   - Climate change
   - Overexploitation of natural resources
3. Consequences of biodiversity loss:
   - They are various consequences of biodiversity loss. At the frontline, there is a change in ecosystem goods and services.
   - These changes lead to different natural dieters including droughts and floods associated to the decrease in food production, and high spread of diseases.

4.9.3. Extended activities

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

Answers of the extended activities

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

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

3. Difference between ecological niche and habitat

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

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

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

UNIT 5:

INTRODUCTION TO CLASSIFICATION

5.1. Key unit competence:

To apply the basic knowledge of classification to group living organisms in three domains.

5.2. Prerequisites

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

5.3. Cross-cutting issues to be addressed*:*

a) Environment and sustainability

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

b) Gender

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

c) Comprehensive sexuality education

When facilitating a lesson of viruses' classification, learners need to be aware that some STIs like syphilis and gonorrhoea have bacteria as causal agent, respectively Neisseria gonorrheae and Treponema pallidium which are microorganisms like a virus.

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

d) Peace and Values Education

Tutor guides learners to promote that all living organisms co – exist in harmony. This cross cutting issue can be integrated at any time in classroom, outside classroom, in school environment and anywhere in life. Learners need to appreciate peace and values and advocate for positive behaviour everywhere.

5.4. Guidance on introductory activity

Tutor guides student-teacher to recognize that all kingdoms' living things are illustrated under introductory activity 5, and to predict what they expect to learn in this unit.

5.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Number of periods
1	Domains of living organisms and Taxonomic hierarchy	- Outline the characteristic features of three domains. - Compare three domains of living organisms and deduce their differences. - Describe the classification of species into the taxonomic hierarchy.	2
2	Characteristic features of the kingdoms	- Outline the characteristic features of kingdoms - Explain the role of bacteria in daily life	1
3	Viruses' classification	- Explain viruses' classification regarding domains.	1
4	Assessment		1

Lesson 1: Domains of living organisms and taxonomic hierarchy

a) Learning objectives:

- Outline the characteristic features of three domains.
- Compare three domains of living organisms and deduce their differences.
- Describe the classification of species into the taxonomic hierarchy.

b) Teaching resources and aids may be:

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

c) Prerequisites/Revision/Introduction

Students have knowledge and skills about biodiversity learnt in the previous unit. These will help them to learn well this lesson.

c) Learning activities

- **Activity 5.1**

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

- Tutor guides students-teacher to arrange from the smallest dimension in increasing order of the size of the words written on them.
- Students should say that the people of the same family have more similarities than those in the whole country.
- A good comparison should indicate that arrangement of the cards in increasing or decreasing order is similar to the increasing order of 8 groups of the biological taxonomic hierarchy.

The arrangement may be:

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

- **Activity 5.2**

  Guide students to use their text books, or if in computer laboratory, guide them to use internet and work on the activity 5.2. So, they have to identify the characteristics of each of the three biological domains: archaea, bacteria and eukarya as they are discussed in the content summary, page 77-80 student-teacher 'book: Three domains: archaea, bacteria and eukarya (main characteristics, types and economic importance).

Lesson 2: Characteristic features of the kingdoms

a) Learning objectives:

- Outline the characteristic features of kingdoms.
- Explain the role of bacteria in daily life

b) Teaching resources:

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

c) Prerequisites/Revision/Introduction

Students have knowledge and skills about biodiversity learnt from the previous unit. They have also learnt domains of living organisms and Taxonomic hierarchy from the previous lesson**.** These will help them to learn well this lesson.

d) Learning activity 5.3

Guide students to use textbooks to discuss characteristic features of kingdoms: protoctista, fungi, plantae, monera and Animalia as indicated by the activity 5.3 from the students' text books. They should discuss characteristic features as they are written in the content summary of the lesson 3.

Lesson 3: Viruses' classification

a) **Learning objectives:**

- Explain viruses' classification regarding domains.

b) Teaching resources

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

c) Prerequisites/Revision/Introduction

Students have knowledge, skills, attitudes and values about biodiversity learnt from the previous unit. They have also learnt domains of living organisms, Taxonomic hierarchy, and Characteristic features of the kingdoms in previous lessons**.** These will help them to learn well this lesson.

d) Learning activity 5.4

Help learners to use textbooks to explain how to classify viruses as indicated by the activity 5.3 from the students' text books. They should classify viruses as indicated in the content summary of the lesson 4.

N.B: A virus is a particle of nucleic acid, proteins and in some cases lipids which can reproduce only by infecting living cells.

A typical virus is composed of core of DNA or RNA surrounded by a protein coat, which is called a capsid.

Bacteriophage is a virus that infects bacteria while a prophage the viral DNA that is embedded in the host cell's DNA.

1. A retrovirus is a virus that contains RNA.
2. Viruses can be classified according to:
   - Type of nucleic acid molecules they have. Most animal viruses contain RNA while plant viruses contain DNA.
   - Type of host cell: plant or animal viruses as they are specific to their hosts.
   - Presence or absence of the envelope: Plant viruses' bacteriophage are no enveloped while animal viruses like HIV and influenza virus are enveloped.

5.6. Summary of the unit

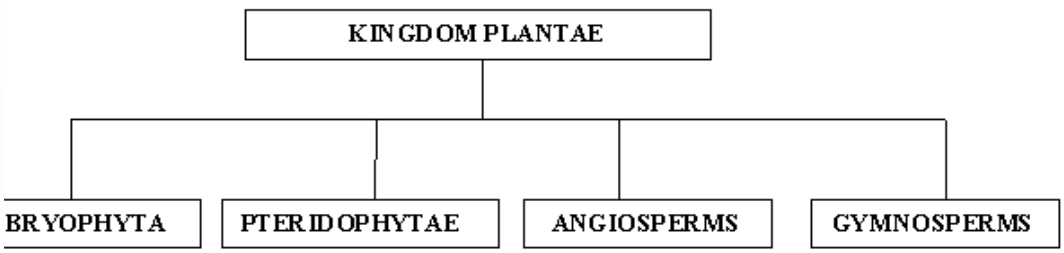
The unit **"Introduction to classification"** is divided into three sub-headings: Domains of living organisms and Taxonomic hierarchy, Characteristic features of the kingdoms, and Viruses' classification.

It deals with:

- Discussing the three domains of life and explaining the taxonomic hierarchy,
- Discussing the characteristic features of the kingdoms,
- Explaining the viruses' classification.

5.7. Additional Information for teachers

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



Division bryophyte: examples areMosses, Liverworts and Hornworts.

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

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

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

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

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

Division Gymnosperm: palms as example

- Gymnosperms are non-flowering plants with undeveloped seeds, which are present in an enclosed structure.

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

5.8. Answers to end unit assessment

1) b
2) a
3) c
4) a
5) a
6) c
7) d
8) c
9) The answers are given in the following table:

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

10) The following are the answers:

a) X Protoctista and Y Monera

b) The following are the answers:

(i) The answers are:

- Both protoctista and monera exhibit autotrophic and heterotrophic nutrition.
- Both x and y are unicellular organisms except few members of x such as algae.
- Both have members with flagella.

(ii) Both x and fungi undergo parasitic mode of feeding.

(iii) Some members of protoctista such as algae and plantae both carry out photosynthesis.

(iv) Most members of x locomote like animals

10) Significance of classification;

- To identify living organisms and place them into their correct groups basing on their observable characteristics.
- To understand the evolutionary relationship between different organisms.
- To arrange information about living organisms in order, for easy study purposes.
- To enable biologists to identify characteristics of organisms.
- To put organisms into small manageable groups basing on their similarities for easy study purpose.

5.9. Additional activities

5.9.1 Remedial activities

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

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

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

2. Describe the three main cell shapes of prokaryotes.

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

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

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

5.9.2. Consolidation activities

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

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

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

Organism C: Unicellular, eukaryotic organisms that have chloroplasts.

Answer:

1. **Organism A:** belongs in kingdom plantae.

Organism B: belongs in kingdom Archaebacteria.

Organism C: belongs in kingdom protoctist.

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

Answer:

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

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

Answer:

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

5.9.3. Extended activities

1. Describe the two ways that viruses cause infection.

Answer:

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

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

Answer:

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

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

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

Answer:

Kingdom: Animalia, Phylum: Chordata, class: mammalia, genus: Cercopithecus, and species: mitis.

UNIT 6:

MOTION ON A STRAIGHT LINE

6.1. Key unit competence:

To apply equations of motion on a straight line to solve real life problems

6.2. Prerequisites

The success of this unit relies partly on the mastery of knowledge and skills acquired in Physics subject in previous units about qualitative analysis of linear motion (S_1 and S_2 O'level).

6.3. Cross-cutting issues to be addressed:

Inclusive education.

Regardless of physical appearance and abilities student-teachers should all equally be treated. This makes the student-teachers to find out that they are all of great importance.

Peace and value Education.

Remember that someone's idea is very important. It may be correct or Not but what is important is to build on that idea.

Gender.

Equal opportunity of boys and girls in the lesson participation. Care should be taken that both Sexes are given equal opportunities.

6.4. 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).
- ✓ Tutor lets student-teacher attempt the introductory activity 6 on page 88 student-teacher's book.
- ✓ When everyone is done and you are done, invite some member(s) or group(s) to discuss their findings to the whole class.

- ✓ Together with students harmonize the points and make a summary on the board. Allow student-teachers to write the main points in their notebooks
- ✓ Linking to the summary and what have discussed in class, emphasize on motion on straight line. You can take some minutes and explain them.

6.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Number of periods
1	Uniform motion in a straight line	- Explain the terms used in rectilinear motion - Plot and Interpret a distance/ time graph, displacement/time, a speed/time graph, velocity/ time graph. - Apply rectilinear motion to different real life situation. - Derive equations of rectilinear motion	1
2	Uniform accelerated motion	- Plot and Interpret a distance/ time graph, displacement/time, a speed/time graph, velocity/ time graph - Apply rectilinear motion to different real life situation - Calculate displacement, time, velocity and acceleration.	1
3	Free fall motion	- Solve problems involving rectilinear motion and free fall.	1
4	Assessment		1

Lesson 1: Uniform motion in a straight line

a) Learning objectives:

- Explain the terms used in rectilinear motion
- Plot and Interpret a distance/time graph, displacement/time, a speed/time graph, velocity/time graph.
- Apply rectilinear motion to different real life situation.
- Derive equations of rectilinear motion

b) Teaching resources

Stopwatches, rulers, tape measures, string, spread sheet, solid object, trolleys.

c) Prerequisites/Revision/Introduction

Through guided discovery, assist student-teachers to describe uniform motion in a straight line recall from qualitative analysis of linear motion (S_1 and S_2).

d) Learning activity 6.1

- Guidance
  - ✓ Take student-teachers in ground
  - ✓ Divide your student-teachers into groups (grouping may depend on the nature of your class or number of student-teacher you have.
  - ✓ Distribute the stopwatches to the groups
  - ✓ Tutor lets student-teachers attempt activity 6.1 in the student-teacher's book.
  - ✓ Tutor invites learner to present findings from their respective group discussion.
  - ✓ Together tutor and student-teachers consolidate and summarize findings from various groups
  - ✓ Tutor guides student-teachers to make connection of physics concept discussed above to how they occur in real life.

Answer to activity 6.1:

The distance moved is directly proportional to the product of speed and time for normal pace.

e) Application activities

Answers to application activities* 6.1*:

Solution

Question 1:

$$speed = \frac{distance\ moved}{time\ taken} = \frac{360\ km}{2h} = 180\ km/h$$

Or

$$speed = \frac{distance\ moved}{time\ taken} = \frac{360\ \times 1000\ m}{2 \times 3600\ s} = 50\ m/s$$

Question 2:

Solution

(a).

$$acceleration = \frac{change\ in\ velocity}{time\ taken} = \frac{final\ velocity - initial\ velocity}{time\ taken}$$
$$= \frac{(20-0)\,m/s}{5\ s} = 4\,m/s^2$$

$$acceleration = \frac{final\ velocity - initial\ velocity}{time\ taken} = \frac{(0-20)\,m/s}{8\ s} = -2.5\,m/s^2$$

Question 3

Solutions

(a) By reading directly from the graph, distance travelled in 10 s = 15 m.

(b) Slope of the graph = speed of the motorist.

$$slope = \frac{\text{change in distance}}{\text{change in time}} = \frac{(10-0)m}{(10-0)s} = 1.5\ m/s$$

(c) i. In the internal BC, distance is not changing but time changes, hence the body is at rest (stationary).

ii. In the internal CD, the motorist is moving at a constant speed towards the starting point.

Lesson 2: Uniform accelerated motion

a) Learning objectives:

- Plot and Interpret a distance/time graph, displacement/time, a speed/time graph, velocity/time graph
- Apply rectilinear motion to different real life situation
- Calculate displacement, time, velocity and acceleration.

b) Teaching resources

Stopwatches, rulers, tape measures, string, spread sheet, ground.

c) Prerequisites/Revision/Introduction

Under your guidance and linking this lesson to the previous one, make student-teachersto plot and interpret distance/time graph and velocity/time graph. Ask them questions like what happens to the velocity of an object if an object accelerates at constant acceleration? Etc

d) Learning activity 6.2

- Guidance
  - ✓ Take student-teachers in ground
  - ✓ Divide your student-teachers into groups (Grouping may depend on the nature of your class or number of student-teacher you have.
  - ✓ Distribute the stopwatches to the groups
  - ✓ Tell the student-teachers to open the activity 6.2 in the student-teacher‘s book and do it.
  - ✓ Tell the groups to choose one member to perform the activity and others count the time using stopwatch.
  - ✓ Assist student-teachers in answering the questions by relating them to Uniform accelerated motion.

- ✓ Permit one learner from one group to read their findings and explain to the rest of the class.
- ✓ Moderate the logical sequence of learner's findings
- ✓ Summarise learner's production.
- ✓ Guide student-teachers to make connection of physics concept discussed above to how they occur in real life.

Answer to activity 6.2:

The speed change is directly proportional to the distance moved and inversely proportional to the time taken.

(a). For the 5.0 s interval, we have $t = 5.0\ s, v_i = 30\,m/s, v_f = 10\,m/s$. Using $v_f = v_i + at$ gives

$$a = \frac{(10-30)\,m/s}{5.0\ s} = -4.0\ m/s^2$$

(b). $x = (distance\ covered\ in\ 3.0\ s) - (distance\ covered\ in\ 2.0\ s)$

$$x = \left(v_i t_3 + \frac{1}{2}at_3^2\right) - \left(v_i t_2 + \frac{1}{2}at_2^2\right)$$

$$x = v_i(t_3 - t_2) + \frac{1}{2}a(t_3^2 - t_2^2)$$

Using $v_i = 30\,m/s, a = -4.0\ m/s^2, t_2 = 2.0s, t_3 = 3.0\ s$ gives

$$x = (30\,m/s)(1\ s) + \frac{1}{2}(-4.0\ m/s^2)(5.0\ s^2) = 2.0\ m$$

Question 2

Solution:

(a).

$$acceleration = \frac{change\ in\ speed}{time\ taken} = \frac{\Delta v}{\Delta t} = \frac{20\ m/s}{4\ s} = 5\,m/s^2$$

(b). Distance travelled = Area under the graph

$$\text{Distance travelled} = \frac{1}{2}speed\left(\frac{m}{s}\right) \times time(s) = \frac{1}{2} \times 20\ m/s \times 4\ s = 40\ m$$

Lesson 3: Free fall motion

a) Learning objectives:

Solve problems involving rectilinear motion and free fall.

b) Teaching resources

Stopwatches, rulers,, spread sheet, solid object, tennis ball.

c) Prerequisites/Revision/Introduction

Through guided discovery, assist student-teachers to describe free fall motion by asking questions like what happens to an object when it is released or thrown vertically upward from rest? Etc

d) Learning activity 6.3

- Guidance
  - ✓ Take student-teachers in ground
  - ✓ Divide your student-teachers into groups (Grouping may depend on the nature of your class or number of student-teacher you have.
  - ✓ Distribute the stopwatches , tennis balls, and other solid material to the groups
  - ✓ Tell the student-teachers to open the activity 6.3 in the student-teacher‘s book and do it.
  - ✓ Tell the groups to choose one member to perform the activity and others count the time using stopwatch and the distance.
  - ✓ Assist student-teachers in answering the questions by relating them to free fall motion.
  - ✓ Permit one learner from one group to read their findings and explain to the rest of the class.
  - ✓ Moderate the logical sequence of learner‘s findings
  - ✓ Summarise learner‘s production.
  - ✓ Guide student-teachers to make connection of physics concept discussed above to how they occur in real life.

Expected answer for activity 6.3:

You may have noticed that when an object is thrown vertically upwards, it starts with a certain speed which decreases as the object moves upwards. At some point the speed of the object becomes zero and the object starts falling back to the earth.

e) Application activities

Put answers with cross reference to textbook

Expected answer for application activity 6.3:

- ✓ Take student-teachers in physics laboratory.
- ✓ Divide your student-teachers into groups (Grouping may depend on the nature of your laboratory or number of student-teacher you have.
- ✓ Distribute the apparatus required: A string, pendulum bob, stand, stop watch, metre rule.
- ✓ Tell the student-teachers to open the activity 6.3 in the student-teacher's book and do it.
- ✓ Ask them to do application activity 6.3 given in student's book.
- ✓ Help them to tabulate their results from the activity and ask them to plot a graph.
- ✓ Let them interpret their graphs.
- ✓ Guide them to find a gradient from the graph.
- ✓ Hold a class discussion on their findings.

It can be shown that the periodic time, T of a simple pendulum of length l is given by the equation

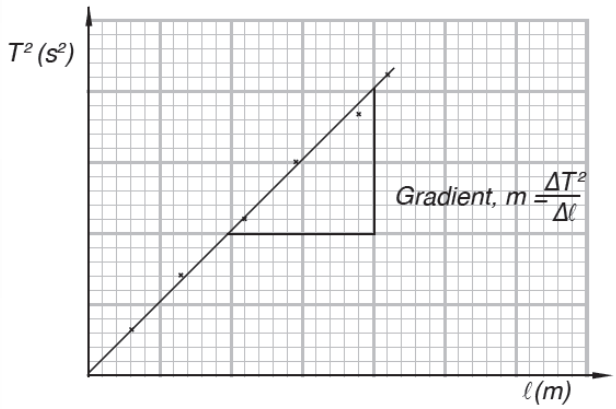
$$T = 2\pi\sqrt{\frac{l}{g}}$$

Squaring both sides of the equation gives $T^2 = \frac{4\pi^2}{g} l$

Comparing this equation with the general straight line equation, $y = mx + c$ shows that

$$T^2 = y, \quad m = \frac{4\pi^2}{g}, \quad l = x, \quad and\ c = 0$$

Therefore, a graph of T^2 against l (Fig. below) is a straight line with gradient $m = \frac{4\pi^2}{g}$



From the gradient, we get

$$g = \frac{4\pi^2}{m} = \frac{4\pi^2}{gradient}$$

Using the results of your experiment, calculate the acceleration due to gravity g using the above equation. Experiments have shown that g is approximately 9.8 m/s^2. However, a more convenient value of 10 m/s^2 is usually used in calculations.

6.6. Summary of the unit

When a particle moves along a straight line, we describe its motion with respect to an origin O by means of coordinate such as x. The particle's average x-velocity v_{av-x}, during a time interval $\Delta t = t_2 - t_1$ is equal to its displacement $\Delta x = x_2 - x_1$ divided by Δt

$$v_{av-x} = \frac{x_2 - x_1}{t_2 - t_1}$$

The instantaneous x-velocity v_x at any time t is equal to the average x-velocity for the time interval from t to $t + \Delta t$ in the limit that Δt goes to zero. Equivalently, v_x is the derivative of the position function with respect to time.

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

The particle's average x-acceleration a_{av-x}, during a time interval $\Delta t = t_2 - t_1$ is equal to the change in velocity $\Delta v_x = v_{2x} - v_{1x}$ divided by Δt

$$a_{av-x} = \frac{v_{2x} - v_{1x}}{t_2 - t_1} = \frac{\Delta v_x}{\Delta t}$$

$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

When the x-acceleration is constant, four equations relate the position and velocity at any time to the initial position x_0, the initial x-velocity v_{0x}(both measured at time t = 0), and the x-acceleration a_x

$$v_x = v_{0x} + a_x t$$

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

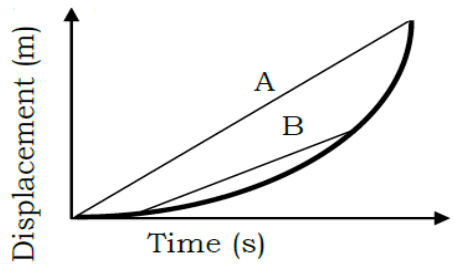
$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$$

Free fall is a case of motion with constant acceleration. The magnitude of acceleration due to gravity is a positive quantity,g. the acceleration of a body in free fall is always downward.

6.7. Additional Information for teachers

Average Speed or Velocity, for UAM

A d-t graph is now curved, so to find average we find the slope of the secant; a line joining the two points of time in question.



The average velocity for the entire trip is found by joining the first and last data points on the graph. (Line A)

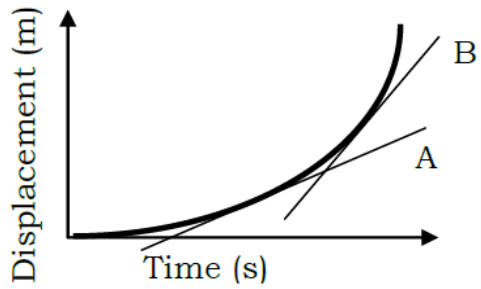
If we wished to find the average velocity for a different time interval, simply connect the two times in question (say from 2.0 to 5.0 s for a trip that lasted 10.0 s) and find the slope of that line. (Line B)

Instantaneous Speed or Velocity, for UAM

As you may expect, the velocity changes with accelerated motion, the slope of a d-t graph will vary with time.

To find the instantaneous speed or velocity, draw a tangent line; a line that touches the graph at the time in question.

Tangent lines will be eyeballed in grade 11 Physics, but usually we would use calculus to find the equation of the line at a point to a curve.



Tangent line A is at an earlier time and shows a slope that is less than at the time for tangent line B. This object is accelerating.

Simply eyeball for symmetry across the curve, pick two points on either side of the tangent point (don't use the tangent point) and calculate the slope.

As everyone will eyeball differently, answers will vary significantly.

In decelerating motion, the tangent slopes will decrease.

6.8. Answers to end unit assessment

Question 1

a. Distance is the total length of the path followed by an object, regardless of the direction of motion.

b. Velocity is a time rate of displacement

c. Displacement is the object's overall change in position from the starting to the end point.

d. Speed is a time rate of distance moved by a body

e. Acceleration is the rate at which something increases in velocity within a time interval

Question 2

(b) and (e)

Question 3

(a) At 3 s , the motion is UARM and the has moved 6 m (from the graph)

$$v_x = v_{0x} + a_x t$$

$$a_x = 2\frac{x}{t^2} = \frac{12\ m}{(3s)^2}$$

$$v_x = a_x t = \frac{12\ m}{(3s)^2}(3s) = 4\,m/s$$

(b)At 7 s, the motion is UARM and the distance moved is 20 m

$$v_x = a_x t = \frac{40\ m}{(7s)^2}(7s) = 5.71\,m/s$$

(c) 14s-10.8 s = 3.2 s

Question 4

(a) the section of the graph the cyclist accelerating most rapidly is A to B

The acceleration is the slope of AB:

$$slope\ (a) = \frac{\Delta v}{\Delta t} = \frac{(30\ m/s - 0)}{(4s - 0)} = 7.5\ m/s^2$$

(b)

$$a = \frac{(0 - 30)}{(10\ s - 8\ s)} = -15\,m/s^2$$

$$the\ retardation\ is\ 15\,m/s^2$$

(c) The motorcyclist was stationary at section DE, for 2 s.

6.9. Additional activities

1. A ball rolls down a hill with a constant acceleration of 2.0 m/s2. The ball starts at rest and travels for 4.0 s before it stops.

(a)How far did the ball travel before it stopped?

a. 8.0 m
c. 12 m
b. 16 m
d. 20 m

(b) What was the ball's velocity just before it stopped?

a. A. 2.0 m/s
b. B. 8.0 m/s
c. C.12 m/s
d. D16 m/s

Answer

a. B

b. B

2. A flowerpot falls off the balcony of a penthouse suite 85 m above the street. How long does it take to hit the ground?

A. 4.2 s

B. 8.3 s

C. 8.7 s

D. 17 s

Answer

A

3. A runner makes one lap around a 200 m track in a time of 25 s. what were the runner's (a) average speed and (b) average velocity?

Answer

(a).

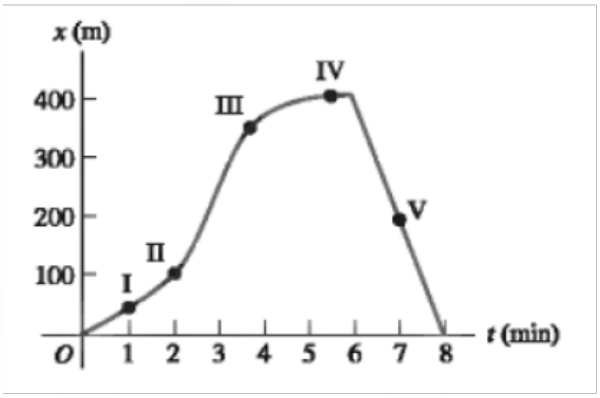
$$Average = \frac{distance\ traveled}{time\ taken} = \frac{200\ m}{25\ s} = 8.0\ m/s$$

(b). Because the run ended at the starting point, the displacement vector from starting point to end point has zero length. Since $\overrightarrow{v_{av}} = \vec{x}/t$

$$|\overrightarrow{v_{av}}| = \frac{0\ m}{25\ s} = 0\ m/s$$

4. A physics professor leaves her house and walks along the sidewalk toward campus. After 5 min it starts to rain and she returns home. Her distance from her house as a function of time is shown in figure below. At which of the labelled points is her velocity (a) zero? (b) Constant and positive? (c) constant and negative? (d) Increasing in magnitude?

(e) Decreasing in magnitude?



Answer

a. The velocity is zero where the graph is horizontal; point IV.
b. The velocity is constant and positive where the graph is a straight line with positive slope; point I.
c. The velocity is constant and negative where the graph is a straight line with negative slope; point V.
d. The slope is positive and increasing at point II
e. The slope is positive and decreasing at point III

5. (a) If a cat can jump straight up to a height of 0.440 m, what is its initial speed as it leaves the ground?

(b)How long is it in the air?

Answers

(a) At the maximum height $v_y = 0$,

$$v_y = 0\ , y - y_0 = 0.440\ m$$

$$v_{0y} = \sqrt{-2a(-9.80\ m/s^2)0.440\ m} = 2.94\ m/s$$

(b) When the cat has returned to the ground $y - y_0 = 0$

$$t = -\frac{2v_{oy}}{a_y} = -\frac{2(2.94\ m/s)}{-9.80\ m/s^2} = 0.600\ s$$

6. A light plane must reach a speed of 33 m/s for take-off. How long a runway is needed if the constant acceleration is $3.0\ m/s^2$?

Answer

$$v^2 = v_0^2 + 2a(x - x_0) \rightarrow x - x_0 = \frac{v^2 - v_0^2}{2a} = \frac{(33\ m/s)^2 - 0}{2(3.0 m/s^2)} = 1.8 \times 10^2 m$$

6.9.1. Consolidation activities

1. An object stars from rest with a constant acceleration of $8.00\,m/s^2$ along a straight line. Find:

a. The speed at the end of 5.00 s
b. The average speed for the 5 s interval,
c. The distance travelled in the 5.00 s.

Answer

We are interested in motion for the first 5.00 s take The direction of motion to be the + x - direction. We know that $v_o = 0$,t = 5.00s, and α = 8.00 m/s^2.

a) $v = v_0 + at = 0 = (8.00m/s^2)(5.00s) = 40.0\ m/s$

b) $(b)\ v_{av} = \frac{v_0+v}{2} = \frac{0+40.0\ m/s}{2} = 20.0\ m/s$

c) $x - x_0 = v_0 t + \frac{1}{2}at^2 \rightarrow x = 0 + \frac{1}{2}(8.00m/s^2)(5.00s)^2 = 100\ m$

Or $x = v_{av}t = (20.0\ m/s)(5.00s) = 100\,m$

2. A truck's speed increases uniformly from 15 km/h to 60 km/h in 20 s. determine

a. The average speed,
b. The acceleration,
c. The distance travelled, all in units of meters and seconds

Answer

For 20 s trip under discussion, taking +x to be in the direction of motion we have

$(a) v_0 = 15\ km/h = 4.17\ m/s, and\ v = 60\,km/h = 16.7\,m/s$

$$v_{av} = \frac{v_0 + v}{2} = \frac{4.17\ m/s + 16.7\ m/s}{2} = 10.4\ m/s$$

(b)

$$a = \frac{v - v_0}{t} = \frac{16.7\ m/s - 4.17}{20\ s} = 0.63m/s^2$$

(c) $x = v_{av}t = (10.4m/s)(20s) = 208\,m$

3. A ball is dropped from rest at a height of 50 m above the ground. (a) What is its speed just before it hits the ground? (b) How long does it take to reach the ground?

Answer

If we ignore air friction, the ball is uniformly accelerated until it reaches the ground. Its acceleration is downward and is 9.8 m⁄s^2 . Taking down as positive, we have for the trip:

$$y = 50.0\ m \quad , a = 9.8\ m/s^2 \quad v_0 = 0$$

(a).

$$v^2 = v_0^2 + 2ay = 0 + 2(9.8 m/s^2)(50.0 m) = 980\ m^2/s^2$$

And so $v = 31.3\ m/s$

(b). From $a = \frac{v - v_0}{t}$

$$t = \frac{v - v_0}{a} = \frac{(31.3\ m/s) - 0}{(9.8\ m/s^2)} = 3.19\ s$$

4. A world-class sprinter can burst out of the blocks to essentially top speed (of about 11.5 m/s) in the first 15.0 m of the race. What is the average acceleration of this sprinter, and how long does it take her to reach that speed?

Answer

$$v^2 = v_0^2 + 2a(x - x_0) \rightarrow a = \frac{v^2 - v_0^2}{2(x - x_0)} = \frac{(11.5 m/s)^2 - 0}{2(15.0\ m)} = 4.408 m/s^2$$

The elapsed time is found by

$$v = v_0 + at \rightarrow t = \frac{v - v_0}{a} = \frac{11.5 m/s - 0}{4.408 m/s^2} = 2.61 s$$

6.9.2. Extended activities

1. A baseball is thrown straight upward on the moon with an initial speed of 35 m/s. compute (a) the maximum height reached by the ball, (b) the time taken to reach the height, (c) its velocity 30 s after it is thrown, and (d) when the ball's height is 100 m.

Answer

Take up as positive. At the highest point, the balls velocity is zero.

(a). From $v^2 = v_0^2 + 2ay$ we have, since $g = 1.6\,m/s^2$ on the moon,

$0 = (35 m/s)^2 + 2(-1.6\,m/s^2)y \rightarrow y = 382.8\,m$

(b). From $v = v_0 + at$ we have

$0 = 35\,m/s + (-1.6\,m/s^2)t \rightarrow t = 21.8\,s$

(c). From $v = v_0 + at$ we get

$v = 35\,m/s + (-1.6\,m/s^2)(30s) = -13 m/s$

Because v is negative and we are taking up as positive, the velocity is directed downward, the ball is on its way down at t = 30 s.

(d). From $y = v_0 t + \frac{1}{2}at^2$, we have

$$100\,m = (35\,m/s)t + \frac{1}{2}(-1.6\,m/s^2)t^2 \rightarrow 0.80t^2 - 35t + 100 = 0$$

By using the quadratic formula, we get t=3.1 s and 41 s. At t=3.1 s the ball is at 100 m and ascending, at t=41 s , it is at the same height but descending.

2. A ballast bag is dropped from a balloon that is 300 m above the ground and rising at 13 m/s. for the bag, find (a) the maximum height reached, (b) its position and velocity 5.0 s after it is released, and (c) the time at which it hits the ground.

Answer

The initial velocity of the bag when released is the same as that of the balloon, 13 m/s upward. Let us choose up as positive and take y = 0 at the point of release.

a) At the highest point, v = 0. From $v^2 = v_0^2 + 2ay$,

$$0 = (13\ m/s)^2 + 2(-9.8\ m/s^2)y \rightarrow y = 8.6\ m$$

The maximum height is $300\,m + 8.6\,m = 308.6\,m\ or\ 0.31\,km$

b) Take the end point to be its position at $t = 5.0\ s$. Then, from $y = v_0 t + \frac{1}{2}at^2$

$$y = (13\ m/s)(5.0\ s) + \frac{1}{2}(-9.8\ m/s^2)(5.0\ s)^2 = -57.5\ m$$

So its height is $300\,m - 57.5\,m = 242.5m$. Also from $v = v_0 + at$

$$v = (13\ m/s) + (-9.8\ m/s^2)(5.0\ s) = -36\,m/s$$

It is on its way down with a velocity of 36 m/s.

c) Just as it hits the ground, the bag's displacement is -300 m. then $y = v_0 t + \frac{1}{2}at^2$ becomes

$$-300\ m = (13\ m/s)t + \frac{1}{2}(-9.8\ m/s^2)t^2 \rightarrow 4.90t^2 - 13t - 300 = 0$$

The quadratic formula gives t=9.3 s and-6.6s. Only the positive value has physical meaning, so the required answer is 9.3 s.

3. A brick is dropped (zero initial speed) from the roof of a building. The brick strikes the ground in 2.50 s. you may ignore air resistance, so the brick is in free fall.

a. How tall, in meters, is the building?

b. What is the magnitude of the brick's velocity just before it reaches the ground?

c. Sketch acceleration – time graph, velocity time graph and distance-time graph for the motion of the brick.

Answer

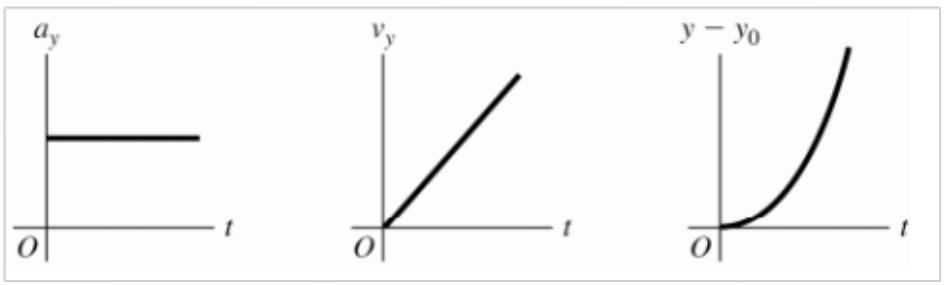
(a).

$$y - y_0 = v_{0y}t + \frac{1}{2}a_y t^2 = \frac{1}{2}(9.80\ m/s^2)(2.50\ s)^2 = 30.6\ m$$

The building is 30.6 m tall

(b). $v_y = v_{0y} + a_y t = 0 + (9.80\ m/s^2)(2.50\ s) = 24.5\ m/s$

(c). The graphs of a_y, v_y and y versus time are:



UNIT 7:

BONDS AND MOLECULAR STRUCTURE

7.1. Key unit competence:

To explain how the nature of the bonding is related to the properties of compounds and molecular structures.

7.2. Prerequisite

Students will learn better "*bonds and molecular structure*" if they have understanding on the symbols of elements and compounds, concept of bonding and the electronic arrangement of, at least, 20 elements in the periodic table.

7.3. Cross-cutting issues to be addressed:

- *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.
- *Comprehensive Sexuality Education:* There is General need of people to associate in order to be stronger, more productive, etc. The bonding character in atoms can be related to relationship in human beings. There is a serious issue of peer pressure and bandwagon (ikigare) in youth. When introducing this unit, it would be an opportunity to guide student-teachers on making informed decisions in their relationships.

Giving advice about these relationships can be done in a short whole class discussion but some points can be given to students as an assignment to be done during their free time. This may be a good point for the Integrated Sciences tutor to confront the individual student-teachers who need advice on relationship matter.

7.4. Guidance on introductory activity

- 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.
- As it is described, in the figure shown in the introductory activity we have six towels of different colours, three having one colour labeled *hydrogen* and other three having another colour labeled *chlorine*. The sewing needle and a thread are to make a strong bond between (to sew) one hydrogen towel to one chlorine towel. The three pairs; obtained by sewing one hydrogen to one chlorine, are now attached to each other using a Velcro. Note that a *Velcro is a fastener for clothes or other items, consisting of two strips of thin plastic sheet, one covered with tiny loops and the other with tiny flexible hooks, which adhere when pressed together and can be separated when pulled apart.* So, the result of the exercise is that we have six towels attached to each other through thread and Velcro as shown in the *figure 7.1*.
- Allow the student-teachers to be aware of different types of bonding, intra- and inter-molecular bonding. Make that they discover that the bonds formed by Velcro are weaker than those formed by the thread; this is become easier for you when you ask them to answer the questions in the introductory activity.
- The expected answers of the introductory activity questions are given to you here below.

Introductory activity

1. The Velcro junctions will fall apart while the sewed junctions will stay as they are.
2. The attachment created by Velcro is much weaker than the attachment created by the thread that we used to sew the pairs of towels together.
3. A slight force applied to either end of the towels can easily bring apart the Velcro junctions without tearing apart the sewed junctions.

Exactly the same situation exists in molecules. Just imagine the towels to be real atoms, such as hydrogen and chlorine. These two atoms are bound to each other through a polar covalent bond, analogous to the thread. Each hydrogen chloride molecule in turn is bonded to the neighboring hydrogen chloride molecule through a dipole-dipole attraction, analogous to Velcro.

7.5. List of lessons/sub-heading

#	Lesson title	Learning objectives	Periods
1	Types of intramolecular bonds	Explain the formation of ionic, covalent and metallic bonds.	1
2	Physical properties of metals	Describe the physical properties of metals.	1
3	Properties of covalent and ionic compounds	Describe the properties of covalent and ionic compounds	1
4	Intermolecular forces	Identify the forces that hold atoms together	1
5	End unit assessment		1

Lesson 1: Types of intramolecular bonds

(a) Learning objective

Explain the formation of ionic, covalent and metallic bonds.

(b) Teaching resources

Use the Student-teacher text book, Periodic Table of Elements, Manila paper, Learning videos and/or printed images depending on the availability of each.

(c) Prerequisites/ Revision/ Introduction

For student-teachers to learn better the "*Ionic, covalent and metallic bonding",* they need to have prerequisites on the atomic structure and electron configurations.

(d) Learning 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 the first lesson.
- As you enter the class, inform the students on the activity taking place.

- Ask learners to sit in groups of 4 to 5 students and ask them to choose their group leader.
- Ask students to read carefully the introductory activity, discuss on it and answer the related questions.
- Ask students to read carefully the *activity 7.1* 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 7.1* and go through the class correcting.
- Give feedback basing on the answers given.

Proposed answers to Activity 7.1

(a) Cl ($1s^2 2s^2 2p^6 3s^2 3p^5$), Na ($1s^2 2s^2 2p^6 3s^1$), F($1s^2 2s^2 2p^5$), H($1s^1$)

(b) Possible reasons

(i) Chlorine needs to form bond with sodium because it lacks only one electron to reach the noble gases electron configuration, the very stable one. This will come from sodium metal, which also needs to lose an electron to become stable.

(ii) Fluorine needs to have the stable configuration, but there is not the atom which wants to lose, hydrogen has a relatively higher electronegativity. In this case, they share the bond pair; each contributes one electron to form the pair to share.

(c) Application Activities

Suggested answer to the Application Activity 7.1

1. Differences between covalent, ionic and metallic bonding.

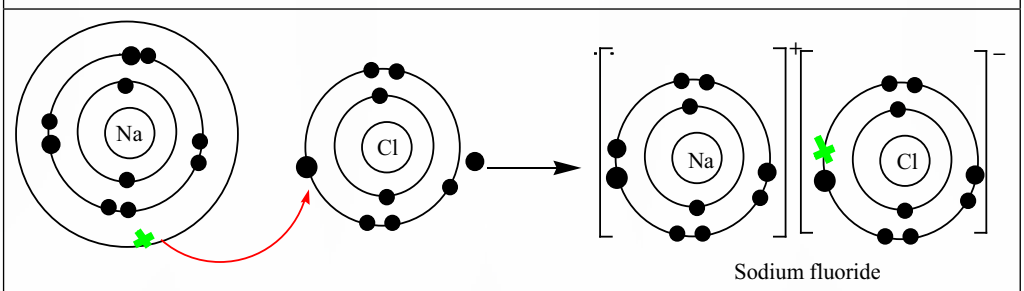
CRITERIA	BONDING		
	IONIC	COVALENT	METALLIC
Definition	Are electrostatic forces arising between negative and positive ions	Are bonds that occur when two elements share a valence electron in order to get electron configuration of neutral gasses.	Are forces between negatively charged freely moving electrons and positively charged metal ions.
Bond Energy	Is higher than metallic bonds.	Is higher than metallic bonds.	Is lower than other primary bonds.
Formation	Form when one atom provides electrons to another atom.	Form when two atom shares their valence electrons.	Form when a variable number of atoms share a variable number of electrons in a metal lattice.
Conductivity	Have a low conductivity.	Have a very low conductivity.	Have very high electrical and thermal conductivity.
Melting and Boiling Points	Have higher melting and boiling points.	Have lower melting and boiling points.	Have high melting and boiling points.
Physical State	Only exist in the solid state.	Exist in the form of solids, liquids, and gasses.	Exist in the form of solid only.
Nature of Bond	Is non-directional.	Is directional.	Is non-directional.

Hardness	Are hard due to the crystalline structure.	Are not very hard with the exception of diamond, silicon, and carbon.	Are not very hard.
Malleability	Materials with ionic bonds are not malleable.	Materials with covalent bonds are not malleable.	Materials with metallic bonds are malleable.

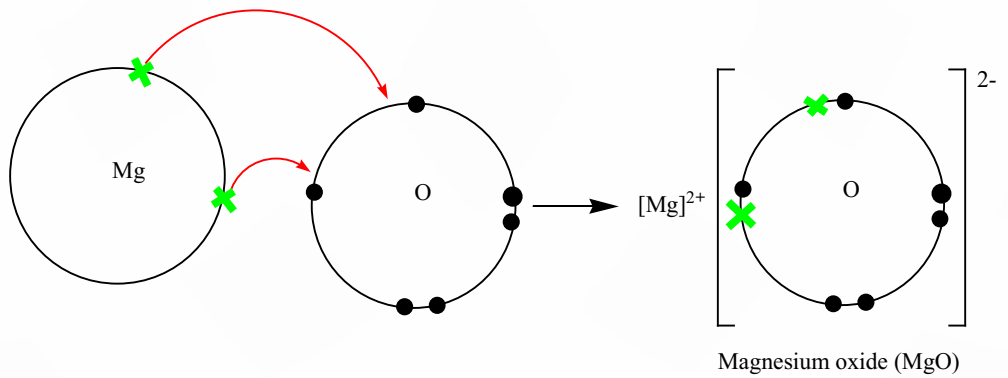
2. A polar covalent bond a covalent bond between atoms of different electronegativities; the bond in which the electrons are not equally shared because one atom attracts them more strongly than the other. Examples of compounds: HBr, H_2O, NH_3, etc.

3. Formation of Sodium chloride, magnesium oxide and magnesium chloride.

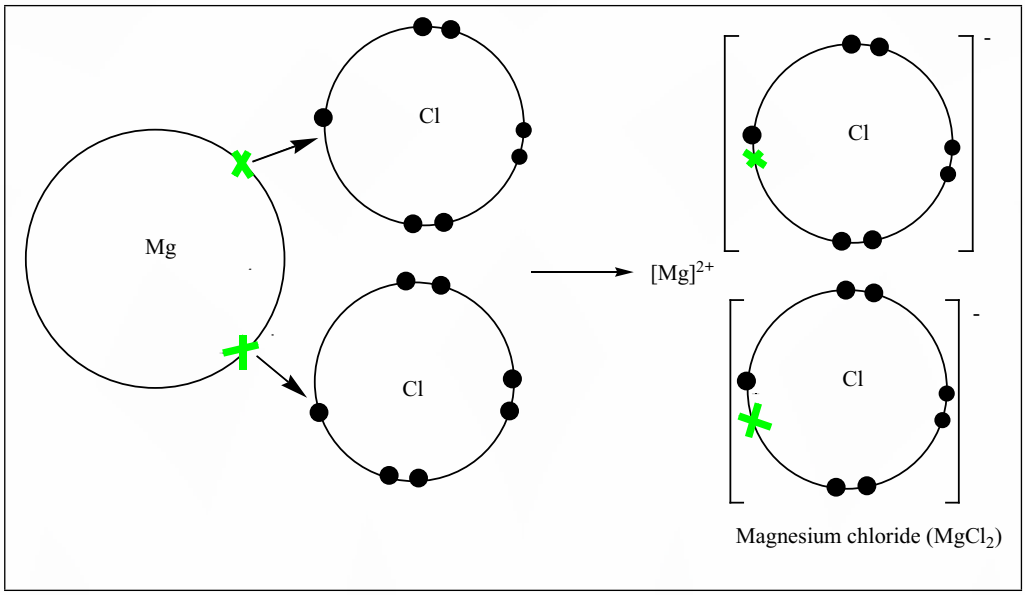
Sodium chloride



Magnesium oxide



Magnesium chloride



Lesson 2: Physical properties of metals

(a) Learning objective

Describe the physical properties of metals.

(b) Teaching resources

- Books
- The Periodic Table of Chemical Elements
- Internet
- Manila papers, flipcharts and movies with computers and projectors if applicable.

(c) Prerequisites/ Revision/ Introduction

For student-teachers to learn better the *"Physical properties of metals",* they need to have prerequisites on the atomic structure, electron configurations and the previously learnt bonding (metallic bonding).

(d) Learning activity 7.2

- *Learning activity 7.2* is suggested in learner's book. However, the teacher is free to add more.

- Form groups of 3-6 student-teachers. The number of groups and members will depend on your class size.
- In the groups students attempt *activity 7.2*, 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 like: Write the chemical formula of the compound and state the type of bond formed and reasons for their answers.
- Guide students to make the summary of the lesson themselves. Make sure the following are emphasized on:
- Make the final conclusion of the lesson.

Expected answer to Activity 7.2

List of metallic objects: Nails, Ringing bell, Dishes, Forks, Knives, Hoes, etc

Physical properties:

- They are hard: They are made of the strong metallic bonding
- They are sonorous: They have this property
- They have high melting points: They are made of the strong metallic bonding
- They do not dissolve in water: No dipole forces to attract the polar solvent like water.
- Etc.

(e) Application activities

Suggested answers to Application Activity 7.2

1. See the Student's Book

2. *Malleability:* Ability to be shaped into thin sheets

Ductility: Ability to be drawn into wires.

Lesson 3: Properties of covalent and ionic compounds

(a) Learning objective

Describe the properties of covalent and ionic compounds

(b) Teaching resources

- The Periodic Table of Chemical Elements
- Charts illustrating metallic sea of electrons.
- Manila papers, flipcharts and YouTube videos with computers and projectors if applicable.

(c) Prerequisites/ Revision/ Introduction

For student-teachers to learn better the "*Metallic bonding",* they need to have prerequisites on atomic structure, electron configurations and the previously studied bonding (metallic).

(d) Learning activity 7.3

- Form groups of 4 to 6 students depending on the size of your class.
- In their respective groups, let students do the activities (experiments to investigate the main physical properties of ionic and covalent compounds (electrical conductivity, brittleness, solubility in water, etc) as indicated in Student-teacher's book, *learning activity 7.3.*
- The lesson also targets practical/experimental skills (manipulation, observation, recording and interpretation, making inferences, generalisation and conclusion).
- Each group representative presents the answers of 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.
- Here, you may use the *Application Activity7.3* 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.

- The expected answers for the questions asked in the activity are herebelow.

Answers to Activity 7.3

(a) Type of bonding: In water = covalent, in table salt = ionic.

(b) Explanation of the observations from the set up.

(i) Because distilled water is a bad conductor of electricity

(ii) Also solid table salt is a bad conductor of electricity

(iii) Solution of table salt is a good conductor of electricity.

(c) The changes observed

(i) It is broken into small parts (it is brittle)

(ii) It dissolves (it is soluble) in water

(iii) No change. It has higher melting point.

(d) Electrical conductivity behaviour: Covalent (bad conductors), ionic (bad conductors when solid and good conductors when molten or dissolved in water) and metallic compounds (good conductors).

(e) Application activities

Proposed answers to Application Activity 7.3

1. Properties of ionic and covalent compounds.

CRITERIA	IONIC	COVALENT
Formation	Are formed when metallic elements combine with non-metallic elements	Atoms of non-metallic elements combine by forming covalent bonds.
Structure and melting points	An ionic compound is composed of giant regular structure consisting of millions of ions. They are crystalline because of this structure. Have high melting point.	Simple molecular (individual and molecular) covalent compounds have weak forces and are mainly gases and liquids with low boiling points. Giant molecular are hard and have high melting and boiling points.
Conduction	Are electrolytes	Are non-electrolytes

Solubility	Many dissolve in water and insoluble in organic solvents.	Are often insoluble in water and many dissolve in organic solvents.

2. Reasons for the following. Use the Student's Book to have more explanation; this is guided as follows.

(a) This is because of the structures and bonding.

(b) Covalent compounds have lower boiling points than ionic compounds because of the structures and bonding.

(c) Ionic compounds are more polar than covalent compounds.

(d) This is because of the structures and bonding.

Lesson 4: Intermolecular forces

(a) Learning objective

Identify the forces that hold atoms together.

(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 the previous lessons about chemical bonding (intramolecular forces/bonds) to understand well the existence of intermolecular forces.

(d) Learning activity 7.4

Learning activity 7.4 in the student's book must be conducted in the laboratory.

- Allow the student to read carefully the activity *7.4* in groups of 4 to 5 students depending on the size of your class.
- Ask the students to perform the experiment and answer the related questions.
- Each group representative presents the answers of his/her group to his/her classmates.

- Record the key points for each presentation in order to harmonize later.
- Evaluate the learners' findings and emphasize on which are correct, incomplete or false
- Ask learners to insert the new knowledge in their presentations and to correct the false information by eliminating all mistakes.
- Summarize the contents by giving more examples and more clarifications about the intermolecular forces.
- Let student-teachers attempt *application activity 7.4*. They should do the *application activity* in any method you wish to use depending on the time (in class group work, homework, etc).

Activity 7.4

- ✓ You should have found that the nail polish remover and the methylated spirits boil before the water, oil and Glycerine.
- ✓ Glycerine, water and methylated spirits have hydrogen bonds between the molecules. However, in water and Glycerine these intermolecular forces are very strong while in the methylated spirits they are slightly weaker. This leads to the higher boiling point for water and Glycerine. Nail polish remover has weaker dipole-dipole forces.
- ✓ Although cooking oil is non-polar and has induced dipole forces the molecules are very large and so these increase the strength of the intermolecular forces.
- ✓ Substances with strong intermolecular forces will have a higher boiling point than substances with weaker intermolecular forces

(e) Application activities

Proposed answers to Application Activity 7.4

1. Intermolecular forces and physical properties Water, ethanol, and cyclohexane.

- The man intermolecular forces in water are hydrogen bonding which is the stronger one. So its boiling point is relatively higher and it dissolves polar substances.

- Ethanol also has hydrogen bonding as the main intermolecular forces. Its boiling point is also higher, close to that of water but as it is an organic substance (it has a non-polar part), it can dissolve some non-polar compounds.
- Cyclohexane is a non polar substance. Only weak van der Waals forces exist between its molecules which make it have lower boiling point and cannot dissolve polar substances like water.

2. 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.

3. According to the information given, the boiling point of methanol is above 50 ^{o}C. Basing on the intermolecular forces in both molecules, the magnitude of van der Waals forces is greater in ethanol (with molar mass of 46 g/mol) than the magnitude of those found in methanol (with molar mass of 32 g/mol), meaning that the boiling point of methanol is below 78.3 ^{o}C.

So, the boiling point of methanol is in the following interval: $50^{o}C < bp(methanol) < 78.3^{o}C$

7.6. Summary of the Unit

In molecules, we can define two different forces:

- *Intramolecular* forces are the forces that hold atoms together *within a molecule*.
- *Intermolecular* forces are forces that *exist between molecules.*

Types of intramolecular forces

- ***Covalent Bond:*** This bond is formed between atoms that have similar electronegativities i.e. the affinity or desire for electrons. Because both atoms have similar affinity for electrons and neither has a tendency to donate them, they share electrons in order to achieve octet configuration and become more stable. A covalent bond involves electrons being shared between atoms.
- ***Ionic Bond:*** This bond is formed by the complete transfer of valence electron(s) between atoms. It is a type of chemical bond that generates two oppositely charged ions. In ionic bonds, the metal loses electrons to become a positively charged cation, whereas the non-metal accepts those electrons to become a negatively charged anion.

- ***Metallic Bond:*** This type of bonding specifically occurs between atoms of metals, in which the *valence electrons are free to move through the lattice*. This bond is formed via the attraction of the mobile electrons, referred to as sea of electrons; and the fixed positively charged metal ions. Metallic bonds are present in samples of pure elemental metals, such as gold or aluminum, or alloys, like brass or bronze.

Physical properties of covalent and ionic compounds

[1] Ionic compounds are formed by the *transfer of electrons that are positively and negatively charged*, whereas, covalent compounds are formed by *sharing the electrons*.

[2] The melting and boiling points of ionic compounds are *much higher* compared to those of the covalent compounds.

[3] Ionic compounds are *hard and crystal-like*, while covalent compounds are *softer and more flexible*.

[4] Covalent compounds are *more flammable* when compared to ionic compounds.

[5] Ionic compounds are *more soluble in water* than covalent compounds.

Physical properties of metals

(1) Electrical Conductivity

(2) Thermal conductivity

(3) Ductility

(4) Malleability

(5) Metallic Luster

Types of intramolecular 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. Intermolecular forces include (listed from weakest to strongest):

- *The London dispersion force is a temporary attractive force that results when the electrons in two adjacent atoms occupy positions that make the atoms form temporary dipoles. This force is sometimes called an induced dipole-induced dipole attraction.*
- *Dipole-dipole forces are attractive forces between the positive end of one polar molecule and the negative end of another polar molecule.*

- *A hydrogen bond is a type of attractive (dipole-dipole) interaction between an electronegative atom and a hydrogen atom bonded to another more electronegative atom like fluorine, oxygen or nitrogen.*

Intermolecular forces control how well molecules stick together. This affects many of the measurable physical properties of substances. Hydrogen bonding interaction makes anomalously high boiling points in molecules. It 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.

7.7. Additional information for tutors

"Why atoms of elements form bonds"

The atoms of most elements form chemical bonds because the atoms become more stable when bonded together. Electric forces attract neighboring atoms to each other, making them stick together. In atoms, electrons are arranged into complex layers called **shells**. For ***most atoms, the outermost shell is incomplete***, and the atom shares electrons with other atoms to fill the shell.

The type of chemical bond maximizes the stability of the atoms that form it.

An ionic bond, where ***one atom essentially donates an electron to another***, forms when one atom becomes stable by losing its outer electrons and the other atoms become stable (usually by filling its valence shell) by gaining the electrons. Covalent bonds form when ***sharing atoms*** results in the highest stability. Other types of bonds besides ionic and covalent chemical bonds exist, too.

Atoms with **incomplete shells** are said to have ***high potential energy***; atoms whose **outer shells are full** have ***low potential energy***. In nature, objects with high potential energy "seek" a lower energy, becoming more stable as a result. Atoms form chemical bonds to achieve lower potential energy.

Like people always relate and connect to others depending on their *values, interests* and *goals* so does **unstable atoms**. They combine together to achieve **stability**. We know that ***noble gases are the most stable elements in the periodic table***. They have a filled outer electron energy level.

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***. So, an atom that has 2 outer electrons will often form a chemical bond with an atom that lacks two electrons to be "complete". The octet rule states that elements gain or lose electrons to attain an electron configuration of the nearest noble gas. Octet comes from Latin language meaning "eight".

Note that the "**Duet Rule**" is also applied. The *noble gas HELIUM has two electrons (a doublet) in its outer shell, which is very stable. Hydrogen only needs one additional electron* to attain this stable configuration, while lithium needs to *lose one*.

7.8. Additional activities

7.8.1. Remedial activities

1. The following compounds are examples of Period 3 chlorides: NaCl (Group 1), $MgCl_2$ (Group 2), $AlCl_3$ (Group 3) and $SiCl_4$ (Group 4). From the chlorides given, choose with explanations, one which is mostly:

(a) Covalent

(b) Ionic

Answer:

From examples of Period 3 chlorides

(a) *$SiCl_4$, the difference in electronegativity is the lowest compared to others (1.26).*

(b) *NaCl, the difference in electronegativity is the highest compared to others (2.23).*

2. The melting point of $H_2O(s)$ is 0 °C. Would you expect the melting point of $H_2S(s)$ to be −85 °C, 0 °C, or 185 °C? Explain your answer.

Answer:

−85 °C. Water has stronger hydrogen bonds so it melts at a higher temperature.

3. Neon and HF have approximately the same molecular masses. Explain why the boiling points of Neon and HF differ.

Answer:

Neon has only dispersion forces, whereas HF is polar covalent and has hydrogen bonding, dipole-dipole, and dispersion forces.

7.8.2. Consolidation activities

1. Aluminium is a metal which has many industrial applications.

(a) Describe the structure and bonding in aluminium metal.

(b) Explain two properties of aluminium as a metal which make it to be widely used.

Answer:

Aluminium is a metal which has many industrial applications.

(a) *This is a type of bonding specifically occurs between atoms of metals, in which the valence electrons are free to move through the lattice. This bond is formed via the attraction of the mobile electrons, referred to as sea of electrons; and the fixed positively charged metal ions.*

(b) *It is a good conductor of electricity, it is light, it has high melting point, etc.*

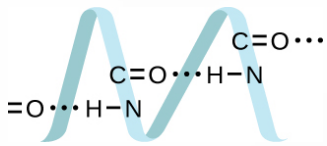
2. On the basis of dipole moments and/or hydrogen bonding, explain in a qualitative way the differences in the boiling points of acetone (56.2 °C) and 1-propanol (97.4 °C), which have similar molar masses.

Answer:

1-propanol contains an OH group, which makes it more polar.

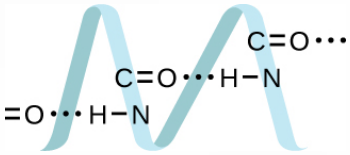
7.8.3. Extended activities

1. *Proteins are chains of amino acids that can form in a variety of arrangements, one of which is a helix. What kind of intermolecular force is responsible for holding the protein strand in this shape? On the protein image, show the locations of the intermolecular forces that hold the protein together:*



Answer:

H-bonding is the principle IMF holding the DNA strands together. The H-bonding is between the N-H and C=O.



2. Explain why non-polar molecules usually have much lower surface tension than polar ones.

Answer:

Because the molecules are not attracted to each other as much as in polar molecules, these molecules are much less likely to have high surface tension.

3. Base your answers to the following questions on the table below.

Physical properties of four gases

Name of gas	Hydrogen	Hydrogen chloride	Hydrogen bromide	Hydrogen iodide
Molecular structure	H-H	H-Cl	H-Br	H-I
Boiling point (K) at 1 atm	20	188	207	237
Density (g/L) at STP	0.0899	1.64	?	5.66

(a) Explain, in terms of molecular polarity, why HCl is more soluble than hydrogen in water under the same conditions of temperature and pressure.

(b) Explain, in terms of intermolecular forces, why hydrogen has a lower boiling point than hydrogen bromide.

(c) Explain, in terms of electronegativity difference, why the bond in Hydrogen bonding is stronger.

Answer:

(a) *Water is a polar molecule. It dissolves the polar substances. HCl is a polar molecule that is why it is soluble in water.*

(b) *In hydrogen molecules, only dispersion forces hold together the molecules while in HCl, there are dipole-dipole interactions in addition.*

(c) *This is stronger because it forms between hydrogen and the more reactive element, meaning that the bond formed is stronger comparing to other intermolecular forces known.*

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