INTEGRATED SCIENCE

TUTOR'S GUIDE

FOR TTC

YEAR

OPTIONS:

Early Childhood

& Lower Primary Education (ECLPE)

FOREWORD

Dear tutor,

Rwanda Education Board is honored to present tutor's guide for Integrated Science in ECLPE Option, Year Three 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 student-teachers 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 student-teacher where concepts are mainly introduced by an activity, situation or scenario that helps the student-teacher to construct knowledge, develop skills and acquire positive attitudes and values.

In addition, such active learning engages student-teachers 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 student-teacher 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:

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

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

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 University lecturers, school 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. NDAYAMBAJE Irénée

Director General of Rwanda Education Board

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

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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 three in ECLPE option of TTC. It is designed to accompany student teacher's book and intends to help tutors in the implementation of competence based curriculum specifically Integrated science syllabus.

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

1.1. The structure of the guide

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

Overall structure

The whole guide has three main parts as follows:

- **Part I: General Introduction**

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

- **Part II: Sample lesson plan**

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

- **Part III: Unit development**

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

Each unit is made of the following sections:

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

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

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

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

- **Guidance on the introductory activity**

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

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

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

- **End of each unit**

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

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

Structure of each sub heading

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

Lesson /Sub heading title 1: ……..

Prerequisites/Revision/Introduction:

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

Teaching resources

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

Learning activities

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

- **Exercises/application activities**

This provides questions and Answers to exercises/ application activities.

1.2. Methodological guidance

1.2.1. Developing competences

Since 2015, Rwanda shifted from a knowledge based to a competence based curriculum for pre-primary, primary and general secondary education. For TTCs, it is in 2019 that the competence based curriculum was embraced. This called for changing the way of learning by shifting from teacher centered to a student-teacher 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 student-teacher can do rather than what student-teachers 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 student-teacher-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 student-teachers; slow, average and gifted student-teachers 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 student-teachers

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

b) Sensing and intuitive student-teachers

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

c) Visual and verbal student-teachers

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

d) Sequential and global student-teachers

Sequential student-teachers tend to gain understanding in linear steps, with each step following logically from the previous one. Global student-teachers 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, student-teachers 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 student-teachers in active learning

Student-teachers 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 student-teacher engaged in active learning:

- Communicates and shares relevant information with other student-teachers through presentations, discussions, group work and other student-teacher-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 student-teachers' 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. Orstudent-teachers write reports in groups and display them on the class notice board for everyone to read.

Main steps for a lesson in active learning approach

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

1) Introduction

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

2) Development of the new lesson

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

- **Discovery activity**

Step 1

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

Step 2

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

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

- **Exploitation of student-teachers's productions**
  - The tutor asks the student-teachers to evaluate the productions: which ones are correct, incomplete or false
  - Then the tutor judges the logic of the student-teachers' products, corrects those which are false, completes those which are incomplete, and confirms those which correct.
- **Institutionalization (summary/conclusion/ and examples)**
  - The tutor summarises the learned knowledge and gives examples which illustrate the learned content.
- **Exercises/Application activities**
  - Exercises of applying processes and products/objects related to learned unit/sub-unit
  - Exercises in real life contexts
  - Tutor guides student-teachers to make the connection of what they learnt to real life situations. At this level, the role of tutor is to monitor the fixation of process and product/object being learned.

3) Assessment

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

PART II: SAMPLE LESSON PLANS

LESSON PLAN 1

School Name: xxxxxxxxxxxxxx **Teacher's name: xxxxxxxxxxxxxxxxxxxxx**

Term	Date	Subject	Class	Unit N°	Lesson N°	Duration	Class size
II	xxxxxxxxxxx	Integrated Science	Y3 ECLPE	1	1 of 9	80 min	43
Type of Special Educational Needs and number of learners				Vision impairment: 1 student teacher. He/she will be sitted on front line, and if possible provided with an audio of the lesson. Hearing impairment: 1 student teacher. He/she will be sitted with a friend who knows sign language.			
Unit title	Human reproductive system and gametogenesis						
Key Unit Competence:	To relate the structures of the human reproductive system to their functions and describe gamete formation						
Title of the lesson	Anatomy of female human reproductive organs						
Instructional objective	By using biological diagram of female reproductive system, student – teachers will be able to locate and describe the function of female reproductive organs correctly.						
Plan for this Class (location: in / outside)	Inside						
Learning Materials (for all learners)	Diagram or wall chart of female reproductive system, projector, computer , manila paper, etc						
References	Beckett, B.S. (1986) Biology a modern introduction, GCSE. Edition Sylvia S. Mader (2010) Biology, New York, The McGraw-Hill. 10th Edition						

Steps and timing	Description of teaching and learning Activity		Competences and cross cutting issues to be addressed
	Using of biological diagram, tutor guides student-teachers in groups to locate and describe the functions of female reproductive organs. Thereafter, the tutor checks the achievement of objectives through setting individual work.		
	Tutor's activities	**Student teacher's activities**	
1.Introduction **[15 min]**	Introduces the lesson by asking the following questions: i) What are primary characteristics that differentiate a baby girl and baby boy? ii) What are secondary sexual characteristics that differentiate a girl and a boy? iii) How baby girls differ from a woman? Displays the diagram of female reproductive system and ask student-teachers to suggest the title of the lesson of the day. Shares the instructional objective with student-teachers.	Brainstorm the primary characteristics that differentiate a baby girl and a baby boy. Brainstorm the secondary sexual characteristics that differentiate a girl and a boy. Predict the differences between a baby girl and a woman. Observe the diagram of female reproductive system and suggest the title the lesson.	Student-teachers develop communication through listening, answering tutor question and following the instruction. Student-teachers develop critical thinking while thinking and predicting the differences between a baby girl and a woman

2. Development of the lesson **[50 min]**	Forms groups using counting methods and ask student teachers to join their respective groups and nominate the team leader and secretary for each group. Distributes the worksheet or writes the work on chalkboard. **Guiding Worksheet:** The diagrams below represent female reproductive system. Observe and use them to:  Use the diagram indicating the female human reproductive system to locate and suggest the function of the following female human reproductive organs on the diagram: urethra, vagina, uterus, ovaries and oviducts. Asks student-teachers to follow the instruction and do the activity using the guidance of worksheet activity. Instructs student-teachers to help each other while doing the activity. Monitors how the student-teachers do the activities. Asks student-teachers to write short notes describing the role of female reproductive organs.	Join their respective groups; select the team leader and secretary. Manipulate the teaching and learning materials. Observe the diagram provided by the tutor Follow the instruction and carry out the activity using worksheet. Do the activity and ask guidance of the tutor in case they have difficulties. Follow guiding worksheet and answer questions on guiding worksheet. Write short notes describing the role of female reproductive organs in their respective groups. Present their findings to the whole class.	Inclusive education is addressed through proving clear guiding worksheet to each group. Student-teachers develop communication through sharing ideas in groups Student-teachers develop critical thinking through answering questions. Student-teachers develop critical thinking, creativity and innovation while writing short notes. Gender education is addressed through inviting both girls and boys to make presentation.

	Asks student-teachers to present the findings. Allows each group to present what they have discussed to the whole class. Compare the findings of all groups and allow students-teachers to comment other's presentation. Through probing questions, guides student-teachers to mention the female reproductive organs observed on the diagram and help them progressively to write on the chalkboard or flipchart. Asks student-teachers to note it in their notebooks.	Ask questions on what they do not understand in the presented findings. Guided by tutor, student-teachers make a summary and write it in their notes progressively.	
3 Assessment **[15min]**	Displays a clear diagram representing a female reproductive system and asks student-teachers to do the related activities individually. Refer to the application activity 1.1 in student-teacher's book. (Consider question 1 and 3). Marks the work and provide feedback.	Observe the displayed diagram and attempt related questions individually, thereafter submit the work.	Student-teachers develop research and problem solving and critical thinking through answering questions. Student-teachers develop critical thinking, creativity and innovation while providing answers.
Teacher self-evaluation			

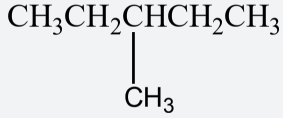
LESSON PLAN 2

School Name: .....Teacher's name: .....

Term	Date	Subject	Class	Unit N°	Lesson N°	Duration	Class size
II	…. /…/….	Integrated science	Y3 ECLPE	3	2 of 5	40 minutes	40
Type of Special Educational Needs to be catered for in this lesson and number of learners in each category				None			
Unit title	Alkanes						
Key unit competency:	To relate the physical and chemical properties of the alkanes to the preparation methods, uses and isomerism.						
Title of the lesson	Physical properties of straight and branched alkanes						
Instructional Objective	During this lesson,student teachers should be able to describe and explain the trend in physical properties of homologous series of alkanes. My objective will be achieved if all present student teachers answer all questions asked in 10minutes reserved by application.						
Plan for this Class (location: in/outside)	Inside the class						
Learning materials (for all learners)	Textbooks for integrated science, manilla paper, flash cards, computer connected to internet, projector where necessary.						
References	E.N.Ramsden (2000), A_Level Chemisrty, Fourth Edition, Nelson Thornes						

Steps and timing	Description of teaching and Activity Through pair discussions, observations and presentations student teachers will brainstorm on the activity 3.2 provided in their student teacher textbookand give the answers on them.		**Generic competences and cross cutting issues to be addressed + a short explanation**
	Tutor's activities	**Student teacher's activities**	
1. Introduction **5 min**	- Ask student teachers to go inpairs. - Provide the materials for student teachers to use for answering activity 3.2.	– -In pairs, student teachers start reading the activity in their student teacher textbook. – - Manipulate the materials provided by the tutor.	– Cooperation and communication skills developed through group discussions. – Practical skills of observing and handling of materials.
2. Development of the lesson **25 min**	- Give the instructions of doing the activity 3.2 - Distribute to the student teachers the teaching and learning materials like (manilla paper, flash cards) for writing their views. - Facilitate and guides the whole activities. - Move around the class to see if all student teachers are working. - Give interventions where needed.	– Listen and respect the instructions given by the tutor. – Take and manipulate the teaching and learning materials. – Share their understanding about the Activity 3.2. – Write the solutions for the questions i. – Student teachers remain in their previous groups and to discuss and answer the questions – Present the findings to the whole class.	– Cooperation and communication skills through discussions. – Lifelong learning by developing research culture. – Environment and sustainability through cleaning working places/ laboratory. – Peace and values education through cooperation, mutual respect, tolerance through discussions with people with different views.

	Invite each pair to join others for sharing what they have discussed. Ask student teachers to remain in their groups and answer the questions for activity 3.2 in their student teacher textbook. - Invite student teachers to present their findings to the whole class. - Request other student teachers to be attentive and give contributions where necessary. - Summarize together the lesson. - Refer to the answers from tutor guide for activity 3.2 in concluding the lesson. - Give the general comments on physical quantities for alkanes.	– Give contributions where necessary about what they have been discussed in their respective groups. – Summarize and conclude the lesson together with tutor.	

3. Assessment **10 minutes**	Assess the student teachers' achievement by providing the following questions: 1. Predict which one of the following compounds has higher boiling point (which one is less volatile) and explain why? a)  b) CH_3-CH_2-CH_2-CH_2-CH_2-CH_3 2. Why alkanes are not soluble in water? Explain your answer	– Student teachers do the exercises individually.	– Critical thinking and problem solving through answering the questions.
Self-assessment			

PART III: UNIT DEVELOPMENT

UNIT 1

HUMAN REPRODUCTIVE SYSTEM AND GAMETOGENESIS

1.1. Key unit competence

Relate the structures of the human reproductive system to their functions and describe gamete formation.

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

Student teachers are equipped with knowledge, skills and attitudes that they have developed from the study of cells, human systems glands and hormones.

1.3. Cross cutting issues to be addressed

A. Comprehensive sexuality education

Comprehensive sexuality education will be addressed through questions that will be asked to student teacher and to the knowledge and skills that will be developed by the unit. The questions should be like: What are the consequences of non-planned pregnancy? Is non-planned an issue in Rwanda? How young people should behave in relation to sexuality?

B. Gender

Gender will be addressed when student teacher will understand that the biological differences in humans are the results of hormonal system. Therefore, they will be sensitised that the biological differences should not be considered in job determination for individuals since all people can achieve.

C. Inclusive education

This unit involves a number of activities on research from different sources and experiments that require the listening and vision. This may be challenging to students with special educational needs especially children with visual impairment. However, the teacher can do the following:

- Grouping student teacher with special educational needs with others and assigned roles basing on individual student teacher's abilities.
- Providing procedure earlier before the experiment so that student teachers

get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have student teachers with low vision remember to print in appropriate fonts.

- Every important point is written and spoken. The written points help student teacher with visual impairment. Speaking aloud helps student teacher with hearing impairment.

1.4. Guidance on introductory activity

Ask student teachers to observe and do analysis of pictures given in student teacher textbook and discuss about them. During discussion, student teachers may find out the following possible answers to introductory activity 1

a) The figure A illustrates a pregnant woman while the figure B illustrates the pregnant of twins.

b) The male produces the sperms and the female the ovum. Through the sex intercourse, the male ejaculated. On normal sperm cells among the billions managed to fertilize the ovum in the Fallopian tube and therefore the zygote developed into the fetus/baby.

c) Refer to student teacher textbook on lesson 1.7

d) For getting one child it's when one sperm fertilizes one ovum but fraternal (non-identical) twins occur when two or more eggs are fertilized during one pregnancy, usually during the same cycle. Often, this is due to hyperovulation, the releasing of two or more eggs instead of one. Identical twins: This type of pregnancy happens when a fertilized egg splits into two separate embryos. The causes of having twins are: Genetics, age, assisted reproduction, previous pregnancies, race, height and weight, breast-feeding.

1.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	The male and female reproductive systems.	– Describe the structure of male and female reproductive systems. – Relate the histology of the testis and ovary to their functions.	4
2	Gametogenesis	– Outline gametogenesis in a male and a female human as a process involving mitosis, growth, meiosis and maturation. – Explain the significance of gametogenesis. – Explain how spermatozoa and oocytes are produced.	4

3	Puberty	– Explain puberty and reproductive hormones and secondary sexual characteristics – Appreciate the significance of the process of gametogenesis at puberty as a key characteristic of sexual maturity.	1
4	The menstrual cycle in humans	– Describe menstrual cycle – Discuss the Sites of production and roles of hormones related to menstrual – Explain how hormones interact to regulate the menstrual cycle. – Demonstrate the role of hormones to the changes in the ovary and uterus during the menstrual cycle.	2
5	Fertilization and fetal development	– Appreciate the role of hormones in the growth and development of organisms.	1
6	Development of an embryo.	– Describe how a human embryo develops and the role of the extra embryonic membranes in pregnancy.	2
7	Physiological changes in females during pregnancy	Appreciate the role of hormones in the growth and development of organisms.	2
	End unit assessment		1

Lesson 1:The male and female reproductive systems

a) Learning objectives:

- Describe the structure of male and female reproductive systems.
- Relate the histology of the testis and ovary to their functions.

b) Teaching resources: Flip-charts showing the male and female reproductive systems, a computer, a projector, biology textbooks.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes related tissues of the human body and the secretions produced by the testes gonads, endocrinology.

d) Activity 1.1

- **Guidance**
  - Tutor will split the activity 1.1 into two parts (One lesson for male reproductive system and another for female reproductive system).
  - Let student teachers go in smart classroom search information on male and female reproductive system and make sure that the network is available.
  - Student teachers form groups of 3 to 4 and share their findings about the activity 1.1 in their student teacher textbook.
  - Guide and facilitate the whole activity done by student teachers in Smart classroom or in library.
  - Make sure that all student teachers are involved during their own research
  - Invite student teachers to write what they will find out during their own research.
  - Give them time to present their findings to the whole class.
  - Summarize together with student teachers.

Answers to activity 1.1

a) The illustration A represents the male reproductive system whereby the illustration B represents the female reproductive system.

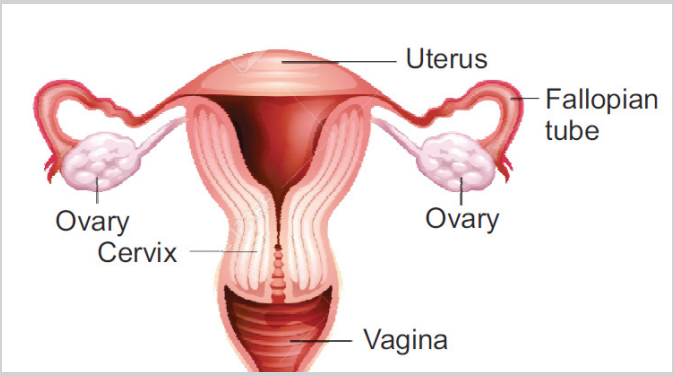
b) Refer to student teacher textbook on sub-lesson 1.1.1

e) Answers to application activity 1.1

1) (a) 1: Epididymis 2: vas deferens 3: bladder 4: ureter 5: seminal vesicles 6: prostate gland 7: penis 8: urethra

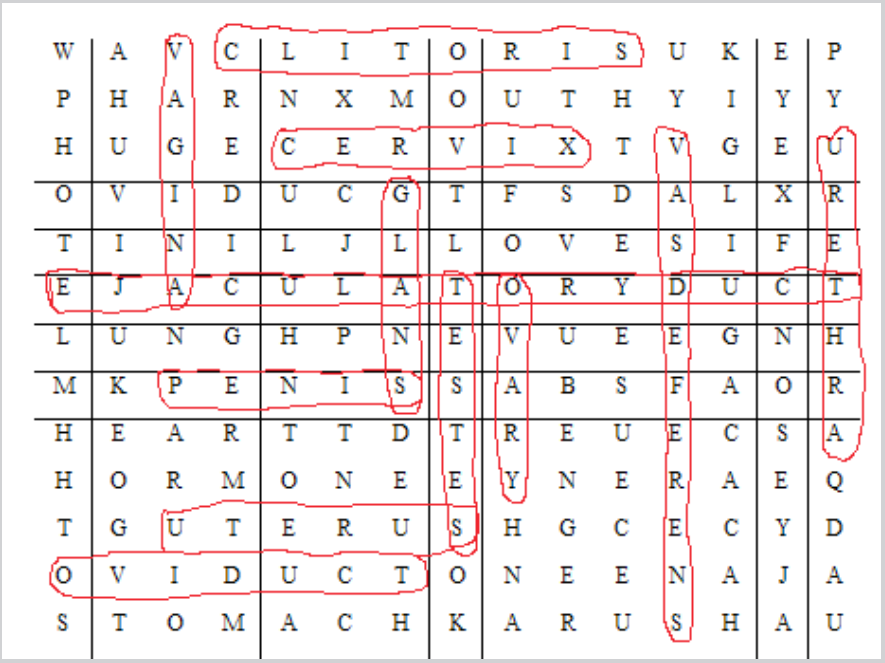
Their functions: Refer to student teacher textbook on table 1.1

b)



Their functions: Refer to student teacher textbook on table 1.2

2)



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O	V	I	D	U	C	T	O	N	E	E	N	A	J	A
S	T	O	M	A	C	H	K	A	R	U	S	H	A	U

Lesson 2: Gametogenesis

a) Learning objective:

- Outline gametogenesis in a male and a female human as a process involving mitosis, growth, meiosis and maturation.
- Explain the significance of gametogenesis.
- Explain how spermatozoa and oocytes are produced.

b) Teaching resources: Computer aided projectors, simulations and charts showing the process of spermatogenesis and oogenesis.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes relatedparts of male and female reproductive system and their functions, cytology, endocrinology.

d) Activity 1.2

- **Guidance**
  - For this activity 1.2, tutors will split it into two parts (One lesson for spermatogenesis processes and another for oogenesis processes).
  - Tutor forms groups of five to six student teachers and watch the movie on the gametogenesis and oogenesis process and tell them to be attentive through their observations.

- They may also be given charts showing spermatogenesis and oogenesis and observe them thereafter write their findings from what they observed.
- In their groups, student teachers work on the activity 1.2 in their student teacher textbook.
- Make sure that the internet is available in the smart classroom.
- Let student teachers brainstorm on the activities 1.2 in student teacher textbook thereafter present their findings to the whole class.

Answers to activity 1.2

1) Refer to student teacher textbook on figure 1.2.1

2) Refer to student teacher textbook on figure 1.2.1

e) Answers to application activity 1.2

1) One sperm mother cell produces 4 sperms, therefore four hundred sperm mother cells will produce = 400 x 4 = 1600 sperms. Each sperm has 23 chromosomes.

2) (a) Refer to student teacher textbook on figure 1.2.4

(b) In the case the tail is not enough developed, it causes the infertility for males

3)

Parts	Function
Nucleus	Contains hereditary information transmitted from male parent.
Acrosome	Contains lytic enzymes which make soft the ovum membrane during fertilization.
Middle piece	Contains mitochondria producing energy used by sperm during movement and a single centriole.
Vitelline membrane	This is a structure surrounding the outer surface of the plasma membrane of an ovum.

Zona pellucida	The zona pellucida supports communication between oocytes and follicle cells during oogenesis; protects oocytes, eggs, and embryos during development, and regulates interactions between ovulated eggs and free-swimming sperm during and following fertilization.
Corona radiata	The corona radiata is the innermost layer of the cells of the cumulus oophorus and is directly adjacent to the zona pellucida, the inner protective glycoprotein layer of the ovum. Its main purpose in many animals is to supply vital proteins to the cell.

4)

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Lesson 3: Puberty

a) Learning objective:

- Explain puberty and reproductive hormones and secondary sexual characteristics
- Appreciate the significance of the process of gametogenesis at puberty as a key characteristic of sexual maturity.

b) Teaching resources: (Computer, projector, manilla papers, scotch, diagrams of puberty people.)

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge,

skills, values and attitudes relatedparts of male and female reproductive system and their functions, cytology, endocrinology.

d) Activity 1.3

- **Guidance**
  - Tutor forms groups of five to six student teachers and give them the activity 1.3 in student teacher textbook.
  - Let student teachers brainstorm on activity 1.5 and present their findings
  - Make sure that all student teachers are working and give their opinions
  - Tutor facilitates the activities and gives contributions where necessary

Answers to activity 1.3

1) Individuals Age A are around 10 years old; Individuals Age B are around 14 years old; Individuals Age C are around 30 years old.

2) Puberty is the time when boys and girls become sexually mature. Biological changes take place in the person's body in preparation for reproduction.

Changes in boys:	Changes in girls:
Facial, pubic and underarm hair starts to grow	Pubic hair starts to grow
Voice deepens	Breasts enlarge
Body size increases and becomes more muscular	Fatty tissue is deposited on the hips and thighs
Sex organs increase in size	Hips broaden
Sperm are produced in the testes (Nocturnal emission or wet dream often occurs)	Menstruation starts and ovum is released during the ovulation
Acne may occur	Acne may occur
Sweat glands become active	Sweat glands become active

3) Yes, individuals in age B can reproduce because they are at puberty i.e. they have achieved sexual maturity. The boy can produce sperm and the girl can release ovum. If they play unprotected sex on the ovulatory period fertilization can take place and therefore, they will produce a child.

4) At puberty, the pituitary gland secretes two hormones in both boys and girls: follicle stimulating hormone (FSH) and luteinizing hormone (LH). These hormones cause the testes in boys and the ovaries in girls to develop.

As the testes develop, they produce testosterone, that leads to the development of male secondary sexual characteristics.

Inside the ovaries, oestrogen and progesterone are produced. They lead to the development of female secondary sexual characteristics.

Answers to application activity 1.3

1) Most girls start their sexual development between the ages of 8 and 13 (the average age is 12), and have a growth spurt between the ages of 10 and 14.
2) Delayed puberty is diagnosed when there is no breast development in girls by the age of 13 or growth of testes in boys by the age of 14.
3) Some evidence suggests that obesity can accelerate the onset of puberty in girls and may delay the onset of puberty in boys. Moreover, the progression of puberty is affected by nutrition. On the other hand, puberty triggers a growth spurt, which increases nutritional needs including macro and micronutrients.

Lesson 4: The menstrual cycle in humans

a) Learning objective:

- Describe menstrual cycle.
- Discuss the Sites of production and roles of hormones related to menstrual
- Explain how hormones interact to regulate the menstrual cycle.
- Demonstrate the role of hormones to the changes in the ovary and uterus during the menstrual cycle.

b) Teaching resources: Kotex, computer, projector, calendar for menstrual periods, manila paper, flip charts for menstrual cycle.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes related to endocrinology.

d) Activity 1.4

- **Guidance**

Download in advance a 10 minute-video on the human menstrual cycle from YouTube link *https://youtu.be/3Lt9I5LrWZw* and prepare a handout of the activity 1.4. for each group.

- The tutor forms groups of five to six student teachers according to the class size
- Then project the video or give the link to each group so that student-teachers can watch the video.

- Give student teacher the flip charts to write their discussions.
- Move around the class to make sure if all student teachers are working.
- Let student teachers present their findings.
- Make general comments on that activity student teachers presented.

Answers to activity 1.4

1) Period or menstruation is a monthly bleeding from the uterus and is a part of a healthy woman's menstrual cycle. All hormonal changes and changes in the ovaries and uterus that happen during a menstrual cycle are aimed at achieving pregnancy. When pregnancy doesn't occur, the uterus sheds its inner lining with blood and mucus through the cervix and vagina due to hormonal changes.

2) The answer is found from the note below the activity 1.4 in the student-teachers book

3) The menstrual cycle is divided into the following phases:
   - **Menstrual phase or menstrual period,** starts from the first day of menstrual bleeding. On day 1 of the phase, the thickened lining of the uterus (endometrium) begins to pass out of the body through the vagina. A normal menstrual period can last from three to seven days.
   - **Follicular phase,** one of the ovaries gets ready to release an egg. At the same time, the uterus starts producing a new lining to prepare for a possible pregnancy.
   - **Ovulation phase,** an ovary releases an egg into the oviduct. This is called **ovulation**. Immediately after ovulation, a woman can fall pregnant by having unprotected sexual intercourse. Ovulation occurs on 14^{th} day of menstrual cycle.
   - **Luteal phase,** the lining of the uterus becomes thicker. If an egg is fertilized by a sperm, the **zygote** then attaches to the uterus lining and a pregnancy begins. If the egg is not fertilized or does not attach, the uterus lining begins to break down and bleeding occurs to mean that the cycle restarts.

e) Answers to application activity 1.4

1) A: Ovulation; B: Primary follicle; C: Graafian (Mature) follicle; D: Early Corpus luteum; E: Degraded Corpus luteum; F: Ovarian events; G: Estrogen; H: Progesterone; I: Menstruation; J: Proliferative phase; K: Secretory phase; L: Ischemic phase; M: Menstruation; N: Endometrium; O: Myometrium.

2) There is a great variety of reasons for menstrual periods to be irregular. The most likely is excessive stress, extreme exercising, and sudden loss of body weight or obesity.

3) A period usually lasts about three to seven days. It may seem like more, but the average amount of menstrual flow for the entire period is about a quarter of a cup! This phase is all about the body preparing for pregnancy each month.

4) The menstrual cycle occurs over a period of about 28 days. The changes during the cycle are due to four hormones, progesterone, oestrogen, FSH (follicle stimulating hormone) and LH (luteinising hormone).

Lesson 5: Fertilization and fetal development

a) Learning objective: Appreciate the role of hormones in the growth and development of organisms.

b) Teaching resources: Computer, projector, charts for fetal development and for internal female reproductive parts, manilla paper, flash cards.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes related to endocrinology, parts of male and female reproductive system and its functions.

d) Activity 1.5

- **Guidance**
  - The tutor forms groups of five to six student teachers according to the class size.
  - Give to student teachers the activity 1.5 in student teacher textbook.
  - Facilitate and guide the activities.
  - Give student teacher the flip charts to write their discussions.
  - Move around the class to make sure if all student teachers are working.
  - Student teachers brainstorm on the concepts of fertilization and fetal development provided on that activity.
  - Let student teachers present their findings.
  - Make general comments on that activity student teachers presented.
  - For the second activity (2), download that movie thereafter project in front of the whole class.
  - Invite all student teachers to observe the movie and write their observations
  - In pairs, let student teachers share their observation.
  - Invite student teachers to present to the whole class their points shared in pairs.
  - Give general comments on those simulations observed.

Answers to activity 1.5

1) (i) A: ovum

ii) B: fertilization. The conditions required for fertilization to take place: mature ovum and sufficient number of sperms. The sufficient number of sperms are involved in the release of enzyme found in acrosome such as hyaluronidases and protease. These enzymes digest corona radiata (narrow path in the follicle cells) and the zona pellucida (a protective glycoprotein surrounding the plasma membrane of the egg) for easy penetration during fertilization.

iii) The process which is happening in C is **Implantation.** (Refer to student teacher textbook on lesson 1.5).

2) Refer to the Student teacher Book, lesson 1.5

e) Answers to application activity 1.5

a)

i) The process is: Ovulation

ii) Mitosis

iii) Corpus luteum

iv) Progesterone

b) The letter should be on the oviduct.

Lesson 6: Development of an embryo

a) Learning objective: Describe how a human embryo develops and the role of the extra embryonic membranes in pregnancy.

b) Teaching resources: Flip charts of female reproductive system (internal parts), computer, projector, manilla paper, flash cards.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes related to endocrinology, parts female reproductive system and its functions.

d) Activity 1.6

- **Guidance**
  - The tutor forms groups of five to six student teachers according to the class size
  - Give to student teachers the activity 1.6 in student teacher textbook

- Facilitate and guide the activities.
- Give student teachers the flip charts to write their discussions.
- Move around the class to make sure if all student teachers are working.
- Student teachers brainstorm on the concepts of development of an embryo provided on that activity.
- Let student teachers present their findings.
- Make general comments on that activity student teachers presented.

Answers to activity 1.6

1) The neural tube (brain, spinal cord, and other neural tissue of the central nervous system) is well formed; the digestive tract and sensory organs begin to develop; bone starts to replace cartilage; the embryo begins to move, although the mother cannot yet feel it.
2) About 3 weeks, one day after fertilization, when the heart first begins to beat, the sound of the little heart is too soft to hear.
3) Refer to student teacher textbook on lesson 1.6

e) Answers to application activity 1.6

1) a)A: amniotic fluid, B: uterus, C: umbilical cord, D: placenta.
   b) Substances which pass from the mother to the embryo: oxygen, glucose, amino acids and vitamins due to their need as nutrients for the embryo.
   c) One substance which passes from the embryo to the mother: carbon dioxide.
2)The terms embryo and fetus both refer to the developing baby inside the mother's womb (uterus). An embryo is termed a fetus beginning in the 11th week of pregnancy, which is the 9th week of development after fertilization of the egg. A zygote is a single-celled organism resulting from a fertilized egg.

Lesson 7: Physiological changes in females during pregnancy

a) Learning objective: Appreciate the role of hormones in the growth and development of organisms.

b) Teaching resources: Projector, computer, flip charts of parts for female reproductive system, manilla paper, flash cards.

c) Prerequisites/Revision/Introduction

The student teacher will learn better this lesson if he/she has the Knowledge, skills, values and attitudes related to endocrinology, parts female reproductive system and its functions, stages of embryo development, endocrinology.

d) Activity 1.7

- **Guidance**
  - The tutor forms groups of five to six student teachers according to the class size.
  - Give to student teachers the activity 1.7 in student teacher textbook.
  - Facilitate and guide the activities.
  - Give student teachers the flip charts to write their discussions.
  - Move around the class to make sure if all student teachers are working.
  - Student teachers brainstorm on the concepts of physiological changes in females during pregnancy provided on that activity.
  - Let student teachers present their findings.
  - Make general comments on that activity student teachers presented.

Answers to activity 1.7

1) (a) Physical changes during pregnancy

- Breast may become large and more tender because of increased level of oestrogen hormone progesterone thus breast gets even bigger to prepare for breast feeding.
- Nipples may stick out more.
- By the end of third trimester, a yellow, watery, pre-milk may leak from nipples.
- Changes in hair and nail growth and texture due to hormone changes.
- Leg cramp caused by fatigue from carrying pregnant weight.
- Feet and ankles may swell because of extra fluid in the body during pregnancy.

b) Behavioral and physiological changes during pregnancy:

- Respiration rate rises for increased maternal oxygen consumption which is needed for demand of placenta, uterus and foetus.
- More blood vessels grow and pressure of expanding uterus on large veins causes blood to slow in its return to the heart.
- Rise up and out of pelvic cavity this action displaces the stomach and intestine.
- Physical discomfort such as urinary frequency can be frustrating.
- Fear and anxiety lessen especially when foetal movements are felt.

2) The change that occurs in uterus during pregnancy period is that the uterus changes the size

3) The cause is that oestrogen and progesterone are the chief pregnancy hormones. High levels of progesterone cause some internal structures to increase in size, including the uterus which changes from the size of a small pear in its non-pregnant state to five times its normal size at full term.

4) The physiological changes that cause nausea and vomiting are alimentary system changes common in early pregnancy. Appetite is usually increased; progesterone causes relaxation of the lower oesophageal sphincter and increased reflux, making many women prone to heartburn.

e) Answers to application activity 1. 7

(1)

Hormone	**Site of secretion**	**Effect(s) of hormone**	
		Ovary	**Endometrium**
FSH	Pituitary gland	Stimulates the growth of follicles in the ovary	None
LH	Pituitary gland	Stimulates the process of ovulation.	None
Estrogens	Ovary	None	Stimulates the thickening of the endometrium wall.
Progesterone	Ovary	None	Stimulates the maintenance of the endometrium wall.

(2) Human chorionic gonadotropin interacts with the LHCG receptor of the ovary and promotes the maintenance of the corpus luteum during the beginning of pregnancy. This allows the corpus luteum to secrete the hormone progesterone during the first trimester.

(3) Maternal blood oestrogen levels rise steadily throughout pregnancy whatever the sex of the fetus, although female fetuses do show a higher oestrogen concentration in the amniotic fluid early in the second trimester.

(4) If oestrogen is low it will cause infertility; it can prevent ovulation and make getting pregnant difficult. Also this happens during menopause due to low estrogen levels.

1.6. Summary of the unit

Both male and female reproductive systems have internal and external structures. Reproductive organs are considered to be either primary or secondary organs. The primary reproductive organs are the gonads (ovaries and testes), which are responsible for gamete (sperm and egg cell) and hormone production.

The female reproductive system primarily consists of internal organs. The female gamete, ovum, is produced in the ovaries and is released monthly to travel to the uterus via the Fallopian tubes.

Fertilization can occur if the penis is inserted through the vulva into the vagina and sperm is ejaculated towards the cervix. If an ovum is currently in the uterus, it can then be fertilized by sperm that manage to enter the cervix. Once fertilized, an ovum becomes a zygote and if all goes well, develops into a fetus in the uterus. Natural birth occurs when the fetus is pushed from the vagina after nine months in the uterus.

1.7. Additional information for tutor

- At birth, and usually until sexual intercourse or vigorous physical activity ruptures it, a vascularized membrane called the **hymen** partially covers the vaginal opening in humans. The vaginal opening and the separate urethral opening are located within a region called the vestibule, bordered by a pair of slender skin folds, the labia minora. A pair of thick, fatty ridges, the labia majora, encloses and protects the labia minora and vestibule. During sexual arousal, the clitoris, vagina and labia minora all engorge with blood and enlarge. The clitoris consists largely of erectile tissue. Richly supplied with nerve endings, it is one of the most sensitive points of sexual stimulation.
- G – Sport is a sensitive area of the anterior wall of the vagina believed by some to be highly erogenous and capable of female ejaculation. The G-spot, also called the Gräfenberg spot is characterized as an erogenous area of the vagina that, when stimulated, may lead to strong sexual arousal, powerful orgasms and potential female ejaculation. It is typically reported to be located 5–8 cm (2–3 in) up the front (anterior) vaginal wall between the vaginal opening and the urethra and is a sensitive area of a female.

Guidance on skills Lab

This skills lab has two end goals: to help all student teachers to know their fertile period for girls or women with irregular menstrual cycle and to know the use of pregnancy test. It is important that everyone knows how to calculate the fertile period as it can help to avoid unintended pregnancy and also to help in family planning. This skills lab will also help student teachers to know the working and use of pregnancy test.

- The tutor brings the real pregnancy test material in the class and shows it to student teachers
- The tutor shows to student teachers how pregnancy test works according to the skills lab they have in their student teacher textbook.
- Let all student teachers manipulate the pregnancy test.

1.8. End unit assessment (answers)

1) The epididymis is the tube which moves the sperm from the testicles to the Vas deferens. This is a tube in which the sperm is stored and it carries the sperm out of the scrotal sac.

2) Difference between human sperm and ovum is that sperm is the male gamete, produced in the testis of a male, while ovum is the female gamete, produced in the ovary of a female. ovum, also known as egg cell and is said to be the largest cell in the female body. On the contrary sperm cells is the smallest cell in the male body.

3) No. Only one ovulation can happen per cycle. Once a woman ovulated, She's empty follicle turns into something called a corpus luteum.

4) The embryo has developed a head and a trunk, structures that will become arms and legs, called limb buds, begin to appear thereafter blood vessel forms which will later develop into the heart and circulatory system.

5) a) Estrogens, b: FSH, c: progesterone, d: LH

   b) Ovulation happens about 14 days before your period starts. If your average menstrual cycle is 28 days, you ovulate around day 14, and your most fertile days are days 12, 13 and 14. If your average menstrual cycle is 35 days, ovulation happens around day 21 and your most fertile days are days 19, 20 and 21.

6) The length of the menstrual cycle is the number of days between the first day of one period and the first day of the next period. In most women, it is about 28 days. The length of the cycle between 21 to 35 days is considered to be normal. The menstrual cycle is too short if your menstruation starts 21 or even fewer days after the onset of your previous period.

7) Hormonal imbalances are more common during puberty, menstruation, and pregnancy. Many hormonal imbalances are caused by external factors, such as stress or hormone medications. However, hormonal imbalances can also be caused by any medical condition that impacts or involves the endocrine system or glands.

8) It's because when Oogenesis occurs within embryo sac and leads to formation of single egg cell. During oogenesis each diploid primary oocyte produces one functional egg and three polar bodies.

9)

Reproductive Organ	Function	Adaptation
Penis	During sexual intercourse, the penis becomes erect and delivers the sperm into the cervix of the vagina.	The penis is on the outside of the male body, and it is elongated so that it can insert into the vagina and deliver the sperm into cervix. The penis contains the urethra and becomes erect so that it can insert into the vagina.
Testes and scrotum	The testes produce the sperm and the scrotum hold the testes outside of the body.	The testes need to be at 35°C, which is lower than body temperature, in order to produce sperm. The testes are therefore outside of the male body and hang in the scrotum, which can adjust the temperature of the testes so that the right temperature is maintained in order to produce sperm.

10) a) Oogenesis is the process by which the female gametes, or ova, are produced. The female gamete is called an ovum. The diploid germ cells that have the potential to develop into ova are called oogonia.

b) When a female ovulates, the oocyte is in metaphase II, until it becomes fertilized by a sperm. It then completes the second phase of meiosis to make a mature ovum. All oocytes undergo meiosis I during fetal development, and are kept suspended in prophase II until ovulation, when they shift to metaphase II. Meiosis only continues beyond metapahse II if fertilization occurs.

c) The hormones involved in gametogenesis are collectively called gonadotropins. FSH acts on the gamete-producing cells to regulate gametogenesis. LH acts on the endocrine or hormone-producing cells, stimulating release of steroid sex hormones.

11) The chance of fertilization in humans is restricted to only a few days each month because the menstrual cycle in the female has only one phase in which the ovum is ready released and survived for at least 24 hours while the sperm can survive for 3 days after ejaculation in the female body .

12) The organs of the male reproductive system are specialized for three primary functions:

- To produce, maintain, transport, and nourish sperm (the male reproductive cells), and protective fluid (semen).
- To discharge sperm within the female reproductive tract.

- To produce and secrete male sex hormones.

13) Yes, in most cases, people with one testicle can get someone pregnant. Remember, one testicle can provide enough testosterone for the man to get an erection and ejaculate. This is also enough to produce adequate sperm for fertilization.

14) One adaptation of the sperm cell is that it has a tail, which helps it to swim to the egg cell. The sperm cell also has an acrosome, which contains enzymes so that the sperm can get into the egg. Finally, the sperm cell has many mitochondria, which produce energy for movement towards the egg.

15) The ovum is one of the largest cells in the human body, typically visible to the naked eye without the aid of a microscope or other magnification device. The human ovum measures approximately 0.1 mm in diameter.

16) Hyaluronidase is a type of enzyme which catalyses degradation of hyaluronic acid. It is released to help the sperm to penetrate into the ovum.

17) a) It is normal to have menstrual periods twice a month only in case the menstrual cycle is about 21 days long and she has periods twice during one calendar month. There may be some underlying reasons for that like hormonal imbalance, ovarian cysts, endometriosis, uterine fibroids, pelvic inflammatory disease or even cervical neoplasia.

b)Progesterone prepares the endometrium for the potential of pregnancy after ovulation. It triggers the lining to thicken to accept a fertilized egg.

c) The menstrual cycle is regulated by two hormones secreted from the pituitary gland, follicle stimulating hormone (FSH) and luteinizing hormone (LH). FSH and LH control the production of estrogen and progesterone, hormones are produced in the ovaries that determine the different stages of the menstrual cycle.

d) The main hormone that helps primordial follicles develop into primary follicles is FSH Follicle-stimulating hormone.

18.a) The implantation of a fertilized egg is estimated to take place about 9 days (+/-) after ovulation.

b) As long as the ejaculate wasn't inside women body or on her vagina, she can't get pregnant. Ejaculate on the outside of her body isn't a pregnancy risk. But if her partner ejaculates near the vagina and then fingers her, they may push some of the semen into her vagina. If this happens, pregnancy is possible.

c) It takes just one sperm to fertilize a woman's egg. For each sperm that reaches the egg, there are millions that don't. On average, each time a man ejaculates he releases nearly 100 million sperm.

d) The distinction between embryo and fetus is made based on gestational age. An embryo is the early stage of human development in which organs are

critical body structures are formed. An embryo is termed a fetus beginning in the 11th week of pregnancy, which is the 9th week of development after fertilization of the egg.

e) A morula (Latin, morus: mulberry) is an early stage embryo consisting of 16 cells (called blastomeres) in a solid ball contained within the zona pellucida.

f) The developing baby is called an embryo from the moment of conception to the eighth week of pregnancy. After the eighth week and until the moment of birth, the developing baby is called a fetus.

g) Within about three days after conception, the fertilized egg is dividing very fast into many cells. It passes through the fallopian tube into the uterus, where it attaches to the uterine wall. The placenta, which will nourish the baby, also starts to form.

19) (e) All of the above

20) It degenerates

21) It divides to form a hollow ball of cells, called the blastocyst

22) In positive feedback, rising levels of hormones feedback to increase hormone production. During most of the menstrual cycle, estrogen and progesterone provide negative feedback to the hypothalamus and pituitary gland.

23)Factors affecting fetal growth can be maternal, placental, or fetal. Maternal factors include maternal size, weight, weight for height, nutritional state, anemia, high environmental noise exposure, cigarette smoking, substance abuse, or uterine blood flow. Inappropriate growth can result in low birth weight.

24) Pituitary hormone stimulates the process of gametogenesis in this way: The Gonadotropin release is controlled by the hypothalamic hormone gonadotropin-releasing hormone (GnRH). FSH stimulates the maturation of sperm cells in males while LH stimulates the production of the androgen testosterone.

1.9. Additional activities (Questions and answers)

1.9.1. Remedial activities

1) From which body layer in embryo does brain develop?
2) List the extraembryonic membranes.
3) Which membrane form the foetal side of the placenta.
4) What is the role of: i) relaxin and ii) oxytocin during pregnancy?
5) What is the name given to an embryo when it reaches 8 old weeks?
6) Out of the following, which hormone does not secret from corpus luteum?

Explain your answer
a) Estrogen; b) Progesterone; c) Relaxin; d) Testosterone

7) Name the hormone which is at peak during ovulation thereafter give your opinion.
a) Progesterone; b) Estrogen; c) FSH; d) LH

8) The fluid from which of the following accessory gland neutralize the acidity in a vagina of the female? Explain your reason

a) Seminal vesicle; b) Prostate gland; c) Cowper's gland; d) Urethra

Answers

1) Ectoderm

2) Amnion, York sac, chorion and allantois.

3) Chorion

4) i) relaxes connective tissue in bones of pelvic girdle, ii) Stimulates uterine contraction

5) Foetus

6) d.(Testosterone) because corpus luteum is the yellow body which left after the procedure of ovulation. It secretes four hormones, i.e., progesterone, estrogen, relaxin, and inhibin. Testosterone is male hormone and it doesn't discharge from the corpus luteum.

7) d. (LH) because Leutilizing hormone secrets in a huge amount from the anterior pituitary on the 14th day of 28 days menstruation cycle. This hormone is responsible for the release of the ovum.

8) c. Cowper's gland or bulbourethal glands are small in size and located near the base of the penis. After getting sexual stimulation, these glands secrete alkaline fluid which neutralizes the acidity of the vagina.

1.9.2. Consolidation activities

1) Some lactating mothers have plenty of milk but it does not flow freely to nipple. They therefore have difficult in breast feeding their babies. Suggest which hormone might lack.

2) What is the function of:

(i) The acrosome reaction and

(ii) The cortical reaction?

3) Explain any process which begins after the fertilization

3) Which hypothalamic hormone contributes to the regulation of the male reproductive system?

4) What happens to the cell cycle of the secondary oocyte?

5) What cells produce HCG and why is it important?

Answers:

1) Oxytocin.

2) (i) Acrosome reaction enable sperm to penetrate an oocyte.

   (ii) Cortical reaction form fertilization membrane, preventing further entry of sperm into ovum.

3) Embryogenesis is the process of multiplication of cells by mitosis and formation of tissues and organs of a living baby. It starts once the egg has been fertilized.

4) Gonadotropin-releasing hormone.

5) It arrests in the metaphase of Meiosis II and will only finish this if it is fertilized.

6) The production of human chorionic gonadotropin (HCG) is essential to the survival of the implanted embryo. This hormone provides continued stimulation of the corpus luteum and thus continued maintenance of the endometrium. In subsequent weeks, the placenta will also become an important source of other hormones (e.g. estrogen, progesterone) necessary for normal gestation.

1.9.3. Extended activities

1) Briefly explain why mature gametes carry only one set of chromosomes.

2) What special features are evident in sperm cells but not in somatic cells, and how do these specializations function?

3) What do each of the three male accessory glands contribute to the semen?

4) While anabolic steroids (synthetic testosterone) bulk up muscles, they can also affect testosterone production in the testis. Using what you know about negative feedback, describe what would happen to testosterone production in the testis if a male takes large amounts of synthetic testosterone.

5) What happens to the endometrium during the proliferative phase of the menstrual cycle?

6) Provide what happens to the other Graafian follicles that have matured but not ovulated during the cycle?

7) What is the difference in appearance between a primordial and a primary follicle?

Answers

1) A single gamete must combine with a gamete from an individual of the opposite sex to produce a fertilized egg, which has a complete set of chromosomes and is the first cell of a new individual.

2) Unlike somatic cells, sperm are haploid. They also have very little cytoplasm. They have a head with a compact nucleus covered by an acrosome filled with enzymes, and a mid-piece filled with mitochondria that power their movement. They are motile because of their tail, a structure containing a flagellum, which is specialized for movement.

3) The three accessory glands make the following contributions to semen: the seminal vesicle contributes about 60 percent of the semen volume, with fluid that contains large amounts of fructose to power the movement of sperm; the prostate gland contributes substances critical to sperm maturation; and the bulbourethral glands contribute a thick fluid that lubricates the ends of the urethra and the vagina and helps to clean urine residues from the urethra.

4) Testosterone production by the body would be reduced if a male were taking anabolic steroids. This is because the hypothalamus responds to rising testosterone levels by reducing its secretion of GnRH, which would in turn reduce the anterior pituitary's release of LH, finally reducing the manufacture of testosterone in the testes.

5) During the proliferative phase of the endometrium, endometrial tissues, both epithelial tissues and stromal cells, are mitotically active. This results in the development of a thick stratum functionalis layer from the underlying stratum basalis.

6) The remainder of the follicles will undergo degeneration into atretic follicles (corpora fibrosa).

7) The primordial follicle is surrounded by flattened, squamous-appearing epithelial cells and no evident zona pellucidum. In the primary follicle, there is a prominent zona pellucidum and a single layer of cuboidal granulosa cells.

UNIT 2

METHODS OF BIRTH CONTROL

2.1. Key Unit competence

Apply the methods of birth control in their life situation.

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

Student-teachers have learnt the unit 1of Human reproductive system and gametogenesis

As tutor, you start this unit by asking questions related to that unit studied in year two to ensure that student-teachers have good foundation to this new unit.

2.3. Cross cutting issues to be addressed

In this unit, the following cross cutting issues will be addressed:

(a) Standardisation culture

Bring to the attention of student-teachers the importance of seeking medical attention from qualified doctors or gynecologists in case they have any conditions or diseases of affecting the reproductive system. Student-teachers need to pay attention while making choice of materials to be used in pregnancy prevention and how to use them.

(b) Gender education

Emphasise to student-teachers that anybody irrespective of their gender can pursue a career in human physiology, medicine or gynecology and can take decision in terms of birth control regardless to his or her gender.

(c) Comprehensive sexuality education

Comprehensive sexuality education, which is age-appropriate, gender-sensitive and life skills-based can provide young people with the knowledge and skills to make informed decisions about their sexuality and life style. Preparing young people for the transition to adulthood has been one of humanity's greatest challenges with human sexuality and relationships at its core.

Few young people receive adequate preparations for their sexual lives. This leaves them potentially vulnerable to coercion, abuse and exploitation unintended pregnancy and sexually transmitted infections (STIs) including HIV/AIDS. Many young people approach adulthood faced with conflicting and confusing messages about sexuality and gender. This is often exacerbated by embarrassment, silence, disapproval and open discussion of sexual matters by adults (parents, tutors) at the very time when it is most needed.

Comprehensive sexuality education supports a rights - based approach in which values such as respect, acceptance tolerance, equality, empathy and reciprocity are inextricably linked to universally agreed human rights. A clear message concerning these dangers and how they can be avoided, from right across the curriculum, is the best way to ensure that young people understand the risks and know how to stay healthy.

(d) Inclusive education

All learners should be encouraged to participate during lessons and group activities. Special arrangement should be done to take care of learners with special needs.

For addressing inclusive education, while student-teachers will be conducting Activity, instructional information should be given clearly. They can sometimes use their sense organs for identifying the results and observe the learning materials in order to draw conclusion.

Provide procedure earlier before any experiment so that student-teachers get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts.

2.4. Guidance on introductory activity 2

Tutor introduces the unit using a story telling about the consequences of rapid population growth. Ask student-teachers to answer the related questions of **introductory activity 2** as designed in Student-teacher's book.

Notes: This activity is very essential since it captures the attention of student-teachers. As a tutor, you are required to give such activity because it has the following benefits:

- It creates curiosity among student-teachers and enhances active learning through practice.
- It promotes critical thinking and allows student-teachers to predict the next lesson.
- The tutor is encouraged to set clear introductory activity which can give a general picture of the whole unit if possible.

Answers of the introductory activity 2

The answers from the student-teachers will include the following key ideas:

a) Family planning: the practice of controlling the number of children one has and the intervals between their births, particularly by means of contraception or voluntary sterilization.

b) Family planning helps people to have the desired number of children, which as a result improves the health of mothers and contributes to the nation's social and economic development.

c) And (d) the answers vary according to the examples given by the student-teachers.

2.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Natural contraceptive methods	Describe the main types of natural birth control techniques. Discuss the advantages and disadvantages of different natural birth control methods. Recognize and run a session of sensitization on effective use of contraceptive methods.	1
2	Artificial contraceptive methods	Describe the main types of artificial birth control techniques. Discuss the advantages and disadvantages of different artificial birth control methods. Recognize and run a session of sensitization on effective use of contraceptive methods.	2
3	STIs and HIV prevention	State the causes and ways of prevention of STIs and HIV.	2
4	End assessment unit		1

Lesson 1: Natural contraceptive methods

a) Learning objective

- Describe the main types of natural birth control techniques.
- Discuss the advantages and disadvantages of different natural birth control methods.
- Recognize and run a session of sensitization on effective use of contraceptive methods.

b) Teaching resources: Scenario written on Manila paper or rice sac, chart of birth control methods, text books andinternet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Human male and female reproductive organs anatomy.
- Male and female physical changes in puberty.

d) Activity 2.1

- **Guidance:**
  - Organize student-teachers into groups to carry out **Activity 2.1in unit 2** of Student-teacher's Book.
  - Provide the diagrams that represent examples of natural contraceptive methods.
  - Encourage student-teachers to observe the diagram and work as a team as they share duties, ideas and openly share their views while carrying out the activity.
  - Provide student-teachers with reference materials for research. If computers with internet are available, they can do their research.
  - Allow student-teachers to discuss their findings with their classmate. Hold a class discussion on natural contraceptive methods and their effects (advantages and disadvantages.
  - Go further and explain what natural contraceptive method is, giving examples. Help student-teachers to get conclusion by referring on the **Student-teacher's Book unit 2.**

Answers to activity 2.1

a) Natural contraceptive method is a method of preventing pregnancy without the use of medications or physical devices. These concepts are based on awareness and observations about a woman's body and menstrual cycle.

b) The calendar rhythm method.

c) Abstinence, basal body temperature method, mucus inspection method, withdrawal method and lactation amenorrhea method.

e) Answers to Application activities 2.1

Ask student-teachers to work individually or in pair to answer the questions of application activity 2.1.

First fertile period: 27 – 18 = 9 (August 9 + 9 =August 17)

Last fertile period: 36 – 11 = 25 (August 9 + 25 =September 3)

The fertile period of Mary will be from 17 August to 3 September 2019

NB. In this exercise it is better to update the date according to the time the lesson will be delivered in order to mark the learning process standard e.g. tell them she has had her menstruation on 09/05/2020 if you are in June 2020.

Lesson 2: Artificial contraceptive methods

a) Learning objective

- Describe the main types of artificial birth control techniques.
- Discuss the advantages and disadvantages of different artificial birth control methods.
- Recognize and run a session of sensitization on effective use of contraceptive methods.

b) Teaching resources: Scenario written on Manila paper or rice sac, chart of birth control methods, text books andinternet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Human male and female reproductive organs anatomy.
- Male and female physical changes in puberty.
- Natural birth control methods.

d) Activity 2.2

- **Guidance:**
  - Organize student-teachers into groups to carry out **Activity 2.2 in unit 2** of Student-teacher's Book.
  - Provide the diagrams that represent examples of artificial contraceptive methods.
  - Encourage student-teachers to observe the diagram and work as a team as they share duties, ideas and openly share their views while carrying out the activity.
  - Provide student-teachers with reference materials for research. If computers with internet are available, they can do their research.
  - Allow student-teachers to discuss their findings with their classmate. Hold a class discussion on artificial contraceptive methods and their effects (advantages and disadvantages.
  - Go further and explain what artificial contraceptive method is, giving examples. Help student-teachers to get conclusion by referring on the **Student-teacher's Book unit 2.**

Answers to Activity 2.2

a) A= Intrauterine device, B= Condom, C= Tubal ligation, D= Diaphragm, E= Pills and F= Vasectomy.

b) C and F. Permanent contraception is methods of sterilisation that prevent pregnancy permanently because they are not reversible.

e) Application activities 2.2

Ask student-teachers to work in pair to answer the questions of application activity 2.2.

a) Contraceptive method that can prevent both STIs and pregnancy is the use of condoms and abstinence. Dual protection may be achieved through either the use of a barrier method such as a male or female condom together with another contraceptive method or through the use of the male or female condom alone. The use of condoms may be effective in preventing transmission of STIs and unwanted pregnancies but they are not 100% effective.

b) The choice depends on everyone and the effectiveness of the methods.

Lesson 3: STIs and HIV prevention

a) Learning objective

- State the causes and ways of prevention of STIs and HIV.

b) Teaching resources:

Scenario written on Manila paper or rice sac, chart of birth control methods, text books andinternet, computer animations, projector, Manila paper with diagrams for improvisation.

c) Prerequisites/Revision/Introduction

Student-teachers learn better this lesson if they know the following:

- Male and female reproductive organs.
- Natural and artificial contraceptive methods.

Allow them to review the above topic through asking questions. This is very relevant to learn well next lesson.

d) Activity 2.3

- **Guidance**
  - Organize student-teachers into groups to carry out **Activity 2.3 in unit 2** of Student-teacher's Book.
  - Provide the diagrams that represent examples of artificial contraceptive methods with one which is used to prevent STIs.
  - Encourage student-teachers to observe the diagrams and work as a team as they share duties, ideas and openly share their views while carrying out the activity.
  - Provide student-teachers with reference materials books for research. If computers with internet are available, they can do their research.
  - Allow student-teachers to discuss their findings with their classmate. Hold a class discussion on STIs, their causes, transmission, symptoms and their prevention measures.
  - Go further and explain the effect of being engaged in sexual activities, giving examples. Help student-teachers to get conclusion by referring on the **Student-teacher's Book unit 2.**

Answers to Activity 2.3

The risks of being engaged in sexual activities are unintended pregnancy, STIs transmission, etc. The prevention measures of the risks are: use of condoms and abstinence. The uses of condoms and abstinence have dual protection as they prevent both unintended pregnancy and STIs.

e) Answers to Application activities 2.3

Ask student-teachers to work individually to answer the questions of application activity 2.3.

a) Syphilis
b) Preventive measures: Use of condoms, abstinence, educating people about STIs, etc.

2.6. Summary of the unit 2

Methods of birth control

Contraception has allowed people to have control over their own fertility. Therefore, people are able to make an attempt to avoid pregnancy at times when they do not plan to have children; or to plan and choose the number of children they wish to have. There are many different techniques encompassed by the term **contraception**.

Birth control is the use of various devices, drugs, agents, sexual practices, or surgical procedures to prevent conception or pregnancy.

A range of devices and treatment are available for both men and women that can help prevent pregnancy.Some methods are more reliable than others. How well a method work often depends on how carefully it is used.

The contraceptive pill, for example, used correctly, is over 99% effective. However, because people make mistakes and women may become pregnant while using it.

Natural contraceptive methods do not involve any type of device or medication.

Artificial birth control is any product, procedure or practice that uses artificial or unnatural means to prevent pregnancy. Barrier methods such as condoms and diaphragms, hormonal methods such as the pill and IUDs, and surgical sterilization procedures such as vasectomy or hysterectomy are all artificial birth control methods.

2.7. Additional Information for tutor

Emergency contraceptive pills or the **“morning - after pill”** may prevent pregnancy after intercourse. It prevents ovulation, fertilization, or implantation of an embryo. It is different from medical methods of termination, because these act after the egg is already implanted in the womb. Emergency contraception can be used to 72 hours after unprotected sex. It is 95% effective during the first 24 hours, falling to 60% by 72 hours. Emergency contraception should only be used when primary methods fail.

Guidance on Lab skills 2

Organize student-teachers in groups and distribute the materials needed for each group. Give them the procedure to follow and guide them to put into practice. Assess the student-teachers work by completing the format provided in student-teacher's book. The most flexible, resistant and not leaking condom is the best to be advised to people because it prevents spread of both sperms and pathogenic germs causing STIs.

2.8. End unit assessment (answers)

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

5. They both target to improved family wellbeing, improved maternal and infant health, etc.

Differences:

Natural contraceptive methods	Artificial contraceptive methods
– Effective method of birth control. – Have no negative health side effects. – An alternative for women who cannot or do not want to use hormonal methods. – Promotes positive body awareness. – Consistent with many religious beliefs and lifestyles. – Alerts women to reproductive health and fertility concerns. – Fosters communication between partners and encourages male involvement.	– Gives great protection against unplanned pregnancy if one follows instructions. – Condoms to some extent protect against pregnancy and STDS. – Combinations of pills reduce/prevent cysts in breasts and ovaries. – Necessity of taking medication continually. – High cost of medication. – Hormonal contraceptive does not protect against STDS. – Eggs may fail to mature in the ovary for a woman who uses hormonal contraceptives. – Woman must remember to take them regularly. – Woman must begin using hormonal contraceptive in advance before they become effective. – Some women experience several; headaches, breast tenderness, chest pain, discharge from vagina, leg cramps and swelling or pain.

6. The contraceptive pill if used correctly is over 99% effective. However, because Musabyimana made mistakes while using it, she became pregnant.

7. The general limitations of natural contraceptive methods are the following:
   a) Provides no protection from sexually transmitted infections.
   b) Often difficult to find trained instructors.
   c) Requires time to learn (usually 3 to 6 cycles).
   d) Requires discipline and commitment to chart fertility signs and follow the rules to avoid pregnancy.
   e) Times of abstinence from intercourse may be a challenge for some couples.

8. The main ways by which HIV is transmitted are:
   - None protected sexual intercourse either homosexually or heterosexually. It passes from infected semen or vagina fluid to blood of health person through damaged tissue in the vagina, penis or rectum.
   - From sick mother to her baby during birth or through breast milk during suckling.
   - Through transfusion blood by contaminated needles.
   - Through sharing contaminated sharp instruments.

9. HIV is a virus that attacks cells in the immune system, which is our body's natural defence against illness. The virus destroys a type of white blood cell in the immune system called a T-helper cell, and makes copies of itself inside these cells. T-helper cells are also referred to as CD4 cells.

AIDS is a set of symptoms (or syndrome as opposed to a virus) caused by HIV. A person is said to have AIDS when their immune system is too weak to fight off infection, and they develop certain defining symptoms and illnesses. This is the last stage of HIV, when the infection is very advanced, and if left untreated will lead to death.

10. Refer to Unit 2, lesson 2.2

2.9. Additional activities

2.9.1. Remedial activities

1) Which of the STDs described are caused by bacteria and, therefore, can be effectively treated with antibiotics?
2) How does HIV infection harm the immune system?
3) Which of the STDs described in this chapter are likely to cause PID-related infertility?

Answers

1) Chlamydia, gonorrhea, syphilis, and bacterial vaginosis.
2) HIV infects helper T lymphocytes, which are important to the immune system because they stimulate B lymphocytes and cause them to produce antibodies.
3) Chlamydia and gonorrhea.

2.9.2. Consolidation activities

1) Which three birth control methods mechanically block sperm from entering the uterus?
2) Which methods can utilize progesterone?

Answers

1) Male condom, female condom and the diaphragm prevent sperm from coming in contact with the egg.
2) Contraceptive implant, vaginal ring, contraceptive injections, etc.

2.9.3. Extended activities

Explain the theory of the disease and the causes, sources, transmission, symptoms and controls of the disease.

Answers

Theory of disease

Before the work of SPALLANZANI and Louis PASTEUR many people believed in **spontaneous generation** i.e. continual creation of new life from non-living things.

Louis PASTEUR developed the **germ theory of disease** which postulates that all contagious and infectious diseases must be caused by pathogenic microorganisms.

The contributions of Louis PASTEUR in microbiology and medicine include:

- The fight against spontaneous generation theory
- The technique of sterile culturing of microorganisms
- The technique of fermentation and conservation of drinks. That technique is known as **Pasteurization**; by treating drinks (wine and milk) at a brief period on moderate heating.

- The technique of antiseptic surgery to prevent contamination of wounds during the surgical operations in hospitals.

Types of diseases

A **disease** is often defined medically as any physical or mental disorder or malfunction with a characteristic set of signs and symptoms. This excludes disorder resulting from physical trauma (for example a tooth lost in a struggle).

Signs are indications of a disease that can be observed by a doctor. **Symptoms** are indications of disease perceive by the patient.

Infectious diseasesare diseases that are caused by organisms known as **pathogens**. They are sometimes called **communicable** diseases as they are passed from infected to uninfected people. Some also affect animals and are passed from animals to humans.

Malaria is one of the most serious of all human diseases. It is endemic in about 100 countries in Latin America, Africa and South-East Asia. The burden of malaria is felt most in countries in Africa: 47% of all deaths from malaria occur in Nigeria and the Democratic Republic of the Congo.

1) Transmission of infectious diseases

Pathogens can spread when you have direct contact with an infected person. For example, if you have contact with the person's blood, body fluids or open wounds. Pathogens can also be spread in contaminated food, water or air. Infected animals can spread pathogens to people. So there are many different ways in which an infectious disease is spread. However, these conditions will usually lead to the spread of an infectious disease from one person to another:

- There must be a pathogen, which causes the disease.
- The pathogen must come from a source, which is a sick or infected person.
- There must be a way of transmitting the pathogen from the source to the host (the host is the new person). For example, some pathogens are carried by water and others are carried by flies.
- The pathogen must be able to enter the body of the new host to cause an infection. For example, the new person drinks the water or the fly bites the new person.
- The host must be someone who is not immune to the disease.

Infectious diseases follow a pattern of development from the time of infection. The pattern of development has four or five distinct periods, as described in table below.

PERIOD	DESCRIPTION
Incubation period	The pathogen grows and multiplies in the host's body. There are no symptoms yet.
Prodromal period	The host is usually tired, lacks appetite and begins to feel ill.
Period of clinical symptoms	The host shows typical symptoms of the particular disease, for example, spots and fever.
Convalescence period	The host usually recovers from the disease and symptoms disappear.
Period of complications	Some diseases cause further complications. For example, a pregnant woman who has German measles may give birth to a deformed baby.

2) Epidemiology or study of patterns of disease

The study of patterns of disease and of the various factors that affect the spread of disease is called **epidemiology.**

Epidemiologists try to discover the factors that cause a disease and develop methods to prevent its spread. The main clue they use come from data about the number of people in a particular area affected by specific diseases, and the number who died. The data are commonly expressed as incidence or morbidity and mortality rates.

The **incidence or morbidity** rate is the number of new cases of disease in a given population occurring during a specific period (a week, month or a year). It is calculated as:

$$\textbf{Incidence (morbidity)} = \frac{\text{number of cases of a given disease}}{\text{number of individuals in the population}} \times 100$$

Example: Among 900 students at a given school, 50 suffer from malaria and 4 are recorded to die from it. Calculate the morbidity or the incidence of malaria at that school.

$$\textbf{Solution: Incidence} = \frac{50}{900} \times 100 = 5.5\%$$

To find how many cases of a disease are new, this calculation requires information about the **prevalence rate**. This is the total number of individuals infected in a population at any one time, no matter when the disease began; information about prevalence is very useful in its own right.

The mortality rate of a disease may be estimated for a whole population irrespective of whether they have the disease or not.

$$\textbf{Mortality rate} = \frac{\text{number of death due to a given disease}}{\text{number of individuals in the population}} \times 100$$

Alternatively, it may be calculated using only those people who have disease.

$$\textbf{Mortality rate} = \frac{\text{number of deaths due to a given disease}}{\text{number of population with the same disease}} \times 100$$

To make fair comparisons between different populations with the same disease, epidemiological information is usually adjusted. For example, the mortality rate among those with a particular disease is usually expressed as a percentage or ratio per year. Hence, if in one year 7500 people in a given area die as a result of AIDS and the total number of population infected was 30 000, the mortality rate would be 25% for the rate.

Epidemiological studies are used to identify whether a disease is endemic, epidemic, or pandemic:

i) **Endemic disease** is a disease that is always present in a people e.g. malaria in tropical Africa.

ii) **Epidemic disease** is a disease that spreads rapidly, suddenly, and unexpectedly to affect many people e.g. cholera in refugees' camp. The term epidemic disease does not include expected rises, for example, the increased incidence of influenza that happens every winter in temperate regions.

iii) **Pandemic disease** is a disease that affects people over very large area, such as a continent or even the whole world e.g. AIDS and TB are pandemic at present.

UNIT 3

ALKANES

3.1. Key unit competence

Relate the physical and chemical properties of the alkanes to the preparation methods, uses and isomerism.

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

Student teachers are equipped with knowledge, skills and attitudes that they have developed from the study chemical bonding and particularly molecular structures, classification of organic compounds, periodic table.

3.3. Cross cutting issues to be addressed

a) Inclusive education:

This unit involves a number of formulae on organic compounds, the writing of formulae. This may be challenging to student teacher with special educational needs especially student teacher with visual impairment or visual difficulties. However, the teacher can make some arrangements like:

Student teachers with special educational needs are grouped with others and assigned roles basing on individual student teacher's abilities.

- If a tutor has student teacher with visual difficulties, when writing on the blackboard, write in large, clear writing, especially when it comes to formulae for alkanes. Read out what you are writing, for the benefit of those who are not able to see the blackboard clearly.
- If student teachers are sharing textbooks, try to arrange for those with visual difficulties to have their own copies, as far as this is possible.
- Give extra time for them to write summary notes or write down observations after doing experiments for alkanes.
- Every important point is written and spoken.
- Remember to repeat the main points of the lessons.
- For student teachers with visual impairment tutor can write of them a summary using the braille alphabet if possible.

- For student teacher with hearing difficulties, the tutor has to encourage them to sit closer to the front of the classroom. When teaching, often stop for a while to ask student teacher whether they have understood, or if they need you to repeat a point.
- Encourage student teacher not to be afraid to ask questions. When teaching, speak clearly and ensure that all the student teachers can hear your voice. Avoid speaking hurriedly as this will make it difficult for student teacher with hearing difficulties to make sense of what you are saying.
- Student teachers with mobility difficulties: Encourage other student teacher to look out for and help their classmates. For example, when working in the laboratory, ensure that they are able to participate, for example, making sure that they can reach the tables and other laboratory equipment comfortably.

b) Financial education: As the unit 3 deals with the importance of alkanes in modern life, the tutor will draw the student teacher's attention on the economic impact of the making of common useful substances made using knowledge of chemistry.

c) Environment and sustainability: The growing awareness of the impact of the human race on the environment has led to recognition of the need to ensure our young people understand the importance of sustainability as they grow up and become responsible for the world around them. Hence Environment and Sustainability is a very important cross-cutting issue.

Student teachers need skills and attitudes in this unit 3 (alkanes) that will enable them in their everyday life to address the environment and climate change issue and to have a sustainable livelihood. While teaching this unit concerning alkanes especially their reactivity, talk about the environment and its sustainability.

3.4. Guidance on introductory activity

Before introducing the lesson one of unit 3, ask student teachers (in pairs) to attempt the introductory activity from student teacher's book. This activity intends to relate the unit with student teachers' daily life and to capture their attention.

Ask student teachers to use library or internet (where is possible) in order to conduct this introductory activity very well. Student teachers may not be able to find the right answers but they are invited to predict possible solutions or answers.

Select some groups to share their findings to the whole class.

After presentation, give your comments showing them how alkanes are very important in our daily life.

It is not necessary to give them all answers of this introductory activity because they will study them in this unit 3. So, you can leave student teacher with the curiosity of knowing the correct answers.

Expected answers

1) a) The *Kivu Watt* Project involves the construction of an integrated methane *gas extraction* facility. Formula CH_4

   b) Rwanda's Lake Kivu, with its high concentration of methane gas and carbon dioxide, was seen as a risk due to its potential for toxic release. On extracting methane from the lake to generate electricity that will expand household access to power, lower costs, and reduce environmental hazards. 2, 3, 4 & 5 Student teachers are free to give their own answers

3.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Nomenclature of straight and branched chain hydrocarbon alkanes.	- Name straight chain alkanes up to carbon -10. - Write the structural formula of the alkanes. - Use IUPAC system to name straight and branched alkanes.	2
2	Physical properties of straight and branched alkanes.	- Be aware of the dangers associated with combustion reactions of the alkanes. - Describe and explain the trend in physical properties of homologous series of alkanes.	1
3	Preparation of the alkanes	- Prepare, collect and test methane gas. - Develop practical skills and interpreting results in making appropriate deductions.	2
4	Uses of the alkanes	- State the physical properties and uses of the alkanes	1
5	Chemical properties of the alkanes.	- State the chemical properties of the alkanes.	1
	End unit assessment		1

Lesson 1:Nomenclature of straight and branched chain hydrocarbon alkanes

a) Learning objective:

- Name straight chain of alkanes
- Write the structural formula of the alkanes.
- Use IUPAC system to name straight and branched alkanes.

b) Teaching resources: Chemistry textbooks and other relevant chemistry books from the library, computer, projector, periodic table.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the nomenclature of alkanes using IUPAC system if they are equipped with knowledge, skills and attitudes that they have developed from the study of covalent bonding and molecular structures.

d) Activity 3.1

- **Guidance**
  - Tutor forms groups (the number of groups and members will depend on your class size and the number of your resources or materials).
  - Give student teachers activity 3.1 (from the student teacher's textbook)
  - Move around the class and check if all student teachers are working effectively.
  - Ask student teachers to present their findings.
  - Guide and facilitate student teachers to make the summary of the lesson themselves. Make sure the following are emphasized on: (un-branched alkanes, branched alkanes).
  - Make the final conclusion of the lesson.

Answersto activity 3.1

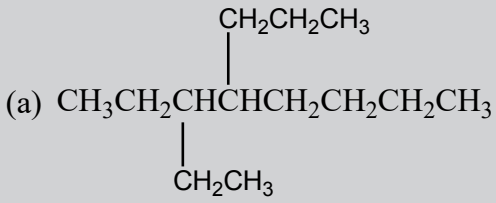
1) The two elements are carbon and hydrogen. All the atoms in these compounds are covalently bonded.
2) Compound (d) and (e) have branches or ramifications.
3) Compounds (d) and (e) are branched or ramified but (b) and (c) are linear.
4) (a): Methane (b): Propane (c):butane(d): 2-methylpropane or methylpropane or isobutane(e): 2,4-dimethylpentane

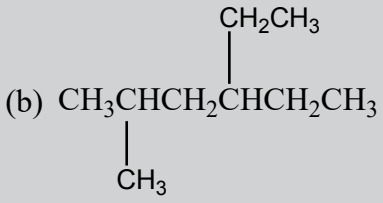
e) Answers to application activity 3.1

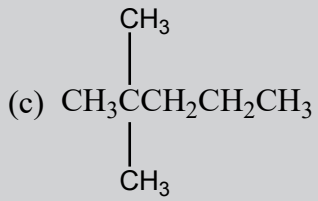
1) a) 2,3-dimethylpentane

b) 5-ethyl-8-methyltridecane

2)







Lesson 2: Physical properties of straight and branched alkanes

a) Learning objective:

- Describe and explain the trend in physical properties of homologous series of alkanes.
- Be aware of the dangers associated with combustion reactions of the alkanes.

b) Teaching resources: Chemistry textbooks and other relevant chemistry books from the library, computer, projector, periodic table, manilla paper, different photos of gases.

c) Prerequisites/Revision/Introduction

Student teachers will learn better physical properties of straight and branched alkanes using IUPAC system if they are equipped with knowledge, skills and attitudes that they have developed from the study introduction to organic compounds.

d) Activity 3.2

- **Guidance**
  - Give student teachers activity 3.2 (from the student teacher's textbook).
  - Ask student teachers to carry out this activity in pairs
  - Move around the class and check if all student teachers are working.
  - Ask student teachers to present their findings.
  - Summarize using student teachers' findings and make comments on that activity done.

- **Answers to activity 3.2**

1) (a) (i)Methane, ethane, propane and butane

ii) It is in gaseous state

(b) The alkanes which are used as gasoline have the number of carbon atoms between 5 and ten (C5- C10).

c) The alkanes which are used to make candle wax have the number of carbon atoms which is above 18.

2) Gasoline is the one which is easily converted into vapours because it is made of alkanes with lower number of carbon atoms.

3) Gasoline does not dissolve in water; once mixed, the two substances form two phases: organic phase and aqueous phase. This is because gasoline is made of non-polar compounds while water molecules are very polar.

e) Answers to application activity 3.2

1) Hexane and heptane do not dissolve in water but they are soluble in organic solvents like carbon tetrachloride.

2) (b) has higher boiling point than (a) because straight chain isomers are closer packed than the branched chain isomers.

Lesson 3: Preparation of the alkanes

a) Learning objective:

- Prepare, collect and test methane gas.
- Develop practical skills and interpreting results in making appropriate deductions.

b) Teaching resources: Chemistry textbooks, stand and accessories, delivery tube, sodium hydroxide solid, sodium acetate solid, calcium oxide solid.

c) Prerequisites/Revision/Introduction

Student teachers will learn better preparation of the alkanes if they are equipped

with knowledge, skills and attitudes that they have developed from the study for types of reactions.

d) Activity 3.3

- **Guidance**
  - Tutor forms groups of four to five student teachers
  - Tutor distributes the materials listed above
  - Ask student teachers to carry out the activity3.3(from the student teacher's book).
  - Ask student teachers to present their findings and deductions to the whole class.
  - Summarize the findings from student teachers' work and give more examples which illustrate the content about preparation of alkanes.

Answer to activity 3.3

Refer to student teacher textbook on summary for activity 3.3

e) Answers to application activity 3.3

a) $CH_3CH_2COONa(s) + NaOH(s) \xrightarrow[\text{heat}]{CaO(s)} CH_3CH_3 + Na_2CO_3(s)$

b) $CH_3CH_2Br + H_2 \xrightarrow{Pd} CH_3CH_3 + HBr$

c) $CH_3CH{=}CHCH_2CH_3 + H_2 \xrightarrow[150^0C]{Ni} CH_3CH_2CH_2\,CH_2CH_3$

d) $CH_3CH_2CH_2Cl \xrightarrow{Ethanol/Zn\text{-}Cu} CH_3CH_2CH_3$

Lesson 4: Uses of the alkanes

a) Learning objective: State the physical properties and uses of the alkanes.

b) Teaching resources: Chemistry textbooks, computer, projector, manilla papers, flash cards.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the uses of alkanes if they are equipped with knowledge,skills and attitudes that they have developed from the study for physical properties of alkanes.

d) Activity 3.4

- **Guidance**
  - Tutor forms groups of four to five student teachers
  - Ask student teachers to carry out the activity 3.4 (from the student teacher's book).
  - Ask student teachers to present their observations and deductions to the whole class.
  - Guide learners to make the summary of the lesson themselves.
  - Together with student teachers conclude the activity

Answers to activity 3.4

Refer to student teacher's summary under activity 3.4

e) Application activity 3.4

1) Usage of alkanes are very versatile and are being used as solvents, heating oils, fuels, in fat synthesis, in the synthesis of fatty acids by air oxidation, in the manufacture of albumen, in the transformation to olefins.
2) The first four alkanes are used for heating, cooking and electricity generation. The main components of natural gas are methane and ethane. Propane and Butane are used as LPG (liquified petroleum gas). Propane is also used in the propane gas burner, butane in disposable cigarette lighters.
3) Alkanes (both alkanes and cycloalkanes) are virtually insoluble in water, but dissolve in organic solvents. However, liquid alkanes are good solvents for many other non-ionic organic compounds.
4) (a) Branching decreases the boiling point, as the length of carbon chain increases, the surface area of the compound will also increase. Van der Waals dispersion force is proportional to the surface area. So the increase of surface area increases the ability of individual molecules to attract each other.

   (b) For any group of isomeric alkanes, the most branched isomer has the lowest boiling point. The normal alkane has the highest boiling point.

Lesson 5: Chemical properties of the alkanes

a) Learning objective: State the chemical properties of the alkanes.

b) Teaching resources: Chemistry textbooks, computer, projector, manilla papers, flash cards.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the uses of alkanes if they are equipped with knowledge, skills and attitudes that they have developed from the study for physical properties of alkanes and types of reactions.

d) Activity 3.5

- **Guidance**
  - Tutor forms groups of four to five student teachers
  - Ask student teachers to carry out the activity 3.5 (from the student teacher's book).
  - Ask student teachers to present their observations and deductions to the whole class.
  - Guide learners to make the summary of the lesson themselves.
  - Together with student teachers conclude the activity

Answers to activity 3.5

The reaction that takes place is **combustion** and the equations are:

$$2CH_3CH_3 + 7O_2 \longrightarrow 4CO_2 + 6H_2O \quad \text{(in the picture A)}$$

$$C_7H_{16} + 11O_2 \longrightarrow 7CO_2 + 8H_2O \quad \text{(in the picture B)}$$

e) Answers to application activity 3.5

1) Refer to student teacher textbook on activity 3.5.
2) Refer to student teacher textbook on activity 3.5.
3) Carbon dioxide is one of the greenhouse gases. Greenhouse gases cause global warming.

3.6. Summary of the unit

Alkanes

Alkanes are hydrocarbons that form the homologous series of general formula $C_nH_{2n+2.}$

The chemical structure of alkanes has three types: linear, branched (or ramified), and cyclic.

Linear alkanes have the carbons bonded together in a chain-like structure. The chemical structure can be drawn two ways.

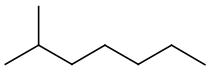
It can be drawn with all the carbon and hydrogen atoms being shown, or it can be drawn as a chain (the hydrogen atoms are not shown), where each edge represents a carbon atom.

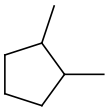
Branched alkanes are derived from linear alkanes, but instead of having just a straight chain in their chemical structure, it is branched with one or more alkyl groups. An alkyl group is a group of carbon and hydrogen atoms attached to an alkane molecule.

Cyclic alkanes or cycloalkanes consist of hydrogen and carbon atoms bonded together with single bonds, where the carbon atoms bond together to form a ring or loop.

- They show structural (chain, position) and isomerism.
- They can be extracted from crude oil by fractional distillation.
- Alkanes are unreactive towards polar or ionic reagent. But, they react with reagents such as oxygen and halogens.
- Alkane molecules break down to smaller molecules at high temperature or in the presence of a catalyst. The reaction called cracking. It is important the petrochemical industry.
- Their main use is as sources of energy by combustion; many of them are used as solvents.
- They react with chlorine and bromine in a free radical substitution reaction, giving chloro or bromoalkanes.

NB: Linear, branched or cyclic alkanes may be drawn using Bond-Line (skeleton) notation, where atoms of carbon and hydrogen are not shown and only bond-line, where each cornerrepresentseither a -CH-, or -CH_2- group and each end denotes a -CH_3group, is shown.

Ex.:  2-methylheptane

 1,2-dimethylcyclopentane

3.7. Additional information for tutor

- **Nomenclature of cycloalkanes**

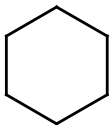
For naming cycloalkanes, the prefix "**cyclo"** is recommended, followed by the name of the alkanes of the same carbon number.

Examples:


Cyclopropane

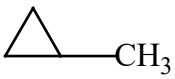

Cyclobutane


Cyclopentane

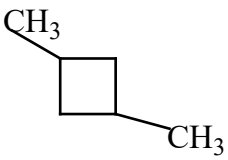

Cyclohexane

But in case of ramified (branched) cycloalkanes, the priority is for the ring.

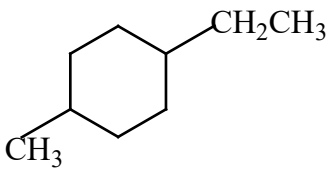
Examples:



methylcyclopropane



1,3-dimethylcyclobutane



1-ethyl-4-methylcyclohexane

Guidance on skills Lab (including answers where possible)

This skills lab will help student teachers to be familiar for making their own beeswax candle even at school or at their home place.

- Give to student teachers those apparatuses used for making beeswax candle
- Before making beeswax candles, prepare by getting all of your supplies together and setting up an area to work. To make these candles student teachers will need: beeswax sheets, scissors or a knife, candle wicks, a cutting board or other hard surface for cutting.
- Lay out a sheet of beeswax. If using coloured wax in combinations cut the sheet and add other colored pieces. Lay them close together so they overlap.

- Take the wick and place it near the beginning of the wax sheet. Let an inch or so of the wick hang out of the bottom of the candle and two inches out of the top of the beeswax sheet.
- Press the wick gently into the beeswax sheet. The wick needs to be secured so that it will not be displaced during rolling. After the wick is firmly in place, it is time to create the candle.
- Slowly, roll the beeswax sheet over itself. Keep the rolls tight so no gaps are present in the wax. Continue rolling until the entire sheet is finished or the candle is as wide as you would like it. Larger candles like pillars have one or three wicks depending on width.
- Cut the wick at the bottom even with the bottom of the candle. Trim the wick at the top of the candle until it is about half an inch long.

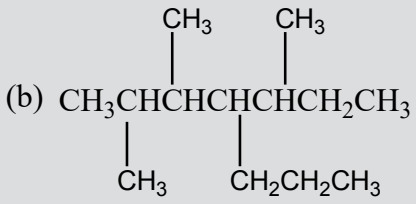
Invite your student teachers to go in TRC (Teaching Resource Centre) to exercise themselves and tell them to bring the final products they will got as beeswax candle. For any more information about making beeswax candle visit this website and observe this movie (https://www.youtube.com/watch?v=-DZrEXxdUks).

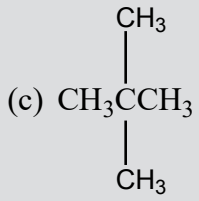
3.8. End unit assessment (answers)

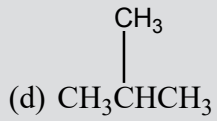
1) a) True b) True

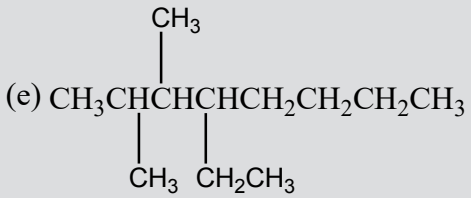
2)

(a) $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

(b)


(c)


(d)




3). Refer to the student teacher textbook on activity 3.1

4). Refer to the student teacher textbook on activity 3.2

5).

a) $CH_3\text{-}Br + CH_3\text{-}CH_2\text{-}Br + 2Na \longrightarrow CH_3\text{-}CH_2\text{-}CH_3 + NaBr$

b) $CH_3\text{-}CH{=}CH\text{-}CH_3 + H_2 \xrightarrow{Pd} CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$

3.9. Additional activities (Questions and answers)

3.9.1. Remedial activities (Questions and answers)

Questions

1) Explain the following terms:
   a) Cracking
   b) Fractional distillation

2. a) Write an equation for the combustion of hexane in a plentiful supply of oxygen.

b) Which different products would be formed if the supply of oxygen were limited?

Answers:

1) a**) Cracking** is the breaking down of long-chained saturated hydrocarbons to form a mixture of shorter-chained alkanes and alkenes.

b) Fractional distillation separates liquids from a mixture according to their different boiling points.

2)

a) $C_6H_{14} + O_2 \longrightarrow 6CO_2 + 7H_2O$

b) If the supply of oxygen were limited, carbon monoxide (CO) would be produced instead of carbon dioxide.

3.9.2. Consolidation activities (Questions and answers)

Questions

1) Name three greenhouse gases. For each gas, state the bonds that absorb infrared radiation.

2) A deodorant contains a mixture of butane, 2-methylpropane and propane as propellant.
   a) Suggest a property of these alkanes that makes them suitable as the propellant.
   b) Why alkanes now being used as propellants in aerosol sprays?

Answers:

1) - Carbon dioxide: C=O bonds absorb infrared radiation.
- **Water vapour**: O-H bonds absorb infrared radiation.
- **Methane:** C-H bonds absorb infrared radiation

2) a) Liquid under pressure but vaporise when pressure is released.
b) Alkanes have replaced CFCs which cause damage to the ozone layer.

3.9.3. Extended activities (Questions and answers)

Questions

1) a) What are the constituents of crude oil?
   b) Describe how they are separated.
   c) Briefly explain cracking and state its use in petroleum industry

Answers:

1) a) Gas, petrol, kerosene, diesel oil, lubricating oil.
   b) Crude petroleum is first freed from solid impurities by filtration. It is then first heated in a separate furnace to about 400°C after which the hot liquid is then passed into a fractionating tower. As the hot mixture of gases ascends the tower various vapours condense at different levels of the tower depending on their boiling points. These products are then separately tapped off.
   c) Cracking is the process in the petroleum refinery where less volatile hydrocarbon of the kerosene or diesel fractions are converted to more volatile hydrocarbon (petrol) by application of heat. Cracking can be classified as thermal and catalytic. In thermal cracking the hydrocarbon fractions of long carbon chains (C_{12}-C_{18}) are broken down into shorter chains of petrol by heating to about 500°C under pressure of about 200 atmospheres.

UNIT 4

ALKENES AND ALKYNES

4.1. Key unit competence

Relate the physical and chemical properties of the alkenes and alkynes to their reactivity and uses.

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

Student teachers are equipped with knowledge, skills and attitudes that they have developed from the study chemical bonding and particularly molecular structures, classification of organic compounds, periodic table, concepts of isomerism, general rules of naming organic compounds, types of reactions.

Student teachers have the skills to use effectively the common laboratory apparatus and are aware of the safety precautions to take when working in a chemistry laboratory.

4.3. Cross cutting issues to be addressed

a) Inclusive education

This unit involves a number of formulae on organic compounds and experiments. This may be challenging to student teachers with special educational needs especially student teachers with visual and physical impairment or visual difficulties. However, the tutor can make some arrangements like:

i) Student teachers with visual difficulties

Student teachers with special educational needs are grouped with others who can help them.

- If a tutor has student teacher with visual difficulties, when writing on the blackboard, he/she may write in large and clear writing.
- If student teachers are sharing textbooks, try to arrange for those with visual difficulties to have their own copies, as far as this is possible.
- Give extra time for them to write summary notes or write down observations after experiments.

- Remember to repeat the main points of the lessons.
- For student teachers with visual impairment tutor can write of them a summary using the braille alphabet if possible.

ii) **Student teachers with hearing difficulties,** the tutor has to encourage them to sit closer to the front of the classroom. Encourage student teachers not to be afraid to ask questions. When teaching, speak clearly and ensure that all the student teachers can clearly hear you.

iii) **Student teachers with mobility difficulties:**

These include student teachers on crutches, in wheelchairs, or with walking difficulties. These student teachers can be helped by their classmates. Ask their fellow student teachers to help them with their notes, if their conditions hinder them from writing well.

iv) **Student teachers with reading difficulties:**

Student teachers with this kind of difficulties struggle to make sense of words or understand written work and take longer to read than other student teachers. Encourage them to pay careful attention during class time and participate for example by asking questions and 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 student teachers start to present their findings encourage both (boys and girls) to present.

c) Financial education

As the unit deals with the importance of organic chemistry in modern life, the tutor will draw the student teachers' attention on the economic impact of the making of common items made using knowledge of chemistry.

When performing experiment, they have to avoid waste of chemicals: they have to use the amounts that are just required.

d) Peace and values education

During group activities, the tutor will encourage student teachers to help each other and to respect opinions of colleagues.

e) Standardization culture

Some lessons involve carrying out experiments. Student teachers have to always check if they are not using expired or contaminated 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 and relevant results.

f) Environment and sustainability

In order to avoid the environment pollution, before, during or after experiments student teachers have to not throw away chemicals anywhere.

Student teachers also have to be aware of the impacts of the use plastics on the environment.

4.4. Guidance on introductory activity

Before introducing the lesson one of unit four, you will have to introduce the whole unit. Ask student teachers (in pairs) to attempt the introductory activity from student teacher's textbook. This activity intends to relate the unit with student teachers' daily life and to capture their attention.

- Ask student teachers to use library or internet (where is possible) in order to conduct this introductory activity very well. Student teachers may not be able to find the right answers but they are invited to predict possible solutions or answers.
- Ask student teachers to present their findings.

1) a) Plastics are made from natural materials such as cellulose, coal, natural gas, salt and crude oil through a polymerisation or polycondensation process. Plastics are derived from natural, organic materials such as cellulose, coal, natural gas, salt, crude oil.

b) All of these monomers contain double bonds between carbon atoms such that the carbon atoms can subsequently *react*to form polymers. Other raw material *chemicals*are isolated from petroleum, such as benzene and xylenes. These *chemicals* are reacted with others to form the monomers for polystyrene, nylons, and polyesters.

c) - The advantages of plastics: it is durable, low cost, water resistant, lesser energy and heavy chemicals requirements in manufacture and are light weight.

The disadvantages of plastics:

- Flammable: plastics can release toxic fumes into the environment; cost of recycling, environmental harm; chemical risk.

2) The gaseous plant hormone is ethylene.

4.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Nomenclature and structure of the alkenes	- Apply IUPAC rules to name alkenes. - Write the structural formulae of straight chain alkenes	3
2	Preparation and Chemical test of ethene	Describe the laboratory process of preparing the alkenes and alkynes.	2
3	Physical properties and uses of the alkenes	Explain the reactivity of alkenes in comparison to alkanes.	1
4	Chemical properties of alkenes	Appreciate the combustion reaction as source of fuels.	1
5	Polymerization of ethene and Chloroethene	Explain the use of polymers for alkynes	1
6	Structure and nomenclature of straight and branched alkynes	- Apply IUPAC rules to name alkynes. - Write the structural formulae of straight chain alkynes.	1
7	Physical properties and uses of the alkynes	Explain the reactivity of alkynes	1
8	Chemical properties of alkynes	Describe the additional reaction for alkynes	1
	End unit assessment		1

Lesson 1: Nomenclature and structure of the alkenes

a) Learning objective:

- Apply IUPAC rules to name alkenes.
- Write the structural formulae of straight chain alkenes

b) Teaching resources: Computer, projector,Atomic models, flip charts, molecular models, chemistry textbooks and other relevant chemistry books from the library.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the nomenclature of alkenes using IUPAC system if they are equipped with knowledge, skills and attitudes that they have developed from the study to the covalent bonding and molecular structures, general rules for naming organic compounds.

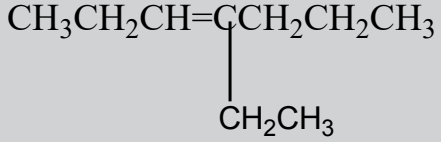
d) Activity 4.1

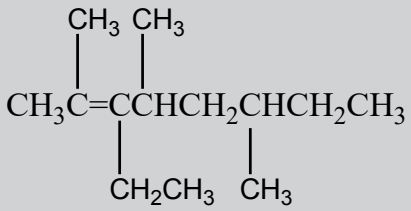
- **Guidance**
  - Tutor forms groups (the number of groups and members will depend on your class size and the number of your resources or materials).
  - Give student teachers activity 4.1 (from the student teacher's textbook)
  - Tutor moves around the class and check if all student teachers are working.
  - Ask student teachers to present their findings.
  - During the presentation, ask some questions that lead to lesson objectives.
  - Guide student teachers to make the summary of the lesson themselves.
  - Make the final conclusion of the lesson.

Answers to activity 4.1

1) Refer to student teacher's textbook on lesson 4.1
2) Refer to student teacher's textbook on lesson 4.1
3) - All three molecules have the same molecular formulae but their atoms are bonded differently and **C** is branched while others are linear.
   - All are isomers from Butene (C_4H_8)

e) Answers to application activity 4.1

1. a) 

b) 

c) $CH_2=C=CHCH_3$

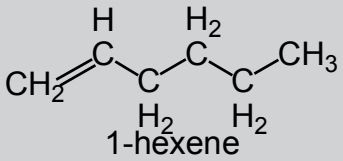
2. a) Hept-2- ene **OR** 2-heptene

b) 4,7-dimethyloct-3-ene **OR** 4,7-dimethyl-3-octene

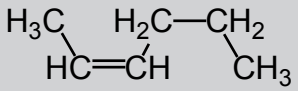
c) 6-ethyl-3,8-dimethylnon-4-ene **OR** 6-ethyl-3,8-dimethyl-4-nonene

d) 6-butyl-10-methyldodec-3-ene **OR** 6-butyl-10-methyl-3-dodecene

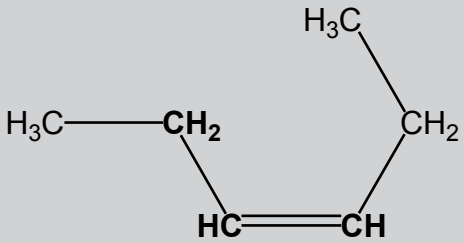
3. a)



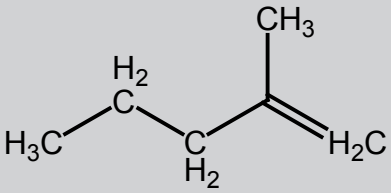
1-hexene



2-hexene

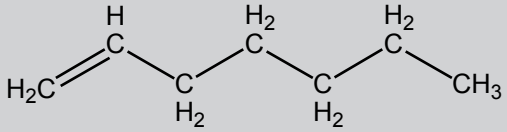


3- Hexene

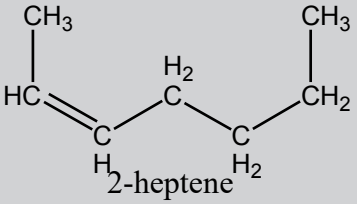


2-methyl-1-pentene

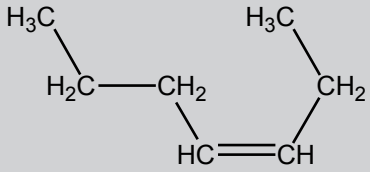
b)



1-heptene



2-heptene



3-heptene

Lesson 2: Preparation and Chemical test of ethene

a) **Learning objective:** Describe the laboratory process of preparing the alkenes and alkynes.

b) **Teaching resources:** Chemistry textbooks, internet (where possible), ethanol, aluminium oxide, lime water, mineral wool, boiling tube, rubber stopper with hole,delivery tube,test- tube rack, test tubes,spatula, bunsen burner,glass rod,matches.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the Preparation and Chemical test of ethene if they are equipped with knowledge, skills and attitudes that they have developed from the study chemical equations, types of reactions, covalent bonding.

d) Activity 4.2

- **Guidance**
  - Tutor forms groups according to the size of the class.
  - Give student teachers the required resources as mentioned above.
  - Ask student teachers to carry out the activity **4.2** (from the student teacher's textbook).
  - Facilitate and guide the activity and make sure that all student teachers are working well.
  - Ask student teachers to present their observations and deductions to the whole class.

Answers to activity 4.2

1) Refer to student teacher textbook on sub-lesson 4.2.1
2) In organic chemistry, the bromine test is a qualitative test for the presence of unsaturation (carbon-to-carbon double or triple bonds). An unknown sample is treated with a small amount of elemental bromine in an organic solvent, being as dichloromethane or carbon tetrachloride.

e) Answers to application activity 4.2

1) a) 2-methylpropene **OR** methylpropene
   b) 2,3-dimethylbut-2-ene **OR** 2,3-dimethyl-2-butene
   c) 2-methylbut-2-ene **OR** 2-methyl-2-butene
2) a) 2-methylpropene **OR** methylpropene
   b) 3-methylpent-2-ene **OR** 3-methyl-2-pentene
   c) 3-ethylpent-2-ene or 3-ethyl-2-pentene
3) a) $(CH_3)_2CHCH=CHCH_3$
   b) $CH_3CH_2C(CH_3)=CHCH_2CH_3$
4) Refer to student teacher textbook on sub-lesson 4.2.2

Lesson 3: Physical properties and uses of the alkenes

a) Learning objective: Explain the reactivity of alkenes in comparison to alkanes.

b) Teaching resources: Chemistry textbooks, internet (where possible), test tubes, cyclohexene, tetrachloromethane and water.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the physical properties and uses of the alkenes if they are equipped with knowledge, skills and attitudes that they have developed from the study to the covalent bonding, molecular structures and isomerism.

d) Activity 4.3

- **Guidance**
  - Distribute the above resources in pairs of student teachers
  - Let student teachers manipulate those materials
  - Ask student teachers to carry out the activity **4.3** (from the student teacher's book).
  - Guide and facilitate all activities
  - Ask student teachers to present their observations and deductions to the whole class.

Answers to the activity 4.3

Refer to student teacher textbook on sub-lesson 4.3.1

e) Answers to application activity 4.3

1) The boiling point of each alkene is very similar to that of the alkane with the same number of carbon atoms. Ethene, propene and the various butenes are gases at room temperature. All the rest that you are likely to come across are liquids. Boiling points of alkenes depends on more molecular mass (chain length). The more intermolecular mass is added, the higher the boiling point. Intermolecular forces of alkenes get stronger with increase in the size of molecules. For propene the boiling point is **-47**, for butane is **0.9**.
2) Alkenes contain at least one carbon-carbon double bond. It is the presence of this double bond that makes alkenes more reactive than alkanes. Alkenes undergo an addition reaction with water in the presence of a catalyst to form an alcohol. This means that when pentene is mixed with water, it forms an alcohol.

Lesson 4: Chemical properties of alkenes

a) Learning objective: Appreciate the combustion reaction as source of fuels.

b) Teaching resources: Textbooks, internet connection (where possible), test tubes, droppers, ethene, bromine, lime water, matches, splints, stoppers, manila paper, flash cards, computer, projector.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the chemical properties of alkenes if they are equipped with knowledge, skills and attitudes that they have developed from the study chemical equations, types of reactions, covalent bonding.

d) Activity 4.4

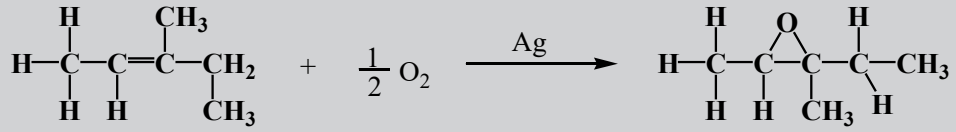
- **Guidance**
  - Student teachers form groups, five to six according to the class size
  - Ask student teachers to carry out the activity **4.4** (from the student teacher's textbookbook).
  - Help, guide and facilitate the whole activities where necessary
  - Invite student teachers to write their observation
  - Make sure that all student teachers participate in that activity
  - Ask student teachers to present their observations and deductions.
  - Give comment on that activity referring to your objective

Answers to activity 4.4

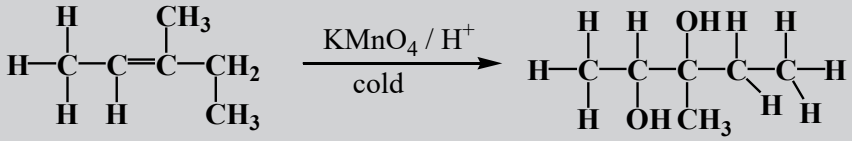
Refer to student teacher textbook on sub-lesson 4.4.1

e) Application activity 4.4

1) a)



b)



2) Refer to student teacher textbook on sub-lesson 4.4.1

Lesson 5:Polymerization of ethene and Chloroethene

a) Learning objective: Explain the use of polymers for alkynes

b) Teaching resources: Chemistry textbooks, internet connection, flip charts/ chalkboard, items made in plastics, computer, projector.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the Polymerization of ethene and Chloroetheneif they are equipped with knowledge, skills and attitudes that they have developed from the study for thetypes of reactions, physical properties of alkenes.

d) Activity 4.5

- **Guidance**
  - Allow student teachers to form pairs and ask them to perform the scenario described in activity 4.6.
  - Let student teachers predict what will happen if many molecules of alkenes add to each other.
  - Allow student teachers to do research using textbooks to clarify the concept of polymer and polymerization.
  - Guide and facilitate student teachers discussions.
  - Each pair record their findings.
  - Call upon randomly five pairs to share their findings.
  - Let student teachers harmonise the key points.
  - From student teachers' ideas, write a short summary on the addition polymerisation of alkenes.

Answers to activity 4.5

a) The number of people on the photos are same, they form a long line occupying more space than each individual couple.

b) If many molecules of an alkene or different alkenes add to each other's, they form a large molecule with physical properties different from those of each single molecule.

e) Answers to application activity 4.5

1) The C=C double bond in ethene is involved in the polymerisation reaction. It allows ethene molecules to join together to form a single product, so it is an example of an addition reaction, poly(ethene) is an addition polymer.

2) Refer to student teacher textbook on the summary of activity 4.5

Lesson 6: Structure and nomenclature of straight and branched alkynes

a) Learning objective: Write the structural formulae of straight chain alkynes.

b) Teaching resources: Atomic models, flip charts, chemistry textbooks and other relevant chemistry books from the library, computer, projector.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the structure and nomenclature of straight and branched alkynes if they are equipped with knowledge, skills and attitudes that they have developed from the study general rules for naming organic compounds, chemical equations, types of reactions, covalent bonding and molecular structures.

d) Activity 4.6

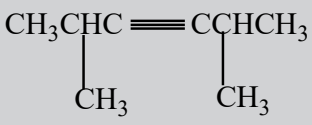
- **Guidance**
  - Student teachers form groups (the number of groups and members will depend on your class size and the number of your resources or materials).
  - Give student teachers activity4.6 (from the student teacher's textbook)
  - Move around the class and check if all student teachers are working.
  - Facilitate and guide the activities and give support where needed
  - Ask student teachers to present their findings.
  - Make comments on their presentations

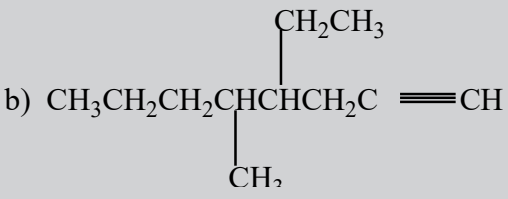
Answers to activity 4.6

1) Refer to student teacher on the summary of activity 4.6
2) Refer to student teacher's book on the summary of activity 4.6

e) Answers to application activity 4.6

1) a) 4-methylhept-1-yne **OR** 4-mehyl-1-heptyne
   b) 6-ethyl-3-methylnon-4-yne **OR** 6-ethyl-3-methyl-4-nonyne

2) a) 

b) 

Lesson 7: Physical properties and uses of the alkynes

a) Learning objective: Explain the reactivity of alkynes

b) Teaching resources: Chemistry textbooks, internet (where possible),calcium carbide, conical flask, dropping funnel, water, test tube, bromine, trough, delivering tube, potassium manganate (VII), computer, projector.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the Physical properties and uses of the alkynes if they are equipped with knowledge, skills and attitudes that they have developed from the chemical bonding and preparation of different gases.

d) Activity 4.7

- **Guidance**
  - Tutor forms groups according to the class size
  - Give student teachers the above mentioned resources
  - Ask student teachers to carry out the activity 4.7(from the student teacher's textbook).
  - Facilitate and guide the activities
  - Ask student teachers to record their observations
  - Ask student teachers to present their observations and deductions to the whole class.

Answers to activity 4.7

Refer to student teacher textbook on the summary of activity 4.7

e) Answers to application activity 4.7

1) Refer to student teacher textbook on activity 4.7
2) Refer to student teacher textbook on activity 4.7
3) Refer to student teacher textbook on activity 4.7

Lesson 8: Chemical properties of alkynes

a) Learning objective: Describe the additional reaction for alkynes

b) Teaching resources: Chemistry textbooks, internet (where possible),test tubes, droppers, bromine, potassium manganate (VII) and ethyne, computer, projector.

c) Prerequisites/Revision/Introduction

Student teachers will learn better the chemical properties of alkynes if they are

equipped with knowledge, skills and attitudes that they have developed from the chemical bonding and types of reactions.

d) Activity 4.8

- **Guidance**
  - Student teachers form groups according to the class size
  - Give student teachers the resources mentioned above
  - Ask student teachers to carry out the activity 4.8(from the student teacher's textbook).
  - Guide and facilitate all activities and make sure that all student teachers are working
  - Ask student teachers to present their observations and deductions to the whole class.
  - Give the general comment through what they have been presented.

Answers to activity 4.8

1) Refer to student teacher textbook on activity 4.8

e) Answers to application activity 4.8

1) a) $CH_3CH_2CH_2\text{-}\overset{\overset{O}{\|}}{C}\text{-}CH_3$ pentan-2-one or 2-pentanone

b) $CH_3CH_2CH_2\overset{\overset{Cl}{|}}{\underset{\underset{Cl}{|}}{C}}CH_3$ 2,2-dichloropentane

2) Alkynes, much like alkene, can be cleaved with as powerful oxidizing agents such as ozone or $KMnO_4$. Because triple bonds are generally less reactive than double bonds the yields of the reaction are sometimes low.

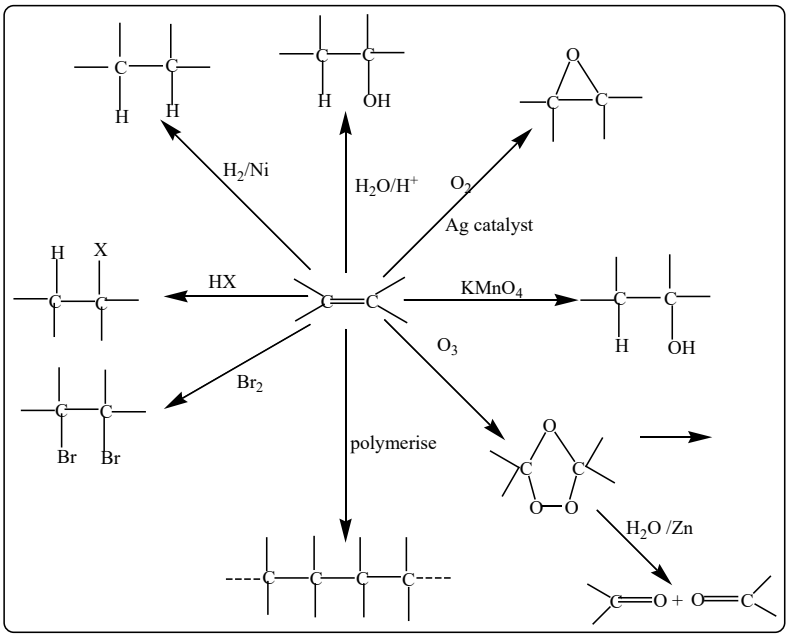
3) As with alkenes, the addition of water to alkynes requires a strong acid, usually sulfuric acid, and is facilitated by mercuric sulfate. However, unlike the additions to double bonds which give alcohol products, addition of water to alkynes gives ketone products (except for acetylene which yields acetaldehyde).

4.6. Summary of the unit

Alkenes and alkynes

Alkenes are unsaturated hydrocarbons containing at list carbon-carbon double bond. They have the general formula C_nH_{2n}.

- As the rotation around the double bond is restricted, alkenes exhibit a cis-trans isomerism. The cis-trans isomers differ in the way their substituents are arranged around the double bond.
- They are widely present in the nature where the play many roles.
- For example, ethene is a plant hormone in the fruit ripening, seed germination ...
- Alkenes are industrially obtained by cracking of large alkanes.
- They are also obtained by elimination reactions from alcohols, halogenoalkanes or partial hydrogenation of alkynes.
- As unsaturated hydrocarbon, they undergo addition reactions. Having a region of high density of electrons, they undergo electrophilic addition reactions.
- They form epoxides when they react with oxygen in the presence of silver catalyst.
- The unsaturated is tested using bromine water and/or potassium manganite (VII).
- Alkenes undergo addition polymerisation reactions to yield plastics having a wide range of applications.
- Some reactions of alkenes are summarized in the table below:

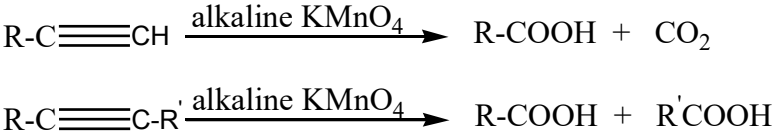


- Alkynes are unsaturated hydrocarbons with a carbon-carbon triple bond. Their general formula is C_nH_{2n-2}.
- There are two classes of alkynes: terminal and non-terminal alkynes.
- Alkynes are less volatile than alkenes because their linear structure allows them to pack together more closely than alkenes.
- Like other hydrocarbon alkynes are insoluble in water.
- Alkynes undergo addition reactions to give alkenes, alkene derivatives or alkanes.

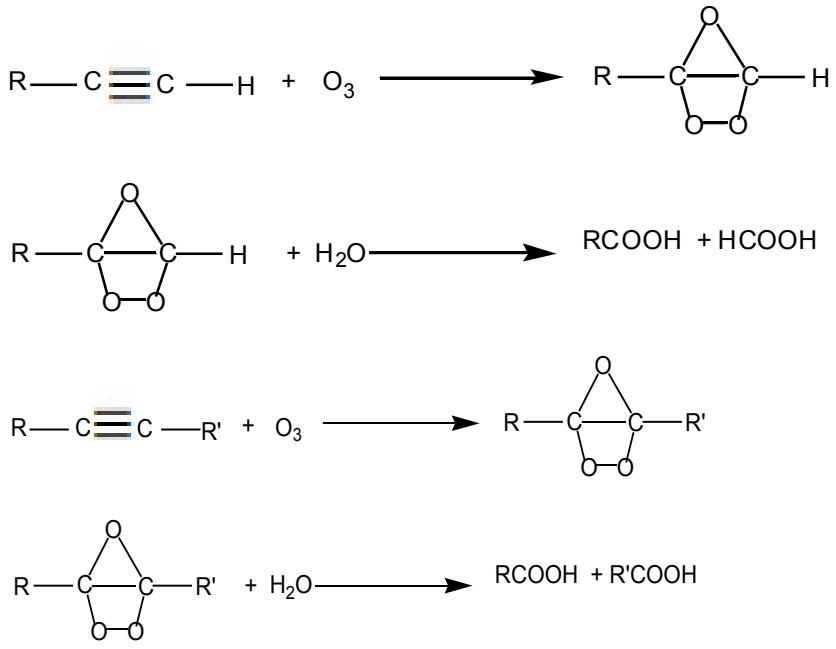
4.7. Additional information for tutor

Oxidising agents that are effective against the carbon-carbon double bond are also effective against the carbon-carbon triple bond. But the carbon-carbon triple bond which is shorter than the carbon-carbon double bond is less reactive because electrons are more strongly attracted by the nuclei.

The oxidation of alkynes with hot alkaline potassium manganate (VII) cleaves the molecule at the site of the triple bond.



Alkynes react with ozone to yield ozonides which on decomposition with water yield carboxylic acids:



Guidance on Lab skills

Ask learners to make a research and design the following projects:

1) A project of making plastics which are biodegradable.

2) A project of recycling plastics.

4.8. End unit assessment (answers)

I. Multiple choice questions. Choose the best answer in the following by noting the corresponding letter.

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

II. Open questions

6) - Pent-1-ene
- Pent-2-ene
- 3-methylbut-1-ene
- 2-methylbut-1-ene
- 2-methylbut-2-ene

7) $CH_3CH{=}CH_2 + Br_2 \xrightarrow{CCl_4} CH_3CHBrCH_2Br$

$CH_3CHBrCH_2Br + KOH \xrightarrow{\text{ethanol/heat}} CH_3C{\equiv}CH + 2KBr + 2H_2O$

8) a) Alkenes such as ethene and propene have been described as the building blocks of theorganic chemical industry because they can undergo addition polymerization to give a large range of plastics which have many applications.

Examples:

Polyethene (polyethylene) which is for making bags, cups, bottles,

Polypropene which is used for wrapping, insulator, ropes,

In addition, ethene and propene are starting materials for the preparation of carbonyl compounds, carboxylic acids, etc.

b) Presence of a double bond.

9) The distinguish test between ethene and ethyne could be performed with Bromine. Ethene would react with Bromine and convert reddish brown bromine into colorless whereas Ethyne would not react with bromine.

10) (a) $RCHOHCH_2OH$
(b) $RCHBrCH_2Br$
(c) $RC(OSO_2OH)\ HCH_3$
(d) $RCHOHCH_3$

4.9. Additional activities (Questions and answers)

4.9.1. Remedial activities (Questions and answers)

Questions

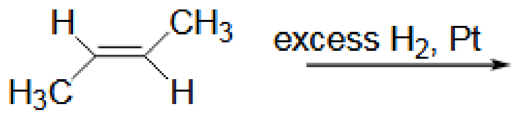
1) Write the structural formula for:
   a) 4-ethylhex-2ene
   b) 3-ethyl-2,5-dimethylhept-3-ene
   c) 5-isopropyl dec-4-ene
   d) 5-propylnon-3-yne

2) Write the formula or the name of the product of the reaction between pent-1-yne and:
   a) Hydrogen bromide(excess)
   b) 2moles of hydrogen
   c) Sodium amide
   d) H_3O^+/Hg^{2+}
   e) Ammoniacal copper (I)chloride

3) What is the product of the ozonolysis of:
   a) But-2-ene
   b) 2-methylpent-2ene

4) Four members of the homologous series of alkenes are ethene, propene, but-1-ene and pent-1-ene. Give **one** structural feature of the compounds that makes them members of the homologous series of alkenes.

5) Complete the products (if any) formed in the following reactions:

(a) 

(b) $H_3C-C\equiv C-CH_3 \xrightarrow{\text{excess } H_2\text{, Pt}}$

(c) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3 \xrightarrow{\text{excess } H_2\text{, Pt}}$

(d) $H_3C-C\equiv C-CH_3 \xrightarrow[\text{catalyst}]{H_2\text{, Lindlar's}}$

Answers

1.

a) $CH_3CH{=}CHCHCH_2CH_3$
CH_2CH_3

b) CH_3
$CH_3\text{-}CH\text{-}C{=}CHCHCH_2CH_3$
CH_3 CH_2CH_3

c) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH{=}CCH_2CH_2CH_2CH_2CH_3$
CH_3CHCH_3

d) $CH_3CH_2C\equiv CCH_2CHCH_2CH_2CH_3$
$CH_2CH_2CH_3$

2)

a) 2,2-dibromopentane

b) Pentane

c) $CH_3CH_2CH_2C{\equiv}C^-Na^+$

d) $CH_3CH_2CH_2COCH_3$

e) $CH_3CH_2CH_2C{\equiv}C^-Cu^+$

3)

a) Ethanal

b) Propanone and propanal

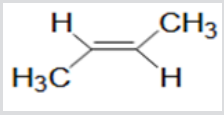
4) The same general formula or C_nH_{2n} / the same functional group / a C=C / a double bond / differ from their immediate neighbour by CH_2

5)

a) CH_3-CH_2-CH_2-CH_3

b) CH_3-CH_2-CH_2-CH_3

c) No reaction

d) 

4.9.2. Consolidation activities (Questions and answers)

Questions

1) a) What do you understand by the term "Electrophile?"

b) Explain why alkenes and alkynes are readily attacked by electrophiles.

2) Give all structural formulae of alkynes with molecular formula C_6H_{10}.

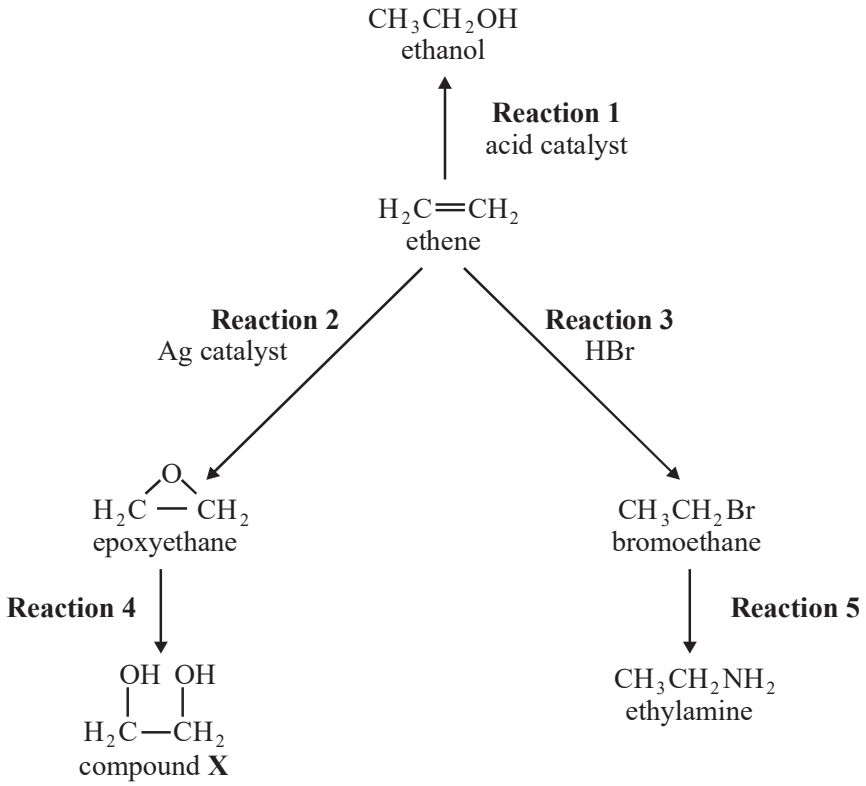
3) Explain how, using chemical tests:

a) propene could be differentiated propane

b) propene could be differentiated from propyne

c) propene could be differentiated from carbon dioxide

4) Outline the importance of controlling global warming resulting from atmospheric increases in greenhouse gases



Provide the reagent for **Reaction 1**

Answers:

1) a) An electrophile is a chemical species which electron deficient.

b) Alkenes are readily attacked by electrophiles because the carbon-carbon double bond is an electron rich region.

2)

- $CH_3CH_2CH_2CH_2C{\equiv}CH$
- $CH_3CH_2CH_2C{\equiv}CCH_3$
- $CH_3CH_2C{\equiv}CCH_2CH_3$
- $(CH_3)_2CHCH_2C{\equiv}CH$
- $(CH_3)_3CHC{\equiv}CCH_3$

3) a) Propene decolourises bromine water but propane does not.

b) Propyne reacts with sodium amide but propene does not.

c) Carbon dioxide turns milky lime water but propene does not.

4) The ability of gases in the atmosphere to absorb some of the infra-red radiation emitted by the earth is a good thing; it keeps the earth warm.

But if the concentrations of these gases increase, then the earth gets too warm. This effect is called "global warming".

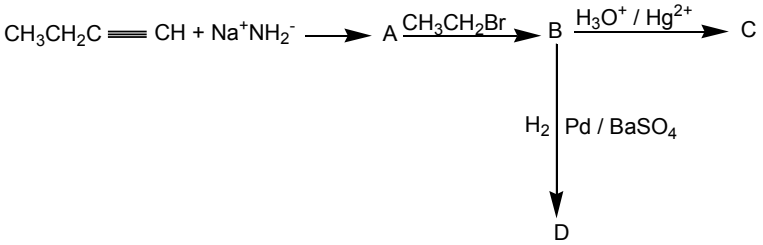
5) Reaction 1 H_2O or steam

4.9.3. Extended activities (Questions and answers)

Questions

1) How do the physical properties of the alkene homologous series change as the chain length increases?

2) Suggest structural formulae for compounds A, B, C, and D in the following reaction scheme.



3) This question is concerned with the six reactions shown in the following scheme. The four compounds involved are represented by their molecular formulae and labelled using the letters **A, B, C** and **D**.

$C_3H_6 \xrightarrow{\text{reagent W}} C_3H_7Br \xrightarrow{\text{reagent X}} C_3H_8O \xrightarrow{\text{reagent Y}} C_3H_6O$

Compound A $\xleftarrow{\text{reagent X}}$ compound B $\xleftarrow{\text{reagent W}}$ compound C $\xleftarrow{\text{reagent Z}}$ compound D

a) State the names of the three homologous series to which compounds **A, B** and **C** belong.

b) Give the name of the type of reaction occurring in each of the following conversions:

i) compound **A** to compound **B**;

ii) compound **B** to compound **C**;

c) Give the name or formula of reagent **X** and state the different conditions under which it would be used in the conversions of compound B to compound C, and of compound B to compound A.

d) Write an equation for each of the following reactions:

i) the conversion of compound B to compound A;

ii) the conversion of compound B to compoundC.

Answers

1) Melting point increases, boiling point increases, they are liquids, the higher members are solids, density increases, viscosity increases.

2) A: $CH_3CH_2C{\equiv}C^-Na^+$

B: $CH_3CH_2C{\equiv}CCH_2CH_3$

C: $CH_3CH_2COCH_2CH_3$

D: $CH_3CH_2CH{=}CHCH_2CH_3$

3) a) A – Alkene

B – Halogenoalkane / bromoalkane / alkyl halide / haloalkane

C – Alcohol (ignore primary, secondary)

b) (i) Addition ignore nucleophilic / electrophilic / free radical

(ii) Substitution **not** replacement / displacement

c) Sodium hydroxide / NaOH / KOH **not** just hydroxide
(**B** to **C**) aqueous **not** dilute
(**B** to **A**) alcoholic

d) (i) $CH3CH(CH_3)Br + NaOH \rightarrow CH_3CH{=}CH_2 + NaBr + H_2O$

(ii) $CH3CH(CH_3)Br + NaOH \rightarrow CH_3CH(CH_3)OH + NaBr$

UNIT 5

ALCOHOLS

5.1. Key Unit competence

Compare the physical and chemical properties of alcohols to their preparation methods, reactivity and uses

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

Student teachers will learn better this unit if they have knowledge on general rules of nomenclature of organic compounds, alkanes and alkenes.

5.3. Cross cutting issues to be addressed

a) **Standardization culture:** Student teachers will be taught about the standard of the alcoholic drinks and other beverages by giving them the example of how non-standardized things are harmful to organism, give them the examples on how some local beers are prepared in unsafe way and how the government fights against non-standardised drinks.

b) **Gender:**The student teachers in their groups guided by the tutor will be taught about gender violence as the cause of alcohol abuse when drunk in non-controlled way, but also remember that both girls and boys must be involved equally.

c) **Peace and values:** Self-respect even while taking the alcohol not to be directed by it but also to have self-control while drinking and take the amount just needed to quench their thirst and if possible advise them to avoid it completely.

d) **Financial education:** While discussing in their groups or while harmonizing the work, you have to reinforce on the financial opportunities of alcohols; how alcohols bring money for the sellers and distributors of alcoholic drinks. Here also you have to focus on the avoidance of expenses brought by the consumption of alcoholic beverages.

5.4. Guidance on introductory activity

Before introducing the first lesson of this unit, you will have to introduce the whole unit. Ask student teachers (in pairs) to read carefully the introductory activity from

student's book. This activity intends to relate the unit with student teachers' daily life and to capture their attention.

- Ask student teachers to answer freely. They may not be able to find the right answers but they are invited to predict possible solutions or answers.
- Ask student teachers to present their findings.
- After presentation, give your comments showing them how alcohol can be locally prepared from available raw materials, and that from it many other compounds may be obtained. It is not necessary to give them all answers of this introductory activity because they will study them in this unit. So, you can leave student teachers with the curiosity of knowing the correct answers.

Here are some proposed answers to questions that appear in the Introductory Activity.

1) See the flow chart in the Student Teacher Book (the introductory activity)
2) See the Student Teacher Book, lesson 5.4
3) The ethanol obtained can be used in different domains. In laboratory, different compounds can be prepared from it but also ethanol finds many applications in many daily works.
   a) Ethene (by dehydration), ethanoic acid (by oxidation), ethylether (in presence of acid at medium temperature), etc.
   b) Combustion (as fuel), hair cutting (as antiseptic), in beverage (to make them alcoholic), etc.
4) Flammable (it is used as fuel), mainly liquid at room temperature (used as solvent), etc.

5.5. List of lessons

#	Lesson title	Learning objectives	Periods
1	Nomenclature, isomerism and the classification of alcohols.	- Name and explain isomers in alcohols - Write and name alcohols according to IUPAC system. - Classify alcohols as primary, secondary and tertiary.	3
2	Physical properties and uses of alcohols	- Describe the physical properties and uses of alcohols. - Give different uses of alcohols as drinks, solvents and motor fuels. - Appreciate the uses and dangers of alcohols to the society.	3

3	Preparations of alcohols	- Describe important methods of preparation of alcohols. - Recall the steps involved in fermentation process. - Prepare ethanol at school.	2
4	Local preparation of ethanol by fermentation	Describe the local process of making alcohol.	1
5	Chemical properties of alcohols	- Describe different chemical properties of alcohols - Explain the effect of oxidation on urwagwa (banana wine) when it overstays (urwagwa rushaje). - Carry out an experiment to compare the oxidation reactions of primary, secondary and tertiary alcohol - Carry out experiments to distinguish between primary, secondary and tertiary alcohols.	4
	End unit assessment		2

Lesson 1: Nomenclature, isomerism and the classification of alcohols

a) Learning objective

- Name and explain isomers in alcohols
- Write and name alcohols according to IUPAC system.
- Classify alcohols as primary, secondary and tertiary.

b) Teaching resources

Chemistry textbooks and other relevant chemistry books from the library, where possible use internet

c) Prerequisites/Revision/Introduction

The learning of this lesson will be better if the students have knowledge on:

Functional groups, general rules of naming organic compounds and isomerism in organic chemistry; you can use some questions to diagnose if they remember all of them.

d) Activity 5.1

Form groups (the number of groups and members will depend on your class size and the number of your resources or materials).

- Give to student teachers activity 5.1 (from the student teacher's book)
- Move around the class and check if all student teachers are actively working.
- Ask student teachers to present their findings.
- During their presentation ask some questions that lead to lesson objectives.
- Guide student teachers to make the summary of the lesson.
- Make the final conclusion of the lesson.
- After giving final conclusion, assess your student teachers using application activity 5.1 (from student's book). Student teachers can do this application activity individually or in pairs. If you do not have enough time in your lesson, give it as individual home work.

Answers to Activity 5.1

A=Ethane, B=Propene, C=Chloroethane, D=Ethanol, E=Butan-1-ol (1-butanol)

D and E are Alcohols

Any possible isomer like $CH_3CHOHCH_2CH_3$

e) Answers to Application Activity 5.1

Primary

$CH_3CH_2CH_2CH_2CH_2OH$ pentan-1-ol or 1-pentanol

$CH_3CH(CH_3)CH_2CH_2OH$ 3-methylbutan-1-ol or 3-methyl-1- butanol

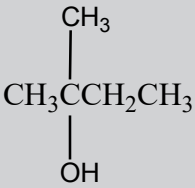
$CH_3C(CH_3)_2CH_2OH$ 2,2-dimethylpropan-1-ol or 2,2-dimethyl -1-propanol

Secondary

$CH_3CH_2CH_2CH(OH)CH_3$ pentan-2-ol or 2-pentanol

$CH_3CH(CH_3)CH(OH)CH_3$ 3-methylbutan-2-ol or 3-methyl -2-butanol

Tertiary



2-methylbutan-2-ol or 2-methyl-2-butanol

Lesson 2: Physical properties and uses of alcohols

a) Learning objective

- Describe the physical properties and uses of alcohols.
- Give different uses of alcohols as drinks, solvents and motor fuels.
- Appreciate the uses and dangers of alcohols to the society.

b) Teaching resources

Chemistry textbooks and other relevant chemistry books from the library/Where possible use internet

c) Prerequisites/Revision/Introduction

Student teachers will understand better this lesson if they have understanding on the concept of chemical bonding. Ask some questions to make sure that the still remember them.

d) Activity 5.2

- Give activity 5.2 to student teachers (from the student's book).
- Ask student teachers to carry out this activity in pairs.
- Move around the class and check if all student teachers are working.
- Ask student teachers to present their findings.
- Summarize the findings from students' work and give more examples which illustrate the content about physical properties and uses of alcohols.
- Assess your student teachers using application activity 5.2 (from student's book).

Answers to Activity 5.2

1) See Student-teacher Book, lesson 5.2
2) Alcohols are less volatile than alkanes of approximately the same molecular mass and the same carbon number because of formation of hydrogen bonds which is not possible with hydrocarbons. Also the boiling point increases as the size of the molecule increases due to the increase of intermolecular forces.

e) Answers to Application Activity 5.2

1) Ethanol can form hydrogen bonding between their molecules but butane cannot.
2) Alcohols can form hydrogen bonding with water but alkanes cannot.
3) Drink, fuel, solvent, antiseptic, etc.
4) Propan-2-ol has lower mass (and size) than nonan-2-ol, this makes that
5) Propan-2-ol is more soluble in water than nonan-2-ol due to the long non-polar chain of nonan-2-ol which enhances more intermolecular forces.
   a) Propan-2-ol is more volatile than nonan-2-ol due to the long non-polar chain of nonan-2-ol which enhances more intermolecular forces.

Lesson 3: Preparations of alcohols

a) Learning objective

- Describe important methods of preparation of alcohols.
- Recall the steps involved in fermentation process.
- Prepare ethanol at school.

b) Teaching resources

Chemistry textbooks and other relevant chemistry books from the library/Where possible use internet

c) Prerequisites/Revision/Introduction

Student teachers will understand better this lesson if they have understanding on the concept of reactivity of alkenes and reactivity of halogenoalkanes.

d) Activity 5.3

- Give student teachers *activity 5.3* (from the student's book).
- Ask student teachers to carry out this activity in pairs
- Move around the class and check if all student teachers are working.
- Ask student teachers to present their findings.
- Harmonize the findings from students' work and give more examples which illustrate the content about preparations of alcohols.
- Assess your student teachers using application *activity 5.3* (from student's book).

Answers to Activity 5.3

(a) $CH_3CH_2CH_2CH_2Cl + KOH \xrightarrow{water} CH_3CH_2CH_2CH_2OH + KCl$

Butan-1-ol

(b) $CH_2{=}CH_2 + H_2O \xrightarrow{H_2SO_4} CH_3CH_2OH$

Ethanol

e) Answers to application activity 5.3

1) See preparation of alcohols in the Student-teacher book
2) Completing reactions:

(a) $CH_3CH_2CH_2CH{=}CHCH_3 + H_2O \xrightarrow{H_2SO_4} \mathbf{CH_3CH_2CH_2CHOHCH_2CH_3}$

(b) A= $(CH_3)_2CHCHClCH_3$ B = $(CH_3)_2CHCHOHCH_3$

Lesson 4: Local preparation of ethanol by fermentation

a) Learning objective

Describe the local process of making alcohol.

b) Teaching resources

Chemistry textbooks and other relevant chemistry books from the library/internet

c) Prerequisites/Revision/Introduction

Student teachers will understand better this lesson if they have understanding on the concept of fermentation.

d) Activity 5.4

- Give student teachers activity *5.4* (from the student's book).
- Ask student teachers to carry out this activity in pairs
- Move around the class and check if all student teachers are working.
- Ask student teachers to present their findings.
- Harmonize the findings from students' work and give more examples which illustrate the content about local preparation of ethanol.

Answers to Activity 5.4

1) See Student-teacher book in lesson 5.4
2) Ethanol (CH_3CH_2OH)
3) $CH_3CH_2OH \rightarrow CH_3COOH$ (by oxidation), $CH_3CH_2OH \rightarrow CH_2=CH_2$ (by dehydration), etc.
4) They are used as solvents, as fuels, etc.

e) Answers to Application Activity 5.4

Questions about the preparation of ethanol

1) Equations to show the production of ethanol by:
   a) Fermentation of glucose

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2\ CH_3CH_2OH + 2\ CC$$

   b) Hydration of ethene

$$CH_2=CH_{2(g)} + H_2O_{(g)} \overset{H_3PO_4}{\rightleftharpoons} CH_3CH_2OH_{(}$$

2) See Student teacher Book, lesson 5.4

Lesson 5: Chemical properties of alcohols

a) Learning objective

- Describe different chemical properties of alcohols
- Explain the effect of oxidation on urwagwa when it overstays (urwagwa rushaje).
- Carry out an experiment to compare the oxidation reactions of primary, secondary and tertiary alcohol
- Carry out experiments to distinguish between primary, secondary and tertiary alcohols.

b) Teaching resources

Chemistry textbooks, internet (where possible), methanol, ethanol, 2M sulphuric acid, potassium dichromate solution, test tubes, burner, droppers, propan-2-ol and 2-methylpropan-2-ol.

c) Prerequisites/Revision/Introduction

Student teachers will understand better this lesson if they have understanding on the concept of preparation of alkenes and preparation of halogenoalkanes.

d) Activity 5.5

- Form groups (the number of group members depend on the class size, but do not exceed 6).
- Give student teachers activity 5.5 (a) (from the student's book).
- Ask student teachers to carry out this activity
- Move around the class and check if all student teachers are working.
- Ask student teachers to present their findings.
- Summarize the findings from students' work and give more examples which illustrate the content about chemical properties of alcohols.
- Assess your student teachers using application activity 5.5 (a) (from student's book).
- Next session, use the laboratory to perform the experiment in activity 5.5 (b).

Answers to Activity 5.5 (a)

1) Orange to green for primary and secondary alcohols, and no change for tertiary alcohols.
2) Potassium dichromate is a powerful oxidizing agent; it oxidises the primary and secondary alcohols (yellow colour of dichromate changes to green).

It cannot oxidise 2-methylpropan-2-ol because it is tertiary alcohol (the colour does not change).

3) Equations for the reactions (See Student teacher's Book).

Answers to Activity 5.5 (b)

If it is possible at your school (when materials and chemicals required are available), you have to perform experiment about Lucas Test just to plasticize what have learnt theoretically.

e) Answers to Application Activity 5.5

1) Completing chemical reactions and naming organic products obtained:

a) Propan-2-ol + Na → $(CH_3)_2CH_2ONa$ [Sodium propanolate] + ½H_2

b) Propan-2-ol + HBr → $(CH_3)_2CH_2Br$ [2-bromopropane] + H_2O

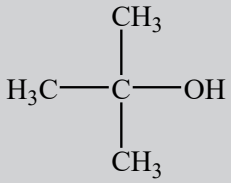
c) Methanol + CH_3CH_2COOH → $CH_3CH_2COOCH_3$ [Methylpropanoate] + H_2O

d) Butan-1-ol + PCl_5 → $CH_3CH_2CH_2CH_2Cl$ [1-chlorobutane] + $O{=}PCl_3$ + HCl

e) Butan-1-ol + $SOCl_2$ → $CH_3CH_2CH_2CH_2Cl$ [1-chlorobutane] + SO_2 + HCl

f) 2-methylpentan-3-ol + PBr_3 → $CH_3C(CH_3)CHBrCH_2CH_3$ [3-bromo-2-methylpentane]+ H_3PO_3

2) Structure of **A**



3) Organic product or products formed by the dehydration:
   a) Ethene
   b) But-1-ene
   c) But-2-ene

4) Using structural formulae, write equations for the following processes:
   a) $CH_3CH_2CH_2OH \rightarrow CH_3CH_2CHO$
   b) $CH_3CHOHCH_3 \rightarrow CH_3COCH_3$

5) Butan-1-ol can be oxidised by acidified potassium dichromate (VI) using two different methods.
   a) In the first method,
   i) $CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO$
   ii) Orange to green
   b) In a second method,
   i) $CH_3CH_2CH_2COOH$ (butanoic acid),
   ii) $C(CH_3)_3OH$ (2-methylpropan-2-ol) and $CH_3CH(CH_3)CH_2OH$ (2-methylpropan-1-ol)

5.6. Summary of the unit

ALCOHOLS

Alcohols are organic compounds that are derivatives of hydrocarbons where one or more hydrogen atoms of hydrocarbon is or are replaced by hydroxyl (-OH) group. They (monohydrated) are represented by the general formula:

CnH_2n+1 –OH or R-OH where R is a radical: alkyl or aryl (phenyl).

In the IUPAC system, alcohols are named by replacing the final “e” of the parent hydrocarbon (like alkane or alkene) with “ol”, then specify the position of -OH group before ending by -ol using a number. The numbering is done such that the carbon atom attached to the -OH group gets the lowest number.

For naming polyhydric alcohols, the name of the alkane is retained and the ending -e is not dropped. Thus dihydric alcohols are named as alkane diols and trihydric alcohols are named as alkane triols. The position of carbon atoms carrying -OH groups are indicated by locants written after the name of alkane.

The number of hydroxyl groups is indicated by adding the multiplicative prefix di,tri, tetra, etc., before the suffix-ol and in the case there are more than one locants; they are separated by a comma. OH group takes priority over alkyl substituents, double or triple bonds and even halides. Alcohols are classified into primary, secondary and tertiary. Theyexhibit different types of isomerism: Chain isomerism, position isomerism and functional isomerism.

There exist different alcohols with different uses. They are used as drinks, solvent, fuel, antiseptic, etc. Alcohols are prepared with different methods such as:

- From alkyl halides (halogenoalkanes)
- From alkenes
- From carbonyl compounds
- From esters
- From primary amine to give primary alcohol

Urwagwa and ikigage locally available and traditionally prepared in Rwanda, contain ethanol. So, when they are being prepared, we say that also ethanol is being prepared. “urwagwa” and “ikigage” The preparation of “urwagwa” and “ikigage” is done locally using “beer” bananas collected from rural areas in Rwanda, and the sorghum. Here, ethanol is prepared from **starch** and **sugar molasses** by fermentation process.

In alcohols, -**OH** group is the functional group. Thus the chemical properties of alcohols generally involve the reactions of **-OH** group. They can undergo substitution as well as elimination reaction.

The molecule of an alcohol consists of an alkyl group and functional –OH group. The C-O bond and O-H are both polarized with oxygen atom carrying a partially charge and yet it has unshared pair of electrons. The main reactions undergone by alcohols are:

- Action of electropositive metals on alcohols
- Action of hydrohalic acids (HX)
- Esterification
- Action of phosphorus halides and thionyl halide
- Reaction with sulphuric acid
- Reaction of oxidation

5.7. Additional information for tutor

Halogenoalkanes are compounds in which a halogen atom has replaced at least one of the hydrogen atoms in an alkane chain. When the halogen atom is attached to a hydrocarbon chain the compound is called a **halogenoalkane** or **haloalkane** or **a**n **alkyl halide**.

The homologous series called **halogenoalkanes** have the functional group –C-X

In order, for any reagent, to react with the halogenoalkanes, the carbon-halogen bond has got to be broken. Because that gets easier as you go from fluoride to chloride to bromide to iodide, the compounds get more reactive in that order. Iodoalkanes are the most reactive and fluoroalkanes are the least.

1) Nucleophilic substitution reaction

Because the carbon atom attached to the halogen atom is deprived of its electron, it carries a partial positive charge $\delta^{+}\ C\ \delta^{-}\ X$. Thus when electron rich substrates called nucleophiles, approach the carbon atom, the halogen atom leaves as a halide ion. Hence alkyl halides undergo **nucleophilic substitution** reaction. Reaction with aqueous alkali is the typical reaction which shows substitution reactions.

When alkyl halides are refluxed with aqueous alkali, alcohols are produced through substitution of the halogen by hydroxide ion. This reaction is also called "**hydrolysis**".

Examples:

$$CH_3 - CHBr - CH_2 - CH_3 + OH^- \xrightarrow[Dilute\ KOH]{} CH_3 - CHOH - CH_2 - CH_3 + Br^-$$

$$CH_3 - CH_2Br + KOH \xrightarrow{waerm} CH_3CH_2OH + KBr$$

The hydrolysis can also take place when water alone is added to tertiary alkyl halides. In this case water molecules act as nucleophiles.

$$(CH_3)_3CBr + H_2O \longrightarrow (CH_3)_3COH + HBr$$

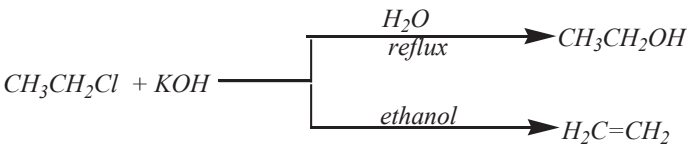
2) Elimination reactions

An elimination reaction is where a saturated organic compound loses an atom or group of atoms to form an unsaturated organic compound. Elimination is the opposite of addition reaction.

Alkyl halides when boiled with alcoholic potassium hydroxide form alkenes by elimination reaction. Hence the alkyl halide loses a molecule of the hydrogen halide.

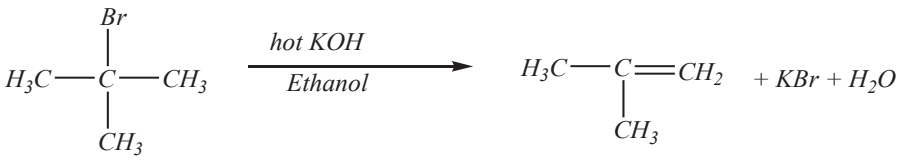
Example: $CH_3\text{-}CHCl\text{-}CH_3 + KOH \xrightarrow{Alcohol} CH_3 - CH = CH_2 + KCl + H_2O$

Note: Elimination reaction usually occurs in competition with substitution reaction. So when chloroethane is treated with a solution of potassium hydroxide two organic products are formed depending on the conditions of the reaction.



Ethene is formed by elimination reaction while diethyl ether is formed by substitution reaction.

Elimination is favoured by use of high temperature and a strong base (for example alcohol) instead of water.



Guidance on Skills Lab 5

The student teachers are guided to remember making a field of any brewery of alcoholic drinks and make a field report. They are also asked to make a debate and after summarize the main ideas of what they deduced from the debate about the uses of alcohols and dangers associated with unsafe use of different types of alcohols on our health, family and society.

The teacher must make sure that this is communicated to student teachers.

5.8. End unit assessment (answers)

A) MULTIPLE CHOICE QUESTIONS

1) **C** [3,3-dimethylpentan-2-ol]

2) **B**[Propan-1-ol]

3) **B** [Butan-1-ol has stronger induced dipole–dipole interactions because it has a straight-chain structure]

4) **D**

5) **B** [$CH_3CO_2CH_2CH_2CO_2CH_3$]

B) OPEN QUESTIONS

6) Compound **X**($CH_3CH_2CH_2CH_2CH_2$-OH)

a) Pentan-1-ol

b) Primary

c) Hydrogen bonds

d) $CH_3CH_2CH_2CH_2CHO$ and $CH_3CH_2CH_2CH_2COOH$

7)

a) **A** is tertiary and **B** is secondary

b) 2-methylpropan-2-ol

c) i) **C** or **D**

ii) **C** will give $CH_3CH_2CH_2CHO$ and **D** will give $CH_3CH(CH_3)CHO$

iii) Using the mild oxidizing agent

d) All the alcohols **A**, **B**, **C** and **D** may be readily dehydrated.

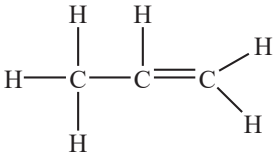
i) Removal of water

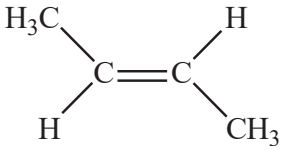
ii) Alkene

iii) Strong mineral acid like H_2SO_4 and H_3PO_4 and heat

iv) **C** or **D**

v) Alcohols **A** or **B**, which, on dehydration, would give the following products..





8) Reagent **X** and the alcohol

a) 3-methylbutan-2-ol

b) Elimination

c) Sulphuric acid

9) Products of some reactions of propan-1-ol

A: $CH_3CH{=}CH_2$

B $CH_3CH_2C(=O)H$

C: $CH_3CH_2C(=O)OH$

D: $CH_3CH_2CH_2Br$

E $CH_3CH_2CH_2Cl$

F: $CH_3CH_2CH_2ONa$

10) Glucose can be used as a source of ethanol. Ethanol can be burned as a fuel or can be converted into ethene.

$C_6H_{12}O_6 \rightarrow CH_3CH_2OH \rightarrow H_2C=CH_2$

Glucose *Ethanol* *Ethene*

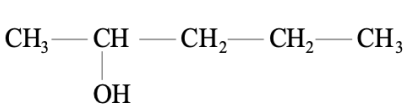
a) Fermentation and dehydration.
b) Zymase enzyme (from a yeast)
c) Phosphoric acid or sulphuric acid
d) Primary
e) Ethanol is a biofuel, it is in cycle, so it does not add more dangerous gas to the environment than petroleum product, it is also not very volatile.

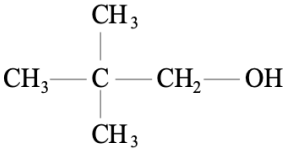
5.9. Additional activities

5.9.1. Remedial activities

Questions

1) What is the general formula of alcohols?
2) Give at least 2 methods of preparing alcohols
3) Describe the method of alcoholic fermentation.
4) Compare the fermentation process and the direct hydration of ethene
5) The structures of two alcohols of formula $C_5H_{11}OH$ are shown below.





a) A third alcohol of formula $C_5H_{11}OH$ is tertiary. Draw the graphical formula and give the name of this alcohol.
b) Draw the graphical formulae of **two** alkenes formed when pentan-2-ol is heated with concentrated sulphuric acid.
c) State the type of reaction taking place in **(b)**.

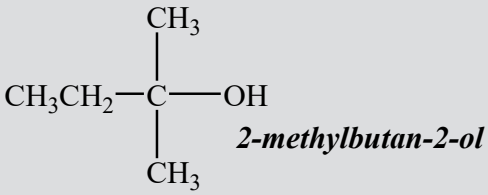
Answers

1) $C_nH_{2n+1}OH$ or R-OH
2)
   - Hydration of alkenes in presence of sulphuric acid; mechanism see student book
   - Addition of water to a halogen alkane, this is a substitution reaction where the OH group from water replaces the halogen atom of halide (mechanism see student book).

3) Refer to the student book, unit 5, lesson 5.4

4) Refer to student book (section about alcoholic fermentation)

5) a) Graphical formula and name.



2-methylbutan-2-ol

b) $CH_3CH_2CH_2CH=CH_2$ and $CH_3CH_2CH=CHCH_3$

c) Elimination

5.9.1. Consolidation activities(Questions and answers)

Questions

1) Propan-1-ol can be formed by the hydration of an alkene in presence of a suitable catalyst.

a) Suggest the catalyst used in the reaction

b) Establish the mechanism of reaction

2) One reaction in the Krebs cycle, in which energy is released to the human body, is the conversion of *fumaric acid* into *malic acid*.

$HO_2CCH=CHCO_2H \rightarrow HO_2CCH(OH)CH_2CO_2H$

Fumaric acid Malic acid

Which reagent(s) could achieve this conversion in the laboratory?

3) Alcohol **X** has the structure $(CH_3)_2C(OH)CH(CH_3)_2$

a) i) Name alcohol **X.**

ii) Reaction occurs when alcohol **X** is converted into 2,3-dimethyl but-2-ene in the presence of a strong acid. Give the structure of, and name an isomer of 2,3-dimethyl but-2-ene which is also formed in the reaction. Explain why two products are obtained.

b) i) Write an equation for the reaction between alcohol **X** and ethanoyl chloride.

ii) Give an alternative method for obtaining the organic reaction product in part **(b) i)**, starting from alcohol **X**. State the type of reaction, the reagent(s) used and the reaction conditions.

Answers

1)

a) The catalyst used is concentrated sulphuric acid

b) Mechanism: see student book,

2) Acidified water(H_2O/H^+)

3) Alcohol **X** has the structure $(CH_3)_2C(OH)CH(CH_3)_2$

a) i) 2,3-dimethylbutan-2-ol.

ii) $CH_2=C(OH)CH(CH_3)_2$ *2,3-dimethylbut-1-ene*

b) i) Write an equation for the reaction between alcohol **X** and ethanoyl chloride.

$$(CH_3)_2C(OH)CH(CH_3)_2 + CH_3COCl \rightarrow CH_3COOC(CH_3)_2CH(CH_3)CH_3$$

ii) Esterification. Condensation reaction of CH_3COOH under heat and acid

5.9.3. Extended activities (Questions and answers)

Questions

1) A compound (**A**) $C_6H_{14}O$ liberate **H** gas when treated with sodium metal, **A** does not react with NaOH, gives positive Lucas test in several minutes. When **A** treated with PBr_5 the compound (**B**) $C_6H_{13}Br$ is formed; when **B** is treated with alcoholic KOH compound (**C**) and (**D**) both having the formula of C_6H_{12} are formed where (**C**) is the major reaction product while (**D**) is the minor product. When (**C**) is treated with ozone, followed by hydrolysis only a single ketone is obtained. This ketone can be shown to be identical to the compound produced by hydration of propyne in presence of sulphuric acid and mercuric sulphate. From the information deduce and write the names and structural formulae of (**A**) to (**D**).

2) An organic compound **A** possesses the following composition by mass, 87.6% and the rest is hydrogen.

a) If the same molecule possesses the molecular mass of 56 g/mol, deduce the molecular formula of **A**.

b) The reaction of **A** with water produces compound **B**. **B** can be represented in different forms called position isomers. Represent the isomers of **B**. Let them be B_1 and B_2.

c) When $\mathbf{B_1}$reacts with the molecule of $KMnO_4$, it produces the different compounds which are functional isomers depending on the reaction conditions. Write the structural formulae of those compounds and state conditions of their formation.

d) When **B_2** reacts with H_2SO_4 three products are obtained depending on the temperature used. Write structural formulae of those products.

Answers

1) Because the molecule $C_6H_{14}O$ liberate the hydrogen gas when reacted with Na, this shows that it is an alcohol, but also because of its behaviour when it is identified by Lucas test, that shows that this alcohol is a tertiary alcohol (it may be **2,3 dimethylbutan-2-ol** or any tertiary alcohol).

To the molecule of (**A**), the addition of PBr_5 shows a substitution reaction, so the molecule is **2-bromo 2,3 dimethyl butane (B).** The addition of alcoholic KOH compound is added to (**B**), there is an elimination reaction. **(C) is 2, 3 dimethyl but-2-ene (cis or trans), (D) is 2,3 dimethylbut-1-ene.**

2)

a)

Element	**C**	**H**
% composition	87.6	100-87.6=13.3
Relative mole ratio	87.6/12 = 7.14	13.3/1=13.3
Atomic ratio	7.14/7.14= 1	13.3/7.14=1.997=2
Empirical formula	CH_2	

Empirical mass x n = molecular mass

$(CH_2)n = 56$ $14n = 56$ $n=4$

Molecular formula is **C_4H_8**(take one of the isomers)

b) $CH_3CH=CHCH_3 + H_2O/H^+ \rightarrow CH_3CH_2CHOHCH_3$ **(B)** or $CH_3CH_2CH_2CH_2OH$ **(A)**

c) $CH_3CH_2CH_2CH_2OH + KMnO_4 \rightarrow CH_3CH_2CH_2CHO$ (mild oxidation/$KMnO_4$ in water)

d) $CH_3CH_2CHOHCH_3 \xrightarrow{H_2SO_4\ /170^0C} CH_3CH=CHCH_3$

$CH_3CH_2CHOHCH_3 \xrightarrow{H_2SO_4/140^oC} H_3CH_2C-HC(CH_3)-O-CH(CH_3)-CH_2CH_3$

$CH_3CH_2CHOHCH_3 \xrightarrow{H_2SO_4\ cold} CH_3CH_2CH(HSO_4)CH_3$

UNIT 6

CARBONYL COMPOUNDS

6.1. Key unit competence

Compare the chemical nature of carbonyl compounds to their reactivity and uses.

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

Student teachers will learn better the content related to carbonyl compounds if they have understanding on the introduction to organic chemistry, alkenes and alcohols. They have the skills to use effectively the common laboratory apparatus and are aware of the safety precautions to take when working in a chemistry laboratory.

6.3. Cross cutting issues to be addressed

a) **Environment protection**: Student teachers must be aware that some polymers formed from carbonyl compounds, for instance aldehyde like methanal which forms bakelite,are harmful to the environment.

b) **Standardization culture:** The students will be taught about the standard of the table sugar and how some local beers are oxidized in aldehyde and carboxylic acids when are exposed on air.

6.4. Guidance on introductory activity

Before introducing the first lesson of this unit, you will have to introduce the whole unit. Ask student teachers (in pairs) to attempt the introductory activity from student's book. This activity intends to relate the unit with student teachers' daily life and to capture their attention.

- Make sure that every student teacher can have access to the book.
- Let them discuss on the introductory activity given in the book. Here you will be supervising the discussion to help student teachers to think deeply on the picture and structure given.
- After they have discussed in their groups then give them time for presentation, four pairs will be sufficient.

- After all the presentation, you will give the time to the student teachers so that they evaluate the suggestion on the answers of others by adding or comment on the answers of others.
- After you will tell them to draw their own conclusion in order to discover the definition of aldehyde and ketone and the general idea about carbonyl functional group.
- The intervention of the teacher will be here by adding the comments. And relate it with the content.

Answers to the Introductory Activity

1) Glucose: Alcohol and aldehyde functional groups and Fructose: Alcohol and ketone functional groups.
2) Banana, oranges, etc.
3) Similarity: They have six carbon atoms; difference: They have different functional groups.
4) Glucose will be more reactive than fructose because aldehyde group (in glucose) allows additional reactions mainly its oxidation.
5) The role of glucose meter is to measure the sugar level in a given food or drink such as fruits, vegetable, honey, juice, etc.

6.5. List of lessons

#	Lesson title	Learning objectives	Periods
1	Nomenclature and isomerism of carbonyl compounds.	- Name carbonyl compounds and show isomers of ketones and aldehydes. - Write and name carbonyl compounds and isomers of ketones and aldehydes.	2
2	Physical properties and uses of aldehydes and ketones	- State the physical properties of aldehydes and ketones - Compare the physical properties of carbonyl compounds to those of alcohols and alkenes. - State the uses of carbonyl compounds - Appreciate the importance and dangers associated with carbonyl compounds in daily life.	2

3	Preparation methods of ketones and aldehydes.	- Describe the preparation reactions of ketones and aldehydes. - Prepare ketones from secondary alcohols by oxidation reaction.	2
4	Chemical reactions of carbonyl compounds	- Describe the reactivity of carbonyl compounds. - Write equations for the reactions of carbonyl compounds with other substances.	4
	End unit assessment		2

Lesson 1: Nomenclature and isomerism of carbonyl compounds

a) Learning objectives

- Name carbonyl compounds and show isomers of ketones and aldehydes.
- Write and name carbonyl compounds and isomers of ketones and aldehydes.

b) Teaching resources

Chemistry textbooks and other relevant chemistry books from the library/Where possible use internet

c) Prerequisites/Revision/Introduction

The learning of this lesson will be better if the students have knowledge on: Functional groups**,** rules of naming organic compound and isomerism in organic chemistry.

d) Activity 6.1

- Form groups (the number of groups and members will depend on your class size and the number of your resources or materials).
- Give student teachers *activity 6.1* (from the student's book)
- Move around the class and check if all student teachers are working properly and effectively.
- Ask student teachers to present their findings.
- During the presentation ask some questions that lead to lesson objectives.
- Guide student teachers to make the summary of the lesson themselves.
- Make the final conclusion of the lesson.
- After giving final conclusion, assess your student teachers using application *activity 6.1* (from student's book).

Answers to Activity 6.1

Category 1: **Aldehydes: C, D, E and F**

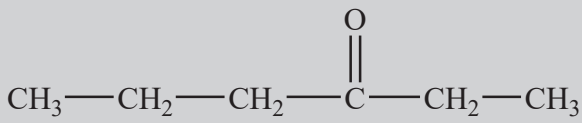
Category 2: Ketones: **A, B** and **G**

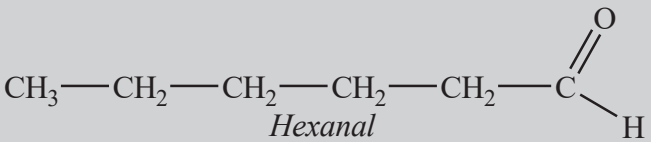
1) Groups of atoms around –CO- group
2) Given in part 1.
3) Pentan-3-one, Propanone, ethanal, Methanal, Pentanal, Propanal and Butan-2-one

e) Answers to Application Activity 6.1

1) **A**=Butanal, **B**=Butan-2-one or 2-butanone, **C**=Hexanal and **D**=Pentan-2-one or 2-pentanone.

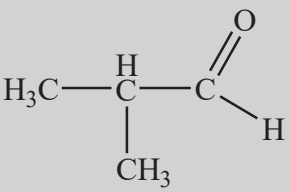
2)





Hexanal

3)



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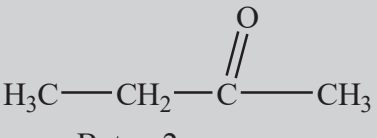


Butan-2-one

Lesson 2: Physical properties and uses of aldehydes and ketones

a) Learning objectives

- State the physical properties of aldehydes and ketones
- Compare the physical properties of carbonyl compounds to those of alcohols and alkenes.
- State the uses of carbonyl compounds
- Appreciate the importance and dangers associated with carbonyl compounds in daily life.

b) Teaching resources

Chemistry textbooks, internet (where possible), beakers, ethanal, butanal and propanone (or acetone)/Chemistry textbooks and internet (where possible)

c) Prerequisites/Revision/Introduction

Student teachers will learn better the physical properties of aldehydes and ketones if they have a good understanding on the chemical bonding, molecular structures and geometrical isomerism.

Student teachers will understand better this lesson if they have understanding on the concept of chemical properties and physical properties of aldehydes and ketones.

d) Activity 6.2

There are two different activities entitled 6.2(a) and 6.2(b)

Activity 6.2 (a)

- Give student teachers the required materials and chemicals in pairs.
- Ask student teachers to carry out the activity 6.2(from the student's book, lesson 6.2).
- Ask student teachers to present their observations and deductions.
- During the presentation ask some questions that lead to lesson objectives.
- Summarize the findings from students' work and give more examples which illustratethe content about physical properties of aldehydes and ketones.

Activity 6.2 (b)

- Form groups (the number of groups and members will depend on your class size and the number of your resources or materials).
- Give student teachers *activity 6.2(b)* (from the student's book)
- Move around the class and check if all student teachers are working.
- Ask student teachers to present their findings.
- During the presentation ask some questions that lead to lesson objectives.
- Guide student teachers to make the summary of the lesson themselves.
- Make the final conclusion of the lesson.

Assess your student teachers using application activity 6.2 (from student's book).

Answers to Activity 6.2 (a)

Refer to the Student teacher Book, lesson 6.2

Answers to Activity 6.2 (b)

1) They are used in jewelry, in clothing (buttons), etc.
2) See Student teacher Book

e) Answers to Application Activity 6.2

1)
   a) Ethanol has ability to form hydrogen bonding between their molecules.
   b) Ethanal may form hydrogen bonding with water molecules.
2) Carbonyl compounds are very useful compounds as it is shown by their applications in everyday life.
3)
   a) They are polar and they have ability to form hydrogen bonds with water molecules.
   b) The solubility of aldehydes and ketones falls as the molecules get bigger because the non-polar (hydrophobic) part is increasing.

Lesson 3: Preparation methods of ketones and aldehydes

a) Learning objective

- Describe the preparation reactions of ketones and aldehydes.
- Prepare ketones from secondary alcohols by oxidation reaction.

b) Teaching resources

Chemistry textbooks, internet (where possible), ethanoic acid, round-bottomed flask, water, concentrated sulphuric acid, anti-bumping granules, distillation apparatus, and any other required laboratory equipments.

c) Prerequisites/Revision/Introduction

Students will understand better this lesson if they have a good understanding on oxidation reactions of alkenes and alcohols.

d) Activity 6.3

This lesson contains two activities 6.3 (a) and 6.3 (b)

- Form groups,
- Ask student teachers to carry out the two activities (from the student's book).
- Ask student teachers to present their observations and deductions.
- During the presentation ask some questions that lead to lesson objectives.

- Summarise the findings from students' work and give more examples which illustratethe content about chemical properties of alkenes.
- Assess your student teachers using application activity 6.3 (from student's book).

Answers to Activity 6.3 (a)

1) $CH_3CH_2OH + [O] \rightarrow CH_3CHO$
2) It is immediately removed as it is being produced. This is important because delaying leads to the production of ethanoic acid by further oxidation.
3) Like fruits (sweetish smell)

Answers to Activity 6.3 (b)

1)

$$\underset{\displaystyle \mathrm{CH_3}}{\underset{|}{CH_3CHOH}} \xrightarrow{H^+\text{,heat / }K_2Cr_2O_7} CH_3-\underset{\displaystyle \mathrm{O}}{\underset{||}{C}}-CH_3$$

2) Orange to green

e) Answers to Application Activity 6.3

1) $3CH_3CHOHCH_3 + Cr_2O_7^{2-} + 8H^+ \longrightarrow 3CH_3COCH_3 + 2Cr^{3+} + 7H_2O$
2) Carbonyl compounds formed

   (i) CH_3CH_2CHO
   (ii) $CH_3CH_2CH(CH_3)CHO$
   (iii) $CH_3CH_2COCH_3$

3) Draw the structure of the alcohol you would oxidize in order to obtain each of the following compounds.

i) Pentan-2-ol

ii) Butan-1-ol

4) Refer to Student Book. Preparation of carbonyl compounds.

Lesson 4: Chemical reactions of carbonyl compounds

a) Learning objective

- Describe the reactivity of carbonyl compounds.
- Write equations for the reactions of carbonyl compounds with other substances.

b) Teaching resources

Chemistry textbooks and internet (where possible), propanal, propanone, ethanol, glucose, test tubes, water bath, heating source, beakers, and other required laboratory equipments.

c) Prerequisites/Revision/Introduction

Students will understand better this lesson if they have a good understanding on oxidation, reduction and addition reactions.

d) Activity 6.4

This lesson has five activities:

- Form groups,
- Ask student teachers to carry out the activity 6.4 (a)(from the student teacher's book).
- Ask student teachers to present their observations and deductions.
- During the presentation ask some questions that lead to lesson objectives.
- Summarise the findings from students' work and give more examples which illustrate the content about chemical properties of aldehydes and ketones.
- Assess your student teachers using application activity 6.4(a) (from student teacher's book). For the guidance of other activities of this lesson, use the same guidance.

Answers to Activity 6.4 (a)		
Substance	**Observations**	**Deductions**
Aldehyde (propanal)	Yellow precipitate	Presence of carbonyl group
Ketone (propanone)	Yellow precipitate	Presence of carbonyl group
Alcohol (ethanol)	No precipitate	Absence of carbonyl group
Sugar (glucose)	No precipitate	Absence of carbonyl group

Answers to Activity 6.4 (b)		
Substance	**Observations**	**Deductions**
Aldehydes (propanal)	*Orange colour of $K_2Cr_2O_7$ solution turns green*	There is oxidation
Ketones (propanone)	No colour change	No oxidation

Answers to Activity 6.4 (c)		
Substance	**Observations**	**Deductions**
Ketones (propanone)	No change	Ketone (cannot be oxidised)
Aldehydes (propanal)	Blue solution produces a reddish brown precipitate of Cu_2O	Aldehyde (can be oxidised to carboxylic acid)

Answers to Activity 6.4 (d)		
Substance	**Observations**	**Deductions**
Aldehydes (propanal)	Metallic silver deposits	Presence of aldehyde group
Ketones (propanone)	No change	Absence of aldehyde group
Sugar (glucose)	Metallic silver deposits	Presence of aldehyde

e) Answers to Application Activity 6.4

1) Isomers of C_3H_6O are CH_3COCH_3 (ketone) and CH_3CH_2CHO (aldehyde). These can be distinguished using Tollens reagent, Fehling reagent, etc and the positive test will be observed on the aldehyde.

2) **A=**$CH_3CH_2CH_2CH_2OH$**, B=** $CH_3CH_2CH_2CHO$, **C**= $CH_3CH_2CH=CH_2$

3) Yellow precipitate is observed.

4) An aliphatic aldehyde **A** has the formula RCHO.

a) There is condensation and the yellow precipitate is observed.

b) RCOOH

c) RCH_2OH

d) Silver deposits (mirror test)

e) $RCOOCH_2R$

5) Warfarin

a) Ester, ketone, alkene, alcohol and benzene.

b) Yellow precipitate will be formed because it contains the –CO-CH3 structure.

c) One. This is because it will react only with carbonyl group present in aldehydes or ketones only. It does not react with that found in esters.

6.6. Summary of the unit

CARBONYL COMPOUNDS (Aldehydes and Ketones)

Aldehydes and Ketones compounds belong to a class of reactive organic compounds resulting from a simple replacement of methylene (-CH_2-) group by *carbonyl group* (>C=O) so called *carbonyl compounds*.

From this, *two classes* of carbonyl compound are known: **R-CO-H** and **R-CO-R'** where **R** and **R'** can be *alkyl* or *aryl groups,* but for aldehydes **R** can be *hydrogen atom* (formaldehyde) or *different to hydrogen* while for ketones, **R** and **R'** should be *different to hydrogen atom* even though they can be the same or different.

In naming aldehydes and ketones, the terminal **–e** of the corresponding alkane is replaced by *–al* or *–one*, respectively. Aldehydes show *chain isomerism* (for aldehydes with 4 or more carbon atoms and ketones with five or more carbon atoms) and *positional isomerism* (for aromatic aldehydes and ketones with five or more carbon atoms) among themselves, and *functional isomerism* with ketones, cyclic ether, and unsaturated alcohols (enol) that may provide geometric isomers (cis and trans or of E-Z convention).

Aldehydes and ketones cannot form hydrogen bonds with themselves but they can have hydrogen bonds with water molecules and this forms the basis for good solubility of aldehydes and ketones in water. This is also because of dispersion forces and dipole-dipole interactions.

Carbonyl compounds are very useful in our everyday life, for instance, Methanal is the main component of formalin and bakelite which are very useful, propanone is a very good organic solvent, from ethanal we can have ethene or ethanol, etc.

Carbonyl compounds can be prepared by different methods. They can be obtained:

- From alcohols by oxidation
- From carboxylic acid salts
- From alkenes by ozonolysis
- From alkynes by hydrolysis
- From acid chlorides by reduction
- From acid anhydrides by decarboxylation

Both aldehydes and ketones have a common functional group >C=O in which oxygen atom being *more electronegative* than carbon attracts more towards itself thus acquiring a *partial negative charge* while the carbon carries a *partial positive charge.* Hence carbon oxygen bond is polarized, therefore nucleophilic reagents and bases will attack the electron deficient carbon with the result that its electrons are shifted towards the oxygen atom. The anion formed then takes up a proton to give the end product.

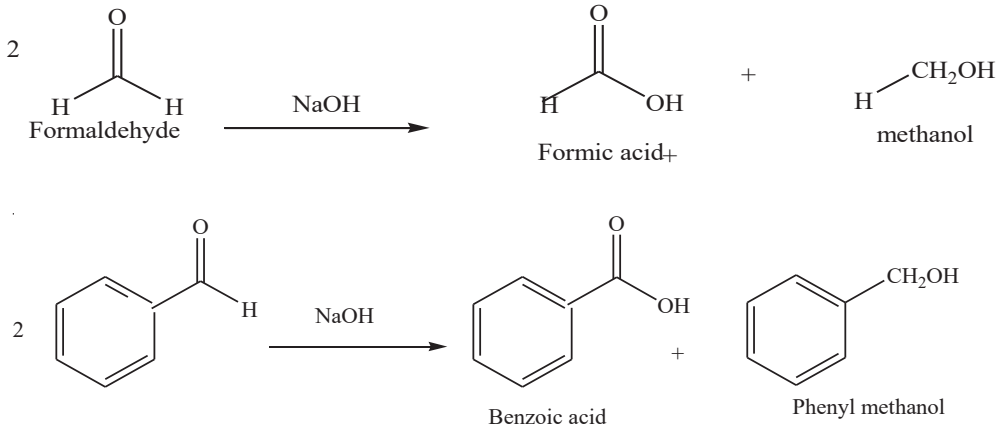
The *carbonyl group in aldehydes will be more reactive than in ketones*. This is because in ketone, due to presence of two alkyl groups which have **positive inductive effect**, the charge on carbonyl carbon will be highly neutralized with the result that any attacking nucleophile is less attracted. Because of this, methanal without any alkyl group, will be more reactive than any **aldehyde** and all **ketones.**

The following are reactions undergone by carbonyl compounds.

a) Reduction reactions
b) Addition reaction of Hydrogen Cyanide
c) Reaction with Phosphorous pentachloride
d) Condensation reactions
e) Oxidation reactions of carbonyl compounds
f) Iodoform reaction

6.7. Additional information for tutor

- *CANNIZARO reaction*is a reaction which is only undergone by Aldehydes **without α-hydrogen**. Here half of the Aldehydes are oxidized to carboxylic acid and half reduced to alcohol on treatment with aqueous sodium hydroxide. This is an example of *dismutation. It is a disproportionation reaction* in organic chemistry. Compare this reaction to those of Aldehydes with α-hydrogen. It is only undergone by methanal and Benzaldehyde.



- Only Aldehydes **withα-hydrogen** and not ketones react with concentrated sodium hydroxide solution under a high temperature at about 100 ^{0}C in order to facilitate **dehydratation process** or operate in concentrated sulfuric acid to give a **brown resinous mass** containing aldehydes function. The resin is formed after a series of condensation steps so called *condensation polymerization*, moreover **homopolycondensation**.

Example:

$$2CH_3CHO \xrightarrow{OH^-} \underset{\text{OH: ALDOL}}{CH_3CH-CH_2CHO} \xrightarrow{-H_2O} CH_3CH=CHCHO \xrightarrow{CH_3CHO/OH^-} \underset{\text{OH}}{CH_3CH=CH-CHCH_2CHO}$$

$$CH_3CH=CH-CH=CHCHO + H_2O$$

The product is thus represented as:

$$nCH_3CHO \xrightarrow{Conc\ OH^-} \underset{\text{Ethanal resin}}{CH_3(CH=CH)_nCHO}$$

- This reaction between two aldehydes (condensation of two units of aldehydes) at low temperature gives an **aldol (***organic compound containing aldehydes group and an alcohol group on neighboring carbon atom***)** product, hence the reaction is known as *aldolization and ketolization* for ketones cases. The resin can be a *natural* (semi solid substance secreted in the sap of some plants and trees used in varnish, paints, inks, adhesive and also in medicine) or **synthetic polymer** used in manufacturing of petrochemicals and plastic. Ethanal through condensation of two units in alkali at high temperature give buta-1,2-diene which is the lower material in the manufacturing of synthetic rubber.

FUCHSIN-ALDEHYDE REAGENT (SCHIFF'S REAGENT)

Schiff's reagent is **a fuchsin dye decolourised by passing sulphur dioxide through it.** In the presence of even small **amounts of an aldehyde**, it turns **bright magenta.**

It must, however, be used absolutely cold, because ketones react with it very slowly to give the same colour. If you heat it, obviously the change is faster and potentially confusing.

Guidance on Skills Lab 7

Some answers in the Skills Lab are given below. You, tutor, have to use it in need, the time student teachers may need some information from you.

1) They can collect clothes buttons (clothing), billiards board (game), etc. It is used in electrical switches, handles of many utensils.
2) Hard solid, thermosetting (heat resisting), insoluble in water, it can be molded very quickly, resistant to electricity (low conductivity), etc. It is used in electrical switches, handles of many utensils
3) Preparation: Heating formaldehyde and phenol in the presence of one of the following (catalysts): Zinc chloride (ZnCl2), hydrochloric acid (HCl) or ammonia (NH3).

6.8. End unit assessment (answers)

1) a) C [Ketones]
   b) B [Aldehydes]

2) $CH_3COCOCH_3$

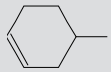
3) **E**=Cyclopropanol, **F**=Propanone (CH_3COCH_3),
G=Propanal (CH_3CH_2CHO)

4) Carbonyl compound **X**

The evidence shows: X is a carbonyl compound (adds 2,4-Dinitrophenylhydrzine). X contains a CH_3CO- group (gives positive iodoform test). It is not aldehyde. It has no C=C bond (does not react with Br_2) and Hydrogen must reduce C=O group to >CHOH. X is $CH_3C^*OCH_2CH_3$, Y and Z is $CH_3C^*HOCH_2CH_3$. Since C^* is chiral, a mixture of stereoisomerisms is formed.

5) The three compounds given
   a) $CH_3CH_2CH_2CH_2OH$ (or $CH_3CH_2CH_2CHO$) + [O] → $CH_3CH_2CH_2COOH$
   b) $CH_3CH_2CH_2CHO$
   $2Ag(NH_3)_2^+{}_{(aq)} \rightarrow 2Ag_{(s)} + 4NH_{3(aq)}$

6) Considering the pair of isomers.
   a) Pentan-2-one
   b) See Tollens, Fehling, etc reagents and their respective observations. (See lesson 6.4)
   c) Draw the structure of the chain isomer of **F** which shows optical isomerism.
   d) 2-methylbutanal

7) The two functional groups in compound **A**,  CHO, behave independently.
   a) See Test of carbonyl compounds (lesson 6.4)
   b) RCHO + HCN → RCH(CN)(OH)

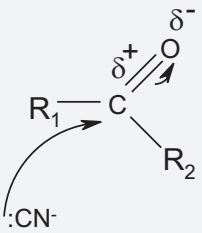
The mechanism

Step 1: The HCN is a weak acid and dissociates:

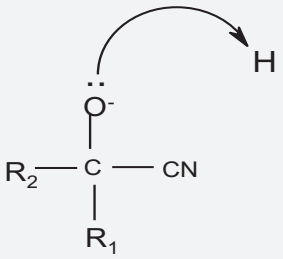
$$HCN \rightarrow H^+ + CN^-$$

The CN^- behaves as a nucleophile.

Step 2: The nucleophile attacks the carbonyl:



Step 3: The O atom picks up the H^+ ion:



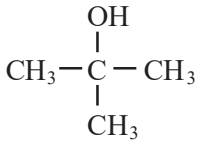
8) See Student teacher Book, Preparation of carbonyl compounds (lesson 6.3).

6.9. Additional activities

6.9.1. Remedial activities

Questions

1) Explain the reasons of the following observations:
   a) Unlike the similar-sized alkanes, the small aldehydes and ketones are soluble in water.
   b) The solubility of aldehydes and ketones falls as the molecules get bigger.
2) Three alcohols **A, B** and **C** of molecular formula $C_4H_{10}O$ were separately heated with acidified $K_2Cr_2O_7$ (potassium dichromate). Alcohol **C** did not undergo any change while **A** and **B** did. Alcohol **A** produced compound **D** which reacted further to form compound **E**. Alcohol **B** reacted to form a compound **F.** Compound **F** did not react with Fehling's solution but reacted with 2,4-dinitrophenylhydrazine.Suggest structural formulae of **A** and **F**.
3) Given the molecular formula $C_4H_{10}O$.



Isomer 1

Isomer 2

a) What type of alcohol is *Isomer 1*? Suggest a reason why this type of alcohol is not easily oxidised.

b) Draw the structural formulae of the two remaining alcohols of molecular formula $C_4H_{10}O$

c) *Isomer 2* was oxidised by adding it dropwise to acidified potassium dichromate (VI) solution and immediately distilling off the product. When this product was treated with Fehling's solution, a red precipitate was formed. State the type of product distilled off during the oxidation by acidified potassium dichromate (VI) solution.

d) Write an equation for the oxidation by potassium dichromate (VI), showing clearly the structure of the organic product. Use [O] to represent the oxidising agent.

e) Name and draw a structure for the organic product formed by the reaction with Fehling's solution.

f) State one advantage and one disadvantage of the production of ethanol by the hydration of ethene compared to the fermentation of glucose.

Answers

1)

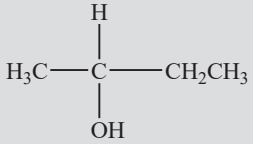
a) They are able to form hydrogen bonds with water molecules.

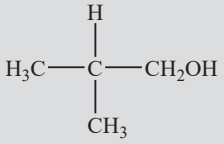
b) As the molecule gets bigger, the insoluble

2) **A**=$CH_3CH_2CH_2CH_2OH$, **B**=$CH_3CH_2COCH_3$, **C**=$CH_3C(CH_3)_2(OH)$, **D**=$CH_3CH_2CH_2CHO$ and **E**=$CH_3CH_2CH_2COOH$

3) a) Tertiary. There is no hydrogen to be removed on the carbon.

b) Draw the structural formulae of the two remaining alcohols of molecular formula $C_4H_{10}O$





c) Isomer 2

d) Aldehyde

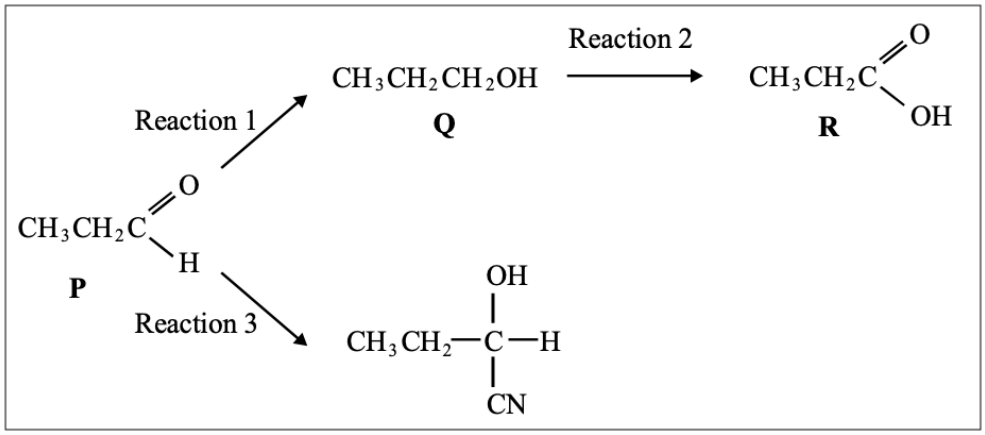
e) $CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO$

f) Name: Butanal and *structure:* $CH_3CH_2CH_2CHO$

6.9.2. Consolidation activities

Questions

1) Consider the following reaction scheme.



a) Give the reagent(s) for ***Reaction 1*** and name the type of reaction involved.

b) Give the reagent(s) and conditions for ***Reaction 2***.

c) Give the reagent(s) and name the mechanism involved in ***Reaction 3***.

d) ***Reaction 3*** produces a mixture of two stereoisomers.

i) What is the relationship between these two isomers?

ii) How can separate samples of these isomers be distinguished?

e) Draw the structure and state the name of the organic product formed when **Q** reacts with **R**.

f) Draw the structure of an isomer of **R** which forms ethanol on hydrolysis.

2) State and explain the conditions necessary for converting an aldehyde into a cyanohydrin.

Answers

1)

a) Any suitable reducing agent ($LiAlH_4$, H_2/Pt) /Reduction

b) Any suitable oxidizing agent ($KMnO_4$/$K_2Cr_2O_7$)

c) HCN/Nucleophilic addition

d) ***Reaction 3***

i) They are mirror images of each other.

ii) Using polarimeter.

e) $CH_3CH_2COOCH_2CH_2CH_3$/Ester (propylpropanoate)

f) $CH_3CH_2CH_2COOCH_2CH_3$

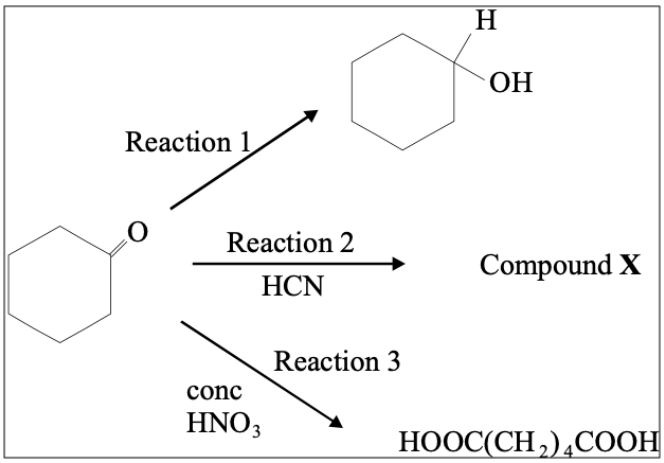
2) An aldehyde reacts with HCN in the presence of a strong base or aqueous KCN. The strong base or KCN is used to facilitate the release of CN^- ions as HCN is a weak base.

6.9.3. Extended activities

Questions

1) An organic compound **(A)** with molecular formula C_8H_8O forms an orange-red precipitate with 2,4-DNP reagent and gives yellow precipitate on heating with iodine in the presence of sodium hydroxide. It neither reduces Tollens' or Fehling's reagent, nor does it decolourise bromine water or Baeyer's reagent. On drastic oxidation with chromic acid, it gives a carboxylic acid**(B)** having molecular formula $C_7H_6O_2$. Identify the compounds **(A)** and **(B)** and explain the reactions involved.

2) Consider the following three reactions of cyclohexanone, $C_6H_{10}O$.



a) Give a suitable reagent for ***Reaction 1.***

b) Name the type of reaction and outline a mechanism for ***Reaction 2***.

c) Name the organic product of ***Reaction 3***.

Answers

1) **A**=C_6H_5-CO-CH_3 **B**=C_6H_5-COOH

2)

a) Acidified water

b) Electrophilic addition. Mechanism: See Student teacher Book

c) Hexane-1,6-dioic acid

UNIT 7

CARBOXYLIC ACIDS

7.1. Key unit competence

Analyze the chemical nature of the carboxylic acids to their reactivity

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

In general, the study of carboxylic acids will require the prior knowledge about general IUPAC rules of nomenclature of organic compounds, types of formulae that are used to represent organic compounds, knowledge about inductive effects of different atoms and group of atoms and chemical reactions of alcohols.

7.3. Cross cutting issues to be addressed

The cross-cutting issues that can be addressed in this unit are specifically:

a) **Gender:** The teacher has always to mind about the gender balance in assignment of roles during Activity. He/she must make sure that both genders are represented and avoid using examples that minimize/praise any of them (boys or girls).

b) **Financial education:** In the lesson 7.2 (physical properties and uses of carboxylic acids), the teacher must emphasize on industrial applications of carboxylic acids, where they are used to manufacture many more useful products such as pharmaceuticals, foods and drinks which are sources of income for many business owners. It has also to be underlined that in the laboratory student teachers should avoid wasting chemicals. They must use them economically.

7.4. Guidance on introductory activity

This activity has the objective of making students think critically about the phenomenon and the observations they always encounter in their daily life. Then they try to interpret those observations by using scientific concepts. To help the students in this regard, the teacher will start by challenging the students with the questions given in introductory activity as a way of awakening their curiosity.

Here students will give diverse opinions, but at the end the teacher will guide them towards a collective understanding.

Answers of questions in the introductory activity

1) Fresh juice taste is sweet, but after some time the taste changes to sour, the same is observed for milk. The explanation is that after some time in either juice or fresh milk glucose undergoes fermentation that forms ethanol which gets oxidized by oxygen in air to form acetic acid. It is the one responsible for the sour taste.

2)

a) The ants' sting causes an injury of the part of the body affected.

b) Ants inject formic acid (methanoic acid) in the part their stings and it is that acid that is responsible for the swelling and painful sensation.

3)

a) They are used to burn the vegetables so that they can be a little bit soft and to change the vegetables' taste.

b) They burn the vegetables because of their acidity and the same property is responsible for their sour taste.

c) They all have carboxylic functional group -COOH, in their structure.

7.5. List of lessons

#	Lesson title	Learning objectives	Periods
1	Nomenclature and isomers of carboxylic acids	- Apply the IUPAC rules to name different carboxylic acids and show their isomers - Write the structural formula and isomers of the carboxylic acids.	2
2	Physical properties and uses of carboxylic acids.	- Explain the physical properties and uses of the carboxylic acids - Compare the physical properties of the carboxylic acids to those of alcohols.	1
3	Reactions of the carboxylic acids	- Prepare carboxylic acids from oxidation of aldehydes or primary alcohols - Describe the inductive effect on the acidity of the carboxylic acids. - Explain the reactions of the carboxylic acids	4
	End unit assessment		1

Lesson 1: Nomenclature and isomers of carboxylic acids

a) Learning objective

- Apply the IUPAC rules to name different carboxylic acids and show their isomers
- Write the structural formula and isomers of the carboxylic acids.

b) Teaching resources

The teaching and learning resources that are needed for this lesson are:

- Student teacher's textbooks
- Chalk board and pieces of chalk

c) Prerequisites/Revision/Introduction

The study of carboxylic acids requires a prior knowledge of:

- IUPAC general rules of naming organic compounds that will help student teacher in the nomenclature of carboxylic acids.
- Isomerism and types of isomerism in organic compounds that was seen in year 2.

d) Activity 7.1

- Since it is not their first time to deal with nomenclature and isomerism of organic compounds, start by giving student teachers the questions in **activity 7.1** to discuss them in small groups of five or six student teachers.
- Student teachers should apply general rules of naming organic compounds in naming carboxylic acids given and identify the types of isomers that are possible in carboxylic acids.
- After discussion, student teachers will be asked to suggest their answers from which the teacher will build his/her whole lesson by simply emphasizing on the points where student teachers demonstrated some difficulties.
- Focus on the fact that the side branches and substituents on the carboxylic longest carbon chain are given position by starting from the carboxylic functional group.
- Clearly explain how optical isomers arise in carboxylic acids and how to distinguish them by using plane polarized light in a polarimeter.

Answers to Activity 7.1

1)

a) Ethanoic acid
b) 2-methylpropanoic acid
c) Methanoic acid

d) Ethane-1,2-dioic acid

e) 2-methylbutanoic acid

2)

a) $CH_3C(CH_3)_2COOH$

b) $CH_3CH\ (CH_3)CH_2COOH$

3)

$C_3H_6O_2$:$HOCH_2CH_2CHO$:1-hydroxy propanal

:$CH_3CHOHCHO$:2-hydroxy propanal

:CH_3CH_2COOH :propanoic acid

:CH_3COOCH_3 :methyl ethanoate

:$HOCH=CHCH_2OH$:1-propene-1,3 diol

:$HOCH=CH(OH)CH_3$:1-propene-1,2 diol

4)

a) One is the mirror-image of the other and they are non-superimposable like right and left hands.

b) They can be distinguished using a polarimeter, where L-lactic acid rotates plane polarized light to left and D-lactic acid rotates plane polarized light to the right.

e) Answers to Application Activity 7.1

1)

(a) $CH_3CH_2CH(CH)_3CH(CH_3)COOH$

(b) $HOOC\text{-}CH(CH_3)CH_2CH_2CH_2COOH$

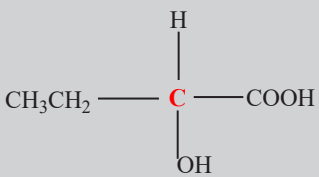
2) a) 6-methylhept-4-enoic acid

b) 3-hydroxybutanoic acid

3) a) Functional group isomers

b) Chain isomers

4) 2-hydroxybutanoic acid and 2-methylbutanoic acid are optically active because they have asymmetric carbon (in red)



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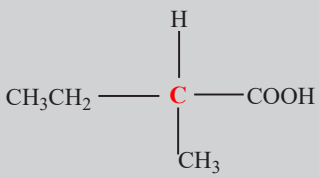


5) See question above (Q4)

Lesson 2: Physical properties and uses of carboxylic acids

a) Learning objective

- Explain the physical properties and uses of the carboxylic acids
- Compare the physical properties of the carboxylic acids to those of alcohols.

b) Teaching resources

The teaching and learning resources that are needed for this lesson are:

- Student teacher's textbooks
- Chalk board and pieces of chalk
- Samples of carboxylic acids such as acetic acid, vinegar, lemon juice, etc.

c) Prerequisites/Revision/Introduction

Physical properties of chemical substances in general are determined either by the chemical bonds, the structure or the intermolecular forces. To understand the physical properties of carboxylic acids requires a prior knowledge of:

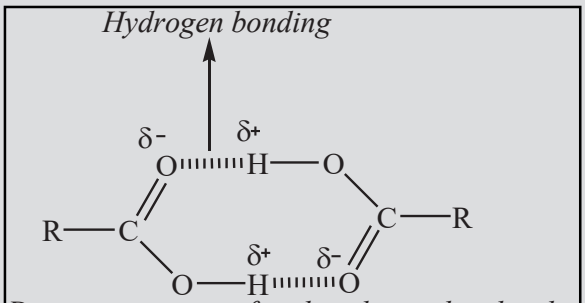
- Chemical bonding and structure of molecules
- Type of intermolecular forces learnt in year 1

d) Activity 7.2

- Start the lesson by asking student teachers to brainstorm the answers and their ideas about the questions in *activity 7.2.1* and *7.2.2*. Here, questions are asked to the class and student teachers can give their ideas.
- Put the focus on the fact that molecules held together by strong intermolecular forces are likely to be liquids and solids, they also have high melting and boiling points.
- Use the answers given to compare the boiling and melting points of carboxylic acids with those of alcohols and other homologous series learnt in the previous units.
- Emphasize on the dimeric structure of molecules of carboxylic acids because of double hydrogen bonds. Highlight that this fact makes carboxylic acids have higher boiling and melting points than alcohols even though they all interact by hydrogen bonding as intermolecular forces.
- Emphasize also on the uses of carboxylic acids in everyday life(industry, medicine…).

Answers to Activity 7.2.1

1) Carboxylic acids have ability to form hydrogen bonds which enhance the possibility of bringing two acid molecules together by forming a kind of dimer as shown in the diagram.



Dimeric structure of carboxylic acid molecules

2) Refer to Student Teacher's book, lesson 7.2

e) Answers to Application activity 7.2.1

1) Octadecanoic acid has higher melting point because it has greater molecular mass (greater size) than that of hexadecanoic acid. Van der Waals forces become stronger as the molecular mass of the molecule increases.

2) Butanoic acid has higher boiling point than that of pentan-2-one because of two main reasons:
   - Butanoic acid molecules interact with strong hydrogen bonds while pentan-2-one molecules interact with Van der Waals forces (dipole-dipole interactions) that are weaker.
   - Butanoic acid has greater molecular mass than that of pentan-2-one, which also favour the stronger Van der Waals forces in butanoic acid.

3) Yes, butanoic acid has higher solubility in water than butan-1-ol because carboxylic acids form stronger hydrogen bonds with the molecules of water.

Answers to Activity 7.2.2

1) Three primary carboxylic acids are found in wine: tartaric, malic and citric acids.
   - **Sodium benzoate** is obtained by dissolving benzoic acid (a carboxylic acid) in a sodium hydroxide solution.
   - **Soaps** are made from the sodium and potassium salts of long chain carboxylic acids.

- Animal **wax** esters are typically derived from a variety of carboxylic acids and fatty alcohols.
- **Aspirin** is a carboxylic acid known as acetylsalicylic acid (2-Acetoxybenzoic acid)
- *T*o produce the raw **rubber** used in tire manufacturing, the liquid latex is mixed with acids that cause the rubber to solidify.

2) Use the content in Student teacher Book in section 7.2.2

Answer to Application activity 7.2.2

See the sub-lesson in student teacher Book (7.2.2)

Lesson 3: Preparation methods and Reactions of the carboxylic acids

a) Learning objective

- Prepare carboxylic acids from oxidation of aldehydes or primary alcohols
- Describe the inductive effect on the acidity of the carboxylic acids.
- Explain the reactions of the carboxylic acids

b) Teaching resources

The teaching and learning resources that are needed for this lesson are:

- Student teacher's textbooks
- Chalk board and pieces of chalk
- Samples of carboxylic acids or compounds known to contain them such as acetic acid, lemon juice, vinegar, etc.
- Litmus paper or any acid-base indicator
- Chemicals: Strong mineral acids (HCl or H_2SO_4), sodium carbonate, lime water and acetic acid
- Apparatus: test tubes, rubber stopper and delivery tubes

c) Prerequisites/Revision/Introduction

- Chemical reactions of alcohols mainly oxidation,
- Cleavage oxidation of alkenes (ozonolysis).
- Acid-base theories.
- Positive and negative inductive effects of diverse atoms or group of atoms.

d) Activity 7.3.1 & 7.3.2

Activity 7.3.1

- This activity 7.3.1 can be carried out in a way that the tutor starts developing an awareness of the student teachers about the need of preparing carboxylic acids by asking them question 1 of activity 7.3.1
- He continues by guiding them to realize that they might already know some methods of preparation of carboxylic acids that they learnt in previous units. He/she asks them to have discussions in their groups and come up with some answers about question 2 of the activity 7.3.1
- Ask student teachers to present the results of their group discussions to the whole class.
- Then, to the methods that student teachers will have suggested during presentations, add more others which are in the student teacher's book, lesson 7.3.1

Answers to activity 7.3.1

1) There is no specific correct answer, accept any relevant opinion of the student.
2) Refer to the student teacher book section 7.3.1 about preparation of carboxylic acids. The students may suggest some of the methods given this content (specifically oxidation of alcohols and aldehydes).

Activity 7.3.2

- To effectively conduct this activity, the tutor starts by asking student teachers to tell the characteristics of an acidic substance as in question 1 of activity 7.3.2. He/she allows student teachers to brainstorm what they think about an acidic substance.
- For the practical activity, the tutor groups the student teachers appropriately; a group of more than 6 student teachers would be very large. The group should be heterogeneous in a way that boys and girls, brilliant and slow learners are mixed.
- The tutor provides student teachers with indicated apparatus and chemicals; and asks them to follow the procedure suggested in the student teacher's book while carrying out activity 7.3.2. After that different groups have presented their findings, ask the student teachers to evaluate the findings; the tutor judges the logic of the student teachers' products, corrects those which are false, completes those which are incomplete, and confirms those which are correct.

- It must also be explained that the strength of the acidity depends on the atoms or group atoms that are in the molecule, if they have a positive inductive effect or a negative inductive effect. Here relevant examples are needed to explain this concept (see student teacher's book, lesson 7.3).

Answers to Activity 7.3.2

1) Carboxylic acids can be transformed into other more useful substances because they can undergo chemical reactions. The property that is exploited in this case is their reactivity.

2) It is possible because fatty acids can react with appropriate reagents, under appropriate conditions to form soap.

3. a) The main observation of this reaction is the escaping of CO_2 **(effervescence)**

b) $CH_3\text{-}COOH\ (aq) + Na_2CO_3\ (aq) \rightarrow CH_3\text{-}COONa\ (aq) + H_2O\ (l) + CO_2\ (g)$

e) Answers to Application activity 7.3.1

1)

a) $CH_3CH_2CH(CH_3)CH_2CH_2Br + KOH \rightarrow CH_3CH_2CH(CH_3)CH_2CH_2OH + K_2Cr_2O_7 \rightarrow CH_3CH_2CH(CH_3)CH_2COOH$

b) $CH_3CH_2CH{=}CHR$ + conc. acidified hot $KMnO_4 \rightarrow CH_3CH_2COOH + RCOOH$

c) $CH_3CH_2CH_2NH_2 + NaNO_2/HCl \rightarrow CH_3CH_2CH_2OH + K_2Cr_2O_7 \rightarrow CH_3CH_2COOH$

2) Banana beer tastes sour after some time because ethanol in banana beer gets oxidized by oxygen into ethanoic acid which responsible for the sour taste.

Answers to Application activity 7.3.2

1)

a) Sodium hydroxide reacts with carboxylic acids in a neutralization reaction, but there is no reaction of sodium hydroxide with alcohols.

b) Base- acid neutralization (during the process potassium hydroxide was neutralized by acetic acid. Since the equimolar amount of the base and the acid were mixed there was complete neutralization.)

2)

a) $CH_3CH_2COOH + PCl_5 \rightarrow CH_3CH_2COCl + O{=}PCl_3 + HCl$

b) $CH_3COOH + P_2O_5 \rightarrow CH_3COOOCCH_3 + H_3PO_3$

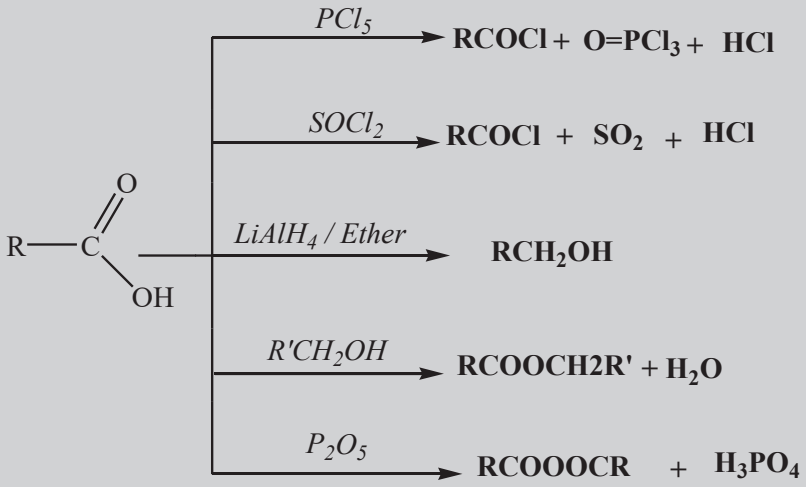
c) $CH_3COOH + C(CH_3)_3OH + H_2SO_4 \rightarrow CH_3COOC(CH_3)_3 + H_2O$

3)

a) The student is asked to take a sample from each of the liquids and test them either using solution of sodium carbonate or methyl orange indicator. Emphasis should be put on acidic nature of carboxylic acid (Ethanoic acid), unlike alcohol (2-methylpropan-2-ol

b) Use sodium carbonate as a chemical test that will give a positive test with carboxylic acid, but there is no observable change in case of a phenol. Note that the indicator is not appropriate because it would give similar observations in both compounds.

4)



7.6. Summary of the unit

Carboxylic acids

Carboxylic acids also called organic acids form a class of organic compounds that are characterized by the presence of carboxyl group in their chemical formula. The general formula for carboxylic acids is **R-COOH** where **R**- refers the alkyl group of the molecule.

Carboxylic acids are named by following the general rules of naming organic compounds, where the suffix '**oic acid'** is added to the stem name of the longest carbon chain that contains the acid functional group. The side branches are also positioned by starting from the carbon with carboxylic functional group. Here, the carboxylic group takes priority to other functional group when numbering carbons in thecase of substituted chain.

A solution containing equal amounts of enantiomers, 50% laevorotatory and 50% dextrorotatory is known as a **racemic mixture** that will not rotate polarized light,

because the rotations of the two enantiomers cancel each other out. Carboxylic acids have high melting and boiling points because their hydrogen bonds enhance the possibility of bringing two acid molecules together by forming a kind of **dimer.**

Carboxylic acids occur naturally in fats, acidic dairy and citrus fruits, and among their most important uses.There are several methods of preparation of carboxylic acids where the most common are from primary alcohols and aldehydes by oxidation and from alkenes (Oxidation of alkenes).

Organic or carboxylic acids are weak acids in opposition to some mineral acids such as hydrochloric acids which are strong acids. The carboxylate ion formed by ionization of the acid is more stable than the acid because it has many *resonance* structures and ethanoic acid is a weaker acid because its *methyl group has a positive inductive effect.*

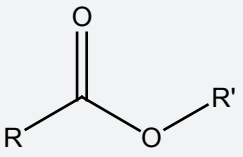
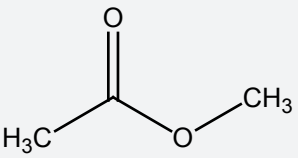
Carboxylic acids are reactive, and their reactions can be classified into:

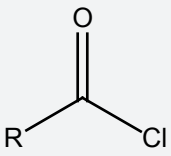
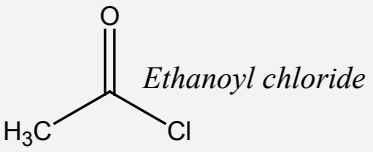
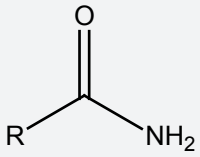
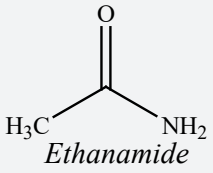
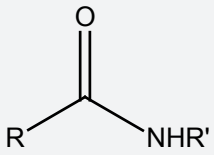
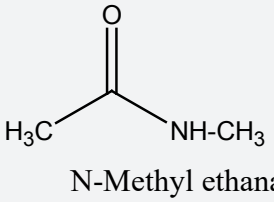
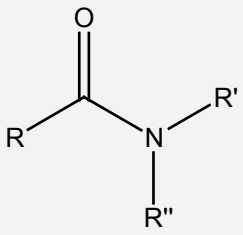
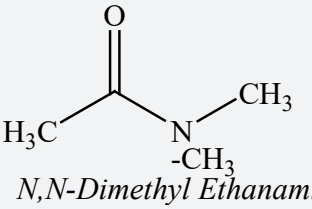
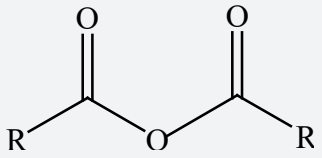
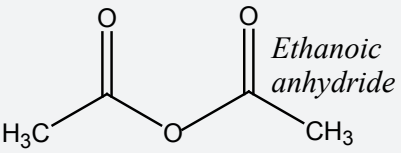
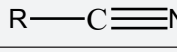
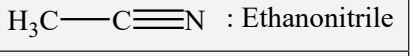
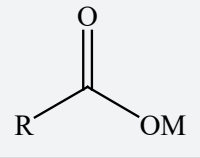
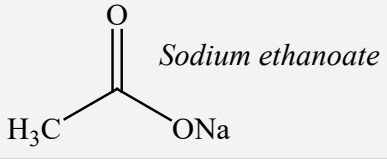
- Reaction involving –H of hydroxyl group O-H (i.e. reaction as acids)
- Reaction involving -O-H group of carboxylic acid (i.e. nucleophilic substitution reactions)
- Reaction involving carbonyl group –CO- (reduction reaction to alcohols):
  1) Reaction with metals
  2) Reaction with alkali solutions
  3) Reaction with sodium carbonate and sodium hydrogencarbonate
  4) Reaction with alcohols (Esterification)
  5) With phosphorus halides, thionyl chloride
  6) Reaction with phosphorous pentoxide
  7) Reduction of carboxylic acids

7.7. Additional information for tutor

Derivatives of carboxylic acids

The carboxylic derivatives can be classified and defined in the following table:

CLASS	GENERAL FORMULA	EXAMPLE
1. Ester		 Methyl ethanoate

2. Acid chlorides		
3. Amides (Primary)		
a). Monosubstituted (Secondary)		
b). Disubstituted (Tertiary)		
4. Acid anhydrides		
5. Nitriles		
6. Carboxylic salts		

▪ ACID CHLORIDES

They have the general formula: **R-CO-Cl**. In their nomenclature, the suffix-ic acid of the acid is replaced by 'yl'chlorides.

Their isomers can be chain isomerism, positional isomerism and functional isomerism with chloro aldehydes and ketones, alcohols with double bond C=C and chlorine as a substituent, cyclic ethers with chlorine, etc.

▪ ESTERS

See the next unit (Unit 8)

- **AMIDES**

Amides are obtained when the –O-H group of –COOH group is replaced by –NH_2, hence amide has the following formula: **R-CO-NH_2**.

From the above definition amides are classified in 3 classes: primary, monosubstituted and disubstituted.

They are named by replacing the final **'e**' of the parent hydrocarbon by<***amide***>. But for most acid that do not respond to IUPAC nomenclature you have to replace ic by amid and cancel the starting word acid.

Isomerism may be functional isomers with aldehydes, ketones with amino groups and possibility of different position in chain or rings if possible. Note: Amides form tautomers with iminol.

- **ACID ANHYDRIDES**

Acid anhydrides are organic compounds resulting from carboxylic acids by loss of water. Their general chemical formula is **R-CO-O-CO-R**

According to IUPAC nomenclature, acid anhydrides are named by starting with the ***name*** of an acid without the word acid, followed by the word ***anhydride***.

Isomerism can result from atoms connectivity and group function that is functional isomerism with esters, ketones, aldehydes acids, alkynes with hydroxyl groups, etc.

- **NITRILES**

Nitriles are organic compounds derivatives of carboxylic acid whose general formula is **R-CN**. From the general formula, it easy clear that they do not contain oxygen atom and has no remarkable similarity with acids or acid derivatives.

According to IUPAC, nitriles, so called organic cyanide are named by taking the corresponding hydrocarbons and replacing the ending "e" by "nitrile"or more generally as an acid derivative by replacing "ic" of the corresponding acid by "onitrile".

Isomerism can result from different connectivity between atoms, therefore functional, chain and position isomers are possible.

GUIDANCE ON SKILLS LAB 7

The teacher has to ask student teachers to remember to attempt the skills lab given. Some proposed answers to questions appeared in the skills lab.

a) The tastes changes over ageing
b) pHs are different

c) The taste changes because the alcohol is being changed into carboxylic acid and the pHs decreases because the acidity is decreasing (from alcohol to acid).

$CH_3CH_2OH + [O] \rightarrow CH_3COOH$

7.8. End unit assessment (answers)

Multiple choice questions

1) (a) Esters

2) (d) Both **(b)** and **(c)**

3) (d) All of them

Open questions

4) Observations

a) It turns red.

b) Effervescence

5) Matching

$CH_3—CO_2H$	**118°C**
$CH_3(CH_2)_{10}—CO_2H$	**299°C**
$CH_3(CH_2)_3—CO_2H$	**186°C**
$CH_3CH_2—CO_2H$	**141°C**

6) Increasing order of boiling point:

Propanal<Propan-1-ol<Propanoic acid. One propanoic acid molecule has two sites of hydrogen bonding, propan-1-ol has one site and propanal has any.

7) Starting from any aliphatic carboxylic acid, how could you make its derivative;

a) An acyl chloride: Reaction of a carboxylic acid with halogenating agents like PCl_5, $SOCl_2$, etc.

b) An ester: Reaction of the carboxylic acid with an alcohol.

Necessary conditions for reaction and equations for the reaction (See Student Book 7.8)

8) Reasons for the observations

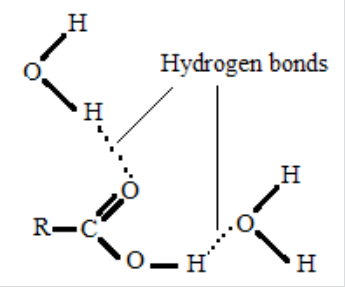
a) The positive inductive effect of additional methyl group on 2-methylpropanoic makes the oxygen denser in electrons pulling strongly H, thus reducing the acidity

b) The negative inductive effect of fluoro makes electrons less available on oxygen of OH and the O-H bond becomes weak, so the acid becomes strong.

9) 4<1<2<3

10) Pyruvic acid

a) Pyruvic acid is soluble in water because it can form with it hydrogen bonds. Diagram is like the following:



b) Propan-1,2-diol

c) Pyruvic acid has a ketone functional group whereas compound A has aldehyde group. The test that could be carried is to use Fehling or Tollens reagent and there will be positive on the compound A.

d) Propan-1,3-diol

7.9. Additional activities

7.9.1. Remedial activities

Questions

1) Give the systematic names of the following organic compounds

a) CH_3-CH(CH_3)-CH_2-CH(CH_3)-COOH

b) CH_3-CH(OH)-CH_2-CH_2-COOH

c) HOO-C-CH_2-CH_2-COOH

2) Explain the following observations:

a) Propanoic acid has lower boiling point than that of pentanoic acid

b) Ethanol is much more volatile than ethanoic acid

c) The palmitic acid forms two layer with water when they are mixed, but acetic acid mixes with water in all proportions.

3) Acetic acid, unlike ethanol, readily reacts with ammonia solution to form ammonium and acetate ion. Explain the property that acetic acid has which makes it behave in this way.

4) Complete the following reactions:

a) $CH_3\text{-}CH_2\text{-}CH_2\text{-}COOH \xrightarrow{SOCl_2}$

b) $CH_3COOH + CH_3CH(OH)CH_3 \xrightarrow{H_2SO_4/Reflux}$

c) $CH_3COOH\,(aq) + NaHCO_3(aq) \longrightarrow$

5) Describe how you can prepare;

a) Propanoic acid from propan-1-ol

b) Acetic acid from bromomethane

Answers

1)

a) 2,4-dimethylpentanoic acid

b) 4-hydroxypentanoic acid

c) Butanedioic acid

2) a) Propanoic acid has lower boiling point than pentanoic acid because pentanoic acid has stronger Van der Waals forces due to its higher molecular mass than that of propanoic acid.

b) Ethanols in more volatile than ethanoic acid because the hydrogen bonds in ethanol are weaker. Ethanoic acid molecules form double hydrogen bonds that result in the formation of dimeric structure, and this makes it less volatile.

c) The solubility of carboxylic acids decreases as the molecular size increases. This causes the Van der Waals forces between hydrophobic parts of the molecule to dominate hydrogen bonds between molecules of water. Palmitic acid being a large molecule is less soluble in water than acetic acid that is very small.

3) Acetic acid readily reacts with ammonia solution because it has acidic properties, where it readily donates a proton to ammonia which is a base.

4) Complete the following reactions:

a) $CH_3\text{-}CH_2\text{-}CH_2\text{-}COOH \xrightarrow{SOCl_2} CH_3\text{-}CH_2\text{-}CH_2\text{-}COCl + SO_2 + HCl$

b) $CH_3COOH + CH_3CH(OH)CH_3 \underset{}{\overset{H_2SO_4/Reflux}{\rightleftharpoons}} CH_3COOCH(CH_3)_2 + H_2O$

c) $CH_3COOH\,(aq) + NaHCO_3(aq) \rightarrow CH_3COONa\,(aq) + H_2O(l) + CO_2(g)$

5)

a) $CH_3CH_2CH_2OH + KMnO_4(aq) \xrightarrow{H^+/Heat} CH_3CH_2COOH + K^+(aq) + Mn^{2+}(aq) + H_2O(l)$

b) $CH_3Br \xrightarrow{Mg/ether} CH_3MgBr \xrightarrow{CO_2} CH_3CO_2MgBr \xrightarrow{H_2O/H^+} CH_3COOH$

7.9.2. Consolidation activities

Questions

1) Complete the following reactions and identify the compounds represented by the bold letters:

a) $CH_3CH_2Br + CO_2(g) \xrightarrow{Mg/ether} \mathbf{A} \xrightarrow{H_3O^+_{(aq)}} \mathbf{B} + Mg(OH)Br$

b) $\mathbf{C} + C_2H_4O_2 \underset{}{\overset{H^+(aq)}{\rightleftharpoons}} CH_3COC(CH_3)_3 + H_2O$

c) $CH_3CH_2COOH \xrightarrow{\mathbf{D}} (CH_3CH_2CO)_2O$

2) Use the following informations to answer related questions:

Formula	Molar mass (g/mol)	Melting point (°C)	Boiling point (°C)
HCOOH	46	8	100.5
CH_3COOH	60	17	118
CH_3OH	36	-98	65
CH_3CH_2OH	46	-114.1	78.4

a) How is the boiling point of ethanoic acid greater than that of methanoic acid?

b) Explain why the boiling point of methanoic acid is greater than that of ethanol despite of their molecular masses that are the same.

Answers

1)

a) **A:** $CH_3CH_2CO_2MgBrand$ **B:** CH_3CH_2COOH

b) **C:** $(CH_3)_3COH$

c) **D:** P_2O_5

2)

a) The boiling point of carboxylic acids increases as the molecular mass increases. Since ethanoic acid has greater molecular mass than that of methanoic acid, it has greater boiling point.

b) Methanoic acid molecules interact by stronger double hydrogen bonds in dimeric structure, which is not formed in ethanol.

7.9.3. Extended activities

Questions

1) a) Suggest a series of reactions by which ethanol can be converted to 2-hydroxypropanoic acid. For each reaction specify the reagents and conditions necessary.

   b) (b) Explain whether the solution of 2-hydroxypropanoic acid, made in this way, would have any effect on plane polarized light.

   c) (c) 2-hydroxypropanoic acid reacts with lithium tetrahydridoaluminate (III), $LiAlH_4$. State the conditions necessary for this reaction and give the structure of the organic product formed.

2) Esters are products of the reaction between carboxylic acids and alcohols.

   a) Draw the structure of the organic product of the reaction between propan-2-ol with propanoic acid

   b) Explain the alternative way this ester can be prepared by using another reagent in place of propanoic acid.

3) Describe how the following pairs of compounds can be distinguished by a chemical test.

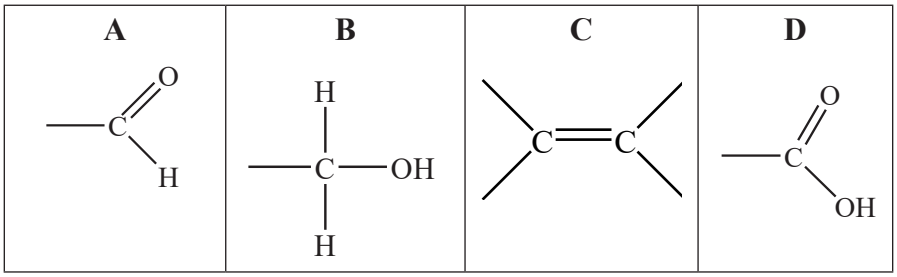
   a) CH_3COOH and CH_3COCl

   b) Propanoic acid and propan-2-ol

4) Certain chemical tests were performed on the pain-relief drug *ibuprofen.* The results of these tests are given in the table below.

Test	***Result***
Aqueous sodium carbonate	Effervescence
Bromine water	Remained orange
Acidified potassium dichromate(VI) and heat	Remained orange
Fehling's solution and heat	Remained blue

Which one of the following functional groups do these results suggest that ibuprofen contains?



0.45g of organic acid on combustion gave 0.44g of carbon dioxide and 0.09g of water.If the molecular weight of the acid is 90,

5) a) Deduce the molecular formula.

b) Write the structural formula and IUPAC name of the acid represented.

Answers

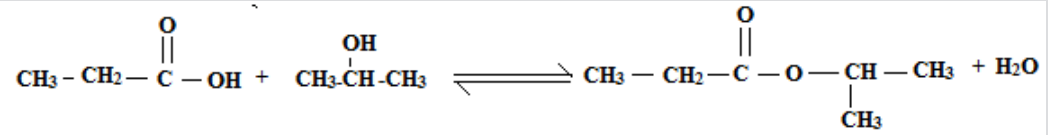
1)

a) $CH_3CH_2OH \xrightarrow{MnO_4^-/H^+/Heat} CH_3CHO \xrightarrow{HCN/NaOH} H_3CH(OH)CN \xrightarrow{H_3O^+(aq)} CH_3CH(OH)COOH$

b) Refer to student's book, lesson 7.1 about nomenclature and isomerism

c) This reaction takes place in dry ether. The organic product formed is propan-1,2-diol: $CH_3CH(OH)CH_2OH$

2) (a)



(b) The same ester can be prepared by using propanoyl chloride.

3)

a) The chemical test that can be used is Sodium carbonate (Na_2CO_3).

With ethanoic acid, there is formation of carbon dioxide that results in effervescence

With ethanoyl chloride, there is no effervescence

b) Acidified potassium permanganate/dichromate can be used.

With propan-2-ol, orange/purple colour turns to green/colourless colour

With propanoic acid, there is observable change.

Or

The chemical test that can be used is Sodium carbonate (Na_2CO_3).

With propanoic acid, there is formation of carbon dioxide that results in effervescence

With propan-2-ol, there is no effervescence

4) D

5)

- Percentage of carbon in CO_2 :12/44 x 0.44/0.45 x100 =26.66%
- Percentage of hydrogen in H_2 O: 2/18 x 0.09/0.45 x100 =2.22%
- Percentage of oxygen = 100-26.66-2.22=71.12%

Elements	C	H	O
% composition	26.66	2.22	71.12
Relative Ratio of atoms,molecules	$\frac{26.66}{12} = 2.22$	$\frac{2.22}{1} = 2.22$	$\frac{71.12}{16} = 4.44$
Atomic ratio	$\frac{2.22}{2.22} = 1$	$\frac{2.22}{2.22} = 1$	$\frac{4.44}{2.22} = 2$
Empirical formula		CHO_2	
Molecular formula	n= 90/45=2	$C_2H_2O_4$	
IUPAC Name	Ethane-1,2-dioic acid (ethanedioic acid)		
Common name	Oxalic acid		

UNIT 8

ESTERS

8.1. Key unit competence

Relate the functional groups of esters to their reactivity, preparation methods and uses

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

Student teachers will learn better esters if, in the previous units, they have understood chemical bonding chemistry of alcohols and chemistry of carboxylic acids. You will use various techniques such as discussions, you will help student teachers to recap the above concepts before you start unit 8.

8.3. Cross cutting issues to be addressed

a) **Inclusive education:** This unit will involve the physical and chemical properties of acid derivatives and their uses in our everyday life and then, the use of molecular structures and many practical activities are obvious. This may be challenging to student teachers with special educational needs especially student teachers with visual and upper and lower limb impairment. However, these student teachers can be catered for in every lesson by using different techniques which are explained in the general introduction. Refer to the general introduction of this book for more information.

b) **Gender:** You should always remember that there is no activity reserved for boys only or girls only. Try to involve both of them in each and every Activity.

c) **Financial education:** This unit tackles the chemistry and uses of esters, the teacher will explain how processes such as saponification are income generating. She/he shall also indicate various manufactures which use acid derivatives and that can make a good starting point for young entrepreneurs.

d) **Peace and values education:** During group activities, you will encourage student teachers to help each other and to respect other's opinions.

e) **Standardization culture:** You should remind student teachers to always check if they are not using expired chemicals or defective apparatus.In addition, they must be trained to record data accurately and present accurate results.

f) Environment and sustainability: In order to avoid the environment pollution, before, during or after experiments student teachers have to not throw away chemicals anywhere.During the lesson of saponification, you will tell student teachers the impacts of using soapless detergents on the environment.

8.4. Guidance on introductory activity

- Help student teachers to form groups of four members, explain what is to be done, and then let them work out the introductory activity.
- You must be sure that all group members are participating.
- Each group will note down the observations made from the pictures in the activity and write answers for the given questions in their books.
- Randomly, you will choose 2 to 3 groups to present the outcomes of their work to the others. Here you should take note of the key points from presentations as they help you to know what to add, what to correct…
- After presentations, you have to engage the class into exploitation of the student teachers' productions. They discuss on the presentations to decide if they are correct, complete and if more information is needed. Here you will act as a moderator but you will also have to add, correct or remove some information. After harmonization you will provide a short summary of the activity and start the new unit.

Answers for the questions in the introductory activity

a) Polyester. Combination of monomers containing alcohol and carboxyl group (one having all the *same time or two different). Ester bond.*

b) *Some chemical substances (like esters) are known to provide needed flavours.*

c) Aspirin can be made by reacting salicylic acid with acetic acid in the presence of an acid catalyst. The phenol group on the salicylic acid forms an ester with the carboxyl group on the acetic acid.

Functional groups: Ester, carboxylic acid, benzene

Molecular formula: $C_9H_8O_4$ (extended formula is $CH_3COOC_6H_4COOH$).

IUPAC name: 2-acetoxybenzoic acid;

d) Esters

8.5. List of lessons

#	Lesson title	Learning objectives	Periods
1	Nomenclature and structure of esters.	Show the structures of esters. Apply IUPAC rules to name esters.	1
2	Physical properties of esters and its uses.	Explain the physical properties and uses of esters Compare the physical properties of esters to those of alcohols and carboxylic acids.	1
3	Chemical properties of esters.	Describe the chemical properties of esters.	2
4	Saponification and the detergents	Describe the formation of the detergents. Make soap and compare its properties with those of soapless detergents. Appreciate the importance of esters in the manufacture of soap Appreciate the importance of esters as intermediate compounds in the manufacture of polyesters	1
	End unit assessment		1

Lesson 1: Nomenclature and structure of esters

a) Learning objectives

- Show the structures of esters.
- Apply IUPAC rules to name esters

b) Teaching resources

Student teacher book and reference books from library or internet, basic organic chemicals and apparatus

c) Prerequisites/Revision/Introduction

This lesson will be well delivered if student teachers have a good understanding of how to draw structures of organic compounds and the reactions of carboxylic acids. You should find a way of testing the understanding level of your student teachers. You can use an exercise or a short discussion.

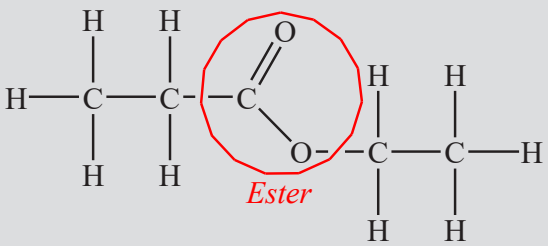
d) Activity 8.1

As a facilitator, the teacher is expected to guide student teachers through the following steps:

- In groups student teachers used in the introductory activity, they will discuss on questions of *activity 8.1* and answer them. The discussion will be done in groups but let each student teacher write answers in her/his exercise book. The teacher must be sure that all student teachers are involved in the activity. Each group must have a leader who will be moderator and a secretary who writes the report and will present findings of the group.
- You have to choose any relevant technique to be used in the formed groups.
- Move around the class, listening to student teachers as they discuss and provide support where needed.
- Have a sample group present their findings to the class.
- Valuing student teachers' presentations (judgment and discovery of possible mistakes by student teachers).
- This is a diagnostic activity; the next step will greatly depend on your judgment. If your class cannot correctly answer the question, extra explanations and exercises are necessary. But if they are correctly answered then the teacher can proceed and give a summary of the first part of the lesson. A summary of the content must be written on the board.

Answer to Activity 8.1

1) (a) & (b)



2) $CH_3CH_2COOCH_3$(Methyl propanoate), $CH_3COOCH_2CH_3$(Ethyl ethanoate), $HCOOCH_2CH_2CH_3$(Propyl methanoate), $CH_3CH_2CH_2COOH$ (Butanoic acid), $CH_3CH(CH_3)COOH$ (2-methylpropanoic acid).

e) Answers to Application Activity 8.1

1) a) Methyl propanoate
b) Ethyl propanoate

c) Propyl propanoate

d) 1-methylethylmethanoate (isopropyl methanoate)

2) a) $HCOOCH_2CH_2CH_3$

b) $CH_3COOCH_2(CH_2)_6CH_3$

3) a) $C_2H_4O_2$: CH_3COOH Ethanoic acid, $HCOOCH_3$: methyl methanoate

b) $C_4H_8O_2$: $CH_3CH_2COOCH_3$: Methyl propanoate, $CH_3COOCH_2CH_3$:ethyle thanoate, $HCOOCH_2CH_2CH_3$: propyl methanoate, $CH_3CH_2CH_2COOH$: butanoic acid, $CH_3CH(CH_3)COOH$: 2-methyl propanoic acid

Lesson 2: Physical properties of esters and its uses

a) Learning objectives

- Explain the physical properties and uses of esters
- Compare the physical properties of esters to those of alcohols and carboxylic acids.

b) Teaching resources

Student teacher book and reference books from library or internet, basic organic chemicals and apparatus

c) Prerequisites/Revision/Introduction

Knowledge and skills of how to draw structures of organic compounds and more carboxylic acids (structure, nomenclature, reactivity, etc).

d) Activity 8.2

This activity is practical. We have two practical activities to be performed.

- *Experiment 1(practical work1)* is about the solubility properties of esters whereas the *Experiment 2* (practical work 2) is about the volatility property of esters.
- Plan how the experiments will be performed as the Activity.
- Let the student teachers follow the procedure, and each experiment will end up with asking the student teachers to draw their own conclusion.
- During the experiment, move around the laboratory room, listening to students as they discuss and provide support where needed.
- Let them submit the laboratory report.
- You will be asked to give them feedback in order to have common understanding on these physical properties of esters examined.

Answers to Activity 8.2

- **Conclusion for Experiment 1***:* Esters are soluble in organic solvents such as ethanol and insoluble in water but the solubility degree of ester in water is less than that of the corresponding acids and alcohols. This is due to the absence of polar hydroxyl group (presents in alcohols and acids) which has the ability to form hydrogen bonds between the alcohol and acid molecules and water molecules.
- **Conclusion for Experiment 2:** Esters have lower boiling points than alcohols and carboxylic acids because they lack hydrogen bonds. A compound having hydrogen bonds has a high boiling point because breaking that bond requires higher energy.

e) Answers to Application Activity 8.2

1) See lesson 8.2 in the Student teacher Book

a) H-COO-CH_3 (**A**), CH_3COOH (**B**)

b) They are isomers. They have the same molecular formula.

2) Carboxylic acids have higher boiling point than equivalent alcohols and esters because of having two sites of hydrogen bonding per molecule. Alcohols have higher boiling points comparing to their equivalent esters because they lack hydrogen bonds.

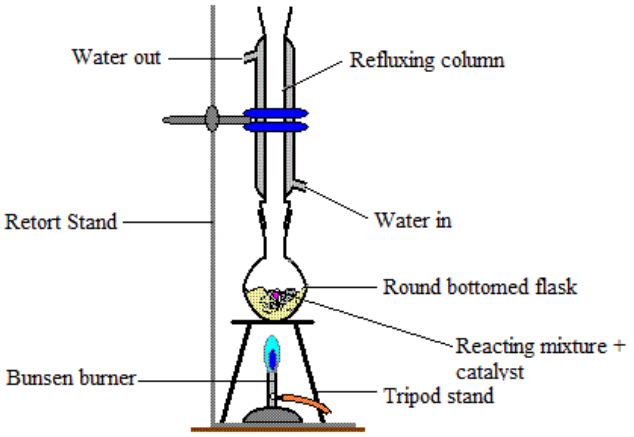
Lesson 3: Preparation and chemical properties of esters

a) Learning objective

Describe the chemical properties of esters.

b) Teaching resources

Student teacher book, reference books or internet, ethanol, ethanoic acid and concentrated sulphuric acid and the set up shown below:



c) Prerequisites/Revision/Introduction

This lesson will be well delivered if student teachers have a good understanding of how to draw structures of organic compounds and reactions of carboxylic acids with alcohols as well as the preparation of alcohols or carboxylic acids from esters, covered in previous units. Give some exercises to help student teachers recap reactions of alcohols and carboxylic acids.

d) Activity 8.3

- Ask the student teachers to join their groups;
- Give student teachers instructions and materials (molecular model and books);
- Tell them to discuss in their groups about the activity8.3
- While discussing and answering the questions in the activity, you will be moving around by facilitating them to accomplish the task;
- Give them the time to represent by writing their answers on the chalk board;
- When all groups will finish presenting their findings, you allow the student teachers to discuss on the answers of their colleagues while controlling the discussion;
- The teacher will enrich the content and add non given ideas;
- The teacher will ask the student teachers to take summary in their book

Answers to Activity 8.3

1). - Physical method: Mixing different available esters to produce a new odour which is an intermediate of the odours of the mixed esters

- Chemical method: Produce new esters chemically by reacting alcohols and carboxylic acids to produce new esters. Use available esters and transform them chemically by reacting them with alcohols through trans Esterification.

2). a) Organic compounds used are: ethanol and propanoic acid.

b)

$$CH_3CH_2OH + CH_3CH_2COOH \underset{Reflux}{\overset{H_2SO_4\ conc}{\rightleftharpoons}} CH_3CH_2OCOCH_2CH_3 + H_2O$$

c) See Student teacher book, lesson 8.3 (preparation and chemical reactions of esters)

e) Answers to Application Activity 8.3

1) $CH_3CH_2COCl + CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2COOCH_2CH_2CH_2CH_3 + HCl$
Butylpropanoate

2) Conversions

a) Propan-1-ol to propyl propanoate

$CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2COOH$

$CH_3CH_2COOH + CH_3CH_2CH_2OH \rightarrow CH_3CH_2COOCH_2CH_2CH_3 + H_2O$

b) Ethanal to ethyl ethanoate

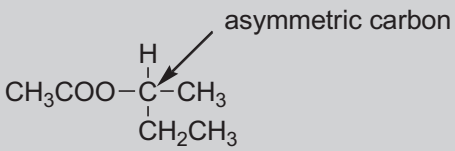
$CH_3CHO + [O] \rightarrow CH_3COOH$

$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$

3)

a) Structure of the alcohol: **$CH_3CH_2CH(OH)CH_3$**.

b) Sketch of the structure of the ester formed



optically active ester

4) Equations:

a) $CH_3CH_2COOCH_3 + NaOH \rightarrow$ **$CH_3CH_2COONa + CH_3OH$**

b) $CH_3CH_2OOCH + CH_3NH_2 \rightarrow$ **$HCONHCH_3 + CH_3CH_2OH$**

c) $CH_3COOCH_3 + CH_3MgCl \rightarrow$ **$CH_3C(CH_3)_2OH + Mg(OH)Cl + CH_3OMgCl$**

5) Conditions for reaction **4 (a)** are sodium hydroxide (NaOH) which must be in aqueous solution and heat must be provided.

6) This reaction produces amides but with a small yield and therefore it is not preferred. Instead acid chlorides are used for the same purpose as they give more yields. Esters react faster with acid chlorides than with amines.

7)

a) Ethanol

b) Catalyst

c) $CH_3CH_2CH_2CH_2CH_2COOH + CH_3CH_2OH \rightarrow CH_3CH_2CH_2CH_2CH_2COOCH_2CH_3 + H_2O$

d) Ethanol is flammable, it may catch fire easily and consequently may cause accident in the laboratory.

e) Food flavouring

Lesson 4: Saponification and the detergents

a) Learning objectives

- Describe the formation of the detergents.
- Make soap and compare its properties with those of soapless detergents.
- Appreciate the importance of esters in the manufacture of soap
- Appreciate the importance of esters as intermediate compounds in the manufacture of polyesters

b) Teaching resources

Student teacher book, NaOH, cooking oil, ethanol, NaCl, heater and glassware

c) Prerequisites/Revision/Introduction

This lesson will be well delivered if student teachers have a good understanding of alkaline hydrolysis of esters, the knowledge of triglyceride structures will also help much. This lesson is linked to biology (lipids). Find a way of checking the understanding of your student teachers.

d) Activity 8.4

This lesson has two activities. The second one is a laboratory experiment. Check the feasibility of performing the experiment in the laboratory.

Activity 8.4 (a)

- Form randomly the groups of 6 to 8 student teachers depending on the class size.
- Provide to each group some cooking oil and concentrated aqueous sodium hydroxide.
- They will mix the two liquids and add some ethanol to facilitate dissolution of oil. The resulting mixture will be heated for ten minutes in a borosilicate beaker. The mixture will then be poured into cold water and student teachers will smell the resulting solution. From the smell they will try to identify the product.
- Choose sample groups to present their findings to other student teachers and after presentation, engage student teachers in a discussion on the answers given by different groups provide necessary complementary information and explanations. From this discussion you will give a summary of the lesson.
- Before closing your lesson, you should reserve some minutes to discuss with student teachers the environmental impacts of acidic wastes.
- Saponification is an economically important reaction and time should be provided to discuss about the benefits of knowing this reaction and being able to make soaps.

- You should also discuss about the dangers of using soapless detergents (because soapless detergents contain a high pH balance, they can react poorly with skin, causing irritations or allergies. When biodegradable soapless detergents degrade, they consume much of the oxygen in the water, which can be harmful to the surrounding life supported by the water).

Answers to activity 8.4 (a)

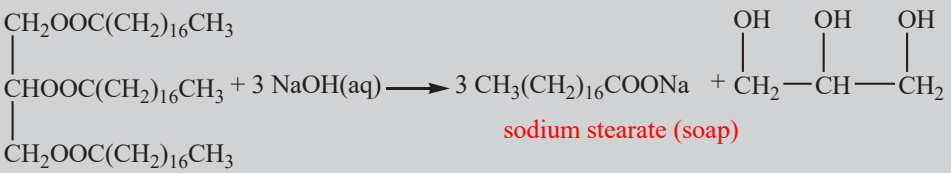
1) Soaps and detergents are used in our everyday life for cleaning.
2) They have the ability to dissolve polar and non-polar substances. In fact, their molecules have two parts: the hydrophobic part which is insoluble but soluble in oil and the hydrophilic part which is soluble in water.
3) Soaps are manufactured by reacting oil of fat with a strong base such as NaOH or KOH. Detergents are prepared by using petroleum derivatives (which have hydrophobic and hydrophilic parts) and NaOH.
4) Both have cleaning properties and molecules made of two parts cited above. Detergents are not prepared by saponification because we do not use oil or fat. Detergents are more effective than soaps because they do not form scum with water. Their magnesium and calcium salts are soluble in water. They foam very easily so that they are used in small quantity.
5) Take some oil mix with NaOH (aq) and heat the mixture. It is better to add some ethanol to facilitate dissolution of oil. After heating, pour the mixture in a concentrated solution of NaCl to precipitate out the salt.

Activity 8.4 (b)

This activity is an experiment. It must be performed in the laboratory. Check first if the materials and substances needed are available, then allow student teachers to perform the experiment in activity 8.4 (b) following the procedure given.

Answers to the Application Activity 8.4

1)



2) Liquid soap is produced by reacting oil or fat with potassium hydroxide (KOH) but solid soap is prepared by reacting oil or fat with sodium hydroxide (NaOH). Electrostatic forces between the hydrophilic part of soap and sodium cation are stronger than with potassium cation.

3) Soap is prepared by using oil or fat but detergents are prepared using other chemicals such as sulphonic acids.

4) Detergents are more effective than soaps because they do not form scum with hard water. Their calcium or magnesium salts are soluble in water. They produce foam easily so that they are used in smaller quantity than normal soap in hard water.

5) Refer to the student's book, lesson 8.3.

6) a) Esters made from long chain fatty acid and glycerol, are primary reagents used to manufacture solid and liquid soaps in surfactant chemical industries and in laboratory preparation of different kinds of soaps.

b) Some esters are monomer units that are polymerized orjoined together to form polymers called polyesters which have found wide commercial use as fibers, plastics and coatings.For instance, vinyl acetate and methyl methacrylate are monomers which polymerize to form polymers called poly (vinyl acetate) And poly (methyl methacrylate) respectively the former is used to manufacture latex paints and different adhesives while the latter is used to make lighting fixtures, solar panels and skylights.

c) Both soaps and detergents are cleaning agents that help us getting rid of dirt, microorganisms. Nevertheless, the detergents are more effective than the soaps because not only they foam easily and therefore can be used in small amount but also, unlike soap, they are notadversely affected by hard minerals in the water.However,detergents may also be a source of pollution since most of them are non-biodegradable and consequently persist in environment.

X= CH_3OH (Methanol)

Y= $HOCH_2CHOHCH_2OH$ (Prop-1,2,3-triol) or glycerol

8.6. Summary of the unit

ESTERS

Esters are derivatives of carboxylic acids. Their general structural formula is **RCOOR'** where **R** may be a hydrogen atom or an alkyl group and **R** may be an alkyl group or an aryl group but not a hydrogen atom.

Esters are compounds produced by the reaction involving an acid (or its derivative) and an alcohol with the elimination of water molecule. They are known for their distinctive odour and they are commonly responsible for the characteristic of food (fruits) aroma, flowers and fragrances.

When naming esters, the alkyl group **R'** is named followed by the name of **$RCOO^-$** group. The group name of the alkyl or aryl portion is written first and is followed by the name of the acid portion. In both common and IUPAC nomenclatures, the **-ic acid** ending of the corresponding acid is replaced by the suffix **–ate**.

Most of the esters are liquids with much lower boiling point than those of the acids or alcohols of nearly equal weight, this is due to the absence of the polar hydroxyl group which found in alcohols and acids and leads to the association of the alcohol and carboxylic acid molecules with hydrogen bonds, esters have a neutral effect on litmus.

The preparation of esters involves different types of reaction such as esterification, reaction of an acid chloride with an alcohol and the reaction of acid anhydrides with alcohols.

Esters undergo several chemical reactions such as:

- Reduction by $LiAlH_4$ giving two alcohols, one from the acyl segment (RC=O) and one from the alkoxide segment (R-O) as shown by the reaction below.
- Hydrolysis (acid or alkaline) giving acid and alcohol.
- Trans-esterification where alcohols react with esters to undergo an exchange of the alkoxide segment.
- Reaction with ammonia, primary or secondary amines to produce amides (*aminolysis)*.
- Reaction with Grignard reagents to form tertiary alcohols.

Esters can be cleaved back into a carboxylic acid and an alcohol by reaction with water and a base. This reaction is called "saponification (soap making)". The *fats* and *oils* used to produce soaps find their sources from animal or plant. Each fat or oil is made up of a distinctive mixture of several different triglycerides. Examples of other fatty acids include stearic acid ($CH_3(CH_2)_{16}CO_2H$), palmitic acid ($CH_3(CH_2)_{14}COOH$), …

Detergents are *organic liquid* or *water-soluble solid cleaning substances* that, unlike soap, are not prepared from fats and oils. The chemical composition of detergents is different from that of soaps but they have the same cleaning mechanism and *are not adversely affected by hard minerals in the water* and this makes them more effective than soaps. However, they are less environmental friendly because of a reduced biodegradability.

When a soap or detergent adds on to water that contains oil or other water-insoluble materials, the soap or detergent molecules surround the oil droplets. The oil or grease is "dissolved" in the alkyl groups of the soap molecules while the ionic end allows the micelle to dissolve in water. As a result, the oil droplets are dispersed throughout the water (this is referred to as *emulsification)* and can be rinsed away.

8.7. Additional information for tutor

Glycerides (fats and oils)

Fats and Oils, group of naturally occurring organic compounds called *triglycerides esters* comprised of three molecules of fatty acids and one molecule of the alcohol "glycerol" (propan-1,2,3-triol). Their *common physical properties* are outlined below.

- They are oily, greasy, or waxy substances that, in their pure state, are normally tasteless, colourless, and odourless.
- Fats and oils are lighter than water and are insoluble in it; they are slightly soluble in alcohol and are readily dissolved in ether and other organic solvents.
- Fats are soft and greasy at ordinary temperatures, whereas fixed oils as distinct from essential oils and petroleum are liquid. Some waxes, which are hard solids at ordinary temperatures, are chemically similar to fats.

The important *difference between oils and fats* is that:

- Oils are liquids and fats are solids at room temperatures i.e. melting point less than 20^0C.
- Oils contains a large proportion of unsaturated acids like oleic acid in olein while fats contain a large proportion of saturated acids such as stearic acid in stearin or palmitic acid in palmitin but also with low melting points.

Therefore, oils can be converted to fats by hydrogenation reaction, for instance, Olein which is an oil of oleic acid and glycerol can be converted to fat through (catalytic) hydrogenation, the process also known as "*oil hardening*".

This process creates saturated fats called trans-fatty acids and is done under pressure in the presence of catalyst at temperature of about 180^0C.

- Fatty acid tails can vary in length and may contain unsaturated bonds.
- Animals fats have saturated fatty acids which are straight molecules and very compact. This is gives them a higher melting point than the plant oils.
- Plant oils have unsaturated and polyunsaturated fatty acid chains that tend to branch and make the molecule less dense and with a lower melting point.

Extraction of fats and oils

- Vegetable fats are usually obtained by pressure extraction from seeds and fruit. Animal fats are often extracted from animal tissue by boiling fat-containing tissue in water and then allowing it to cool. The heat melts the fat out of the tissue; it then rises to the surface of the water because of its low specific gravity and can be skimmed off.

- In the extraction of vegetable oil after removing the husks, the seeds are then crushed in powder form and then boiled with water for some time. The oil floats on top of the water. The solid residue is called cake which is used as animal feeds.
- Palm oil is extracted from the fruit pulp. This yellowish or reddish oil is used mostly in the manufacture of soap and candles. Palm oil is also the largest source of palmitic acid, a fatty acid used in numerous commercial processes.
- Animal oils are esters obtained from animals such as whale, fish (sardines) and lard oil.

Guidance on Skills Lab 8

1) Here the field study is required. Make a follow up for the study to be done and then collect the field report for analysis,
2) Allow student teachers to perform the experiment to prepare (at their own) a liquid and a solid soap. They can follow the procedure given in their Book, lesson 8.4

8.8. End unit assessment (answers)

Part I: Multiple choice questions

1) (c) Alcohol and carboxylic acid molecules
2) (d) Carboxylic acid and an alcohol
3) (a) Amide

Part II: Structured questions

4) Methyl 3-chloro-2-hydroxy-2-methylbutanoate
5) Reagent: ethanol/Conditions: strong acidic medium and heat
6) Refer to the student teacher's book, lesson 8.2.2.
7) a) $CH_3COCl + CH_3CH_2OH \rightarrow CH_3CH_2OOCCH_3 + HCl$

   b) Terylene is polyester (condensation polymer). The ester groups in this polymer are hydrolyzed aqueous sodium hydroxide (caustic soda) destroying it. Polythene is an addition polymer which does not react with NaOH.

8) a) $CH_3(CH_2)_6CH_2\text{-}CH=CHCH_2(CH_2)_6COOH$

   b) $C_7H_{15}CH_2\text{-}CH=CHC_7H_{15}COOH + C_2H_5OH \rightarrow C_7H_{15}CH=CHC_7H_{15}COOC_2H_5 + H_2O$

   c) From the triglyceride oleic acid can be prepared by acidic hydrolysis.

9) i) Carbon: 49.4/12=4.116

   Hydrogen: 9.6/1=9.6

   Nitrogen: 19.1/14=1.3643

Simplest ratio

C= 4.1167/1.3643=3, H=9.6/1.3643=7, N=1.3643/1.3643=1

Empirical formula= **C_3H_7NO**

Molecular formula

$(C_3H_7NO)n=73$

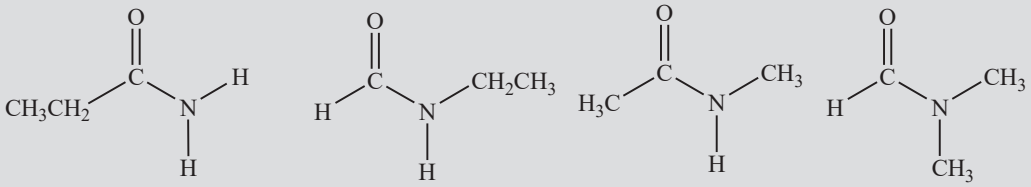
$((12x3) + 7 +14 + 16)n=73$

$73n=73$

$n=1$

Molecular formula is $(C_3H_7NO)x1$ = **C_3H_7NO**

(ii)



10) $HCOOCH_2CH_2CH_3 + NaOH \rightarrow HCOO^-Na^+ + CH_3CH_2CH_2OH$

11) a) $HOCH_2CHOHCH_2OH$ (Propa-1,2,3-triol)

b) $CH_3(CH_2)_{16}COO^-Na^+$. It is a soap (used in cleaning)

8.9. Additional activities (Questions and answers)

8.9.1. Remedial activities

Questions

1) Consider the following compounds:

A) CH_3CH_2COOH **B)** $CH_3OOCCH_2CH_3$ **C)** $HOOC\text{-}CH_2CH_2COOH$

a) Which is an ester?

b) Which is a dibasic acid?

c) Name each compounds.

d) Which would be almost insoluble in water, but would slowly dissolve when boiled with sodium hydroxide solution?

e) Which would form a pleasant smelling liquid when warmed with ethanol and concentrated sulphuric acid?

2) Esters are derivatives of carboxylic acids and occur widely in nature.

a) Draw the structure of the ester formed when ethanol reacts with 2-methylpropanoic acid.

b) Name an alternative reagent which may be used in place of 2-methylpropanoic acid to produce the ester.

3) a) Write an equation for the reaction of ethanoyl bromide with CH_3MgCl.

b) Explain why animal urine is used as a fertilizer

4) Draw the structural formulae of all possible isomers with molecular formula C_4H_9NO and name them.

5) Compare the boiling points of ethanoic acid, ethyl ethanoate and ethanamide. Explain your reasoning.

6) Complete the equations below

a) $CH_3CH_2OOCCH_3 + NaOH \longrightarrow$

b) $HCOOCH_3 \xrightarrow{LiAlH_4}$

Answers

1) 1.

a) B

b) C

c) A: Propanoic acid, B: Methyl propanoate, C: Butane-1,4-dioic acid

d) B

e) A

2)

a) $CH_3CH_2OOCCH(CH_3)_2$

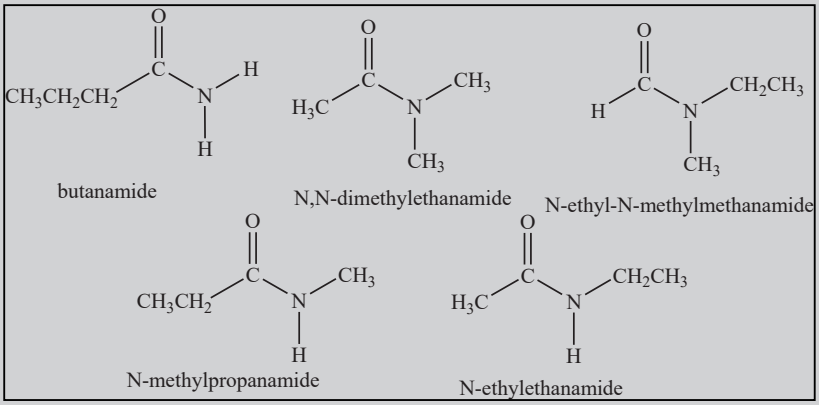
b) Methyl propanoyl chloride

3)

a) $CH_3COCl + CH_3MgCl \longrightarrow CH_3C(OH)(CH_3)_2$

b) Animal urine contains urea, a substance which has high nitrogen content. It is used to provide nitrogen to plants.

4)



5) Ethanoic acid has highest boiling point because it has more and stronger hydrogen bonding. Ethanol will be next to the acid because hydrogen bonds between oxygen and hydrogen are stronger than those involving nitrogen. This is because of small electronegativity of nitrogen.

6) a) $CH_3CH_2OOCCH_3 + NaOH \longrightarrow \mathbf{CH_3COONa + CH_3CH_2OH}$

b) $HCOOCH_3 \xrightarrow{LiAlH_4} \mathbf{2\ CH_3OH}$

8.9.2. Consolidation activities

1) Two esters, **A** and **B**, have molecular formula $C_6H_{12}O_2$. Both show optical isomerism. When heated with aqueous sodium hydroxide, **A** gives sodium ethanoate and another product, and **B** gives methanol and another products. Write the structural formulae for **A** and **B** and name them.

2) A liquid **A** of molecular formula $C_5H_{10}O_2$ was reduced by $LiAlH_4$ to a mixture of two alcohols **B** and **C**. Both alcohols reacted with iodine in alkaline solution to give a pale yellow crystalline solid **D**. The liquid **A** is insoluble in cold, dilute aqueous sodium hydroxide but on boiling the mixture gradually becomes one layer. Given that the boiling point of **B** is higher than that of **C**, identify and draw structural formulae of **A**, **B**, **C** and **D**. Give your reasoning

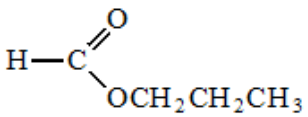
3) a) What do you think would be formed when soap is heated with soda lime?

b) Suggest explanations for the following observations.

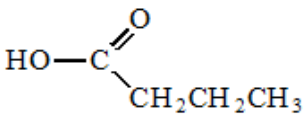
i) Butane, propan-1-ol, propanal and ethanoic acid all have approximately the same relative molecular mass, but their boiling points are 273K, 371K, 322K and 391K, respectively.

ii) When dilute hydrochloric acid is added to an aqueous solution of soap, a white insoluble substance is formed.

4) Consider the following pair of isomers.



C



D

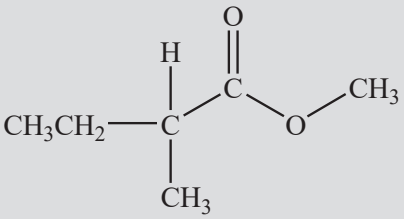
a) Name compound **C**.

b) Identify a reagent which could be used in a test-tube reaction to distinguish between **C** and **D**. In each case, state what you would observe.

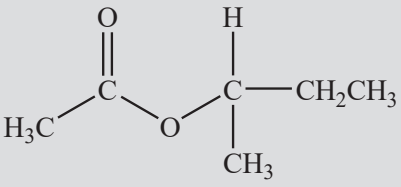
5) You are provided with ethyl ethanoate and asked to prepare isobutyl ethanoate. Describe how you can proceed to prepare that compound. In your explanations, include reagents, conditions and equation(s) for the reaction(s) that take place. You are allowed to use any other organic compound you need.

Answers

1)

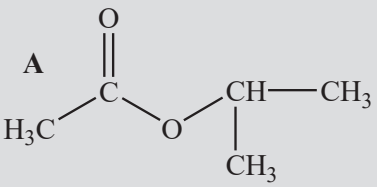


*Methyl 2-methylbutanoate:**B***



*1-methylpropyl ethanoate:**A***

2)



B $CH_3CHOHCH_3$ **C** CH_3CH_2OH **D** CHI_3

Alcohols which react with iodine in alkaline solution must be ethanol or methyl alcohol. A is an ester because it is insoluble cold aqueous NaOH but dissolves on boiling because of being hydrolyzed. B has higher boiling point because it has bigger molecular mass.

3)

a) A hydrocarbon with one less carbon to the number of carbon atoms of the soap. A decarboxylation of a sodium salt of a carboxylic acid will take place.

b) i) These compounds have different intermolecular forces. Butane has weakest intermolecular forces (Van der Waals forces) and propanal has weak dipole-dipole forces. Propan-1-ol has strong hydrogen bonding as well as ethanoic acid, but their magnitude in the acid is bigger.

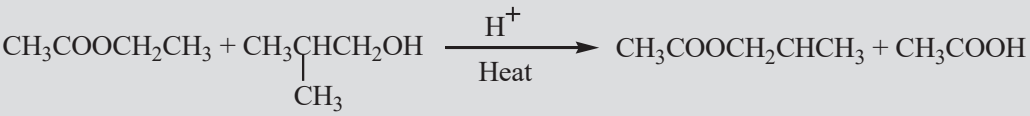
ii) Salts of carboxylic acids react with mineral acids to regenerate the parent acid. Soap is a carboxylic salt which will react to regenerate the parent fatty acid which is insoluble in water, the white substance.

4).

a) Propylmethanoate

b) We can use sodium carbonate, for **C** (ester), there is no observable change but with **D** (a carboxylic acid), the effervescence is observed because of carbon dioxide which wants to escape.

5) Given ethyl ethanoate to prepare isobutyl ethanoate you can carry out a trans-esterification using 2-methylpropan-1-ol.



8.9.3. Extended activities

Questions

1) Naturally occurring fats and oils are esters of acids with an even number of carbon atoms. Acids with an odd number of carbon atoms are rare. Suggest a method of producing a fatty acid and increasing its length by one carbon atom from propyl tristearate. Include equations in your answer.

2) What are the products of the reactions of $CH_3CH{=}CHCH_2CO_2C_2H_5$ with:

a) NaOH, Heat

b) H_2, Ni

c) Br_2

d) O_3 followed by H_2O

e) $LiAlH_4$

3) The complete hydrolysis of 1.76g of an ester of a monocarboxylic acid and a monohydric alcohol required 2.0 $x10^{-2}$mol of sodium hydroxide. Deduce its molecular formula, and write the names and structural formulae of all the esters with this molecular formula.

4) A triglyceride represented by letter **A** is an ester derived from glycerol and 3 fatty acids: hexadecanoic acid, octadecanoic acid and 2,4-hexadienoic acid.

a) Write the structural formula of the triglyceride.

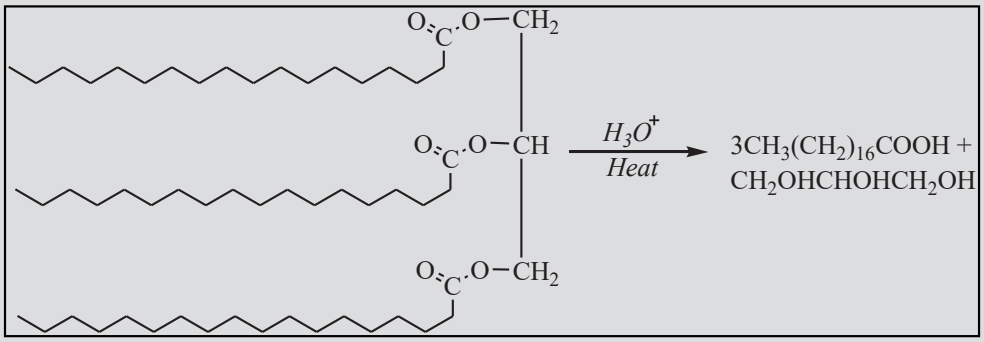
b) Write the equation of reaction between the triglyceride above and sodium hydroxide. What is the importance of this reaction?

Answers

1)

- *Method*: Hydrolyze propyl tristearate; reduce the produced acid to an alcohol, substitute the OH group by a halogen, convert the produced alkyl halide into a Grignard reagent and carboxylate it.

Equations:



$$CH_3(CH_2)_{16}COOH \xrightarrow[Ether]{LiAlH_4} CH_3(CH_2)_{16}CH_2OH$$

$$CH_3(CH_2)_{16}CH_2OH + HCl \xrightarrow{ZnCl_2} CH_3(CH_2)_{16}CH_2Cl + H_2O$$

$$CH_3(CH_2)_{16}CH_2Cl + Mg \xrightarrow{Dry\ ether} CH_3(CH_2)_{16}CH_2MgCl$$

$$CH_3(CH_2)_{16}CH_2MgCl + CO_2 \xrightarrow{H_2O} CH_3(CH_2)_{16}CH_2COOH + ClMgOH$$

2)

a) $CH_3CH{=}CHCH_2COONa + HOC_2H_5$
b) $CH_3CH_2CH_2CH_2CO_2C_2H_5$
c) $CH_3CHBrCHBrCH_2CO_2C_2H_5$
d) $CH_3CH{=}O + O{=}CHCH_2CO_2C_2H_5 + H_2O_2$
e) $CH_3CH_2CH_2CH_2CH_2OH + CH_3CH_2OH$

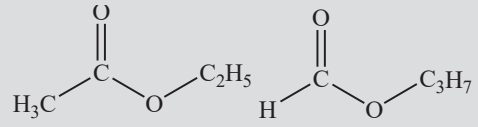
3)

1mol of NaOH reacts with 1mol of the ester (the ester is produced from a monohydric alcohol)

2.0×10^{-2}mol of NaOH will react with 2.0×10^{-2} mol of the ester.

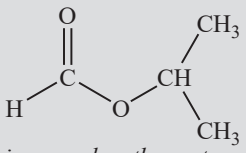
n=m/Mm	14n=56
Mm=m/n=1.76/0.02=88g/mol	n=56/14= 4
$C_nH_{2n}O_2$=88	Molecular formula is $C_4H_8O_2$
12n+2n=88-32	

Structures and names

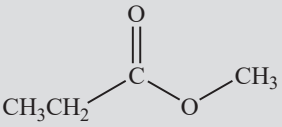


Ethyl ethanoate

propyl methanoate



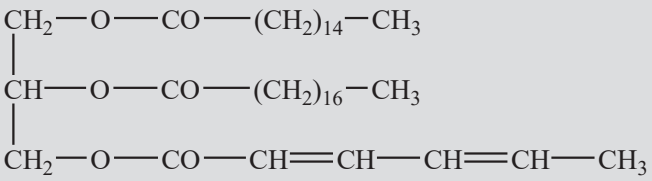
isopropyl methanoate



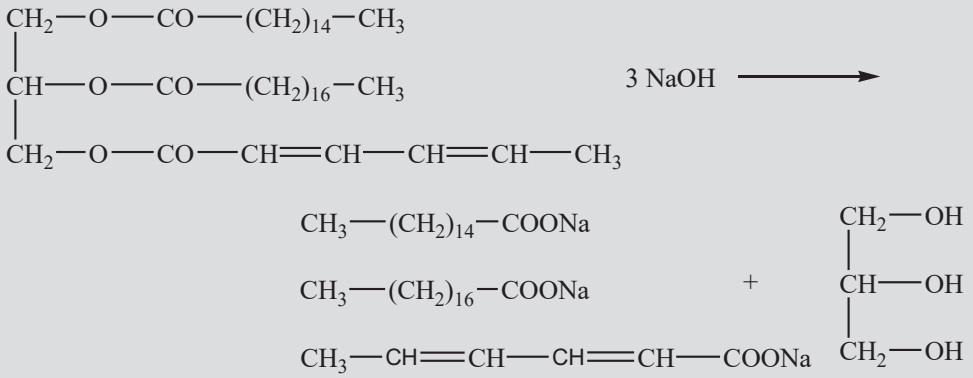
methyl propanoate

4)

a)



b)



This reaction is used in making soap.

UNIT 9

CLIMATE CHANGE AND GREENHOUSE EFFECT

9.1. Key unit Competence

Evaluate the environmental survey conducted on climate change and greenhouse effect.

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

Student-teachers have learnt the following:

- Black body radiation (in unit 2 year 2)
- Energy Sources in Rwanda.
- Environmental problems such as Noise, pollution, Ozone depletion and Global warming.
- Composition, Structure and dynamics of the atmosphere.

As tutor, you start this unit by asking questions related to the above topics studied to ensure that student-teachers have good foundation to this new unit.

9.3. Cross cutting issues to be addressed

a) Inclusive education

All learners should be encouraged to participate during lessons and group activities. Special arrangement should be done to take care of learners with special needs.

For addressing inclusive education, while student-teachers will be conducting Activity, instructional information should be given clearly. They can sometimes use their sense organs for identifying the results and observe the learning materials in order to draw conclusion.

Provide procedure earlier before any experiment so that student-teachers get familiar with them. They can be written on the chalkboard or printed depending on available resources. If you have children with low vision remember to print in appropriate fonts. This makes the learners to find out that they are all of great importance.

b) Peace and value Education

When student teachers are working activities, tell them that they can respect each other's opinion during class discussions (don't blame someone, respect his/her ideas). Remember that someone's idea is very important. It may be correct or Not but what is important is to build on that idea.

c) Standardization culture

Bring to the attention of student-teachers the importance to be aware of machines that do not harm our environment. Student-teachers need to pay attention while making choice of materials to be used in their daily life.

d) Environment and sustainability

Show student-teachers advocate for the mitigation measures that can start from individual level to the worldwide level in other to regulate activities that can bring about climate changes. They will also apply the gained knowledge to grow plant in greenhouse of better yield.

9.4. Guidance on introductory activity

This activity aims at capturing student-teachers' attention and minds towards climate change and greenhouse effect.

- Inform student-teachers that they need to discuss this activity by themselves under your guidance.
- You may split your class into groups (if it is a mixed school, make sure that your groups have boys and girls) and tell them to start working on the introductory activity.
- Give student-teachers like 20 minutes to work by themselves brainstorming the questions. In this period, you can move around overseeing what students are doing. Leave them to work by themselves. In case there are some word/concepts that need to be explained or clarified in the questions, try to help them.
- Invite some groups to present their findings to the whole class. Student-teachers can use power point presentations.
- Ask student-teachers from different groups to judge whether, what have been discussed correspond to the questions.
- Together with student-teachers, make a summary of what have been discussed using learners' findings and deductions.
- Let the student-teachers note down important points and notes in their notebooks for future reference and revision purposes.

Answers to the introductory activities

a) By radiation. This energy is used for:

i) Photosynthesis by plants

ii) Provides human beings Vitamin D

iii) Gives Natural light for vision

iv) Drying our crops, clothes and others

v) Helps in the process of rain formation and others. You can accept student's ideas that answer this part.

b) No! Human absorbs this energy and radiates after being used. Also plants do not maintain this energy forever instead after being used it emitted.

c) A black body. This is a body that absorbs radiations that fall on it. However, a perfect black body absorbs all radiations that fall on it and reflect none.

d) Black body.

i) Its surface temperature would change affecting the climate of that body may be if it is a planet

ii) Once the energy is reflected, it means that there will be distribution of this energy in its atmosphere. Leading to average distribution of temperature with its surface and its atmosphere.

iii) Yes. Since these radiations lead to variations in the temperature, there is a possibility of change in the climate of that planet (objects)

iv) There is also a possibility of these radiations being retained in the atmosphere in case there are elements that may stop these radiations from continuing. Such elements include accumulation of greenhouse gases in the atmosphere.

e) Concentration of these gases in the atmosphere leads to changes (specifically rise) in temperature.

f) This has led to climate change. Man has done the following to minimize the changes:

- Planting trees
- Good methods of farming
- Use of electric/charged engines not those that emit carbon dioxide.
- Stop burning bushes etc

9.5. List of lessons

#	Lesson title	Learning objectives	Number of Periods
1	Climate change	Explain the concept of climate change.	2
2	Solar and black body radiations.	- Analyze the concept of black body. - Explain the nature of black body radiation and its emissivity. - State Stefan-Boltzmann law and apply it to emission rates from different surfaces. - Evaluate and discuss the intensity of sun's radiation reaching the earth. - Evaluate concept of emissivity and relate it to emission rates for different surfaces. - Explain how earth's albedo varies independent of season and latitude.	3
3	Greenhouse effects and its impact on climate change.	- Describe Greenhouse effect. - Describe the usefulness of energy from greenhouse in supporting plant life.	3
4	Climate change mitigation	- Carry out Investigation on greenhouse effect. - Explain the climate change mitigation.	2
5	End assessment unit		2

Lesson 1: Climate change

a) Learning objective

- Explain the concept of climate change.

b) Teaching resources: Textbooks (Student-teacher's book and all reference books in students' book), internet, projectors, videos about Climate change.

c) Prerequisites/Revision/Introduction

Student-teachers have learnt the following:

- Effect of temperature on gases

- Effects of radiations on a surface.

Tutor starts this unit by asking questions related to the above topics studied to ensure that student-teachers have good foundation.

d) Activity 9.1

- **Guidance**

This Activity aims at making student-teachers discovering and analyzing concepts about climate change.

- Ask student-teachers to open their books (in the Student-teacher's book) or print for each group activity 9.1
- Instruct them to read the activity first and then re-write the questions to their notebooks.
- Move around and see the progress and their discussion. During this period, you can assist students with problems.
- Select some student-teachers to share their deductions to the whole class and allow questions from student-teachers if any. Create a good ground for student-teachers to discuss.
- Make a summary by making student-teachers to be aware that climate is changing, and something must be done (by them) to avoid such negativechanges. It's their responsibility as good citizens of Rwanda.

Answers to activity 9.1

a) Change the temperature of the earth's surface and its atmosphere that results into change in its climate.

b) High concentrations of intensity of radiations in the atmosphere lead to the increase in the temperature of the atmosphere.

c) The incidence can be controlled by
   - Conserving the nature that reduce the rate of carbon concentration in air
   - Reducing use of devices that emit carbon dioxide gases
   - And other well discussed points. Let learners discuss their findings and harmonize these points.

d) Floods, prolonged dry seasons, rise in temperatures, change in humidity. Students should fully explain these points.

e) Afforestation, good methods of farming and all practices that aims at conserving the nature.

e) Application activities 9.1

Ask student-teachers to work individually or in pair to answer the questions of application activity 9.1.

1) Factors that have led to climate change in Rwanda
   - Poor methods of farming
   - Deforestation
   - Bush burning
   - Toxic gases from industries and engines of vehicles.
   - Volcanic activity.

2) Different areas in same region may have different climatic conditions due to
   - Different amount of water vapor in its atmosphere
   - Different vegetation cover
   - Different activities taking place in those regions like farming, industrialization and other infrastructures etc.

Lesson 2: Solar and black body radiations

a) Learning objective

- Analyze the concept of black body.
- Explain the nature of black body radiation and its emissivity.
- State Stefan-Boltzmann law and apply it to emission rates from different surfaces.
- Evaluate and discuss the intensity of sun's radiation reaching the earth.
- Evaluate concept of emissivity and relate it to emission rates for different surfaces.
- Explain how earth's albedo varies independent of season and latitude.

b) Teaching resources: Textbooks (Student's book and all reference books in students' book), internet, projectors, videos about black body radiations.

c) Prerequisites/Revision/Introduction

Student-teachers have learnt the black body radiations. Tutor starts this unit by asking questions related to the black body radiations studied to ensure that student-teachers have good foundation

d) Activity 9.2

- **Guidance**

Bring the wall chart that shows how the earth receives the energy from the Sun's radiation. Help student-teachers to discover and analyze concepts about solar and black body radiations.

- Ask student-teachers to look at the activity 9.2.
- Divide them into groups (you can use any technique depending on what you want to achieve at the end of the lesson)
- Instruct them to read the questions under that activity and re-write the questions to their note books.
- Give them time to attempt the question
- While they are doing the work, you can move around helping student-teachers to think critically.
- When everyone is done, invite like 3 or 4 student-teachers (depending on the time you have) to present their answers to whole class.
- Together with student-teachers, make harmonization and come to the general conclusion of answers of each question as given in the answers below.
- Let student-teachers note down important information in their notebooks for future reference.

Answers to Activity 9.2

a) Radiation

b) No. This is because some of the radiations are absorbed what is in the medium while others are reflected. This reduces the intensity of heat reaching the observer.

c) Factors that affect intensity of radiations received by the earth.

- **The shape of the earth**: The earth has a spherical shape and therefore the sunlight is more spread out near the poles because it is hitting the earth at an angle, as opposed to hitting the earth straight-on at the equator.
- **The earth's rotation**: all areas are not consistently exposed to sunlight.

  Areas that are experiencing 'night time' are not receiving a lot of the sun's power; therefore, the time of the day or night will affect the solar constant.
- **The angle of the surface to the horizontal at that particular location**: When the Sun is directly overhead, its rays strike Earth perpendicular to the ground and so deliver the maximum amount of energy. When the Sun is lower in the sky, a sunbeam strikes the ground at an angle and so its energy is "spread out" over a larger area

d) Among other factors, the following are some of the factors that affect the absorption of radiations by the earth include the following: (Extracted from student's book)

- **Clouds**: The atmosphere is usually covered with clouds that usually pass over the earth's surface. This leads to reduction or increase in the temperature of the earth's surface. This is because these clouds may absorb or reflects back sun's light to the free space. However, this depends on the distance from which the clouds are from earth's surface. When sun's radiation is reflected, the earth's surface is cooled and when it is absorbed the earth is warmed.
- **Oceans:** While observing from the space, you will find out that water bodies appear differently from land surfaces. They appear darker and therefore absorb more sun's radiations than land. However, some of the radiations heating the water surface (ocean) may be carried away by the currents while others may form water vapor.
- **Thick vegetation covers or forested areas:** Places covered with vegetation absorb a lot of sun's radiation. This is because the vegetation cover provides a dark surface which absorbs more radiations than the bare land.
- **Surface albedo:** Different surfaces appear differently. Light coloured surfaces absorb different amounts of radiations than dark coloured surfaces. Snow covered areas are highly reflective. They thus absorb less amounts of energy (Sun's radiation). The snow cover reduces the heating effect of the earth's surface. However, if temperatures reduce, the snow cover reduces leading to the absorption of radiation by the exposed ground surface.

e) They are called black bodies.

e) Answers to application activity 9.2

Ask student-teachers to work individually, in pair or in groups to answer the questions of application activity 9.2

1) a. Albedo is the fraction of the reflected solar radiation to the incident solar radiation. Clouds have a high albedo, meaning they reflect a much greater percentage of the incoming light than does vegetation.

b) . The insolation (incoming solar energy) received daily depends primarily on:

- The angle of the Sun above the horizon (solar elevation angle, solar incidence angle),
- The length of time the surface is exposed to the Sun,
- Atmospheric conditions. The higher the sun in the sky and the longer a surface is exposed to the sun, the more insolation.

The clearer the sky, the more insolation. As Earth revolves around the Sun over the course of a year, its orbital and tilt geometry cause seasonal and latitudinal variations in insolation.

c) Generally, equatorial regions experience less fluctuation in daily insolation throughout the year. Further from the equator, seasonal differences are more pronounced. Polar Regions experience many more hours of sunlight than darkness in their respective summer, and many more hours of darkness than sunlight in their respective winter. On the equator, however, there is a nearly constant 12 hour of sunlight throughout the year. Moreover, the distance light has to pass through the atmosphere near the equator is less than the distance it passes through near the poles.

2) a) The formula used is $\lambda_{max} T = b$

Since $6.85\times10^{-7} T = 2.9\times10^{-3}$ gives $T = 4233.576 \simeq 4.23\times10^{3}\ K$ which is the value of B2.

b) Using $L = e\sigma\ AT^4$ and

$$L = 0.039\times10^{27}\ W, \sigma = 5.67\times10^{-9} m^{-2}K^{-4}, T = 4.23\times10^{3}$$

$$A = \frac{0.039\times10^{27}}{5.67\times10^{-8}\times[4.23\times10^{3}]^4} = 0.2\times10^{19}$$

Hence D2 is about 0.2 as expected

3) a) A black body is a body which absorbs all the radiations incident upon it
b) Stefan-Boltzmann law

The law states that, "the power per unit area radiated by a surface of a black body is directly proportional to the forth power of its temperature".

$P = e\sigma AT^4$ **While**

Wien's displacement law states that "the maximum wavelength of the emitted energy from a blackbody is inversely proportional to its absolute temperature".

c) From $\lambda_{max} T = b$

$5.2\times10^{-7} T = 2.9\times10^{-3}$

$T = 5576.9K \approx 6000K$ **Hence proved**

Lesson 3: Greenhouse effects and its impact on climate change

a) Learning objective

- Describe Greenhouse effect.
- Describe the usefulness of energy from greenhouse in supporting plant life.

b) Teaching resources: Textbooks (Student-teacher's book), internet, projectors, videos about greenhouse effect, polythene plastic bags, bean seeds.

c) Prerequisites/Revision/Introduction

Student-teachers have learnt the black body radiations and green gases. Tutor starts this unit by asking questions related to the black body radiations and green gases studied to ensure that student-teachers have good foundation

d) Activity 9.3

- **Guidance**
  - Bring the wall chart or watch a video about greenhouse effect. Help student-teachers to discover and analyze concepts about greenhouse effect.
  - Ask student-teachers to observe or watch the movie about greenhouse effect.
  - Organize student-teachers in groups and ask them to read the questions in the activity 9.3
  - Leave the copy of questions to student-teachers and ask to attempt them by themselves.
  - While student-teachers are doing this work, you can move around marking and guiding student-teachers where there might be a problem.
  - When student-teachers have completed their work and you are also done with marking, invite some student-teachers to discuss their answers and observations to the whole class.
  - Together with student-teachers summarize what you have discussed and note down important points on the board and let them put them in their findings.
  - Link what you have discussed to impact of greenhouse effect and global warming.
  - Allow learners to note down important information in their notebooks.

Answers to Activity 9.3

a) A greenhouse is a structure that makes sunlight to warm surfaces inside an enclosed structure

b) i) Green gases

ii) When these gases Accumulate in the atmosphere, they form a layer that stops radiations from the earth from being dispersed hence absorbed or reflected back to the earth leading to the change in the temperature of the earth's atmosphere hence global warming

c)

- Afforestation
- Sensitizing people on conserving Nature.
- Advocating for Good methods of farming.
- Limiting Carbon Emissions like advocating to using gas instead of charcoal.
- Accept learner's Ideas that are similar to the above suggestions.

e) Answers to application activity 9.3

Ask student-teachers to work in pair or in groups to answer the questions of application activity 9.3

1)

a) Carbon dioxide gas.

b) Factors for rise in emissions of carbon are:

- Industrialization
- Emission of carbon from vehicles and other engines

c) Using alternative energy sources like use of solar panels, Electric/ chargeable vehicles, creating carbon sinks.

d) Yes it's a good idea! This is because when these gases Accumulate in the atmosphere, they form a layer that stops radiations from the earth from being dispersed hence absorbed or reflected back to the earth leading to the change in the temperature of the earth's atmosphere hence global warming. And this is bad! Carbon dioxide that may be necessary for nature (Photosynthesis) can be got from the sun.

e) *Greenhouse effect* is the process by which thermal radiation from the sun is prevented from leaving the atmosphere and then re-radiated in different directions while global warming is the long-term rise in the average temperature of the Earth's climate system.

Lesson 4: Climate change mitigation

a) Learning objective

- Carry out investigation on greenhouse effect.
- Explain the climate change mitigation.

b) Teaching resources: Textbooks (Student-teacher's book and all reference books in student-teachers book), internet, projectors, videos about climate change mitigation.

c) Prerequisites/Revision/Introduction

Student-teachers have learnt the greenhouse effect. Review this unit by asking questions related to the greenhouse effect studied to ensure that student-teachers have good foundation.

d) Activity 9.4

- **Guidance**
  - Create scenario which talk about Rwanda's government mission in terms of climate change mitigation and its causes.
  - Divide student-teachers into groups or chose any method that can suit your class and helps the student-teachers to attempt the activity.
  - Ask student-teachers to read the questions and copy them to their notebooks.
  - Give student-teachers time for discussion while carrying out the activities.
  - After marking invite some members to discuss or present their findings to the whole class.
  - Ask student-teachers (rest of the class) whether their answers correspond to the discussed ones.
  - Connect/link student-teacher's ideas with climate change mitigation. You can use student-teacher's book or other relevant resources.

Answers to Activity 9.4

a) I strongly support the plans of the government. Because these plans will fight all that may cause our climate to change. Like controlling carbon dioxide concentrations in the atmosphere that may lead to global warming.

Note!! Student-teachers must support this idea! Try to convince those that may want to oppose the idea, the relevance of conservation of nature.

b) Student-teachers must give all activities that aim at conserving nature and reducing carbon emissions. The student-teachers may suggest that he/she has done the following: planting trees, stop burning bushes, etc. Using good methods of farming like use of terraces, mulching, etc.

c) Use of electric/rechargeable vehicles, advocating for afforestation and re-afforestation, encouraging farmers to use advanced/good methods of farming, etc.

e) Answer to application activity 9.4

Ask student-teachers to work in groups to answer the questions of application activity 9.4

For this question, Student-teachers are expected to do research about climate change mitigation. The findings may be different depending on where the student-teachers had their research work from. Accept all relevant information about climate change mitigation.

9.6. Summary of the unit

Climate change and greenhouse effect

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without this atmosphere. Radiatively active gases (i.e., greenhouse gases) in a planet's atmosphere radiate energy in all directions.

- **Climate feedback**: This refers to a process that acts to amplify or reduce direct warming or cooling effects.
- **Climate lag:** This is the delay that can occur in a change of some aspect of climate due to the influence of a factor that is slow acting.
- **Climate model**: This is a quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. Models can range from relatively simple to quite comprehensive

This explains a delay that occurs in climate change as a result of some factors that changes only very slowly.

Greenhouse effect, a warming of Earth's surface and troposphere (the lowest layer of the atmosphere) caused by the presence of water vapour, carbon dioxide, methane, and certain other gases in the air. The gases known as greenhouse gases, water vapour has the largest effect.

Almost half of the greenhouse gas emissions in the different countries come from the production of electricity and other industrial process that rely on fossil fuel consumption. To prevent greenhouse effect, countries need to reduce, reuse and recycle their waste materials.Buying products with minimal packaging will help to reduce waste and keep environment and atmosphere clean.

9.7. Additional Information for tutors

Note that an increase in global temperature causes snow and ice to melt, which decreases the extent to which they cover the surface, which then decreases Earth's albedo. This decrease in albedo means more energy is absorbed, which causes further warming and in turn causes more melting.

Guidance on Lab skills

Remember the aim of this activity is to make student-teachers apply what they have studied.

- Make sure you help student-teachers in getting materials needed for the project.
- Help student-teacher(s) to locate places where to construct the greenhouse.
- Inspect student-teachers' progress. You can advise them in case they have difficulties so that they achieve the targeted objective(s)
- Guide student-teachers on how to come up with a wonderful report and on how to make good presentations.
- You can award marks to the student-teachers to motivate them. For marking, you can design your own marking rubric.

9.8. End unit assessment (Answers)

1) A **2.** B **3.** C **4.** A **5**. D **6.** A **7.** D **8.** B

9). a) Wien's displacement law, states that the wavelength of maximum emission from a blackbody is inversely proportional to its temperature.

From this law it can be deduced that shorter-wavelength (higher-frequency) light corresponds to higher-energy photons, which you would expect from a higher-temperature object

b) i) The graph also shows:

As temperature increases, the total energy emitted increases, because the total area under the curve increases.

It also shows that the relationship is not linear as the area does not increase in even steps. The rate of increase of area and therefore energy increases as temperature increases.

ii) Between 4000 and 7000 K, is visible spectrum from red (long wavelength) to violet of short wavelength. At 4000 K the particles are vibrating with a less energy, hence red. As temperatures increase, the energy of particles increases shifting to particles of higher frequency. Hence they change their color to blue, indigo and then Violet.

iii) This is because the curves represent radiations emitted by a black body at different temperatures. That's whys these curves have different shapes.

10). Weather and climate will affect the intensity of the sun. Some areas are cloudier than others.

Due to Shape of the earth (the earth's spherical shape), the sunlight is more spread out near the poles because it is hitting the earth at an angle, as opposed to hitting the earth straight-on at the equator. There are **also fewer atmospheres at the equator, allowing more sunlight to reach the earth.** Therefore, the intensity varies depending on the geographical latitude of the location.

Due to the earth's rotation, all areas are not consistently exposed to sunlight. Areas that are experiencing 'nighttime' are not receiving a lot of the sun's power; therefore the time of the day or night will affect the solar constant. The angle of the surface to the horizontal is at that particular location.

11) a) $\text{Albedo} = \frac{\text{Amount of radiation reflected}}{\text{Amount of radiation incident on surface}} = \frac{1500\ W\ m^2}{1500\ Wm^2} = 1$

Comment: *The body is totally/highly reflective like a polished surface*

b) **Clouds**. The atmosphere is usually covered with clouds that usually pass over the earth's surface. This leads to reduction or increase in the temperature of the earth's surface. This is because these clouds may absorb or reflects back sun's light to the free space. However, this depends on the distance from which the clouds are from earth's surface. When sun's radiation is reflected, the earth's surface is cooled and when it is absorbed the earth is warmed.

Oceans. While observing from the space, you will find out that water bodies appear differently from land surfaces. They appear darker and therefore absorb more sun's radiations than land. However, some of the radiations heating the water surface (ocean) may be carried away by the currents while others may form water vapor while others. All these affect the rate at which the earth either absorb or reflect the sun's radiation hence affecting its albedo.

Thick vegetation covers or forested areas. Places covered with vegetation absorb a lot of sun's radiation. This is because the vegetation cover provides a dark surface which absorbs more radiations than the bare land. This therefore affects the planet's albedo.

Surface albedo. Different surfaces appear differently. Light colored surfaces absorb different amounts of radiations than dark colored surfaces. Snow covered areas are highly reflective. They thus absorb less amounts of

energy (Sun's radiation). The snow cover reduces the heating effect of the earth's surface. However, if temperatures reduce, the snow cover reduces leading to the absorption of radiation by the exposed ground surface.

12) a) i) Climate change refers to any significant change in the measures of climate lasting for an extended period of time

ii) Greenhouse Effect: *Greenhouse effect* is the process by which thermal radiation from the sun is prevented from leaving the atmosphere and then re-radiated in different directions.

b) Some effective ways to reduce emissions it to: use cleaner fuels, use energy efficient machines, develop alternative sources for energy and to plant more trees.

13) At low temperatures a black body emit radiations of short wavelength (Red) that's why her observations indicated red at 1000 K whereas at higher temperatures radiations of high frequency (high energy) are emitted. The mixture of these high frequency radiations is what brings about the body to appear white.

14) No! John is not right. A black body is anybody that absorbs radiations that falls on it. It should be noted that other nonblack objects absorb radiations depending on their surface albedos.

15) Stefan's constant = 5.7×10^{-8} W m^2 K^{-4}

Power radiated=Power received=50 W

$0.7 \times 5.7 \times 10^{-8} \times 2\pi \times 2.5 \times 10^{-5} \times 0.6 \times T^4 = 50$

Solving gives T=1909.7 K

16) **Greenhouse effect** is the process by which thermal radiation from the sun is prevented from leaving the atmosphere and then re-radiated in different directions.

Effects

- Greater strength of extreme weather events like: heatwaves, tropical cyclones, floods, and other major storms.
- Increasing number and size of forest fires.
- Rising sea levels (predicted to be as high as two feet by the end of the next century).
- Melting of glaciers and polar ice.
- Increasing acidity in the ocean, resulting in bleaching of coral reefs and damage to oceanic wildlife.

17) These are gases that are found in the atmosphere of the earth that traps the solar radiations. They trap suns radiations leading to increase in temperature hence global Warming.

18) Trees and other vegetation cover use carbon dioxide during their photosynthesis. This leads to absorption of a certain percentage of carbon dioxide in the atmosphere. This reduces the green gases that are problem.

19) . Climate change mitigation is the process of preventing all these green gases. This is very important as it is aimed at controlling the rise in temperatures of the earth while regulating earth's temperature.

20). The temperature of the earth will rise leading to global warming.

21) . When an object is heated, its temperature rises as heat is added. The increase in heat is called sensible heat. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat. **Heat that causes a change in temperature in an object is called sensible heat.**

Solids can become liquids (ice to water) and liquids can become gases (water to vapor) but changes such as these require the addition or removal of heat. **The heat that causes these changes is called latent heat**

22) i) Climate feedback: this refers to a process that acts to amplify or reduce direct warming or cooling effects.

ii) Climate lag: this is the change in radiation.

iii) Climate model: this is a quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. Models can range from relatively simple to quite comprehensive

23) Any essay in good English with the following

- Heading
- Good introduction
- Well-developed body (Connected to climate change)
- Conclusion.

9.9. Additional activities

9.9.1. Remedial activities

Questions

1)

a) What is the approximate spectral composition of the Sun's radiation before it interacts with Earth's atmosphere?

b) Is the amount of solar energy that reaches the top of Earth's atmosphere constant? Explain.

c) Are all wavelengths of solar radiation transmitted equally through Earth's atmosphere? Explain.

2)

a) What effect does absorption have on the amount of solar radiation that reaches Earth's surface?

b) What additional processes (besides absorption) affect radiation reaching the surface of Earth?

c) What percentage of incoming solar radiation is affected by absorption and scattering (or reflection)?

3)

a) What do we mean when we say that clouds have a high albedo while land vegetation has a low albedo?

b) What factors affect the insolation at a location on a particular day? How do they affect it?

c) What latitudinal regions experience least variation in day-to-day solar radiation? Which experience the greatest? Why?

4)

a) What happens to most radiation that is absorbed by the surface of Earth?

b) What is the difference between sensible and latent heat?

c) Why don't global temperatures rise because of incoming solar radiation?

5)

a) What is the greenhouse effect?

b) What chemical compounds contribute to greenhouse warming?

c) Mars and Venus both have high relative concentrations (~95%) of the greenhouse gas CO2 in their atmospheres. Why is Venus so hot while Mars is colder than Earth?

d) What is global warming?

Answers

1)

a) The Sun's spectral output is composed of approximately 9% ultraviolet (and shorter) wavelengths, 41% visible light, and about 50% infrared radiation.

b) The solar energy that reaches the top of Earth's atmosphere is constant. It does vary a little as Earth revolves annually around the Sun and because of changes in solar activity. See Section 1.1.

c) No. Different wavelengths of light interact differently with water and aerosols in the atmosphere. Some wavelengths are preferentially transmitted, some are scattered, and other wavelengths are absorbed.

2)

a) Absorption reduces the amount of solar radiation that reaches Earth's surface. On average, about 15% of incoming solar radiation is absorbed by atmospheric molecules such as water vapor, oxygen and small particulates (aerosols).

b) Scattering of solar radiation within the atmosphere also accounts for a reduction of energy reaching Earth.

c) Combining the percentages of incoming energy absorbed (18%) and scattered (26%) by the atmosphere plus clouds, the overall effect is that nearly half (18% + 26% = 44%) of the energy entering the atmosphere doesn't make it through to Earth's surface.

3)

a) Albedo is the fraction of the reflected solar radiation to the incident solar radiation. Clouds have a high albedo, meaning they reflect a much greater percentage of the incoming light than does vegetation.

b) The insolation (incoming solar energy) received daily depends primarily on

   i) The angle of the Sun above the horizon (solar elevation angle, solar incidence angle),

   ii) The length of time the surface is exposed to the Sun, and

   iii) Atmospheric conditions. The higher the sun in the sky and the longer a surface is exposed to the sun, the more insolation. The clearer the sky, the more insolation. As Earth revolves around the Sun over the course of a year, its orbital and tilt geometry cause seasonal and latitudinal variations in insolation.

c) Generally, equatorial regions experience less fluctuation in daily insolation throughout the year. Further from the equator, seasonal differences are more pronounced. Polar Regions experience many more hours of sunlight than darkness in their respective summer, and many more hours of darkness than sunlight in their respective winter. On the equator, however, there is a nearly constant 12 hours of sunlight throughout the year. Moreover, the distance light must pass through the atmosphere near the equator is less than the distance it passes through near the poles.

4)

a) Most of the radiation absorbed by Earth's surface is reradiated (emitted) as long wavelength (long wave) radiant energy.

b) Sensible heat is radiant energy that directly flows between objects or areas due to a temperature difference between them. Latent heat is released or absorbed when water changes state during the processes of evaporation, evapo-transpiration, melting, freezing, condensation, and sublimation.

c) A balance exists between incoming solar energy and Earth system reradiation of long wave radiation back into space.

5)

a) The greenhouse effect is the warming of Earth's atmosphere caused by the absorption of long wave energy emitted by the surface of Earth. Atmospheric gases and clouds act like a greenhouse roof to keep heat in the system.

b) Substances that have a significant effect on global warming are water vapor, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and liquid water droplets.

c) Venus has greater relative and absolute amounts of carbon dioxide than Earth and Mars. Despite a 95% relative concentration of carbon dioxide, Mars has a much thinner atmosphere overall so the absolute amount of carbon dioxide is too small to trap the solar insolation reemitted from the surface.

d) Global warming is a consistent trend of increasing global temperatures caused by additional amounts of greenhouse gases accumulating in the atmosphere.

9.9.2. Consolidation activities

Questions

1) Focusing on reducing carbon production to reduce carbon dioxide emissions is argued to be the wrong variable to focus on. Explain what one should focus on?

2) What do we mean when we say "think globally, act locally" in relation to environmental problems?

Answers

1) The focus should be on carbon consumption

Feedback:

In a situation where many countries after many years have made little progress towards achieving their Kyoto emissions reduction targets, critics are starting to point out that the situation would be much worse if these countries had not managed to get reduce their carbon production by exporting it to countries like China, by de facto exporting jobs. But the effect is illusionary, because we still import back from countries such as China the goods which we might have produced ourselves. Of course, the reason for exporting the jobs in the first place is to take advantage of low cost production locations. But if we keep consuming as we did before, at a global level nothing is achieved. We need to focus on carbon consumption. Hence 'The focus should be on carbon consumption' is the correct answer; 'It is impossible to achieve' is not true, as carbon production can be reduced at an aggregate level.

2) While these problems, as we experience them in relation to sustainability issues, are produced by processes operating at a global level, we all have a role to play in our local context in making individual and collective responses, as communities and companies, which will help ameliorate the effects of these problems.

There is a little bit of truth in each of the three incorrect alternatives. International negotiations have a crucial role to play, but local responses are also crucial and are not simply related to self protection measures. Equally, a global perspective of research and thought on environmental issues is crucial, but the results and implications generated from this apply at a range of spatial levels, not just the local. The essential aspect of the phrase or adage in the question is that we need a global perspective on environmental issues so that we can focus correctly on what we can do at a local level to respond.

9.9.3. Extended activities

Questions

1)

a) What general mechanism is responsible for redistributing heat energy in Earth systems?

b) What drives atmospheric circulation?

c) Explain simply how atmospheric circulation develops.

2)

a) Are the oceans or the atmosphere more efficient at storing energy? Explain.

b) Explain what effect ocean heat capacity has on global temperatures.

c) Give an example of how atmosphere and ocean systems affect each other.

3)

a) Explain how humans can affect land surface albedos.

b) Explain how the loss of land vegetation might modify local climates.

c) What impact have humans had on concentrations of greenhouse gases? Give a specific example.

Answers

1)

a) The circulation of the atmosphere and oceans redistributes heat from areas of surplus to areas of deficit.

b) The heat differential between tropical and polar areas (generated by latitudinal differences in insolation) drives atmospheric circulation.

c) Equatorial areas are heated more than polar areas; the warming equatorial air rises as it gets less dense. The rising tropical air gets replaced by cooler, denser air moving down from the poles by a process known as convection. Due to the rotation of Earth and the resulting Coriolis force, several circulating cells in each hemisphere are generated.

2)

a) Oceans are more efficient at storing energy, due to the tremendous volume of water in the oceans and water's capacity to hold heat.

b) The oceans impart a moderating effect on global temperatures.

c) The El Niño-Southern Oscillation (ENSO) that occurs periodically in the southern Pacific Ocean is an example of how ocean circulation and atmospheric circulation interact. Changing moisture budgets, altered winds and decreased coastal upwelling become part of a chain of energy redistribution that affects global climate patterns.

3)

a) Albedo can be changed by modifying land surfaces. In general, presence of vegetation cover reduces albedo, while bare soil and concrete increase albedo. Moisture tends to lower albedos, lack of moisture raises albedos.

b) When vegetation is removed from a surface the localized radiation budget change. Though the surface albedo usually increases and hence relatively more insolation is reflected and less absorbed, the localized area may become hotter overall due to less shading and less evaporative cooling as a result of reduced transpiration. The reverse may be true at times when vegetation is not transpiring; for example, during winter forested areas absorb more insolation and act as wind breaks, and thus may be warmer than cleared areas.

c) Anthropogenic forces have increased atmospheric concentrations of methane (rice cultivation, raising sheep and cattle, gas mining, trash landfills), carbon dioxide (consumption of fossil fuels, biomass burning), and chlorofluorocarbons (refrigerants, solvents, aerosol propellants.

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