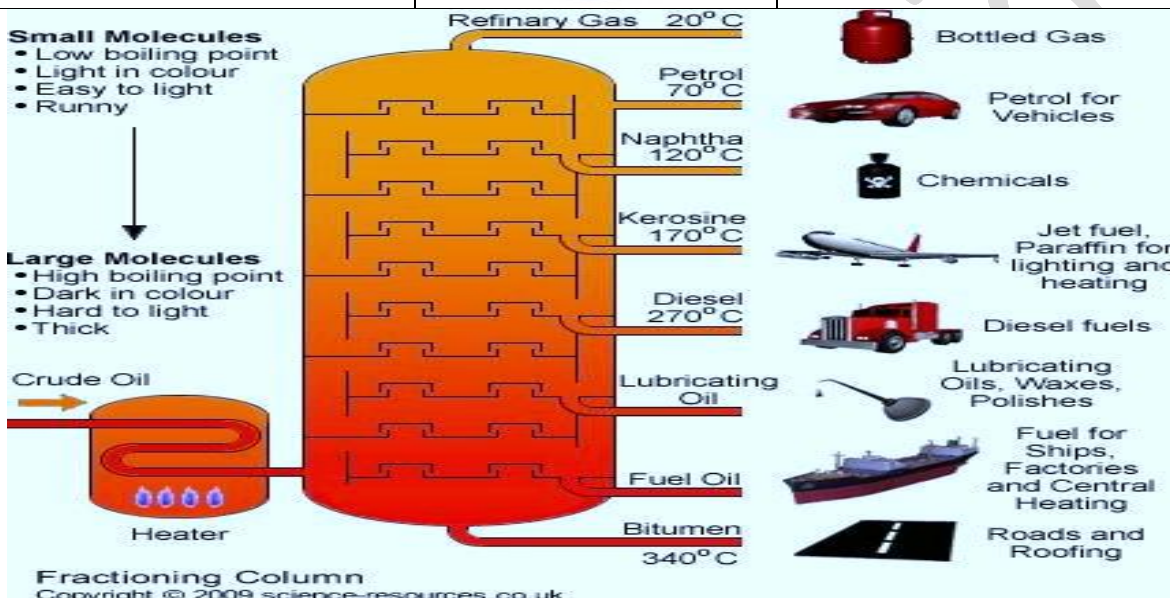
CHAPTER 15: CARBON IN LIFE



KEY WORDS	LEARNING OUTCOMES (L.O)
○ Petroleum oils ○ Hydrocarbons ○ Homologous series ○ Cracking ○ Functional groups. ○ Alkanes. ○ Alkenes. ○ Alkanols. (Alcohols) ○ Carboxylic acids. ○ Fermentation ○ Organic compounds. ○ Structural formulae. ○ Fractional distillation.	By the end of this chapter, you should be able to: a) Recognise that there is a diversity of carbon – based compounds in living things and materials derived from living things, and that these maybe classified into groups, b) Understand that crude oil is a mixture of different fractions of alkanes which can be separated by fractional distillation, that these products are used in fuels and chemicals for feedstocks. c) Know and appreciate that natural gas deposits are found all over the world, that their main constituent is methane gas which is a useful source of fuel and chemical feedstocks. d) Appreciate that biogas is a carbon – based fuel useful for cooking and lighting. e) Know some common synthetic and natural carbon – based polymers and how their properties relate to their use. f) Understand how ethanol is made naturally by fermentation of sugars and other organic chemicals, and awareness of the dangers of abuse of ethanol as drugs.

○ Polymers. ○ Polymerization. ○ Soapless detergents ○ Soaps.	g) Know the process of making soaps and Soapless detergents from natural fats and oils and appreciate that soaps are effective in removing organic stains. h) Know that Soapless detergents are made from crude oil and that Soapless detergents are better cleaning agents in hard water than soapy detergents but have a more deleterious effect on the environments i) Understand how organic compounds can be grouped into homologous series, each of which has similarities in structures and properties.

COMPETENCY: Learner will appreciate the diversity of carbon organic compounds including the alkanes, alkenes, alkanols, and carboxylic acids.

15.1. INTRODUCTION.

In this chapter, you will be learning about the significance of carbon –containing compounds called **organic compounds.** They may be natural, synthetic polymers, hydrocarbons, organic acids, alcohols, foodstuffs, drinks, soaps and soap less detergents

15.2.PETROLEUM OILS. What is petroleum?

Petroleum oil is a smelly mixture of hundreds of different alkanes. They are organic compounds, which means they contain carbon along with hydrogen. In fact, most petroleum oils are called **hydrocarbons**, since they contain carbon and hydrogen only. Petroleum is formed from the remains of **dead** organisms (**plants and animals**) that fell to the ocean floor, and were buried under thick sedimentary rocks. High pressures slowly converted them to petroleum, over millions of years.

ACTIVITY: 1.2(a)

What to do:

1. In groups or individually discuss more about petroleum oils.
2. Share and compare your findings with the rest of members in your class.
3. Write down your work into your chemistry notebook.

Discussion questions:

a) What is meant by the term "**petroleum oil?**"
b) What is another name for petroleum oils?
c) Explain how petroleum oils are formed?
d) Why are crude oils sometimes called fossil fuels?
e) Name the process by which fossil oils are formed.

15.2.1. Refining crude oils. What does refining mean?

15.2.2. Refining crude oils.

In a refinery, the fractional distillation is carried out in a tower that is kept very hot at the base, and cooler towards the top. Petroleum is pumped in at the base. The compounds start to boil off. Those with the smallest molecules boil off first, and rise to the top of the tower, depending on their boiling points, and then condense. As the molecules get larger, the fractions get less runny, or more viscous: from gas at the top of the tower to solid at the

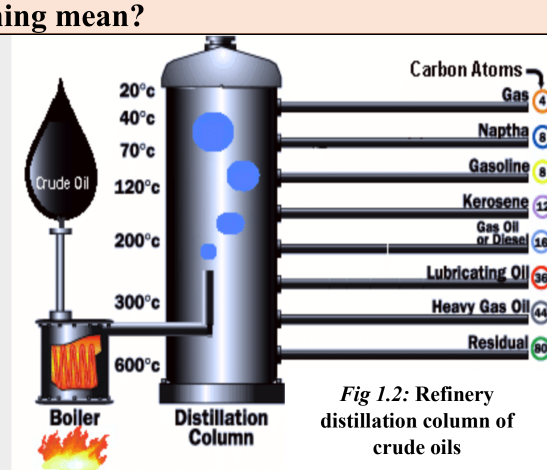


Fig 1.2: **Refinery distillation column of crude oils**

bottom. They also get less flammable. So, the last two fractions in the distillation column are not used as fuels. Why?	

ACTIVITY:15.2(b)

What to do:

In groups or individually, visit a computer library or using your smartphone for internet, conduct the following research to find out more about refinery of crude oils. Share and compare your findings with the rest of the class. Write down your work into your notebook.

Discussion questions:

a) Draw and label the refinery distillation process of crude oils in figure 1.2.

b) Explain how the different fractions of crude oils are refined.

c) Copy and complete the table below correctly. Name the fractions of the crude oils which possess the following number of carbon atoms using the following boiling points. In each case, state two uses of the fractions in our day – to – day life activities.

Fraction	Name of fraction	Number of carbon atoms	Uses of each fraction
1st		C_1 to C_4 (Below 25°C)	
2nd		C_5 to C_{10} (Below 70°C)	
3rd		C_{10} to C_{15} (Below 180°C)	
4th		C_{15} to C_{20} (Below 200°C)	
5th		C_{20} to C_{30} (Below 250°C)	
6th		C_{30} to C_{50} (Below 300°C)	
7th		C_{50} upwards (Above 350°C)	

d) Copy and complete the following. Write your answers in the spaces provided. Use the following words. ***Easily flow or slowly flow; volatile or less volatile; easily burn or burns with difficulty. No smoke and ash or smokey and ashy.***

Fraction	Boiling point range	How easily does it flow?	How volatile is it?	How easily does it burn?	Level of smoke or ash on combustion
1st Natural gas	Below 25°C				
2nd Gasoline	Below 70°C				
3rd Naphtha	Below 180°C				
4th Kerosene	Below 200°C				
5th Diesel	Below 250°C				

6th Fuel oil	Below 300ºC				
7th Lubricating oil	Below 350ºC				

15.2.3. Cracking Hydrocarbons: What does cracking hydrocarbons mean?
After fractional distillation…

Petroleum is separated into fractions by fractional distillation. The fractions all need further treatment before they can be used.

1. They contain impurities – mainly sulfur and lead compounds. If left in the fuels, these will burn to form harmful sulfur dioxide gas and leaded fuels respectively.
2. Some fractions are separated further into single compounds, or smaller groups of compounds. For example, the gas fraction is separated into methane, ethane, propane, and butane.
3. Part of a fraction may be cracked. Cracking breaks molecules down into smaller ones.

Cracking is a **petrochemical method** that involves breaking long chain hydrocarbons to short chained hydrocarbon molecules and other useful products.

Why is steam or thermal cracking used in petrochemical process?

a) Steam cracking: is a petrochemical process in which long chain saturated hydrocarbons are broken down into smaller, often unsaturated, hydrocarbons. It is the principal industrial method used in the production of lighter alkenes (or commonly known as olefins), including ethene (or ethylene) and propene (or propylene).

b) Thermal cracking: Is a method of breaking large hydrocarbon molecules into smaller useful molecules by heating them to high temperatures in the absence of oxygen. It is the most recommended method that help increase the production of valuable products like gasoline, diesel from crude oil.

c) Catalytic cracking: Is method of breaking large hydrocarbons into small useful molecules in the presence of catalysts. Such catalysts include Aluminosilicate (Zeolites).

Why is cracking Hydrocarbons important?

- Cracking makes some petroleum products be put into the best use. Suppose you have too much of the naphtha fraction, and too little of the gasoline fraction. You can crack some naphtha to get much quantities of gasoline fraction in the right size for petrol.
- Cracking always produces short-chain compounds with a carbon–carbon double or triple bond. This bond makes the compounds reactive. So, they can be used as feedstocks for making plastics and other substances.

Examples of cracking Hydrocarbons:

1. **Cracking naphtha fraction:** Compounds in the naphtha fraction are often cracked in the presence of aluminium oxide and silicon dioxide catalyst and high temperatures of 500ºC, to form short chain hydrocarbons. This is the kind of reaction that occurs.

$$C_{10}H_{22} \xrightarrow{500oC,\ SiO_2\ catalyst} C_5H_{12} + C_3H_6 + C_2H_4$$

(Naphtha) ⟶ (Pentane) + (Propene) +(Ethene)

2. **Cracking kerosene fraction:** Kerosene fraction has long chain hydrocarbons that can still be cracked at high temperatures in the presence of a catalyst to produce useful short chain hydrocarbons and other products.

Kerosene$_{(l)}$ $\xrightarrow{550oC,\ catalyst}$ Octene$_{(l)}$ + Octane$_{(l)}$ + Ethene $_{(g)}$

$$C_{18}H_{38(l)} \longrightarrow C_8H_{16(l)} + C_8H_{18(l)} + C_2H_{4(g)}$$

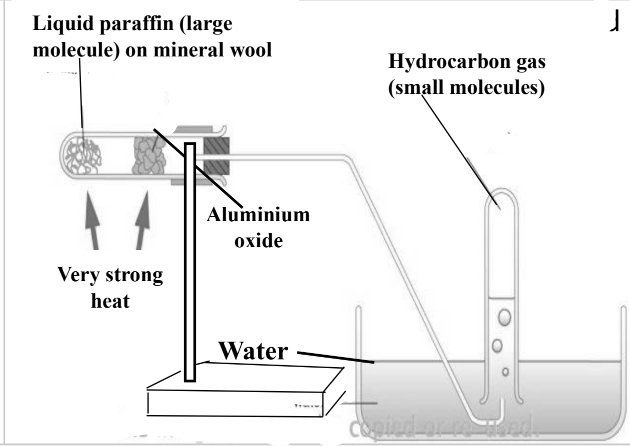
ACTIVITY:1.2(c) Laboratory cracking of Hydrocarbons.

What you need

Kerosene (liquid paraffin), aluminium oxide, sand (mineral wool), test tube, heat source, delivery tube, water, tough and rubber bungs.

What to do:

In groups or individually carryout the following procedure to investigate the products of cracking hydrocarbons.



Procedure:

1. Arrange the set up of the apparatus as shown above.
2. Apply heat on the soaked liquid paraffin in mineral wool until the long chain hydrocarbon is cracked into short chain gaseous products.
3. Pass the short gaseous alkane and alkene over heated aluminium oxide catalyst. NB aluminium oxide can obtained from broken pieces of clay pot.
4. Collect the gaseous products over water.
5. Add a drop or few drops of potassium manganate (VII) solution into the gas collected in the inverted test tube. Make observation.

Discussion Questions:

a) Identify the:

(i) Gas that evolved in the product

(ii) Colour of flame on igniting the gaseous product.

b) State with a reason the role of aluminium oxide in the above experiement.

c) Suggest the name of the process that aided the formation of gaseous product in (b) above.

ACTIVITY: 1.2(d)

Discussion Questions:

a) Crude oil is a mixture of different fractions of hydrocarbons that maybe catalytically cracked at varying temperatures. What is meant by the following terms:

(i) Hydrocarbon.

(ii) Cracking.

b) Name the impurities that should be removed from the fuels after refinery. Give a reason for your answer.

c) After fractional distillation, the fractions obtained may contain complex hydrocarbons. This means there is need for them to be broken down into useful products.

(i) Identify the process that aids the breakdown of long chain hydrocarbons.

(ii) Why is this process important?

d) Explain the process of petroleum oil refinery. Diagram not essential.

15.3.NATURAL GAS. What is the major component of natural gas?

Natural gas is mainly methane. It is often found with petroleum. It is formed in the same way. But high temperatures and high pressures caused the compounds to break down to gas.

Natural gas is a fossil fuel formed over millions of years from dead remains of ancient marine organisms and other organic matter such as zoo or Phyto-plankton, algae that settled on the ocean floor buried by layers of sediments.
Overtime, high heat and pressure transformed this dead organic matter into hydrocarbons (crude oils), which eventually produce natural gas.

Composition of Natural gas

Natural gas constitutes of mainly 90% methane and 5% ethane, and propane.
Common impurities found along with natural gas may include carbon dioxide gas, nitrogen gas, and hydrogen sulphide.

Fig 1.2 shows the processing plant for natural gas

15.4.BIOGAS.

Biogas is a gaseous renewable energy source produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste, wastewater, and food waste. Biogas is produced by anaerobic digestion with anaerobic organisms or methanogens inside an anaerobic digester, biodigester or a bioreactor. **.** The gas composition is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes.

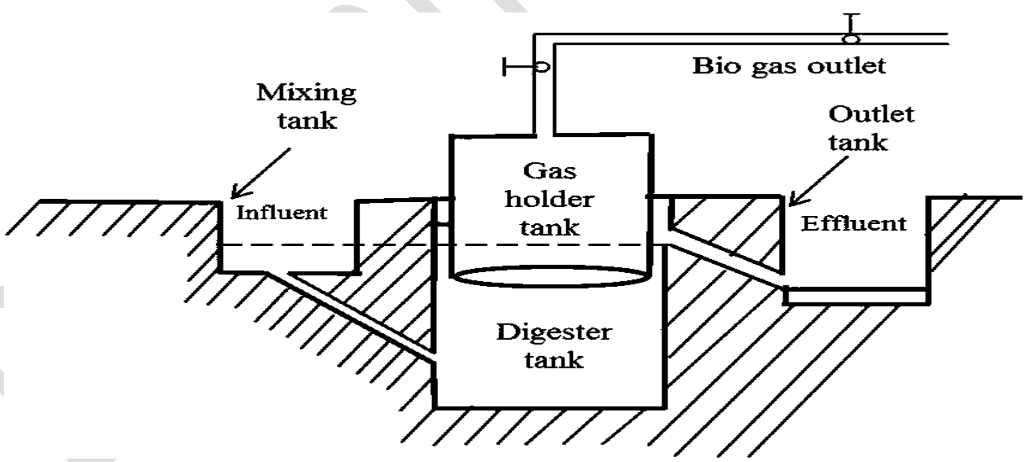


Fig 1.4. A simple schematic of a biogas production plant

ACTIVITY: 1.4(a).
Discussion Questions:

a) Biogas is always obtained from biomass in the presence of anaerobic digesters. Define the term "**Biogas**" as an energy source.
b) Explain why biogas is termed as **a renewable energy** source whereas natural gas is called **non – renewable energy** source.
c) Name the different sources of biomass from which biogas fuel is obtained.
d) Identify the:

(i) main gaseous component(s) of biogas.
(ii) other gaseous components produced as impurities that must be removed when formed.

e) Explain how biogas is formed from biomass.
f) Differentiate between **influent** and **effluent** of biomass in a biogas digester.
g) Describe the different uses of Biogas in our day – to – day life activities.

ACTIVITY: 1.4(b) Project work on constructing Biogas digester.

What you need:
Use locally available materials around you.

What to do:
In groups or individually construct your own biogas digester.

1. Suggest a title (theme) of your project to meet your study findings.
2. Do research and gather information (data) about your project title.
3. List down the requirements you need to achieve the intended project.
4. Plan and design your own procedural steps for the project.
5. Follow up your instructions to start building your intended project.
6. Make test and troubleshoot on your project, to help you evaluate where the problem or failure might be coming from.
7. Compile and document your project using "word" or Pdf for future reference.
   NOTE: *In every single step of your project, always present them first before your teacher for some advice or a go ahead with that activity or to make some adjustment.*

15.5. CLASSIFICATION OF CARBON –COMPOUNDS.

Carbon is one of the most successful elements on the planet Earth. Its existence on Earth has supported many lives and without its life would not have come into existence. Carbon has the ability to form many structural and useful organic compounds which are found in the hydrocarbons, food stuffs, bodies of living organisms but excluding inorganic carbon-compounds like carbonates, oxides.

Carbon has the ability to join each other and other elements to form rings or long chains in their structures called **Organic compounds.** The study of organic compounds and its applications as a branch of Chemistry is called **Organic Chemistry**.

The carbon – organic containing compounds are hydrocarbons, alcohols, carboxylic acids etc.

15.6. HOMOLOGOUS SERIES:

Homologous series: Refers to a group of organic compounds with the same general formula, similar structural formulae, similar chemical properties in which the successive members differ from the next by methylene group. (– CH_2 – group).

Examples include **alkanes**, **alkenes, alcohols,** and **carboxylic acids** etc.

Each homologous series differs in their chemical properties from the next series by a "**functional group**".

Functional group: refers to an atom or a compound which determine the chemical properties of any given homologous series.

General characteristics of Homologous series.

Property	Alkanes	Alkenes	Alcohols	Carboxylic acids
Physical state at room temperature	**Gases** (first four lower molecular mass) **liquids** (medium molecular	**Gases** (first four lower molecular mass) **liquids** (medium molecular	Most of them exist as **liquids** and some as **solids**	Most of them exist as **liquids** and some as **solids**

	weight) and **solids** (higher molecular weight)	weight) and **solids** (higher molecular weight)		
Solubility in water	Immiscible with (insoluble in) water but soluble in organic solvents	Immiscible with (insoluble in) water but soluble in organic solvents	Miscible with (soluble in) water and organic solvents to form solution	Miscible with (soluble in) water and organic solvents to form solution but the higher members become immiscible with water
Boiling point	Higher boiling points than alkenes	Lower boiling points than alkanes	Higher boiling points than alkanes due to the presence of hydrogen bonding	Higher boiling points than alkanes due to the presence of hydrogen bonding
Electrical conductivity	Does not conduct electricity	Does not conduct electricity	Does not conduct electricity	Conducts electricity
Odour (smell)	Odorless (has no distinct smell)	Typically, pungent or sweet	Typically, pungent or sweet	Typically, pungent
Density	Less dense than water	Less dense than water	Almost equal to density of water	Dense than water

15.7. HYDROCARBONS

The groups (families) of homologous series such as alkanes and alkenes belong to a group of organic compounds called **Hydrocarbons**.

Hydrocarbons are organic compounds made up of carbon and hydrogen only.

There are two major types of hydrocarbons, namely:

1. Saturated hydrocarbons 2. Unsaturated Hydrocarbons

Properties	**a) Saturated Hydrocarbons**	**b) Unsaturated hydrocarbons**
Type of bond	single C – C bond	double C = C bond
Family	Alkanes	Alkenes
Suffix	– ane	– ene
General formula	C_nH_{2n+2}	C_nH_{2n}

ACTIVITY: 1.6(a)

What to do:

In groups or individually, carryout the following research about homologous series of organic compounds. share and compare your findings with each other group in your class. Write them down in your notebook.

Discussion Questions:

a) Different organic compounds are placed into group called the homologous series because of the difference in their functional groups. Define the following terms:

(i) Homologous series.

(ii) Functional group.

b) How does:

(i) each member of the same homologous series differs from the other successive members?

(ii) each member of the same homologous series similar to the other successive members?

Table showing the general formulae, functional groups of the first homologous series

Homologous series	Alkanes	Akenes	Alcohols	Carboxylic acids
General formula	C_nH_{2n+2}	C_nH_{2n}	$C_nH_{2n+1}OH$	$C_nH_{2n} + O_2$
Functional group	C – C *single bonds*	>C = C< *double bond*	*– OH Hydroxyl group*	*– COOH Carboxyl group*
n = C_1	CH_4	**None**	CH_3OH	$HCOOH$
n = C_2	C_2H_6	C_2H_4	C_2H_5OH	CH_3COOH
n = C_3	C_3H_8	C_3H_6	C_3H_8OH	C_2H_5COOH
n = C_4	C_4H_{10}	C_4H_8	C_4H_9OH	C_3H_7COOH
n = C_5	C_5H_{12}	C_5H_{10}	$C_5H_{11}OH$	C_4H_9COOH
n = C_6	C_6H_{14}	C_6H_{12}	$C_6H_{13}OH$	$C_5H_{11}COOH$

15.8. NOMENCLATURE (NAMES) OF HOMOLOGOUS SERIES

In Uganda, every born baby is usually given a sir name, in line to the tribe from which the biological parents belong. You may have learnt that a tribe is often placed under "**ethnic group**" like-wise any names of any given homologous series must be in line to the group from which the parent structure originated, we normally use ***IUPAC*** naming system (International Union of Pure and Applied Chemistry), to provide universal names that avoid confusion amongst chemists.

To name members of any alkanes, alkenes, alcohols and carboxylic acids we count mainly the number of carbon atoms in the general formulae as n =1,2,3,4,5 etc in the compounds.

1. All names given to any member of **alkanes** must end with a suffix **"ane"**
2. All names given to any member of **alkenes** must end with a suffix "**ene**"
3. All names given to any member of **alcohols** must end with a suffix "***ol***"
4. All names given to any member of **carboxylic acids** must end with a suffix "***oic***"

Foot note: All the names given to any member of **alcohols** and **carboxylic acids** always replace the ending **"e"** of **"ane"** in **alkanes** with a suffix ***"ol"*** and ***"oic"*** respectively**.**

Homologous series Carbon No	Root name	Alkanes "ane"	Alkenes "ene"	Alcohols "*ol*"	Carboxylic acids. "*oic*"
1	Meth -	Meth***ane***	*N. A*	Methan***ol***	Methan***oic*** acid
2	Eth -	Eth***ane***	Eth***ene***	Ethan*ol*	Ethanoic acid
3	Prop -	Prop***ane***	Prop***ene***	Propan*ol*	Propan***oic*** acid
4	But -	But***ane***	But***ene***	Butan*ol*	Butanoic acid
5	Pent -	Pent***ane***	Pent***ene***	Pentan*ol*	Pentanoic acid
6	Hex -	Hexane	Hexene	Hexan*ol*	Hexanoic acid

15.9.ALKANES [C_nH_{2n+2}]

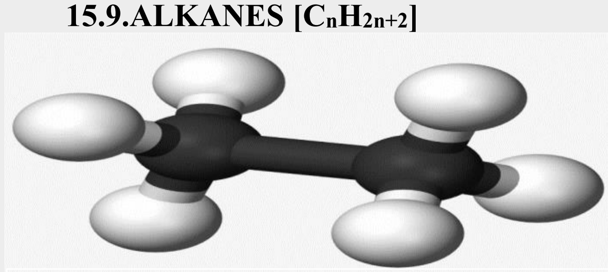
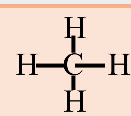
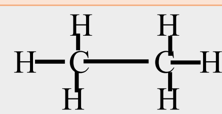
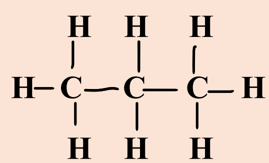
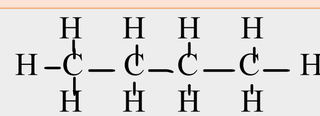
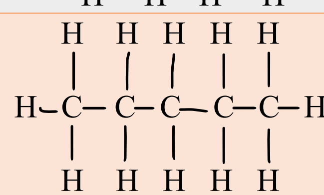


Figure 1.8. Model of the structure of ethane

General characteristics of alkanes as hydrocarbon compounds

- Alkanes are saturated hydrocarbons that contain carbon – carbon single bonds. Alkanes are the first (family) group of homologous.
- They conform to the general formula C_nH_{2n+2}, where n = 1,2,3,4…...etc. They contain only carbon – carbon single bonds, hence they are called saturated hydrocarbons. Examples of alkanes include: gasoline (petrol), diesel, paraffin, naphtha, natural gas, candle wax. This means the petroleum fuels we use in our everyday activities belong to a group of homologous series called alkanes.
- They are found in petroleum and natural gas. Petroleum contains alkanes with up to 70 carbon atoms.
- The first four alkanes are gases at room temperature. The next twelve are liquids. The rest are solids at room temperature and pressure.
- Their melting and boiling points increase with chain length because attraction between the molecules increases – so it takes more energy to separate them.

a) Copy and complete the table below correctly to show a model of the structural formulae of the first five alkanes. Remember that each carbon atom has four (4) bonds.

No. carbon atoms	Name of alkane	Molecular formula	Structural formulae	Compressed structure
1	Methane			**CH_4**
2	Ethane	C_2H_6		**CH_3CH_3**
3	Propane	C_3H_8		**$CH_3CH_2CH_3$**
4	Butane	C_4H_{10}		**$CH_3CH_2CH_2CH_3$**
5	Pentane	**C_5H_{12}**		**$CH_3CH_2CH_2CH_2CH_3$**

15.9.1. PHYSICAL PROPERTIES OF ALKANES

a) Boiling points and densities of alkanes

Boiling point increases with increase in molecular mass of each chain length, increasing the intermolecular forces in the molecules, a lot of heat will be required to break these forces. Density alkanes increases with increase in molecular mass but decreases with branching.

Alkane	M.pt/ °C	B.pt/°C	Density (g/cm³)
Methane	-182	-164	0.716
Ethane	-183	-89	0.546
Propane	-190	-42	0.582

Butane	-138	-0.5	0.601
Pentane	-130	36.3	0.626
Hexane	-95	69	0.659

ACTIVITY: 1.8(b)

What to do

In groups or individually, discuss how the increase in the number of carbon atoms affect the boiling points of the first four alkanes. Share and compare your findings with other groups in your class. Write them down in your notebook.

Discussion Questions:

a) Copy and complete following precisely by filling in the missing information using the table below.

Alkane	Methane	Ethane	Propane	Butane	Pentane	Hexane
Molecular formula						
Structural formula						
No. carbon atom						
Physical state (at 25°C)						

b) State and explain the trend in the:

(i) boiling points of the first six alkanes.

(ii) density of the first six alkanes.

ACTIVITY: 1.8(d)

What to do

In groups or individually, discuss on the following physical properties of alkanes. Share compare your findings with the rest of other groups in your class. Use the table below to write your comprehensive work in your note book.

Discussion Question:

a) Copy and complete the following by explaining how alkanes behave with each physical property. Use the table below.

Physical property	Expected behaviours of alkanes
○ General formula	
○ Functional group	
○ Existence	
○ Physical state at r.t.p	
○ Boiling points	
○ Physical appearance	
○ Solubility in water	
○ Effect on **blue** and **red** litmus paper	
○ Density	
○ Electrical conductivity	
○ Ability to react	

a) ISOMERS OF ALKANES.

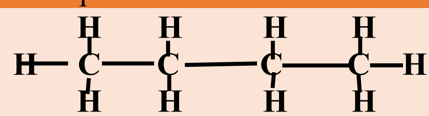
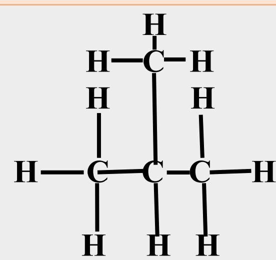
Isomers are organic compounds with the same molecular formula, but different structural formulae. The more carbon atoms in a compound, the more isomers it has. Since isomers have different structures, they also have slightly different physical properties. For example, branched isomers have lower boiling points, because the branches make it harder for the molecules to get close. So, the attraction between them is less strong, and less heat is needed to overcome it.

Compare the butane molecules. Both have the same formula, C_4H_{10}, different structures.

Types of isomers in *n* - Butane

The isomers **in *n* - Butane** can be grouped as:

(i) **Straight chain isomers** (unbranched chain) and(ii) **branched chain**. Consider the following isomers of ***n*-Butane, C_4H_{10}.** We can write their structural formula as below.

Butane, C_4H_{10}.	Open structural formula	Condensed structural formula
Isomer: A		**$CH_3CH_2CH_2CH_3$** C_1 C_2 C_3 C_4 (Boiling point = 0ºC)
Isomer: B		**CH_3** **(Methyl group)** **CH_3CHCH_3** **C_1 C_2 C_3** (Boiling point = -10ºC)

ACTIVITY: 1.8(e)

What you need:

Butane, **C_4H_{10}**; isomer: **A** and isomer: **B**, your notebook.

What to do

In groups or individually, carryout the following activities to find out the different forms of isomers exhibited in alkanes. Use this as a basis to give the meaning of isomers. Share and compare your findings with the rest of the class. Write them down into your notebook

Discussion Questions:

a) Copy and complete the table below correctly. Fill in the missing information about butane.

Physical properties	**Isomer A**	**Isomer B**
Homologous series		
Molecular mass		
Boiling point		
No. carbon on the parent structure		
Type of isomer		
Opened structural formula		
Condensed structural formula		

b) From your discussion in part (a) above. Suggest:

(i) What is meant by the term **"Isomer"**

(ii) With a reason why isomer **A** and isomer **B** have different boiling points and yet they both have a general molecular mass of 58.

c) Suggest the possible ***IUPAC*** name given to the following isomers of A and B.

(i) Isomer **A**: $CH_3CH_2CH_2CH_3$

$$CH_3CH(CH_3)CH_3$$

(ii) Isomer **B:** CH_3CHCH_3 (with CH_3 branch on the middle carbon)

15.9.2. CHEMICAL PROPERTIES OF ALKANES

Generally, alkanes are very unreactive under ordinary conditions. However, under drastic conditions, they react to form new products.

a) Reaction of alkanes with chlorine gas:

Chlorine gas can react with an alkane gas like methane to form chloromethane. This reaction requires Ultra – violet light (U.v light) from sunlight. In the dark, no reaction takes place, hence a **photochemical reaction** just like photosynthesis. The reaction between chlorine gas and methane gas is called **chlorination** or **substitution** reaction.

ACTIVITY:1.8(f)

What to do:

In groups or individually, discuss the following by researching on the chemical reaction of chlorine gas with methane gas under limited chlorine gas using sunlight. Share and compare your work with other groups in your class.

Discussion Questions:

a) Copy and complete the table below precisely by filling in the missing information about the chemical reaction between chlorine gas and methane gas.

No. chlorine atom	Chlorine gas	Methane gas	Major product	Minor product
1	Cl_2	CH_4	CH_3Cl	HCl
2	Cl_2	CH_4	CH_2Cl_2	2HCl
3	Cl_2	CH_4	$CHCl_3$	3HCl
4	Cl_2	CH_4	CCl_4	4HCl

b) From your discussion, in part (a) above. Write a:

(i) word equation for the reaction between chlorine gas and methane to form chloromethane gas and hydrogen chloride gas. Illustrate with condition for the reaction.

(ii) chemical for the reaction in (b) (i) above with state symbols.

c) Write the ***IUPAC*** Names of the following compounds:

(i) CH_3Cl (ii) CH_2Cl_2 (iii) $CHCl_3$ (iv) CCl_4

b) Combustion of alkanes in air.

All alkanes on combustion, undergo **complete combustion** in supply of excess oxygen, forming carbon dioxide and water vapour, and giving out plenty of heat energy. So, they are used as fuels. Methane burns the most easily. If there is not enough oxygen, the alkanes undergo **incomplete combustion**, giving out poisonous carbon monoxide gas and less heat energy.

ACTIVITY: 1.8(g) To prove that water and carbon dioxide gas are formed when candle wax burns in oxygen.

What you need:

Candle wax, glass funnel, delivery tubes, boiling tubes, cold water, calcium hydroxide solution (lime water), anhydrous copper (II) sulphate, petri dish and rubber bungs.

Caution! Take great care on the broken glass materials since they can cut the skin.

What to do:

In groups:

1. Set the apparatus as shown below in the figure 1.8.5.
2. Light the candle wax and leave it to continue with burning for 15 minutes. Making observations on what takes place in tube A &B.
3. Add a few solid powders of anhydrous copper (II) sulphate into tube A, after the experiment. Make your observation.

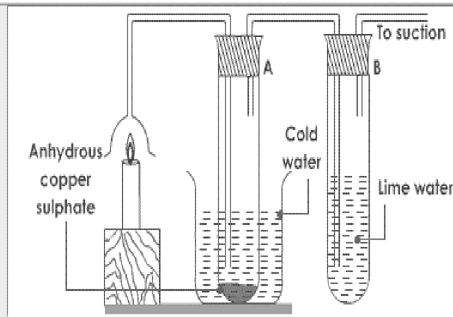


Fig 1.8.5. To prove that carbon dioxide and water are formed when candle wax burns

Discussion Questions:

a) State what was observed in the boiling tube A and B when candle wax burnt.

(i) Tube **A**______________(ii) Tube **B**__________________

b) Name the compounds formed in the tube A and B when candle wax burnt.

(i) Tube **A**_____________ (ii) Tube **B** __________________

c) **I**dentify the major elements which constitute the candle wax that formed the compounds named in (b) above.

d) Write:

(i) a word equation for the reaction that took place when candle wax burnt in air.

(ii) a chemical equation for the reaction in (d) (i) above with state symbols.

e) Why was ice – cold water used in this experiment?

f) Write:

(i) a word equation for the reaction that took place in the tube **B** containing calcium hydroxide solution and gaseous product formed.

(ii) a chemical equation for the reaction in (f) (i) above with state symbols.

15.10. ALKENES (C_nH_{2n})

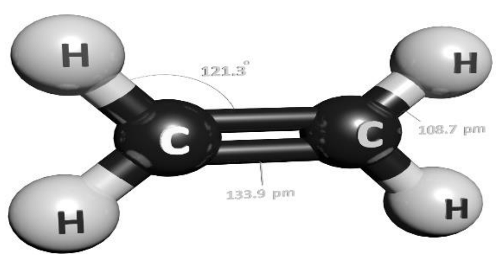


Figure 1.9. Model of the structure of ethene

General characteristics of alkenes as hydrocarbon compounds:

- Alkenes are unsaturated hydrocarbons with carbon – carbon, (C = C) double bonds.
- They conform to the general formula C_nH_{2n} where n = 1,2,3,4…...number of carbon atoms.
- They contain only carbon – carbon double bonds, hence they are called unsaturated hydrocarbons.
- The first four alkenes are gases at room temperature. The next twelve are liquids. The rest are solids at room temperature and pressure.
- Alkenes are known as olefins meaning oil forming organic compounds.
- The melting and boiling points of alkenes increase with chain length because attraction between the molecules increases – so it takes more energy to separate them.

ACTIVITY: 1.9(a) To make models of the structure of alkenes as hydrocarbons.

What you need:

Access to small raw fruits, toothpicks and your notebook.

What to do:

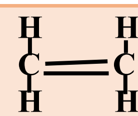
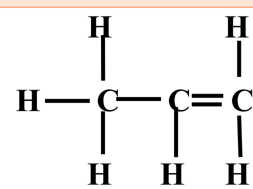
In groups or individually, conduct the following research to investigate more about alkanes. Share and compare your findings with other groups in your class. Write the down in your notebook.

Discussion Questions:

a) Copy and complete the table below correctly. Use this general formula $\mathbf{C_nH_{2n}}$

No. carbon atoms	Root name	No. Hydrogen atoms	Molecular formular	Add suffix **"ene"** to complete the name
2	Eth-	**4**		
3	Prop-	**6**		
4	But-	**8**		
5	Pent-	**10**		
6	Hex-	**12**		
7	Hept-	**14**		
8	Oct-	**16**		
9	Non-	**18**		
10	Dec-	**20**		

b) Copy and complete the table below correctly to show a model of the structural formulae of the first five alkenes. Remember that each carbon atom has four (4) bonds.

No. carbon atoms	Name of alkene	Molecular formular $\mathbf{C_nH_{2n}}$	Open structural formula	Condensed structure
2	Ethene	$\mathbf{C_2H_4}$		
3				
4		$\mathbf{C_4H_{10}}$		$\mathbf{CH_3CH_2CH{=}CH_2}$
5	Pentene			
6	Hexene			

15.10.1.PHYSICAL PROPERTIES OF ALKENES

ACTIVITY: 1.9 (b) To investigate the general Physical properties of alkenes.

What to do

In groups or individually, discuss on the following physical properties of alkenes. Share compare your findings with the rest of other groups in your class. Use the table below to write your comprehensive work in your note book.

Discussion Question:
Copy and complete the following by explaining how alkanes behave with each physical property. Use the table below.

Physical property	Expected behaviours of alkanes
1) General formula	
2) Functional group	
3) Existence	
4) Physical state at (r.t.p)	
5) Melting points	
6) Boiling points	
7) Physical appearance	
8) Solubility in water	
9) Effect on **blue** and **red** litmus paper	
10) Density	
11) Electrical conductivity	
12) Ability to react	

a) BOILING, MELTING POINTS AND DENSITY OF ALKENES

Melting or Boiling points of alkenes increase with increase in the molecular mass which increases the intermolecular forces of attraction between the molecules hence more heat is required to break these forces leading to increased melting or boiling points.

Alkene	M. Pt / °C	B. Pt / °C	Density (g/cm^3) at 25°C
Ethene	-169.2	-103.7	0.570
Propene	-185.2	-47.6	0.597
But – 1 – ene	-185.2	-6.3	0.617
Pent – 1 – ene	-165.0	30	0.643
Hex – 1 – ene	-140.0	63	0.654

ACTIVITY: 1.9(c)

What to do

In groups or individually, discuss how the increase in the number of carbon atoms affect the boiling points of the first four alkanes. Share and compare your findings with other groups in your class. Write them down in your notebook.

Discussion Questions:

a) Copy and complete following precisely by filling in the missing information using the table below.

Alkane	Ethene	Propene	But – 1 -ene	Pent – 1 – ene	Hex – 1- ene
No. carbon atom					
Molecular formula					
Structural formula					
Physical state at 25°C					

b) State and explain the trend in the:

(i) boiling points of the first six alkenes.

(ii) melting points of the first six alkenes.

(iii) **d**ensity of the first six alkenes.

b) ISOMERS OF ALKENES.

S No	Structure	IUPAC NAME
1	$CH_3-CH=CH_2$	**Prop** -1 – ene
2	$CH_3-CH=CH-CH_3$	But – 2 – ene
3	$CH_2=C(CH_3)-CH_3$	2 -methyl **prop-** 1 – ene
4	$CH_2=CH-CH(CH_3)-CH_2-CH_3$	3-methyl **pent** – 1 – ene

Alkenes exhibit both **chain** isomers and **position** isomers. The positions of the **functional** group of an alkene in its structures can be (-1-ene or – 2 – ene).

ACTIVITY:1.9(c)

What to do:

In groups or individually, discuss the following. Share and compare your findings with the rest in your class.

Discussion Questions:

a) Using the table 1.9.3 above. Copy and complete the table below and answer by filling in the spaces provided precisely.

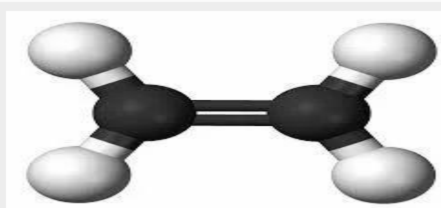
IUPAC name	**Prop -1 -ene**	**But -2-ene**	**2-methyl prop -1 -ene**	**3-methyl Pent -1 -ene**
Structural formula				
Position of **methyl** group (**-CH_3**)				
Position of **C = C** double bond				
No. carbon atoms				

b) State **one** similarity and difference between **but– 2 – ene** and **2 – methyl prop – 1 – ene.**

(i) Similarity. (ii) **Difference**

c) What general term is given to the two compounds in (b) above?

15.11. ETHENE GAS:



A model of the structure of Ethene gas

ACTIVITY: 1.10(a) Laborator ... ydration of ethanol.

What you need:

Round bottomed flask, delivery tube, heat source, gas jar, water trough, glass jar stand, ethanol, concentrated Sulphuric acid, bromine water, sands and acidified potassium manganate (VII) solution.

CAUTION!

- Perform this experiment in fume chamber, to avoid inhaling poisonous sulphur dioxide gas produced by concentrated Sulphuric acid.
- Concentrated Sulphuric acid is highly corrosive, handle it with care.
- Avoid putting ethanol near fire point, since it is highly flammable.

- This experiment **MUST** be performed only by a teacher or a technician and **NOT** by learners.

What to do:

1. Arrange the setup of the apparatus as shown below.
2. Place a few sands into the flask, add ethanol a half – way the flask
3. Run concentrated sulphuric acid through a dropping funnel into the flask containing a mixture of sand aluminium sulphate and ethanol to dehydrate off water from ethanol. Aluminium sulphate facilitates dehydration of ethanol, and sand prevents frothing formation in the flask.
4. Heat the mixture with great care until bubbles of a colourless gas evolved.
5. The gas is then passed into a washed bottle of sodium hydroxide solution to remove any carbon dioxide gas produced and collected over water.
6. **6.** Bubble the collected gas through bromine water and acidified potassium manganate (VII) solution. Make observations.

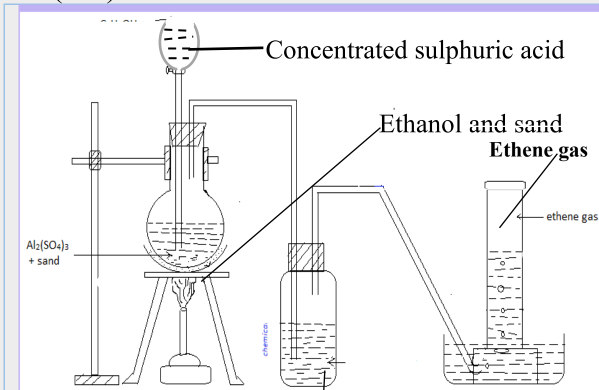


Fig. Laboratory preparation of ethene

Discussion Questions

a) Copy and complete the following by filling in the missing information precisely.

Physical property of ethene gas	**Description**
○ Colour	*Colourless gas*
○ Odour (smell)	*Has pungent smell*
○ Solubility in water	*Immiscible with water*
○ Density	*Less dense than water*

b) State the role of each of the following in the experiment.

(i) Concentrated Sulphuric acid.

(ii) Sodium hydroxide solution.

(iii) Sand.

c) State the temperature at which the reaction takes place.

d) Ethene gas was bubbled through the following solutions. State what was observed in each case. Use the table below.

	Test	**Expected observations**
(i)	Bromine water	*Turns from brown to colourless solution*
(ii)	Acidified potassium manganate (VII) solution.	*Purple solution of manganate (VII) turns to colourless solution*
(iii)	Acidified potassium dichromate (VI) solution.	*Orange solution of dichromate (VI) turns to green solution*

e) State the role of each of the following reagents.

(i) Bromine water.

(ii) Acidified potassium manganate (VII) solution.

(iii) Acidified potassium dichromate (VI) solution

f) Write:

(i) a word equation for the reaction between bromine water and ethene gas to form 1,2-dibromoethane.
(ii) the chemical equation for the reaction in (f) (i) above with state symbols.

g) Write:
(i) a word equation for the reaction leading to the formation of ethene gas.
(ii) the chemical equation for the reaction in (g) (i) above with state symbols.

15.12. USES OF ALKENES

ACTIVITY:1.11(a) To find out the various applications (uses) of alkenes

What you need:

Access to computer or smartphone for internet, textbooks, and your notebook.

What to do:

In groups or individually, visit a computer library or using your smartphone, carryout research to explore the various applications (uses) alkenes. Share and compare your findings with the rest of the class. Write them down in your notebook.

Discussion Questions:

a) Explain the different uses of alkenes of in our day – to – day life activities.

15.13. ALCOHOLS ($C_nH_{2n+1}OH$) What are alcohols?

The alcohols are the family of organic compounds that contain carbon, hydrogen and oxygen atoms. The general formula of alcohols is $\mathbf{C_nH_{2n+1}OH}$ where ***n*** is the carbon number. The ***OH*** is the functional group of alcohols, the ***Hydroxyl group***.

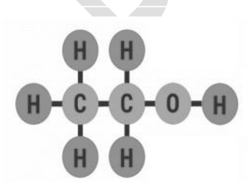
ACTIVITY: 1.12(a)

Discussion Questions:

a) Copy and complete the following by filling in the missing information correctly. Use the formula $\mathbf{C_nH_{2n+1}OH}$ in the table below.

No. carbon atom **Root Name**	**n=1 Methan-**	**n=2 Ethan-**	**n=3 Propan-**	**n=4 Butan-**	**n=5 Pentan-**
Alcohol name $\mathbf{C_nH_{2n+1}OH}$					
Molecular formula					
Molecular mass	**31**	**45**	**59**	**73**	**87**
Structural formula					
Boiling point/°C	**65**	**78**	**87**	**117**	**137**

a) ETHANOL



Ethanol can be prepared in two methods, one by **biological** method and two by **Chemical** method. **Biological method** of preparing ethanol involves fermentation process.

Fermentation: Refers to the anaerobic break down of carbohydrates such as sugars and starch into ethanol using biological enzymes from yeast or bacteria. It occurs in the absence of oxygen.

ACTIVITY: 1.12(b) Laboratory preparation of Ethanol by fermentation of glucose

What you need:

Measuring cylinder, boiling tube, test tube, delivery tube, yeast, saturated glucose solution, rubber bungs.

What to do: In groups or individually,

1. Arrange the setup of the apparatus as shown in fig 1.12(b)
2. Measure 50cm^3 of glucose solution into a boiling tube.
3. Leave the setup in a warm place for three days. Make observation.
4. Record the observation after three (3) days.

Fig.1.12(b) Fermentation of glucose solution

Discussion Questions:

a) State what was observed in the test tube containing lime water.

b) Identify the gas that is responsible for the colour change of the lime water.

c) What are the conditions necessary for fermentation process to take place?

d) Write:

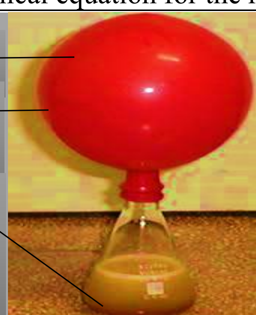
(i) a word equation for the reaction leading to formation of ethanol and carbon dioxide from glucose solution.

(ii) a chemical equation for the reaction that took place in (d) (i) above with state symbols.

Gas X

Inflated balloon

A mixture of Yeast and glucose solution



Discussion Questions:

a) Identify gas X and name one reagent which can be used to identify the gas. State what would be observed if the reagent named above is treated with the gas8.

b) State your observation if the reagent named in (a) above is treated with the gas X.

c) State the process that led to production of gas X.

d) What are the necessary conditions for the process stated in (c) above?

16. 2. Preparation of Ethanol from starch

Sources of starch: Millets, sorghum, maize corn, and cassava.

What happens:

When they are grounded and mixed with water. Starch eventually undergoes hydrolysis to form malt. Malt contains an enzyme **diastase** which hydrolyses starch to maltose.

$$2C_6H_{10}O_{5(aq)} + H_2O_{(l)} \xrightleftharpoons{\text{Diastase enzyme}} C_{12}H_{22}O_{11(aq)}$$

(Starch) + (Water) (Maltose)

When yeast is added to the ***maltose*** at room temperature and left to ferment for 3 days, ***glucose*** molecules are formed. Yeast contains two enzymes, ***maltase*** and **zymase**. ***Maltase*** catalyses the hydrolysis of maltose to glucose as below.

$$C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \xrightleftharpoons{\text{Maltase enzyme}} 2C_6H_{12}O_{6(aq)}$$

(Maltose) +(Water) (Glucose)

Zymase catalyses the breakdown of glucose into ethanol, carbon dioxide, producing heat in the process.

$$C_6H_{12}O_{6(aq)} \xrightleftharpoons{\text{Zymase enzyme}} 2C_2H_5OH_{(l)} + 2CO_{2(g)} + Heat$$

Glucose*(aq)* $\rightleftharpoons$ Ethanol*(l)* + Carbon dioxide*(g)* + Heat

ACTIVITY:1.12(c)

What you need:

Cassava flour, water, millet (sorghum) yeast, polythene bag (banana leaves), distillation pot (flask), copper (laboratory) Liebig condenser, heat source, filter funnel, glass (beakers) bottles.

What to do: In groups

1. Mix the grounded cassava flour with clean water to form a sloid paste.
2. Transfer the paste into the drum or ground and cover it with polythene bag or banana leaves. Leave it to stay for 1 week. Make observation.
3. After 1 week, roast the fermented cassava paste and dry it in the sun.
4. Mix the roasted fermented cassava paste with millet (sorghum) yeast.
5. Transfer the mixture into a big drum and add adequate amounts of water that cover up the mixture. Leave it to stay for 3 days. Observe the heat produced if it is exothermic (heat loss) or endothermic (heat gain).
6. After 3 days, filter the mixture to obtain liquid filtrate.
7. Arrange the set of the apparatus for distillation process of the liquid filtrate.
8. Carryout the distillation process to obtain pure ethanol as distillate.

Discussion Questions:

a) What is the purpose of:

(i) Leaving the paste in the drum for 1 week before roasting?

(ii) Mixing the roasted paste with millet (sorghum) yeast?

(iii) Covering the mixture of roasted cassava paste and yeast for 3 days?

b) Name the:

(i) process under investigation in this experiment.

(ii) enzymes found in the cassava paste before adding yeast.

(iii) enzymes found in the millet (sorghum) yeast that catalyzed the process.

c) Write:

(i) a word equation for the reaction that took place when starch is hydrolyzed to maltose sugars.

(ii) a balanced chemical equation for the reaction that took place in (c) (i) with state symbols.

d) Write:

(i) a word equation for the reaction that took place when maltose is hydrolyzed to glucose sugars.

(ii) a balanced chemical equation for the reaction that took place in (d) (i) with state symbols.

e) Write:

(i) a word equation for the reaction that took place when glucose is hydrolyzed to ethanol, carbon dioxide gas and heat.

(ii) a balanced chemical equation for the reaction that took place in (e) (i) with state symbols.

b) Industrial manufacture of Ethanol (Chemical method):

In Uganda, there are local brewing industries such as Nile breweries in Jinja, Uganda breweries limited in Luzira Kampala among others produced ethanol on large (commercial) scale for local and international consumers.

Most of them obtain their raw materials from starch plant materials to prepare beer (ethanol). However, others produce ethanol on large scale by hydrolysis of Ethene.
Ethene can be converted directly to ethanol by steam cracking of long chain alkanes. After cracking, ethene gas is passed through steam in the presence of concentrated phosphoric acid as catalyst at temperatures of 300ºC and pressure of 60 atmosphere.

Ethene ***(g)*** + Steam ***(g)*** $\xrightarrow[300^oC/60atm]{Conc\ H_3PO_4}$ Ethanol***(l)***

$$CH_2{=}CH_{2\,(g)} + H_2O_{(g)} \xrightarrow[300^oC/60atm]{Conc\ H_3PO_4} C_2H_5OH_{(l)}$$

ACTIVITY:1.12(d): Field study to a nearby chemical plant for brewing Ethanol.
What to do: In groups

1. Organize a field trip along with your teacher to a nearby brewing industry (factory).
2. Prepare topical questions (questionnaire) that you will use to engage the laboratorians in their respective fields.

Field study task:

a) Prepare and write down a final report of your findings from the factory. Your final report should include the following:
(i) title of the filed study.
(ii) raw materials used in the process of making ethanol.
(iii) descriptive stages of the entire process of making ethanol.

b) Present your final report to the rest of the class, HOD Chemistry and the Headteacher. Use word (Power point) document of the computer.

PHYSICAL PROPERTIES OF ETHANOL

ACTIVITY:1.12(e)
What to do: In groups
Discuss how the physical properties of Ethanol are affected by each of the following. Share and compare your findings with the rest of the class. Write them down in your notebook.
Discussion Questions:

a) Copy and complete the table below by filling in the missing information precisely.

Property	**Expected behaviour of ethanol**
o Colour	
o Odour (smell)	
o Density	
o Boiling point.	
o Physical state at r.t.p	
o Effect on litmus paper	
o Solubility in water	

CHEMICAL PROPERTIES OF ETHANOL

a) Combustion of ethanol.
Alcohols such as ethanol burn in plenty supply of air with a yellow non – sooty flame to form carbon dioxide gas, water and heat energy.

Ethanol***(l)*** + Oxygen***(g)*** $\longrightarrow$ Carbon dioxide***(g)*** + Water***(l)*** + Heat

$$C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)} + \Delta H^{\Theta}$$

b) Dehydration reaction of Ethanol

When concentrated Sulphuric acid is heated at temperatures between 170 – 180°C, ethanol is dehydrated to form ethene gas and water.

Ethanol*(l)* $\xrightarrow[170 - 180^oC]{Conc\,H_2SO_4}$ Ethene*(g)* + Water*(l)*

$$CH_3CH_2OH_{(l)} \xrightarrow[170 - 180^oC]{Conc\,H_2SO_4} CH_2{=}CH_{2(g)} + H_2O_{(l)}$$

Table showing what happens during the dehydration of ethanol

Dehydration of Ethanol	Expected behaviour
(i) Conditions of the reaction	Concentrated sulphuric acid and temperatures of 170 – 180°C
(ii) Final product(s) formed	Ethene gas and water
(iii) Identification test of the product	Use of liquid bromine: Turns from brown to colourless Acidified potassium manganate (VII) solution: Turns from purple to colourless
(iv) Word equation	Ethanol*(l)* $\xrightarrow[170 - 180^oC]{Conc\,H_2SO_4}$ Ethene*(g)* + Water*(l)*
(v) Chemical equation	$CH_3CH_2OH_{(l)} \xrightarrow[170 - 180^oC]{Conc\,H_2SO_4} CH_2 = CH_{2(g)} + H_2O_{(l)}$

c) Oxidation reaction of Ethanol:

An alcohol such as ethanol can be oxidized using strong oxidizing agent like acidified potassium manganate (VII) solution [O], to form the corresponding carbonyl compound then finally the corresponding carboxylic acid. This reaction occurs in two stages.

The **first stage** involves **partial** oxidation of ethanol on heating to form ethanal (an aldehyde of carbonyl compound) and water.

Ethanol*(l)* $\xrightarrow[Heat]{[O]}$ Ethanal*(l)* + Water*(l)*

$$CH_3CH_2OH_{(l)} \xrightarrow[Heat]{[O]} CH_3CHO_{(l)} + H_2O_{(l)}$$

The **second stage** involves **complete** oxidation of ethanal (an aldehyde of carbonyl compound) to form Ethanoic acid (an acid of carboxylic acid).

Ethanal*(l)* $\xrightarrow[Heat]{[O]}$ Ethanoic acid*(l)* | $CH_3CHO_{(l)} \xrightarrow[Heat]{[O]} CH_3COOH_{(l)}$

USES OF ALCOHOLS

- Used as disinfectant such as hand sanitizers for killing germs
- Ethanol blended with gasoline serves as fuels in some vehicles to reduce greenhouse gas emissions.
- Ethanol is used in cleaning products, to disinfect surfaces, equipment and medical devices.
- Ethanol is used as food additive, a solvent and a preservative in the food industry.
- Ethanol is used as biofuels reducing total dependence on fossil fuels
- Ethanol is used as a solvent and a reagent in the production pharmaceutical products.
- Ethanol is used as consumable products in beverages such as beer, spirits, wine.

ETHANOL AND THE SOCIETY.

a) Individual impacts of excessive consumption of ethanol

- It leads to total dependence and addiction to an individual.

- Too much consumption can lead to chronic health related problems such as liver disease, heart disease and increase risk of certain cancers.
- Excessive consumption of ethanol, exacerbates mental health conditions of a person causing depression and anxiety.
- Excessive consumption of ethanol, leads to family and relationship impairments.

b) **Societal impacts of excessive consumption of ethanol**

- Drinking while driving cars, leads to fatal accidents in the society.
- Excessive consumption of alcohol disrupts family dynamics and community relationship.
- Excessive consumption of ethanol, can contribute to social issues such as domestic violence, crime, and homelessness.

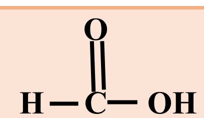
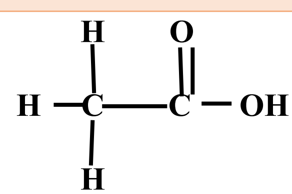
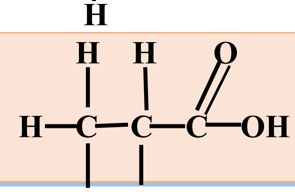
1.13. CARBOXYLIC (ALKANOIC) ACIDS [$C_nH_{2n}O_2$]

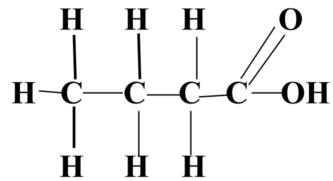
Carboxylic acids are grouped as organic acids. Alkanoic acids form a homologous series with the general formula **$C_nH_{2n}O_2$**. The functional group **-COOH** is also called the carboxyl group. Most organic acid compounds such as citrus fruits (lemon and oranges). Sour milk (yoghurt), Vinegar, tea leaves, Aspirin are examples of carboxylic acids.
The names (Nomenclature) of every member of carboxylic acids in the homologous series come from their corresponding alkane, whereby the ending "e" in alkanes is replaced with the ending "oic acid" in carboxylic acids.

NOMENCLATURE (NAMES) OF CARBOXYLIC ACIDS

No. carbon atoms (n)	**Root name**	**No. Hydrogen atoms**	**Molecular formula**	Add **"oic acid"** to complete the name.
n =1	Methan-	2	**CH_2O_2**	Methanoic acid
n =2	Ethan-	4	**$C_2H_4O_2$**	Ethanoic acid
n =3	Propan-	6	**$C_3H_6O_2$**	Propanoic acid
n =4	Butan-	8	**$C_4H_8O_2$**	Butanoic acid
n =5	Pentan-	10	**$C_5H_{10}O_2$**	Pentanoic acid

b) Copy and complete the table below correctly to show a model of the structural formulae of the first four acids. Remember that each carbon atom has four (4) bonds.

No. carbon atoms	**Name of acid**	**Molecular formula**	**Structural formulae**	**Compressed structure**
1	Methanoic acid			HCOOH
2	Ethanoic acid	**$C_2H_4O_2$**		CH_3COOH
3				CH_3CH_2COOH

			H H	
4		**$C_4H_8O_2$**		$CH_3CH_2CH_2COOH$

SOURCES AND COMMON NAMES OF CARBOXYLIC ACIDS

a) Copy and complete the table below precisely by writing the ***IUPAC*** names and structural formulae of the following carboxylic acids.

Carbon atoms	Common name	Source of the acid	IUPAC Name	Molecular formula	Structural formula
1	Formic acid	Stinger Bees	Methanoic acid	**CH_2O_2**	HCOOH
2	Acetic acid	Vinegar	Ethanoic acid	**$C_2H_4O_2$**	CH_3COOH
3	Propionic acid	Sour milk	Propanoic acid	**$C_3H_6O_2$**	C_2H_5COOH
4	Butyric acid	Sour milk and animal colon.	Butanoic acid	**$C_4H_8O_2$**	C_3H_7COOH
5	Valeric acid	Roots of valerian plants	Pentanoic acid	**$C_5H_{10}O_2$**	C_4H_9COOH
6	Caproic acid	Goat's, cow's milk, coconut oil	Hexanoic acid	**$C_6H_{12}O_2$**	$C_5H_{11}COOH$
7	Enanthic acid	Fats and oils	Heptanoic acid	**$C_7H_{14}O_2$**	$C_6H_{13}COOH$
8	Caprylic acid	Coconut or palm oil	Octanoic acid	**$C_8H_{16}O_2$**	$C_7H_{15}COOH$

b) Copy and complete the following by suggesting the possible sources of the following carboxylic acids. Use internet to access possible details.

Plant acids	Source	Animal acids	Source
Citric acid	Citrus fruits	Stearic acid	Animal fats
Oxalic acid	Plant species of oxalis	Palmitic acid	Palm oil and vegetable oils
Malic acid	Wine, fruits, vegetables like carrots, peas, potatoes		
Tannic acid	Nutgalls of oak trees	Oleic acid	Animal and vegetable oils (Olive oil)
Salicylic acid (Aspirin)	Vegetables like cauliflowers and fruits like watermelons, bark and leaves of willow and poplar trees		

PHYSICAL PROPERTIES OF ALKANOIC ACIDS

a) BOILING AND MELTING POINTS OF ALKANOIC ACIDS

The melting or boiling points of carboxylic acids generally increase with increasing molecular mass of the acids. All carboxylic acids associate to each other through hydrogen bonding. This increases their melting and boiling points as the number of hydrogen bonds increases with length of the carbon chain and functional group.

Acid	M.pt/ °C	B.pt/°C	Density (g/cm^3)
Methanoic acid	8.4	101	1.220
Ethanoic acid	16.6	118	1.049
Propanoic acid	-20.8	141	0.992
Butanoic acid	-6.5	164	0.964
Pentanoic acid	-34.5	186	0.939
Hexanoic acid	-4.0	205	0.659
Benzoic acid	122	266	1.27

ACTIVITY: 1.13(b)

Discussion Questions:

a) Copy and complete following precisely by filling in the missing information in the table below.

Carboxylic acid	Methanoic acid	Ethanoic acid	Propanoic acid	Butanoic acid	Pentanoic acid
Molecular formula					
Structural formula					
No. carbon atom					
Physical state (at 25°C)					

b) State and explain the trend in the:

(i) boiling points of the first five carboxylic acids.

(ii) melting points of the first five carboxylic acids.

ACTIVITY: 1.13(c)

What to do

In groups or individually, discuss on the following physical properties of Carboxylic acids. Share compare your findings with the rest of other groups in your class. Use the table below to write your comprehensive work in your note book.

Discussion Question:

a) Copy and complete the following by explaining how carboxylic acids behave with each physical property. Use the table below.

Physical property	Expected behaviours of alkanoic acids
o General formula	
o Functional group	
o Existence	
o Physical state at r.t.p	
o Melting points	
o Boiling points	
o Solubility in water	
o Effect on **blue** and **red** litmus paper	
o Density	
o Electrical conductivity	

CHEMICAL PROPERTIES OF CARBOXYLIC ACIDS

a) Esterification of carboxylic acids.

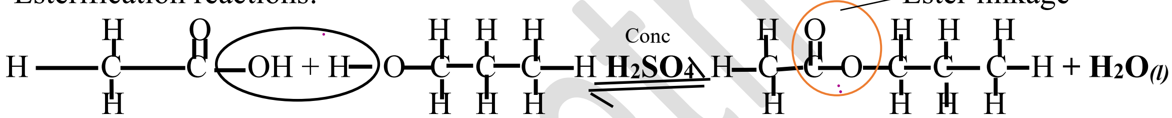
Esterification refers to the reaction between alcohols and carboxylic acids in the presence of concentrated sulphuric acid forming ester and water. Esters have sweet fruity smell in the compounds in which they form. The names of all esters are derived from the alcohols and carboxylic acids which form them. Consider the table below:

Note these points:

- Two molecules join together form a larger molecule called **Ester**, with the loss of a small molecule, water. So, this reaction is called **condensation reaction.**
- The reaction is **reversible**, and **sulfuric acid** acts a catalyst.
- The alcohol part **comes first** in the name – but **second** in the formula.
- Many esters have attractive smells and tastes. So, they are added to shampoos and soaps, Jellies for their smells (Scents), and to ice cream and other foods as flavourings.

Alcohol	Part of ester name from an alcohol	Carboxylic acid	Part of ester name from the acid	Complete name of Ester
Methanol	Methyl	Ethanoic acid	Ethanoate	Methyl ethanoate
Ethanol	Ethyl	Methanoic acid	Methanoate	Ethyl methanoate
Propanol	Propyl	Ethanoic acid	Ethanoate	Propyl ethanoate

Esterification reactions: Ester linkage



(Ethanoic acid) (Propanol) ⇌ (Propyl ethanoate) (Water)

$$CH_3COOH_{(l)} + C_3H_7OH_{(l)} \xrightleftharpoons{\text{Conc } H_2SO_4} CH_3COOC_3H_{7(l)} + H_2O_{(l)}$$

ACTIVITY:1.12(g) To explore the Esterification reaction of alcohols.

What to do: In groups

Discuss the following chemical properties of the alcohols using the table below. Share and compare your finding with the rest of the other group members.

Discussion Questions:

a) Copy and complete the following using the table below precisely.

Alcohol	Part of ester name from an alcohol	Carboxylic acid	Part of ester name from the acid	Complete name of Ester
i) Methanol		Ethanoic acid		Methyl ethanoate
ii) Ethanol		Methanoic acid		Ethyl methanoate
iii)Ethanol		Ethanoic acid		Ethyl ethanoate
iv)Propanol		Ethanoic acid		Propyl ethanoate

b) Write:

(i) a word equation for the reaction which took place in (b) (i) up to (iv) to form ester.

(ii) a chemical equation for the reaction which took place in (c) (i) above.

c) Suggest the name of the process that aided the formation of esters.

d) Copy and complete the table below precisely.

Ester	Alcohol		Carboxylic acid	
	Name	Formula	Name	Formula
$HCOOCH_3$				
$HCOOC_2H_5$				
$CH_3COOC_2H_5$				
$CH_3COOC_3H_7$				

APPLICATIONS OF CARBOXYLIC ACIDS

Carboxylic acids are versatile compounds with a wide range of applications due to their various unique properties they exhibited. Below are some of their applications:

(1) Preservatives:

Carboxylic acids like benzoic acid and sorbic acid, are used to preserve food stuffs, beverages and pharmaceuticals to prevent microbial growth and spoilage.

(2) Synthesis of drugs:

They are used as intermediates in the synthesis of drugs such as aspirin, ibuprofen etc.

(3) Synthesis of soaps and detergents:

Fatty acids are used in the production of soaps and detergents through saponification reactions

(4) Production of polymers:

Carboxylic acids are also used as monomers in the production of polymers like polyamides that makes Nylon, polyesters.

(5) Cosmetics

Carboxylic acids such as glycolic acid and lactic acid, are used in skincare products due to their moisturizing and exfoliating properties.

(6) Cleaning agents

They are used in cleaning surfaces and products as disinfectants and degreasers, due to their ability to dissolve and remove all stains. Example include vinegar.

QUICK EXAM STYLE QUESTIONS:

1. Ethanoic acid is a member of the homologous series that conform to a general formula $\mathbf{C_nH_{2n}O_2}$.

a) Name the series to which ethanoic acid belongs.

b) What is the functional group of the series?

c) Ethanoic acid is *a weak* acid. Explain what this means, using an equation to help you.

d) Ethanoic acid reacts with sodium carbonate.

(i) What would you see during the chemical reaction?

(ii) Write a balanced equation with state symbols for the reaction between ethanoic acid and sodium carbonate.

e) Another member of the series for which n =3 reacts in similar way as ethanoic acid.

(i) Name the member and draw its structural formula.

(ii) Write a balanced equation for the reaction between this compound and sodium hydroxide with state symbols.

2. Ethanoic acid reacts with ethanol in the presence of concentrated Sulphuric acid.

a) Name the organic product formed.

b) Which type of compound is it?

c) What is the function of Sulphuric acid?

d) The reaction is *reversible*. What does it mean?

e) Write a chemical equation for the reaction.

3. Hex-1-ene is an unsaturated hydrocarbon. It melts at 2140°C and boils at 63°C. Its empirical formula is $\mathbf{CH_2}$. Its relative molecular mass is 84.

a) (i) To which family does hex-1-ene belong?
(ii) What is its molecular formula?

b) (i) Hex-1-ene reacts with bromine water. Write an equation to show this reaction.
(ii) What is this type of reaction called?
(iii) What would you see during the reaction?

4. The saturated hydrocarbons form a homologous series with the general formula $\mathbf{C_nH_{2n+2}}$.

a) What is a homologous series?
b) Explain what the term saturated means.
c) Name the series described above.
d) (i) Give the formula and name for a member of this series with two carbon atoms.
(ii) Draw its structural formula.
e) (i) Name a homologous series of unsaturated hydrocarbons, and give its general formula.
(ii) Give the formula and name for the member of this series with two carbon atoms.
(iv) Draw the structural formula for the compound.

f) Copy and complete the following statements correctly by using the words below to fill in the missing words in the passage. The words maybe used once or twice at times**.**
Fractional distillation; boiling point; crude oil; hydrocarbons; temperatures; lighter; longer; heavier; shorter; high; volatile; cracking.

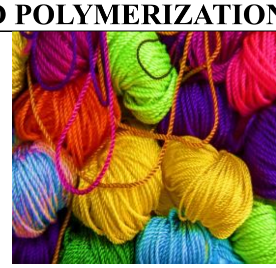
(i) ……………is a method of separating the different fractions of …………...basing on the principle that each fraction has different……….. After…………. the complex hydrocarbons are broken down at high …………into useful short chain …………by a process called …………...in the present of a catalyst.

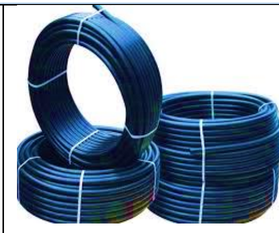
(ii) The …………...and ………...chain hydrocarbons are less ……….and have ………boiling points compared to the ……….and …………...chain hydrocarbons.

5. When ethanol vapour is passed over heated concentrated Sulphuric acid, a dehydration reaction occurs, and the gas ethene is produced.

a) Draw a diagram of suitable apparatus for carrying out this reaction in the lab.
b) What is meant by a dehydration reaction?
c) Write an equation for this reaction, using the structural formulae.
d) (i) What will you see if the gas that forms is bubbled through bromine water?
(ii) You will not see this if ethanol vapour is passed through bromine water. Why not?

1.14. POLYMERS AND POLYMERIZATION

			
Wood	Sisal	Nylon	Rubber

			
Cotton wool	Paper	Perspex	Polyethylene

A polymer can be natural or synthetic materials. Most of the common materials used in carrying out today's activities are made up of polymers.

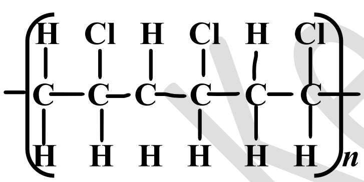
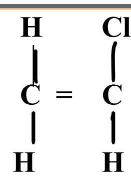
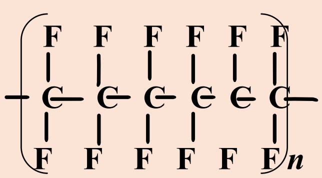
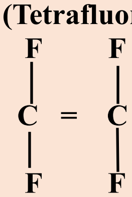
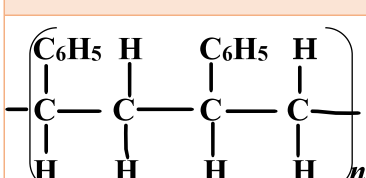
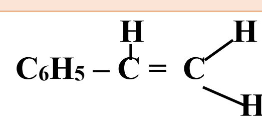
Polymers: are large molecules made up of repeated units of monomers joined together to form long chain of complex molecules. **Monomers**: are units of small molecules which chemically combine together to form large and complex molecules called polymers.

Natural polymers: These are complex molecules made up of repeated units of natural monomers. **Synthetic polymers**. These are complex molecules made up of repeated units of man-made monomers.

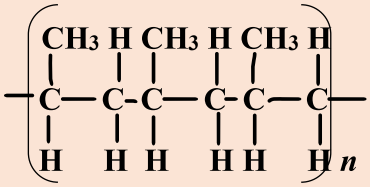
Polymerization reaction is a chemical reaction where several monomers react with each other to form repeated units of large molecules. It involves two types of reactions, addition polymerization and condensation polymerization.

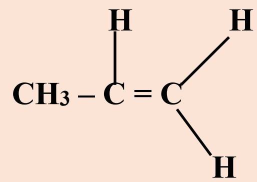
ADDITION POLYMERIZATION OF PLASTICS

Addition polymerization is the process in which unsaturated monomers react with each other to form a polymer without loss of any byproducts. This type of polymerization commonly occurs with unsaturated monomers such as alkenes which contain carbon – carbon double bonds.

Polymer	**Monomer**
 Polychloroethene (Polyvinyl chloride PVC)	 **(Chloro ethene)**
Polytetrafluoroethene (Teflon) 	**(Tetrafluoro ethene)** 
 **Polysterene**	 **(Phenyl ethene)**

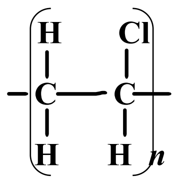
Polypropene

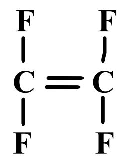




QUICK EXAM STYLE QUESTIONS:

1. a) The polymer ‘Teflon’ is obtained from the monomer tetrafluoroethene, which has this structure **(Y)** **(X)**





(i) Which feature of the monomer makes polymerization possible in **X**?
(ii) Which type of polymerization occurs in structure **X**?
(iii) Draw three units in the structure of the macromolecule that forms polymer of **X**.
(iv) Give the chemical name for this polymer **X**

b) The polymer Polychloroethene **Y** has been used to make ‘cling film', for covering food to keep it fresh.
(i) What does **n** represent?
(ii) Name the monomer, and draw its structural formula.
(iii) Which type of polymerization takes place?

c) One property of Polychloroethene is its low *permeability* to moisture and gases.
(i) Explain what is meant by the term ***permeability***.
(ii) That property is important in keeping food fresh. Why?

2. Polychloroethene is *non-biodegradable*.
a) Explain the term **non -biodegradable** materials**.**
b) Describe the major environmental problems caused by the poor disposal of such plastics.

USES OF SYNTHETIC POLYMERS

ACTIVITY: 1.14(b) To find out the different uses of synthetic polymers:

What you need:
Access to computer or using your smartphone for internet, textbook, notebook.

What to do:
In groups or individually, carryout the following research to investigate the different uses of synthetic polymers in our day – today life activities. Share and compare your findings with the rest of the class.

Discussion Questions:

a) Copy and complete the table below precisely.

Synthetic Polymer	Monomer	Type of polymerization
Polyethene		
Polyvinylchloride (PVC)		
Teflon		
Polypropene		

Polystyrene		
Nylon (Polyamide)		
Perspex		
Terylene		

PLASTICS: (are here to stay)

Plastics: the problem There were only a few plastics around the world before the 1950s. Since then, dozens of new ones have been developed, and more are on the way. Now it is hard to imagine life without them. They are used everywhere. One big reason for their success is their unreactivity. But this is also a problem. They do not break down or rot away. Most of the plastics thrown out in the last 50 years are still around – and may still be here for another 50 years from now. A mountain of waste plastic is growing.

Polythene: **the biggest problem**

Polythene is the biggest problem. It is the most-used plastic in the world, thanks to its use in plastic bags and food packaging. Around 5 trillion polythene bags are made every year. Most of plastic materials, are used only once or twice, then thrown away.

In many places, rubbish is collected and brought to **landfill sites.** The plastic bags fill up these sites. In other places, rubbish is not collected. So, the plastic bags lie around and cause many problems.

Word problems associated with plastics

- They choke birds, fish including other animals that try to eat them.
- They fill up the animals' stomachs so that they cannot eat proper food, and starve to death. (Animals cannot digest plastics.)
- They clog up drains, and sewers, and cause flooding.
- They collect in rivers, and get in the way of fish. Some river beds now contain a thick layer of plastic, causing death of fish and water pollution.
- They blow into trees and onto beaches. So, the place looks a mess. Tourists are put off – and many places depend on tourists.

Measures and Mitigations to be taken on plastic use:

Because of these problems, plastic bags have been banned in many countries including Bangladesh, Rwanda, Kenya, Morocco, Italy and several states in China and India.

Development of Biodegradable plastics:

Biodegradable polythene is already here in Uganda. Some of the plastics nowadays are **biodegradable**: they contain **additives** such as starch that bacteria can feed on. Some of the plastics are **photodegradable**: it contains **additives** that break them down in the presence of sunlight. In both cases, the result is that the polythene breaks down into tiny flakes. The amount of additive can be varied for different purposes – for example to make rubbish sacks that will break down within weeks.

ACTIVITY: 1.14(c)

In groups or individually, discuss the effects of waste plastics in the society. Share and compare your findings with the rest of the class. present them before the rest of the class.

Discussion Questions:

a) Explain the problems caused by waste plastics in the society.

b) How can the problems of waste plastics be prevented?

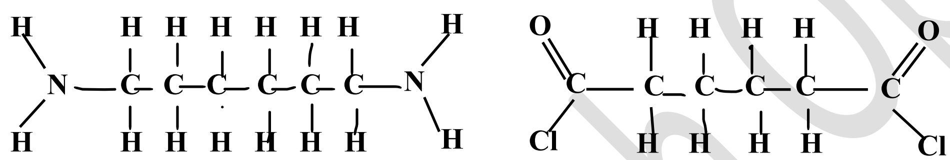
c) Countries such as Rwanda, Kenya Morocco and China are no longer using non – biodegradable plastic bags but rather biodegradable plastic bags. Explain the concept of "***biodegradable plastics"*** to the environment.

CONDENSATION POLYMERIZATION:

Condensation polymerization is the process whereby monomer molecules join up together to form complex molecules with loss of small molecules. Such as water or hydrogen chloride as smaller byproducts. In condensation polymerization, unlike addition polymerization, no double bonds break. Instead:

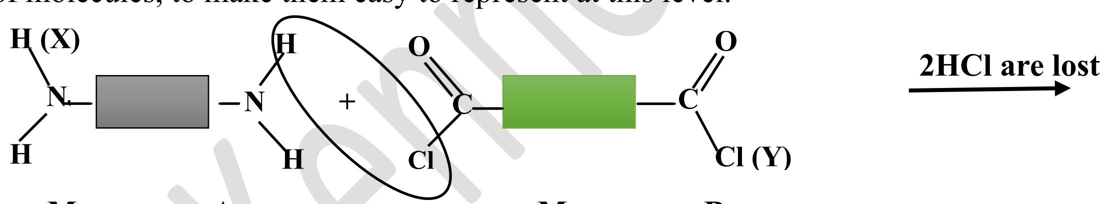
- two different monomers join.
- Each different monomer has two but same functional groups that take part in the reaction.
- the monomers join at their functional groups, by getting rid of or **eliminating** small molecules. **Condensation polymerization of Nylon (Polyamide)**

Below are two but different monomers **A** and **B** used in making Nylon.



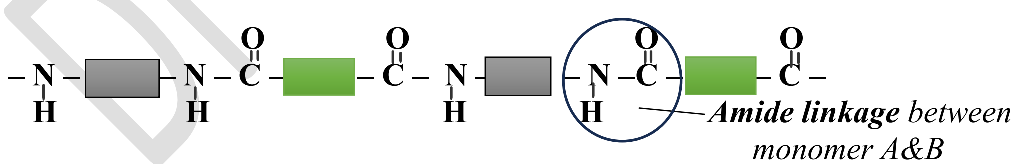
Monomer – A **Monomer – B**

Monomer – A has **two NH_2** group at each end and **Monomer – B** has **two COCl** group at each end also. Only these functional groups take part in condensation polymerization reaction. The other part of **Monomer – A** and **Monomer – B** can be represented as ***blocks*** of molecules, to make them easy to represent at this level.



Monomer – A **Monomer – B**

Monomer – A at part (**X**) joins another **Monomer – B** while **Monomer B** at part (**Y**) also joins another **monomer A** eliminating hydrogen chloride molecule. The overall polymer of **Nylon** (***Polyamide***) is



ACTIVITY:1.14(f)

What to do:

In groups or individually, carryout the following research to investigate the different uses of natural polymers in our day – today life activities. Share and compare your findings with the rest of the class.

Discussion Questions:

a) Copy and complete the table below precisely.

Natural Polymer	Monomer	Type of polymerization
Polyester		
Nylon (Polyamide)		
Cellulose		
Starch		
Protein		
Rubber		
DNA		
Polypeptide		
Polyester		

1.15. FATS AND OILS

Fats and oils: Are natural polymers called lipids obtained from animals and plants. Both fats and oils are composed majorly by natural monomers called **fatty acids** and **glycerol** obtained from both plant and animal sources.

Examples of **animal fats** are:

i)**Butter:** Obtained from dairy products, **Lard:** Obtained from rendered pork fat.

Examples of **plant fats** are, **coconut oil,** and **palm oil.**

Examples of **plant oils** are **olive oil, Avocado oil,** and **sunflower oil**.

Characteristics of fats and oils.

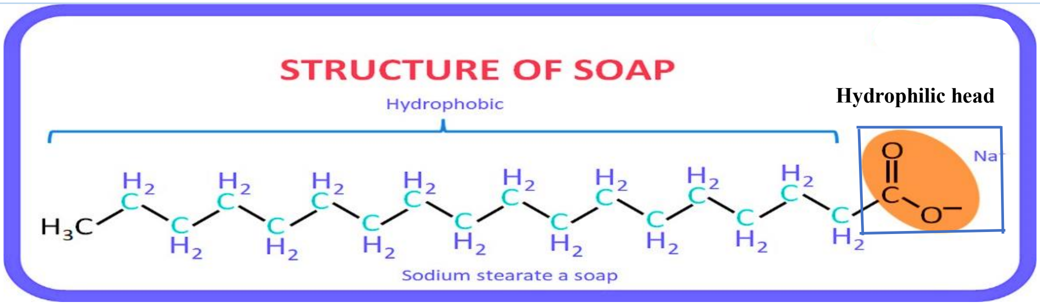
Physical properties	Natural fats	Natural oils
Physical state at r.t.p	Solid at room temperature	Liquid at room temperature
Composition of polymers	Made up of fatty acids	Made up of glycerol
Source	Animal fats	Plant oils

1.16.SOAPS AND DETERGENTS.

SOAPS:

Soap is a sodium or potassium salt of a long chain carboxylic acids or fatty acids. Soap is also known as sodium stearate or potassium stearate. The process of making soaps using sodium (potassium) hydroxide and fatty acid (oil) is known as **saponification**.

Sodium stearate is mainly used as washing soaps while potassium stearate is used as bathing soaps



STRUCTURE OF SOAPS

Soaps are made of two ends, one end is the sodium (potassium) ion, the other end is the long chain carboxylic acids (esters). The end which is made up of sodium (potassium) ions forms the **hydrophilic head** of the soap while the other end of the soap forms **hydrophobic tail** of esters. The hydrophilic head of the soap loves water, hence water loving, forming **polar head** of the soap while the other end hates (repels) water, it forms **non – polar tails** of the soap.

The whole soap is called **Sodium stearate** with the general formula $\boldsymbol{StCOO^{-}}$**Na**$^{+}$ where **St** is the long chain Hydrocarbon tail (Hydrophobic tail / non – polar tail) while $\boldsymbol{COO^{-}}$**Na**$^{+}$ is the (Hydrophilic head / Polar head) of soap

How to make bar soaps

ACTIVTY1.15(a)

What you need:

Coconut oil, 20% sodium hydroxide, sodium chloride, soap mould board, stirring rod, mixing bucket, weighing balance, measuring cylinder, heat source, glass beaker and hand gloves.

CAUTION!

- Avoid getting into contact with sodium hydroxide since it is very corrosive.
- Avoid carrying out this activity with windows and doors closed since sodium hydroxide release strong shocking and suffocating particles in the air, or conduct the activity in a fume cupboard to avoid inhaling these particles.
- Always put on hand gloves and eye goggles to avoid getting into contact with sodium hydroxide.

What to do: In groups

1. Obtain 50cm^3 of coconut oil using a measuring cylinder into a glass beaker.
2. Measure 50cm^3 of 20% sodium hydroxide solution using another measuring cylinder. Transfer it into a beaker containing coconut oil.
3. Transfer the mixture of coconut oil and 20% sodium hydroxide and boil until it forms porridge – like liquid, while stirring using a glass rod.
4. Weigh to obtain 20g of sodium chloride. Transfer the salt into a glass beaker containing a mixture of porridge – like liquid and continue stirring.
5. Transfer the liquid mixture and pour it into a soap mould board, allow it to cool until it solidifies.
6. Present your sample soap to the rest of the class.

Discussion Questions:

a) Explain what is meant by term "**saponification**"

b) State the raw materials you have used in the preparation of the above soap.

c) Of what importance is sodium chloride during soap preparation?
d) Draw a flow chart to show how soap is prepared.
e) What name is given to the process of making soap?
f) Write a:
(i) Word equation for the reaction between sodium hydroxide and stearic acid (coconut oil) to form sodium stearate salt.
(ii) Chemical equation for the reaction in (e) (i) using state symbols.

How to make liquid soaps

ACTIVITY:1.15(b)

What you need:
Access to internet from a computer or smartphones, and your notebook.

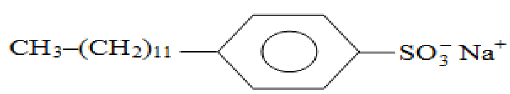
What to do: In groups:
Dicusss by carrying out research on how liquid soap is prepared by visiting computer library or using your smartphone for internet. Share and compare your findings with the rest of the class. write them down in your notebook.

Discussion Questions:
a) State the raw materials required when preparing liquid soap.
b) Describe how liquid soap is formed from the materials stated in (a) above.

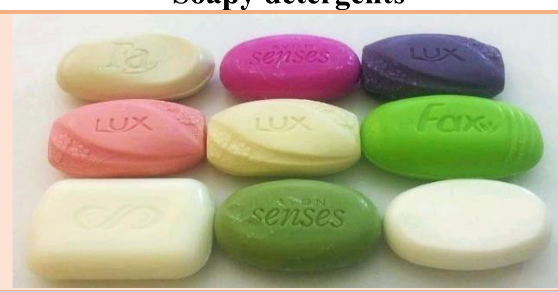
DETERGENTS

$$C_{12}H_{25}–C_6H_4 – SO_3^- Na^+$$

OR



Detergents are also known as **soapy** or **soapless** detergents. Just like soaps, detergents work the same way as soap but they are more effective than soaps. Soapy detergents are soaps obtained from natural fats or oils. Soapless soaps are **synthetic detergents** that have similar properties to soaps but don't contain the usual soaps like sodium salts of fatty acids. Therefore, they are referred to as **soapless soaps.**

Soapless detergents	Soapy detergents
 Soapless detergents include washing powder, washing-up liquids and shampoos. They are called 'soapless' because they contain no soap.	

How to make soapless detergents

ACTIVITY:1.15(c)

What you need:
Castor oil, Glass beaker, Dropper, Concentrated Sulphuric acid, cold water, bucket, measuring cylinder and dropping pipette.

What to do: In groups
1. Using a measuring cylinder, obtain $5cm^3$ of concentrated sulphuric acid and pour it into a clean glass beaker.

2. Add $2cm^3$ of castor oil using a dropping funnel into a glass beaker containing concentrated acid, swirl gently to mix. What happens to the walls of beaker?
3. Gently warm the mixture and add about $10cm^3$ of 4M sodium hydroxide and stir. The mixture gets hot, viscous and dark
4. Add $5cm^3$ of distilled water and stir. Then decant to separate the liquid from the solids. The solid is the Soapless detergent which is then washed with distilled water.
5. Remove a small sample of the product above into a clean test tube. Add about $5cm^3$ of water and shake well for sometimes. Note what happens.

Discussion Questions:

a) Suggest what is meant by soapless detergent.
b) Name the raw materials required in the preparation of soapless detergents.
c) Draw a flow chart to show how soapless detergents are prepared from the materials named in (b) above.

Effectiveness of soapy and soapless detergents as Cleansing agents

ACTIVITY:1.15(d)

What you need:

Measuring cylinder, two basins, two pieces of dirty oily cloth, measuring cylinder, 5% soapy detergent solution, 5% soapless detergent solution, $1moldm^{-3}$ magnesium sulphate solution and labels.

What to do:

In groups carryout the following procedures to compare which of the two detergents is more effective as a cleaning agent and readily forms lather with water and removes stains with ease.

1. Obtain basins and label them as $\mathbf{A_1}$ and $\mathbf{A_2}$ respectively.
2. To basin $\mathbf{A_1}$, add one litre of magnesium sulphate solution (hard water).
3. Measure and add $100cm^3$ of 5% soapy detergent solution in basin $\mathbf{A_1}$.
4. Wash a dirty oily piece of cloth in basin $\mathbf{A_1}$. Make your observation after drying the piece of cloth in the sun.
5. Reapeat procedures 2, 3 and 4 using basin $\mathbf{A_2}$ and 5% soapless detergent solution.

Discussion Questions:

a) Identify which of the two detergents (i) Formed lather readily with hard water. (ii) Did not formed lather readily with hard water	b) Which of the two detergents is: (i) More efficient at removing stains in a piece of cloth? (ii) Less efficient at removing stains
c) What conclusion do you make about the two detergents?	d) Make a poster showing how soap removes (emulsifies) fats or oils.
e) Explain your answers in (b) above.	

Emulsification action of soaps or Soapless detergents in removing greasy stains

Both soaps and Soapless detergents are very effective in removing dirt and disease - causing organisms from our bodies and clothes.

Soaps and Soapless detergents have both polar groups (hydrophilic heads, as water loving parts) and non – polar groups (hydrophoboc tails, that attract greasy stains)

The hydrophobic ends of soap molecules move away from the water surface while the hydrophilic ends move towards layer of water molecules. This reduces the surface tension of water, allowing formation of lather with water.

The hydrophobic ends move around in bunches and attract themselves on dirt from clothes and our bodies through chemical reaction and mechanical action. This helps breaking down the dirt (oily) particles into tiny droplets of particles that settle as a suspension called **emulsion**.

Knowledge Check:

a) Name the part(s) of soap that:

(i) Attracts water molecules to form lather readily with water.

(ii) Attracts greasy stain molecules to form emulsions with soap.

b) Explain the cleansing action of soap on dirty stains.

SOAPLESS DETERGENTS AND ENVIRONMENTAL SAFETY

These are sometimes referred to as synthetic detergents, they have several negative effects on the environment, as follows:

1) Water pollution:

Soapless detergents contain phosphates that can pollute water ways when they are washed down the drains, causing harms to aquatic life and ecosystems.

2) Algal blooms:

Algae grow excessively in the presence of excess phosphates produced from the use of soapless detergents, leading to algal blooms. They cover the surface of the water, blocking sunlight and oxygen from reaching other aquatic organisms, causing them to die.

3) Eutrophication:

This is a process where water bodies become highly enriched with nutrients such as phosphorous and nitrogen leading to excessive growth of algae in the water bodies.

4) Oxygen depletion:

When algae die and decompose, bacteria consume oxygen during the decomposition process. This leads to a net reduction in the amount of oxygen in the water, creating high oxygen demand by aquatic life

How to make use of soaples detergents sustainable

1) Encouraging the manufacturers to eliminate or minimize the use of harmful chemicals such as phosphates that can poison and harm aquatic life and disrupt the ecosystems.

2) Encouraging the manufacturers to formulate detergents using biodegradable ingredients that can break down more easily without harming the environment, reducing their impact on waterways and ecosystems.

3) Encouraging the use of surfactants derived from renewable resources such as bio – based surfactants to reduce on their effect on the environment.

ACTIVITY:1.15(e)

What you need:

Access to the computer or smartphone, textbooks, notebooks.

What to do: In groups

Carryout **research** by visiting computer library or using your smartphones for internet or textbooks tp findout the effects of soapless detergents on the enviroments such as water bodies. Share and conpare your findings with the rest of the other groups in your class. write them in your notebook.

Discussion Questions:

a) Explain the following terms as used in water pollution.

(i) Algal blooms (ii) Eutrophication.

b) What are the effects of excessive use of soapless detergents into the water body?

c) What are the:
(i) Advantages of normal soaps over soapless detergents?
(ii) Disadvantages of soapless detergents?
(iii) Differences between normal soaps and soapless detergents?
(iv) Similairities between normal soaps and soapless detergents?

SAMPLE OF ACTIVITY OF INTERGRATION

SCENARIO

Today every house hold in Uganda on a daily basis use carbon to support life. They may include food stuffs, drinks (both hard and soft drinks), household materials, laundry materials, petroleum products, most of these organic products have specific uses, classes of the organic compounds and different functional groups.
Your school is organizing academic day where all the parents are invited. The Headteacher of your school, wants the parents and the rest of the entire school to appreciate the values of "**Carbon in life**" in our day – to – day life activities.

TASK:

The head of Chemistry department, selected you to prepare an article that will be presented before the parents and the rest of the school. Your presentation should include:

a) The class and functional group of the different organic compounds found in the places mentioned above.
b) The different importance of each material of the different classes of organic compounds mentioned above in our day – to – day life activity.

TOPICAL SUMMARY

In this chapter of "**Carbon in life**", you learnt that: -

- **Petroleum oil** is also known as crude oil. Petroleum oil is a smelly mixture of hundreds of different alkanes compounds.
- Products of petroleum oil can only be obtained by fractional distillation in oil refinery, such products may include natural gas, and different fractions of alkanes.
- **Natural gas** is the first fraction and it contains mainly methane gas. Methane gas is used as fuel gas. Methane is a central raw material used as chemical feedstocks for making other useful organic products.
- **Biogas** is a carbon – based fuel obtained from biomass. It constitutes of natural gas (methane gas) used as fuel gas.
- **Homologous series** Refers to a group of organic compounds with the same general formular, similar structural formulae, similar chemical properties in which the successive members differ from the next by methylene group. (– CH_2 – group).
- **Hydrocarbons**: Are organic compounds that contain carbon and hydrogen atoms only. They are groups as **saturated** and **unsaturated** hydrocarbons.
- Alkanes are the first homologous series, with a general formula of C_nH_{2n+2}, followed by alkenes with general formula, C_nH_{2n}, alkynes with general formula, C_nH_n, alcohols with general formula, $C_nH_{2n+1}OH$, Carboxylic acids with general formula, $C_nH_{2n}O_2$. Each homologous series have different physical and chemical properties, different functional groups but same root names.
- Fermentation and chemical methods are the major brewing methods of preparing ethanol, fermentation is biological since it involves enzymes diastase, maltase and zymase. Excessive consumption of ethanol is not good for your health.

- **Polymers**: are large molecules made up of repeated units of monomers joined together to form long chain of complex molecules. **Monomers**: are units of small molecules which chemically combine together to form large and complex molecules called polymers. It involves mainly two types natural and synthetic polymers.
- . **Polymerization reaction** is a chemical reaction where several monomers react with each other to form repeated units of large molecules. It involves two types of reactions, **addition** polymerization and **condensation** polymerization.
- **Soap**: is a sodium or potassium salt of a long chain carboxylic acids (fats and oils). Soap is also known as sodium stearate or potassium stearate. The process of making soaps using sodium (potassium) hydroxide and fatty acid (oil) is known as **saponification**.
- Detergents are mainly Soapless and soapy detergents, they are very effective when used in hard water than ordinary soaps. Some Soapless detergents are non – biodegradable, making them unsustainable to the environment such as water bodies.