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S3 New Curriculum chemistry

Theme: Carbon in life

Chapter 1 – Carbon in life

Carbon is the main components of the very many compound in living things and nonliving things including fossil fuels, synthetic polymers such as plastics, nylon and PVC, natural polymers such as silk, wool, cellulose and sisal fibres and cleansing agents such as soap and detergents.

Crude oil

Crude oil is a naturally occurring, liquid fossil fuel composed mainly of **hydrocarbons**— compounds of carbon and hydrogen. It is formed over **millions of years** from the remains of ancient living organisms that were buried under sediment and subjected to heat and pressure. In Uganda large deposits of crude oil are located south-western region.

Composition & Properties:

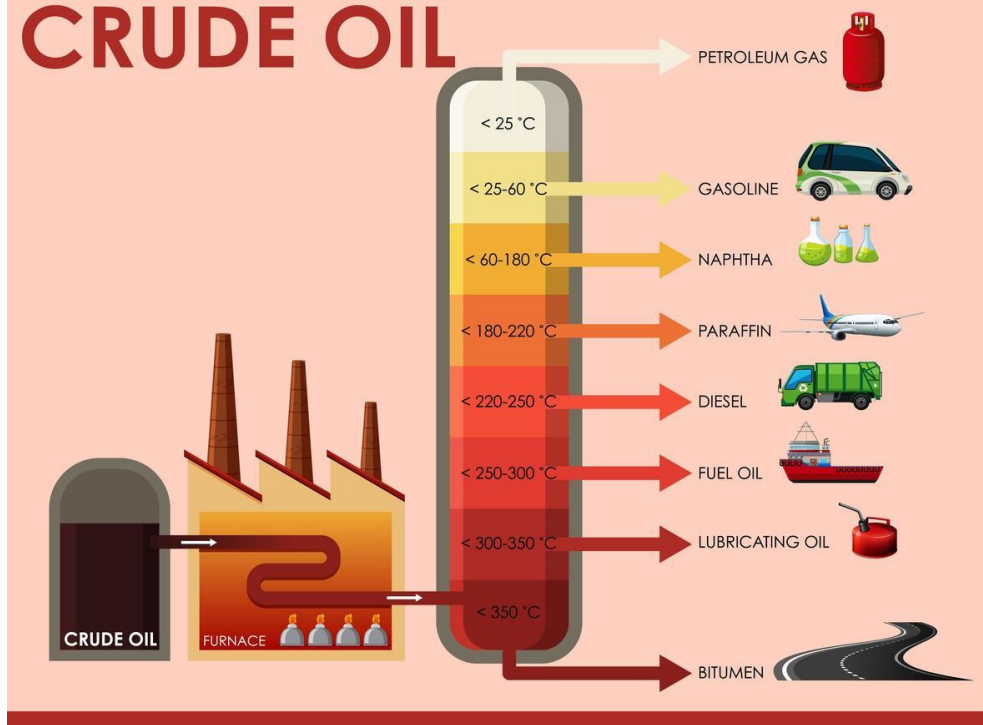
- Made up of organic compounds mainly hydrocarbons or compound made of carbon and hydrogen only such as **alkanes, cycloalkanes, and aromatic hydrocarbons;** alcohols and carboxylic acid.
- Contains **sulfur, nitrogen, and oxygen impurities.**
- Its density, viscosity, and sulfur content vary depending on the source.

Refining & Uses:

Crude oil is **refined** into various useful hydrocarbons classified according depending on their boiling points by **fractional distillation**. **Note that** the boiling points of hydrocarbons depend on the number of carbon atoms in its compounds.

FRACTIONAL DISTILLATION

CRUDE OIL



Main Fractions of Crude Oil & Their Uses:

Fraction	Carbons atoms per molecule	Distilling temperatures (°C)	Uses
Natural gas	1-4	Below 40	Used as fuel for cooking and light
Petrol (gasoline)	5-10	40 - 175	It's a car fuel.
Naphtha	6 - 12	70–200°C	Makes chemicals for plastics, dyes, and medicines.
Kerosene/ paraffin	10 - 14	200–300°C	Used for lighting, cooking and jet fuel for airplanes.
Diesel	14-18	300-350	Used as a fuel for diesel engine for buses, trucks, trains ships and electricity generators.
Lubricating oil	Above 18	350 - 400	It is used for lubricating machines, wax and polishes.
Bitumen	Above 40	Above 400	It is used for road surfacing , roofing and waterproofing materials

Cracking

Cracking is the breakdown of long chain hydrocarbons into useful short chain hydrocarbons by heat (thermos-cracking) or by a catalyst (catalytic cracking)

Natural gas

Natural gas is a **fossil fuel** primarily composed of **methane (CH₄)**, along with smaller amounts of other hydrocarbons like ethane, propane, and butane. It was formed over **millions of years** from the decomposition of organic matter buried deep within the Earth.

Trail exercise 1

Complete the following passage by filling in the missing words

- (a) Crude oil or is separated into different components by a process called The process of breaking down or converting long chain hydrocarbons into molecules with shorter chains is called
- (b) The different hydrocarbons in crude oil can be separated because they have
- (c) Hydrocarbon with longer chains have boiling points than hydrocarbons with shorter chains
- (d) The gaseous products formed from crude oil contain between carbon atoms.
- (e) Is the main gas found in natural gas?

Biogas

Biogas is produced by anaerobic decomposition of organic matter (cow dung, faeces, plant remains) in presence of water. The main component of biogas is methane . Biogas is used for light and cooking. The residue that remains after production of biogas is called bio-slurry and it is used as fertilizers.

Uses of Biogas

- (i) **Electricity Generation** – Burned in power plants or generators to produce electricity.
- (ii) **Cooking & Heating** – Used as a household fuel for stoves, ovens, and water heaters.
- (iii) **Transport Fuel** – Compressed into **Bio-CNG** for vehicles, reducing reliance on petrol and diesel.
- (iv) **Industrial Applications** – Provides energy for manufacturing processes.
- (v) **Waste Management** – Helps in treating organic waste while generating useful energy.
- (vi) **Greenhouse Reduction** – Prevents methane emissions from decomposing organic matter.
- (vii) **Fertilizer Production** – The **digestate** (residue) from biogas production is a rich organic fertilizer for farming.

Advantages of using biogas

- **Renewable & Sustainable** – Produced from organic waste, ensuring a continuous supply.
- **Improves Soil Health** – The byproduct (**digestate**) is a rich fertilizer that enhances crop growth.
- **Cost-Effective** – Reduces dependency on expensive fuels like LPG or electricity.
- **Cleaner Cooking Alternative** – Emits fewer pollutants than traditional wood or charcoal fires.
- **Reduces Deforestation** – Limits the need for firewood and charcoal, helping conserve forests.

Trail exercise 2

- What is the chemical nature of biogas?
- Give advantages of using biogas over using charcoal for fuel
- Why is biogas called clean energy?
- Why is biogas considered as a renewable fuel

Carbon compounds

Carbon forms very many useful compounds with different physical and chemical properties. These include hydrocarbons, proteins, carbohydrates, fats and so on

Importance of carbon compounds

- food
- Drugs
- Perfumes
- Clothes
- Shoes
- Dyes
- Detergents for washing
- Packing materials
- Herbicide to dry weeds

Organic chemistry

It is a branch of chemistry that studies organic compounds

Terminologies of organic chemistry

Hydrocarbons are compounds that contain carbon and hydrogen only

Functional groups are reactive parts of organic compounds for example

Double bonds (C=C) for alkenes

Triple bonds for C \equiv C) alkynes
 Hydroxyl group (-OH) for alcohols
 Carboxylic groups (-COOH) for carboxylic acids

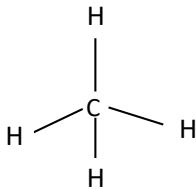
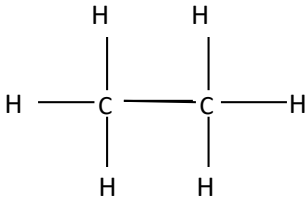
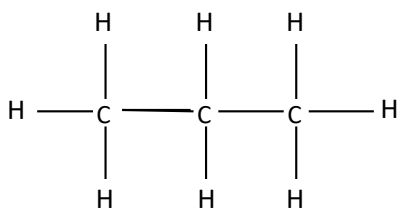
Homologous series

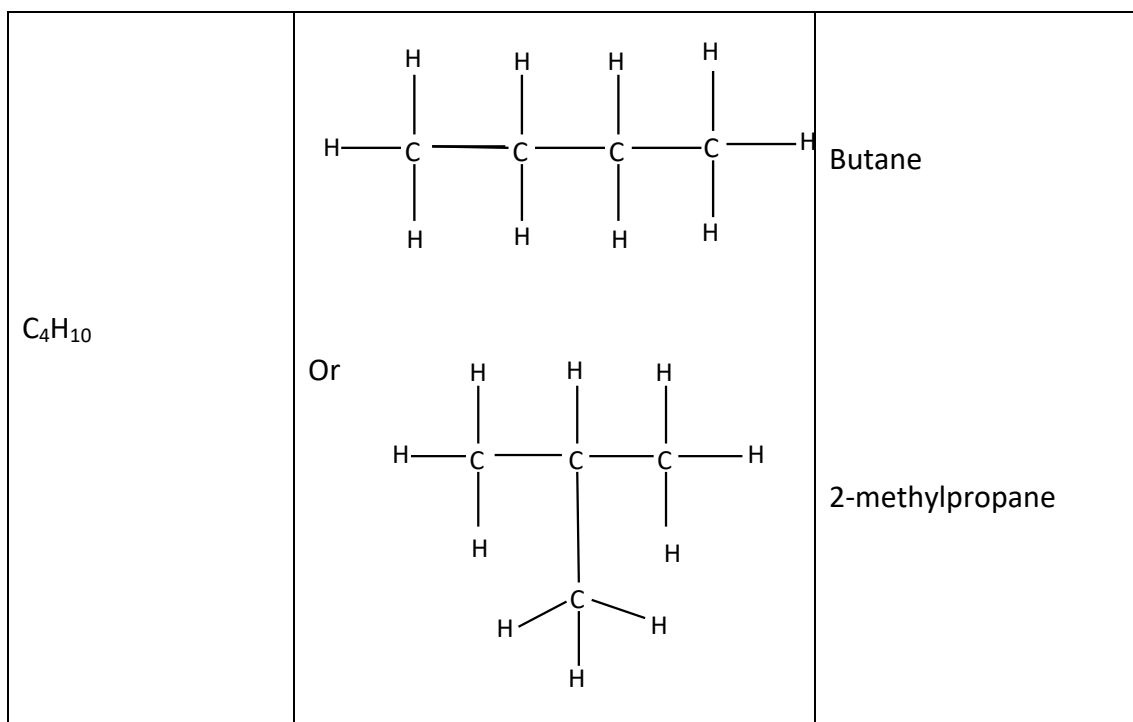
These are group of compounds with members related as follows

- Members have similar general formula e.g. the general formula of alkanes is C_nH_{2n+2} .
- Have similar functional groups and thus same chemical properties
- Have similar methods of preparation
- Show gradual change in physical properties for instance alkanes range from gases to liquids to solids

Alkanes

This is the simplest homologous series with saturated hydrocarbons with a general formula C_nH_{2n+2} . Alkanes are describes as saturated because each carbon atom in their molecules bonds to other atoms by single bonds only.

Examples		
Molecular formula	Structural formula	name
CH ₄		methane
C ₂ H ₆		ethane
C ₃ H ₈		Propane



Compounds with the same molecular formula but different structural formulae like butane and methylpropane are called **isomers**

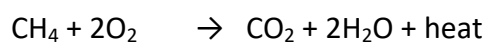
Physical properties of alkane

- they are insoluble in water
- they are soluble in organic solvents
- they range from gases to liquids to waxy solids. The first four members ($C_1 - C_4$) are gases, then next 11 members ($C_5 - C_{16}$) are liquids, the rest are waxy solids.

Combustion of alkanes

Alkanes burn in air to produce carbon dioxide, water and heat. Due to production of heat they are used as fuel.

Example



Preparation of alkanes

1. By distillation of petroleum oil
2. By cracking: cracking is the breakdown of long chain hydrocarbons into useful short chain hydrocarbons by heat (thermos-cracking) or by a catalyst (catalytic cracking)
3. From Biogas: methane is the main component of biogas. Biogas is produced by anaerobic decomposition of organic matter (cow dung, feces, plant remains) in presence of water

Trail exercise 3

- (a) Give the meaning of the following terms
- (i) Hydrocarbons
 - (ii) Functional groups
 - (iii) isomers
- (b) Write the general formula of alkanes.
- (c) Write the products when alkanes are burnt.

Alkenes

These are hydrocarbons that contain a double bond. Alkenes are unsaturated compounds because they contain a double bond.

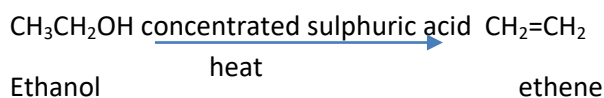
General formula is C_nH_{2n} $n \geq 2$

Examples of alkenes

Name	Molecular formula	Structural formula
Ethene	C_2H_4	
Propene	C_3H_6	
Butene	C_4H_8	

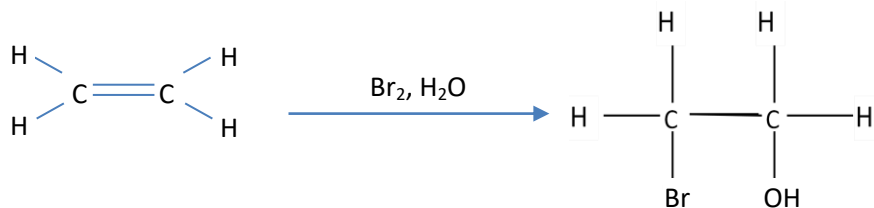
Preparation of ethene

By dehydration (removal of a water molecule from) of ethanol with hot concentrated sulphuric acid

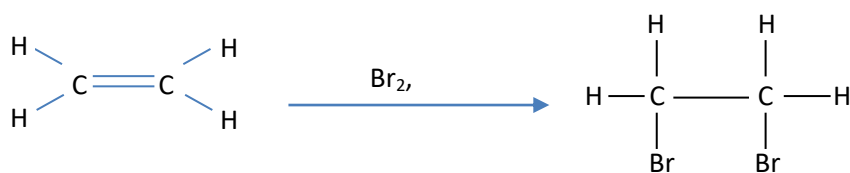


Testing or ethene

1. Ethene decolorizes bromine water.



2. Ethene decolorized bromine in tetrachloromethane



Physical properties of alkene

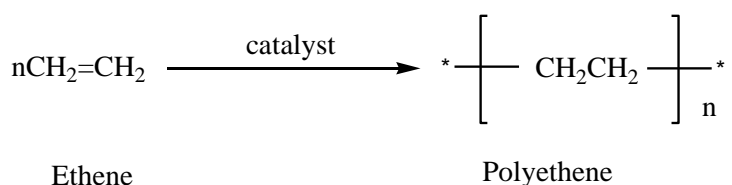
- they are insoluble in water
- they are soluble in organic solvents
- they range from gases to liquids to waxy solids. The first four members ($\text{C}_1 - \text{C}_4$) are gases, ($\text{C}_5 - \text{C}_{10}$) are liquids, the rest are waxy solids.

Uses of alkenes

- (i) They are used as fuel because they burn in air to produce heat. For example, ethene reacts with air to form carbon dioxide, water and heat.
$$\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O} + \text{heat}$$
- (ii) Alkenes react to form polymers used to make plastics such as Jerri cans and chairs.

A polymer is a molecule with high molecular mass formed combination of very many small molecules called monomers. For example ethene polymerises to form polythene.

Examples



Uses of polyethene

- Insulator
- Water pipes
- Packing materials
- Chairs and tables

Trail exercise 4

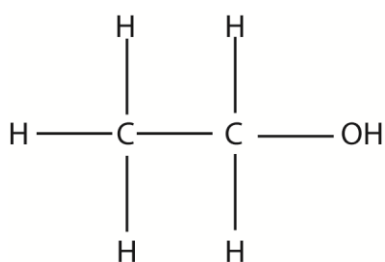
- Write the molecular and structural formulae of ethene
- Mention three use ethene

Alcohols

They are carbon compounds that contain hydroxyl (-OH) group.

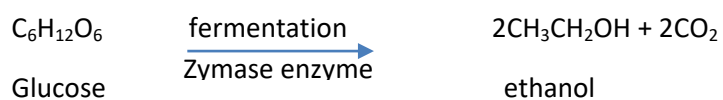
Example

Ethanol or $\text{CH}_3\text{CH}_2\text{OH}$



Preparation of ethanol

By fermentation of glucose or starch containing food (cassava, maize, and bananas)



Our ethanol is obtained from these local drinks by distillation.



Examples of alcoholic drink in Uganda

Uses of ethanol

Social drink
Antiseptic in soft drinks
Production of ethene
Non-smoky fuel



Ugandans enjoying traditional alcoholic drink (Malwa)

Alcohol abuse

Alcohol abuse, also known as **alcohol use disorder (AUD)**, is a condition where a person consumes alcohol excessively, leading to negative effects on health, relationships, and daily life. It can range from **mild to severe**, with symptoms including loss of control over drinking, withdrawal effects, and continued alcohol use despite harmful consequences.

Effects of Alcohol Abuse

- **Physical Health Risks** – Liver damage, heart disease, high blood pressure, and increased risk of cancer.
- **Mental Health Issues** – Depression, anxiety, memory loss, and impaired judgment.
- **Social & Behavioral Problems** – Strained relationships, job loss, financial difficulties, and legal troubles.
- **Addiction & Dependence** – Increased tolerance, withdrawal symptoms, and compulsive drinking.

Treatment & Recovery

- **Therapy & Counseling** – Cognitive behavioral therapy (CBT) and support groups help manage addiction.
- **Medical Treatment** – Detox programs and medications assist in reducing alcohol dependence.
- **Lifestyle Changes** – Healthy habits, exercise, and social support improve recovery outcomes.

Trail exercise 5

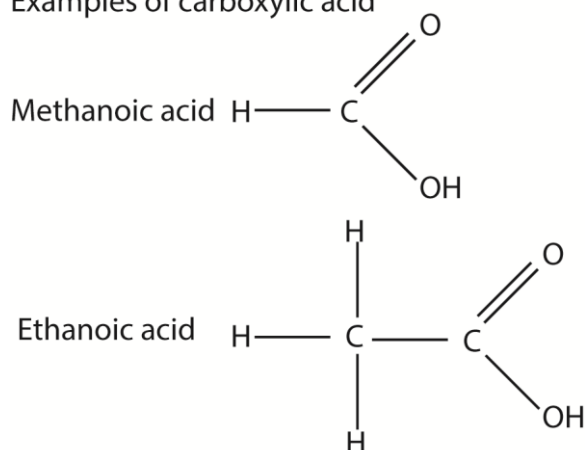
Discuss how any local alcoholic drink is made in your community?

- Identify the raw materials
- Explain the steps and conditions followed.
- How is pure ethanol obtained from these local alcoholic drinks.

Carboxylic acids

They are carbon compounds that contain carboxylic group (- COOH).

Examples of carboxylic acid



Examples of home materials that contain carboxylic acids



Uses of Carboxylic Acids

Food & Beverages

- Acetic acid (vinegar) is used as a preservative and flavor enhancer.
- Citric acid is found in citrus fruits and used as a natural preservative.
- Sorbic acid prevents mold growth in food.

Medicine & Pharmaceuticals

- **Salicylic acid** is used in acne treatments and aspirin synthesis.
- **Benzoic acid** acts as an antimicrobial agent.
- **Ascorbic acid (Vitamin C)** is essential for immune health.

Polymers

A polymer is a molecule with high molecular mass formed combination of very many small molecules called monomers.

Types of polymers

Natural polymers are polymers made plant or animal bodies

Examples of natural polymers

Polymers	monomers	Uses
Starch	glucose	Food, paper, medicine
Cellulose	glucose	Pharmaceuticals, cosmetics, foods
Protein	Amino acids	Pharmaceuticals, cosmetics, foods
Cotton		Textile and paper production
Wool		Textile, surgical dressing
silk		Textile, packaging
sisal		Ropes, marts, packaging

Advantage of natural polymers

- Cheap
- biodegradable

Disadvantage of natural polymers

- not durable
- have low property value such as low tensile strength

Artificial polymers

Artificial polymers are polymers that are man made

Examples of artificial polymers

Polymers	Uses
Nylon	Ropes, insulators, clothes
polythene	Packaging, pipes, insulators
polyester	Clothes, packaging, pipes

Advantage of synthetic polymers/plastic

- light and potable
- resistant most chemicals
- they are durable
- cheap

Disadvantage of synthetic polymers

- they are non-biodegradable
- fire hazards

Thermoplastic and thermosetting polymers

Thermoplastic polymers are those that soften and can be remoulded into new shape. E.g. polyethene

Thermosetting polymers are those that decompose on heating and cannot be remoulded on heating for example vulcanized rubber, melamine, Bakelite.

Soap



Soap is a mixtures of sodium salt of long chain fatty acids. Fatty acids are straight chain carboxylic acid

Saponification is the process of making soap.

To prepare soap

- Mix sodium hydroxide (about 10cm³ of is 5M) with castor oil (about 2cm³).
- Warm to boiling, and stir with a glass rod while it is boiling gently for 5-10 minutes.
- The soap remains in solution.

- Add saturated sodium chloride solution, boil gently and stir for further 2minutes and allow cooling. Soap is insoluble in sodium chloride. Filter off the solid soap.

Fat + alkali \longrightarrow soap + glycerine

i.e. glycerol stearate + sodium hydroxide \longrightarrow sodium stearate + glycerine

Action of soap with hard water

When soap is added to hard water containing calcium or magnesium salts. It first precipitates calcium or magnesium stearate as **SCUM** (*milky substance formed when soap reacts with hard water*) and no lather is formed until the entire calcium ion or magnesium ions are removed.

Detergents

They are synthetic cleansing agents

Examples of detergents on market



Advantages of detergents

- Synthetic detergents are more soluble in water than soap.
- Synthetic detergents do not form scum with hard water unlike soap.

Disadvantages of detergents.

- Detergents are non-biodegradable i.e. cannot be decomposed /acted on by bacteria. (Soap is bio gradable). Therefore, synthetic detergents can pollute rivers, lakes or seas more than soap.
- Detergents are expensive.

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Thanks

Dr. Bbosa Science