CHAPTER 01

Carbon in Life

“Did you know?
Carbon is the building block of life—every living thing contains it!”

By the end of this chapter, you should be able to;

1. Recognise that there is a diversity of carbon compounds in living things and materials de-rived from living things, and that these may be classified into groups
2. Understand that crude oil is a mixture of different alkanes which can be separated by fractional distillation; that these products are used in fuels and to make other useful products.
3. Know and appreciate that natural gas deposits are found worldwide, that their main constituent is methane and that gas deposits are useful source of fuels and chemical feedstock.
4. Appreciate that biogas is a carbon based fuel useful for cooking and lighting.
5. Know some common synthetic and natural polymers and how their properties relate to their uses.
6. Understand and appreciate that alcohols form a group of compounds of which ethanol is a typical member and has many uses.
7. Understand how ethanol is made naturally by fermentation of sugars and other organic substances, and be aware of the dangers of abuse of ethanol.
8. Know the process of making soapy detergents from natural fats and oils and appreciate that soaps are effective in removing oily stains.
9. Know that soapless detergents are made from crude oil and that soapless detergents are better cleaning agents in hard water than the soapy detergents but have a more deleterious effect on the environment.
10. Understand how organic compounds can be grouped into homologous series, each of which has similarities in structure and properties.

6

C

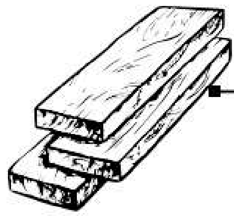
Carbon
12.011

Symbol: C
Atomic Number: 6
Atomic Mass: 12.01 u
Protons: 6
Neutrons: 6
Electrons: 6

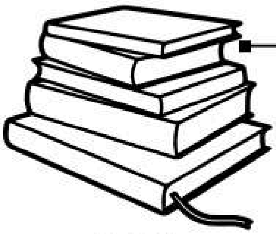
Carbon is the building block of life.
It forms the basis of all organic materials, which are substances containing carbon atoms bonded to other elements such as hydrogen, oxygen, and nitrogen.

Organic materials are present in both the natural world and the things we use every day.
From the wood in **trees** to the **sugars** we consume, carbon is everywhere. It is part of the foo d we eat, the clothes we wear, and even the air we breathe.
This makes understanding carbon's role in organic materials essential for understanding life itself.

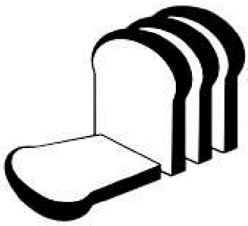
Clothes are made of carbon-based fibers. Natural fabrics like cotton and wool contain cellulose, which is rich in carbon. Synthetic materials like polyester and nylon are also made from carbon-based chemicals, showing how carbon is essential in making the fabrics we wear.



Wood is mostly **carbon.** Trees take in **carbon dioxide (CO_2)** from the air and convert it into wood as they grow. When wood burns or decays, the **carbon is released back** into the air, keeping nature in balance.

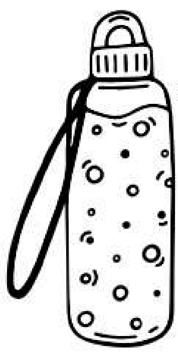


Books are made from paper, which comes from wood. Wood contains cellulose, a carbon-rich material. The ink used for printing also contains carbon compounds, making carbon an important part of books.



Bread contains carbon-based compounds like carbohydrates. During baking, heat causes a reaction that gives bread its texture and color.
The carbon in flour and sugar also plays a role in providing energy when we eat bread.

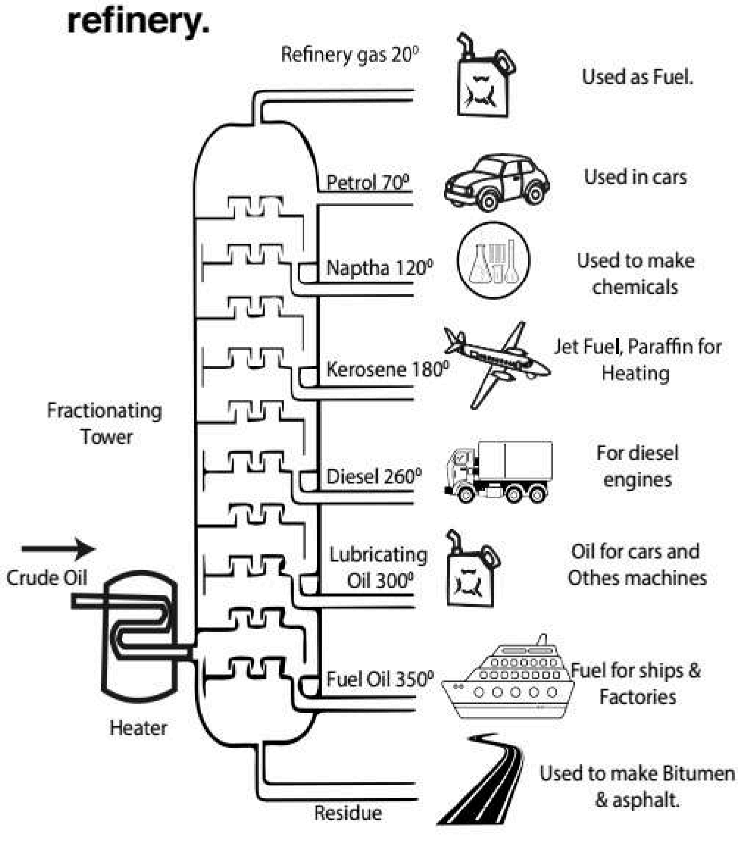
Oil is made from carbon-rich substances formed from ancient plants and animals. Over millions of years, heat and pressure turned their remains into petroleum, a fossil fuel. This oil is used for energy, plastics, and many other products.



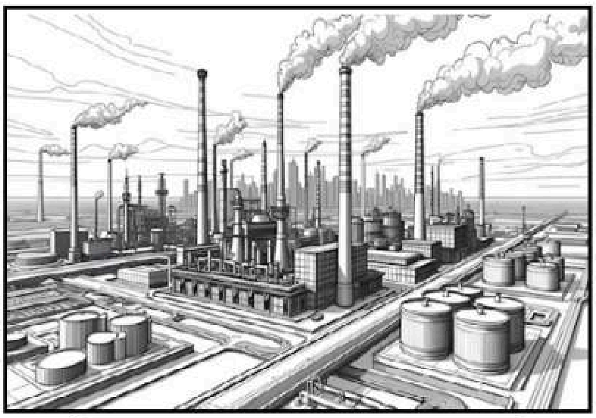
Bottles, especially plastic ones, are made from carbon-based materials like polyethylene and PET (polyethylene terephthalate). These materials come from petroleum, a fossil fuel rich in carbon, making carbon essential in manufacturing plastic bottles.

FRACTIONAL DISTILLATION OF CRUDE OIL

Crude oil is a mixture of many different hydrocarbon molecules. Most of the petroleum that is extracted from the ground is used to make fuel, but around 10% is used as a chemical feedstock, or raw material, in the chemical industry. Before the petroleum can be used, the various hydrocarbon molecules are separated by refining. This is done by **fractional distillation at an oil refinery.**



Fractional distillation Process
Figure 1



Oil Refinery.
Figure 2

At a refinery, crude oil is separated into different groups of **hydrocarbons** that have different boiling points. These groups are known as fractions. These different boiling points are roughly related to the number of carbon atoms **(chain length)** in the hydrocarbons of the hydrocarbons takes place by fractional distillation using a fractionating column (or tower).

At the start of the **refining process,** petroleum is preheated to a temperature of **350-400°C** and pumped in at the base of the tower. As it boils, the vapour passes up the tower. It passes through a **series of bubble caps**, and cools as it rises further up the column. The different fractions **cool and condense** at different temperatures, and therefore at different heights in the column. The fractions condensing at the different levels are collected on trays. Fractions from the top of the tower are called **"light'** and those from the bottom are called **'heavy'**. Each fraction contains a number of different **hydrocarbons**. The individual single hydrocarbons can then be obtained by further distillation.

CRACKING

Cracking is a chemical process used to break down large hydrocarbon molecules into smaller, more useful ones. This process is crucial in the **petroleum industry** to convert heavy fractions of crude oil into lighter, more valuable products such as **petrol (gasoline), diesel, and other fuels.**

Cracking also produces alkenes, which are essential feedstocks for the chemical industry.There are two main types of cracking:

1. **Catalytic cracking**
2. **Thermal cracking.**

All of the fractions obtained from the distillation of petroleum are useful. However, some are more useful than others, and there is a greater demand for those fractions. The demand for the various fractions from the refinery does not necessarily match with their supply from the oil. The petroleum from different oilfields varies in composition so the values shown here are **variable**, but the general trend is true. There is a greater demand for the lighter fractions such as petrol that have shorter chain length. The opposite is true for heavier fractions such as paraffin and diesel.

All cracking reactions gives an **alkane** with a **shorter chain** than the original and s**hort chain alkene** or two or more alkenes with **hydrogen.**

EXAMPLES

Decane $\longrightarrow$ Pentane + Propene + Ethene

$C_{10}H_{22} \longrightarrow C_5H_{12} + C_3H_6 + C_2H_4$

Butane $\longrightarrow$ Butene + Hydrogen

$C_4H_{10} \longrightarrow C_4H_8 + H_2$

Table 1.4

Number of carbon atoms(n)	Name	Molecular formula	Structural formula	Boiling point/^{0}c
2	Ethene	C_2H_4	$H_2C{=}CH_2$	-104
3	Propene	C_3H_6	$H_2C{=}CH\text{-}CH_3$	-47
4	Butene	C_4H_8	$H_2C{=}CH\text{-}CH_2\text{-}CH_3$	-6.7
5	Pentene	C_5H_{10}	$H_2C{=}CH\text{-}CH_2\text{-}CH_2\text{-}CH_3$	30

Displayed structures of some alkanes