

**CHAPTER
3****ORGANIC COMPOUNDS**

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**ORGANIC CHEMISTRY:**

It is the branch of chemistry that deals with the study of those compounds which we get from living organisms such as plants and animals.

OR

It is the branch of chemistry that deals with the study of carbon compounds with the exception of carbon monoxide (CO), Carbon dioxide (CO₂), Carbonates (CO₃⁻²), bicarbonates (HCO₃⁻¹) and carbides.

OR

It is the branch of chemistry that deals with the study of hydrocarbons. Hydrocarbons are the compounds which contain carbon and hydrogen such as methane gas (CH₄)

VITAL FORCE THEORY:

Vital Force Theory (VFT) was given by J. Berzelius. According to this theory, only living things have the ability to make organic compounds and we cannot make it in laboratory.

WOHLER'S EXPERIMENT:

In 1828, a German chemistry, Fredrich Wohler rejected vital force theory and prepared the first organic compound in laboratory. That's why he is known as the father of organic chemistry.

Wohler boiled ammonium cyanate (NH₄CNO), an inorganic compound, in water. He observed that urea is obtained which is an organic compound.



SOURCES OF ORGANIC COMPOUNDS



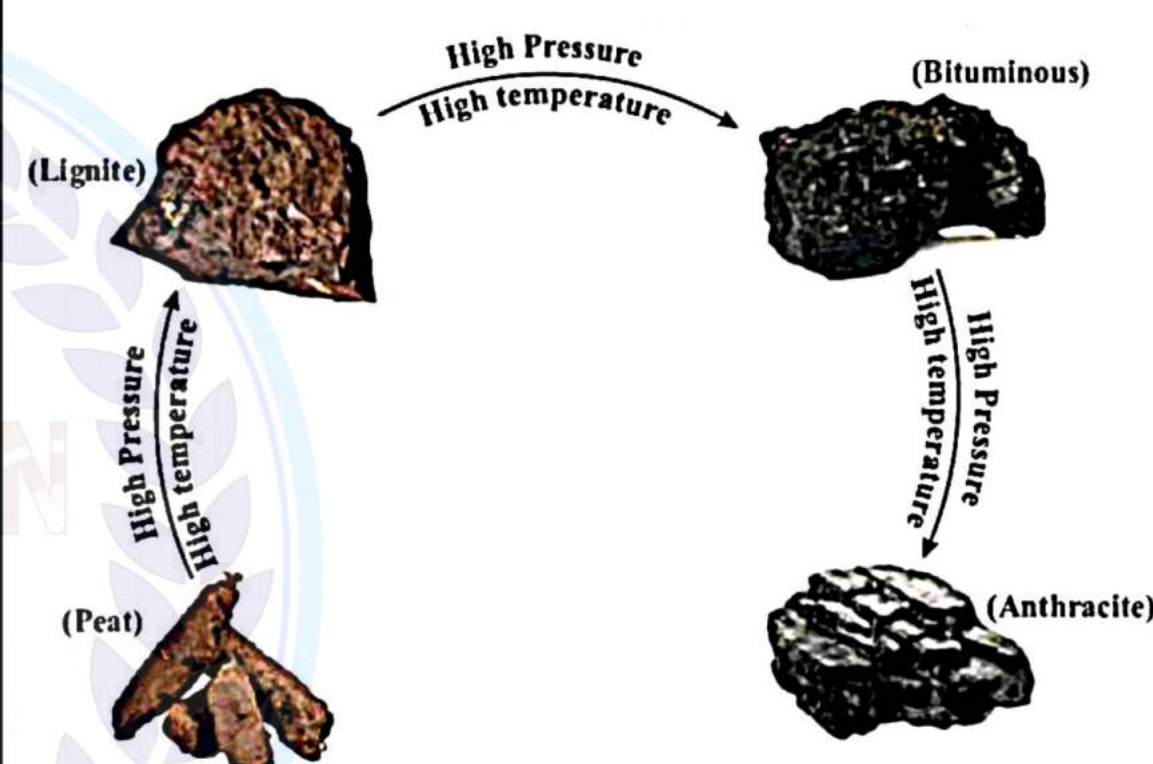
1. Fossil Fuel (Coal, Petroleum, Natural Gas)

Fossils are formed when an organism dies and its remains are quickly buried by sediment without decomposition. The buried remains become compressed and the organic material in the remains is slowly transformed into fossil fuel leaving behind the minerals of the rock. Fossil fuels are nonrenewable energy source. The three main types of fossil fuels are coal, petroleum and natural gas.

Coal

Coal is a plant-derived black mineral found beneath the earth's crust and is a solid fossil fuel that has significance all over the world. Plants that were buried underneath the earth crust millennia ago were slowly turned to coal under high temperature and pressure owing to bacterial and chemical processes

Coal type	% age of carbon contents	Properties and uses
Peat	45 – 60%	It is the earliest stage of coal formation resulting from the decomposition of fossilized remains. It has very low heat contents and use for domestic heating as an alternate of fire wood.
Lignite	60 – 70%	It is a brownish black coloured soft coal. It is typically used to generate electricity in power plants.
Bituminous	70 – 85%	It is a black coloured soft coal. It has a higher carbon content than lignite. It is often used for electric generation and steel production.
Anthracite	90 – 95%	It is a dark black coloured hard coal. It is the highest ranking coal with the highest carbon content. It is used in furnaces, power stations and as a domestic fuel.



Destructive Distillation of Coal:

The process in which coal is heated in the absence of air to produce a range of useful products is known as destructive distillation. The process required an elevated temperature typically 400°C to 900°C in a closed container. The principal products of destructive distillation of coal are coke, coal tar, coal gases and ammonia liquor.

Coke: It is a black hard solid contains 98 – 99% carbon. It is used as fuel and reducing agent.

Coaltar: It is a thick black liquid. Its fractional distillation gives many useful organic compounds such as benzene, toluene, xylene, naphthalene, phenol etc.

Coal Gases: It is a mixture of methane and water gas. It is highly flammable.

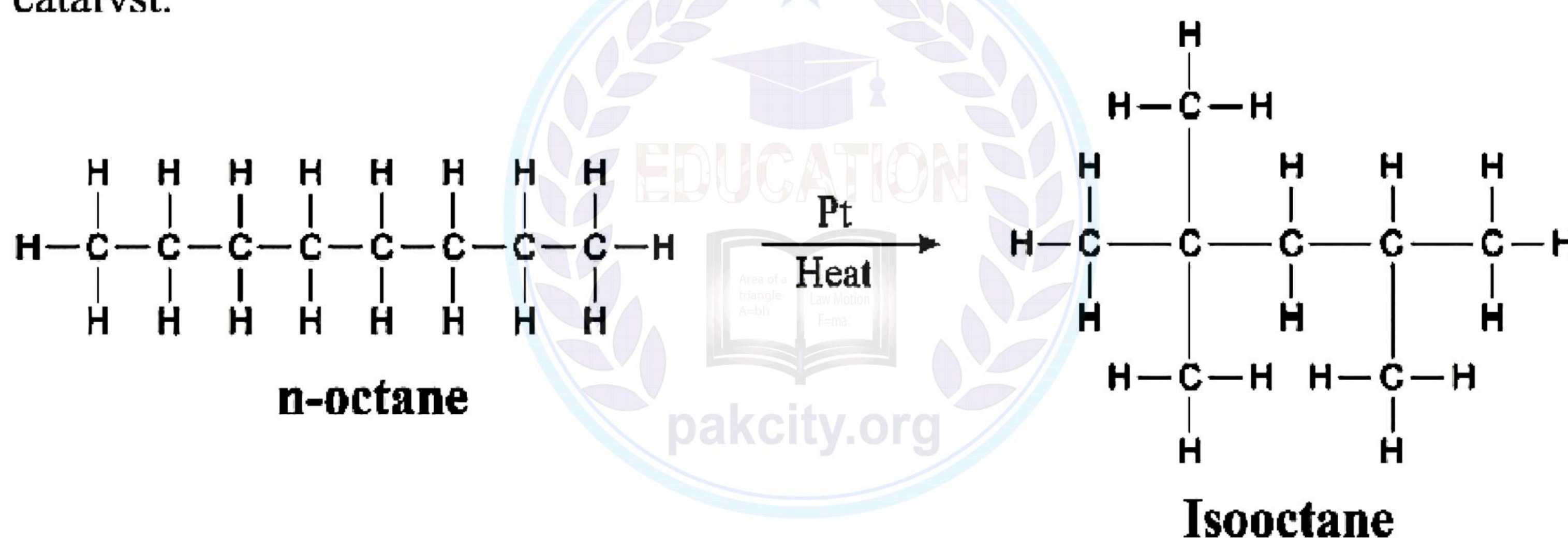
Petroleum

The term petroleum refers to rock oil or crude oil since it is a thick black liquid that oozes out of the earth (Latin words: 'petra' which means rock and 'oleum' means oil). It is a complex combination of alkanes, cycloalkanes and aromatic hydrocarbons etc.

Petroleum is formed from the ancient marine animals that were buried millions of years ago in the earth's crust. It is used for transportation, power generation and many other purposes. Some important products that are extracted from petroleum include gasoline, kerosene, diesel, naphtha, paraffin wax etc.

Reforming of Gasoline:

“The process of conversion of hydrocarbons (gasoline) with low octane rating into those with higher octane rating that can be utilized as a fuel in internal combustion engine is known as reforming”. The process of reforming is carried out under high pressure and temperature using platinum catalyst.



Low quality gasoline can cause knocking when ignited in an internal combustion engine. Knocking produces a sharp sound. High quality gasoline tends to product

less knocking. To measure a fuel's resistance to knocking, chemists use octane number or octane rating.



The octane number of iso-octane is 100.

The octane number of n-heptane is 0.

Previously, Tetra Ethyl Lead (C_2H_5)₄Pb was used to prevent knocking. This method was banned due to toxic nature of lead.

Natural Gas

Natural gas produced by the decomposition of marine microorganisms over the millions of years.

Natural gas is a mixture of methane, ethane, propane and butane. The highest composition in natural gas is methane (85 - 90% approximately). Natural gas is a more beneficial source of energy than coal and petroleum because its combustion causes less pollution.

2. Plants and Animals

Many organic compounds are isolated from plants, animals and microbes. These are referred to as natural products. Some examples of natural products are glucose, cellulose, insulin, cholesterol, caffeine, nicotine, menthol etc.

3. Partial and Total Synthesis

Partial synthesis involves starting with a simpler molecule and modifying it through a series of chemical reactions to create a more complex target molecule.

One example of partial synthesis is the production of the anti-inflammatory drug ibuprofen from a compound called cumene. Cumene undergoes several chemical transformations, including oxidation and rearrangement to yield ibuprofen.

Total synthesis involves building a complex target molecule entirely from simple starting materials.

For example, the total synthesis of the anti-cancer drug "Taxol" involves numerous steps to construct the molecule from simple building blocks.

4. Products of Biotechnology

Biotechnology is the field of biological sciences that deals with the involvement of living organisms in preparation of valuable products.

For example, ethyl alcohol is commercially manufactured by fermentation process in which certain enzymes secreted by microorganism.

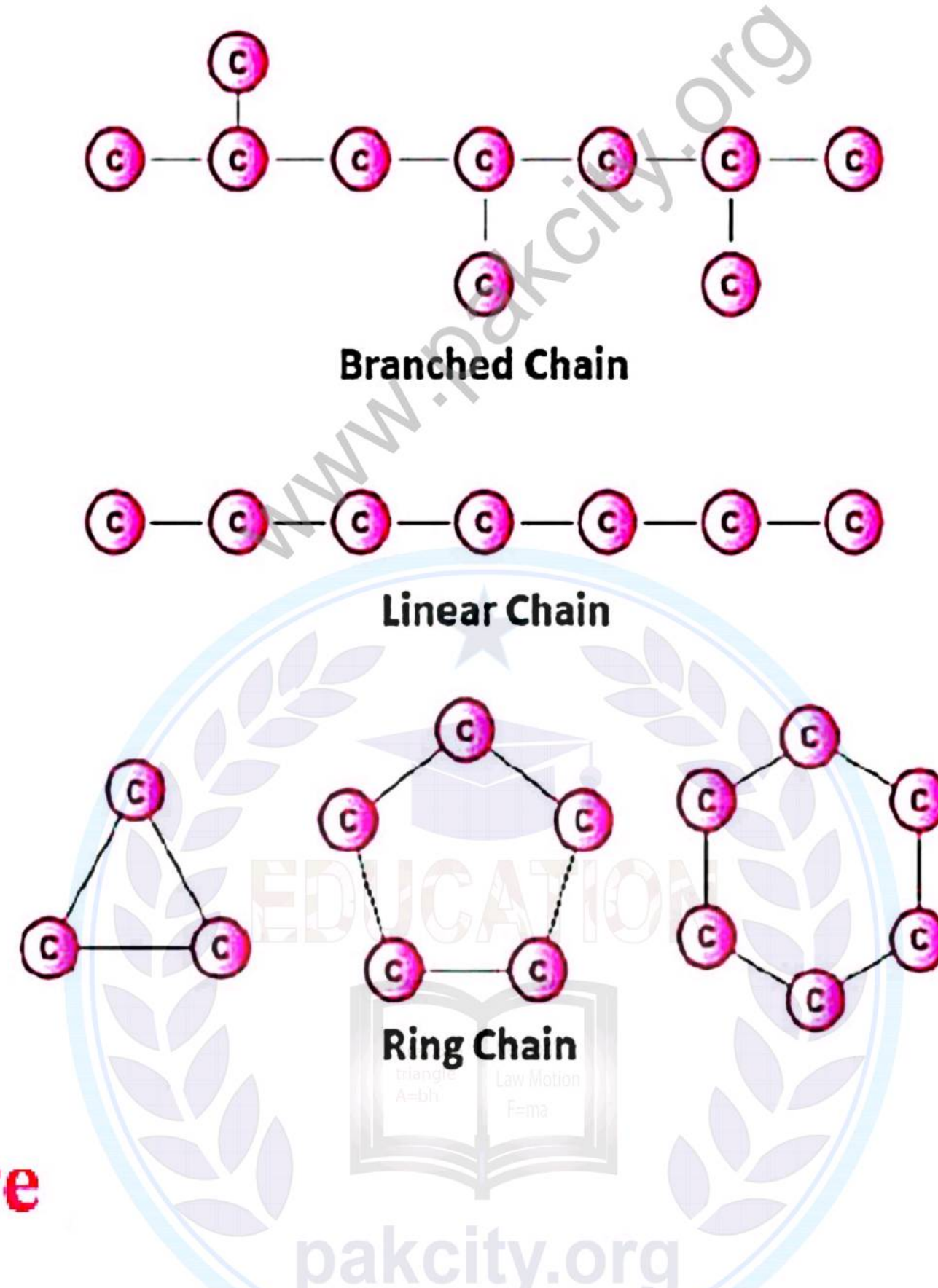
CHARACTERISTICS OF ORGANIC COMPOUNDS

Catenation



The ability of carbon to form long chain and rings is called catenation.

It is due to the tetravalency and small size of carbon atom. A large number of organic compounds are there due to catenation.



Non Ionic Nature

Organic compounds are made up of carbons and a carbon atom contains four valence electrons. It does not have the ability to lose or gain four electrons since it requires very high energy. Therefore, in contrast with inorganic compounds, it forms covalent bonds by the sharing of electrons.

Solubility

The solubility of organic compounds can vary widely depending on their chemical structure and the solvent in which they are dissolved. For examples:

Water-soluble organic compounds: Organic compounds that contain polar functional groups, such as hydroxyl (-OH) or carboxyl (-COOH) groups, tend to be soluble in water due to the ability to form hydrogen bonds with water molecules. For example, ethanol ($\text{C}_2\text{H}_5\text{OH}$) and acetic acid (CH_3COOH) are both water-soluble organic compounds.

Nonpolar organic compounds: Nonpolar organic compounds, such as hydrocarbons, generally have low solubility in water but are soluble in nonpolar solvents like hexane or diethyl ether. For instance, hexane (C_6H_{14}) and toluene ($\text{C}_6\text{H}_5\text{CH}_3$) are nonpolar organic compounds that exhibit poor solubility in water but dissolve readily in nonpolar solvents.

Low Melting and Boiling Point

Organic compounds in comparison to inorganic compounds have lower melting and boiling points. This is due to the comparatively weak intermolecular forces found in these molecules. They exist as gases, liquids and soft solids.

Flammability

The majority of organic compounds are combustible and readily react with oxygen to form carbon dioxide and water, thereby releasing heat. As a result, most fuels are organic, such as wood, coal, oil, gasoline, and natural gas.

Reactivity

Organic compounds react at a substantially slower rate than the ionic reactions that are often found in inorganic compounds. To accelerate the reaction, they generally require heating, mixing, and a catalyst.

Isomerism

The organic compounds having same molecular formula but different molecular structures are called isomers and this phenomena is called isomerism.

For example: there are two isomers of butane: n-butane and isobutane.

n-Butane: $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_3$

Isobutane: $\text{CH}_3\text{-CH(CH}_3\text{)-CH}_3$

Polymerization

Many small organic molecules (monomers) can unite through addition or condensation process to form a single large molecule. This process is known as polymerization and the macromolecule thus formed is called as a polymer.

For example, the polymerization of terephthalic acid (A dicarboxylic acid) with ethylene glycol forms polyethylene terephthalate (PET) which is used for making plastic bottles.

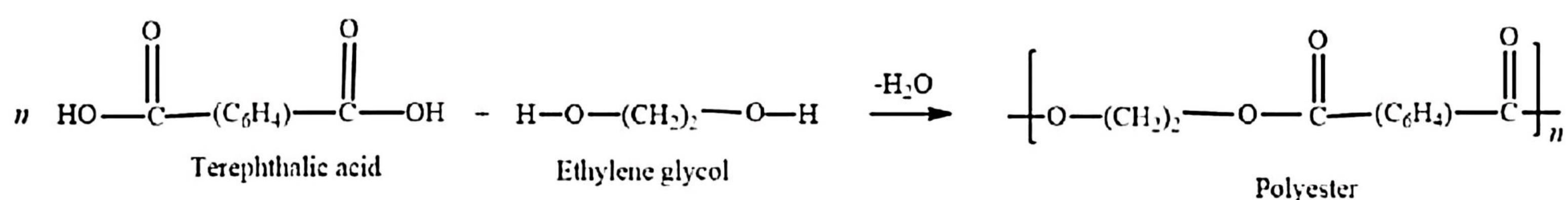


Table 3.2 Use of common organic compounds



Organic Compounds	Common Use
Gasoline	Fuel for automobiles
Natural gas	Domestic fuel
Ethene	Ripening of fruits
Ethyne	Gas Welding
Formalin	Preservative of biological specimen
Ethylene glycol	Antifreeze and coolant in automobiles
Phenol	Antiseptics and ink preservatives
Diethyl ether	Anaesthesia
Acetic acid	Vinegar
Ethyl acetate	Artificial flavors and essences
Acetone	Nail polish remover
Nylon	Ropes and fish nets
Poly ester	Fabrics
Carbohydrate, protein, fats, vitamins	Food components

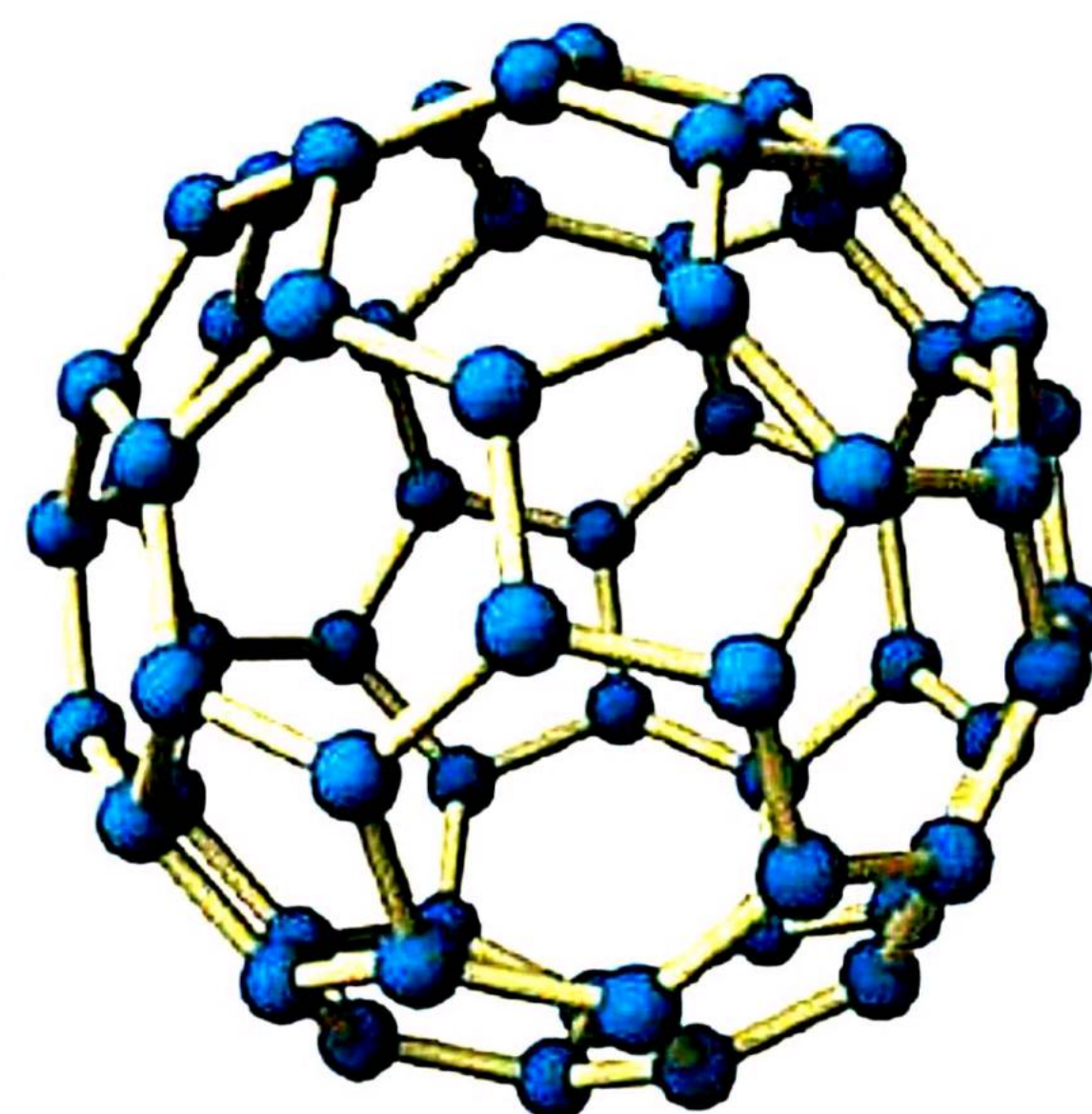
NEW ALLOTROPIC FORM OF CARBON (BUCKY BALLS)

In **1985**, **Richard Smalley** and **Harry Kroto** introduced a new allotropic form of carbons that consist of 60 carbon atoms.

The shape of this newly discovered form of carbon was similar to the dome developed by American architect '**Richard Buckminster Fuller**'. The name of this new form of C_{60} was suggested as **Buckminster Fullerene** or **Bucky Ball**.

It consists of 12 five membered ring and 20 six membered ring.

Bucky balls are good conductors of electricity and they are used in nanotechnology.



Functional Group



Atoms or group of atoms which are responsible for all the physical and chemical properties of organic compounds is called functional group.

Class of Compound	Structure of Functional Group	Class of Compound	Structure of Functional Group
Alkane	>C-C<	Carboxylic acid	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-OH} \end{array}$
Alkene	>C=C<	Ester	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-O-} \end{array}$
Alkyne	$\text{-C}\equiv\text{C-}$	Nitrile	$\text{-C}\equiv\text{N}$
Alcohol	-OH	Thiol	-SH
Ether	-O-	Alkyl Halide	-X
Amine	-NH_2		
Aldehyde	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-H} \end{array}$	Acyl halide	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-X} \end{array}$
Ketone	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-} \end{array}$	Amide	$\begin{array}{c} \text{O} \\ \parallel \\ \text{-C-NH}_2 \end{array}$

Homologous Series

The consecutive members of organic compounds differ with a fix ratio of CH_2 forming a series of compound which is called homologous series.

The general characteristics of homologous series are given below:

- (i) The composition of all the members of a homologous series can be expressed by a general formula.

Alkane	$\text{C}_n\text{H}_{2n+2}$	Alcohol	$\text{C}_n\text{H}_{2n+1}\text{OH}$
Alkene	C_nH_{2n}	Alkyl halide	$\text{C}_n\text{H}_{2n+1}\text{X}$
Alkynes	$\text{C}_n\text{H}_{2n-2}$	Amine	$\text{C}_n\text{H}_{2n+1}\text{NH}_2$

- (ii) The molecular mass of each member of homologous series differs from the next higher or lower member by **14 a.m.u.**
- (iii) All the members of homologous series show similar chemical properties due to the presence of similar functional group.
- (iv) There is a gradual variation in the physical properties such as physical state, solubility, melting and boiling points etc as the number of carbon atoms per molecule increases.



Self-Assessment

- Write the names of ten organic compounds used in daily life.



- | | |
|----------------|-----------------|
| 1) Sugar | 6) Diesel |
| 2) Glucose | 7) Paraffin Wax |
| 3) Vinegar | 8) Polyethene |
| 4) Methane gas | 9) Paracetamol |
| 5) Gasoline | 10) Aspirin |



$$\begin{array}{c}
 \text{H} \quad \text{O} \quad \text{H} \\
 | \quad || \quad | \\
 \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\
 | \quad \quad | \\
 \text{H} \quad \quad \text{H}
 \end{array}
 \qquad
 \begin{array}{c}
 \text{H} \quad \text{O} \\
 | \quad || \\
 \text{H}-\text{C}-\text{C}-\text{H} \\
 | \\
 \text{H}
 \end{array}$$

(a) (b)

- a) Ketone functional group is present b) Aldehyde functional group is present



Write down the general molecular formula of the homologous series of ethers and alcohols.

General formula of ethers is $C_nH_{2n+2}O$

General formula of alcohols is $\text{C}_n\text{H}_{2n+2}\text{O}$

Multiple Choice Questions

- (i) The functional group that contains a nitrogen atom is:
(a) Alcohol (b) Ketone
(c) Ester (d) Amide
- (ii) The compound belongs to the alkene family is:
(a) CH_4 (b) C_2H_6
(c) C_3H_8 (d) C_2H_4
- (iii) Destructive distillation of coal gives coke, coaltar, coal gas and:
(a) Natural gas (b) Petroleum
(c) Naphtha (d) Ammonia liquor
- (iv) The knocking of internal combustion engine can be reduced by the following petroleum process:
(a) Reforming (b) Refining
(c) Distillation (d) Condensation

- (v) The general formula of the homologous series of alcohol is:
(a) C_nH_{2n} (b) C_nH_{2n+2}
(c) $C_nH_{2n+1}OH$ (d) $C_nH_{2n-1}OH$
- (vi) The number of five membered and six membered rings in C_{60} Bucky ball are respectively:
(a) 12 and 12 (b) 5 and 15
(c) 12 and 20 (d) 40 and 20
- (vii) The pair of compounds that exhibit isomerism is:
(a) C_2H_5-OH and C_3H_7-OH
(b) $CH_3-CH_2-CH_2-CH_3$ and $CH_3-CH(CH_3)-CH_3$
(c) $C_2H_5-CH_2-Cl$ and $C_3H_7-CH_2-Cl$
(d) CH_3-NH_2 and $CH_3-CH_2-NH_2$
- (viii) The type of coal that is hard and high ranked is:
(a) Peat (b) Lignite
(c) Bituminous (d) Anthracite
- (ix) Which of the following hydrocarbon is the chief constituent of natural gas?
(a) CH_4 (b) C_2H_6
(c) C_3H_8 (d) C_4H_{10}
- (x) Urea was first synthesized by Wohler from an inorganic material named as:
(a) Ammonium nitrate (b) Ammonium chloride
(c) Ammonium cyanate (d) Ammonium bicarbonate