LEARNING MATERIAL
OF
ENGINEERING CHEMISTRY
(1ST & 2ND SEM)

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CHAPTER – 9
HYDROCARBONS

Introduction:

The branch of chemistry which deals with the study of covalently bonded compounds of carbon except, oxides of carbon (CO, CO_2), carbonates, bicarbonates, nitriles, and carbides (Na_2CO_3, $NaHCO_3$, NaCN, KCN, CaC_2, etc.) of certain metals is called organic chemistry.

Lemery classified all the substances in to three categories.

1. Compounds of Plant Origin: Vanaspati ghee, vegetable oil, honey, etc.
2. Compounds of animal origin: fats, etc.
3. Compounds of mineral origin: Rock salt, gypsum, limestone, bauxite, etc.

Lavoisier could be able to show that the first two categories of compounds essentially contain carbon, while the third category may or may not contain carbon. Hence, he reclassified the compounds into two categories. The first two categories are called organic compounds, while the third category referred as inorganic.

Till 18th century it was believed that organic compounds cannot be prepared in laboratories. The scientist Berzelius, put forth a theory called '***vital force theory'*** according to which "There is an unseen supernatural force called 'vital force', which guides the formation of organic compounds." Since plants and animals (from which organic compounds are derived) are the creation of the almighty God and as human being we do not have any power over God, we can't prepare organic compounds in laboratories.

In 1828, a German Chemist named Wohler for the first time prepared an organic compound in laboratory. He heated ammonium cyanate, an inorganic compound and got the rearranged product 'urea' which is purely an organic compound.

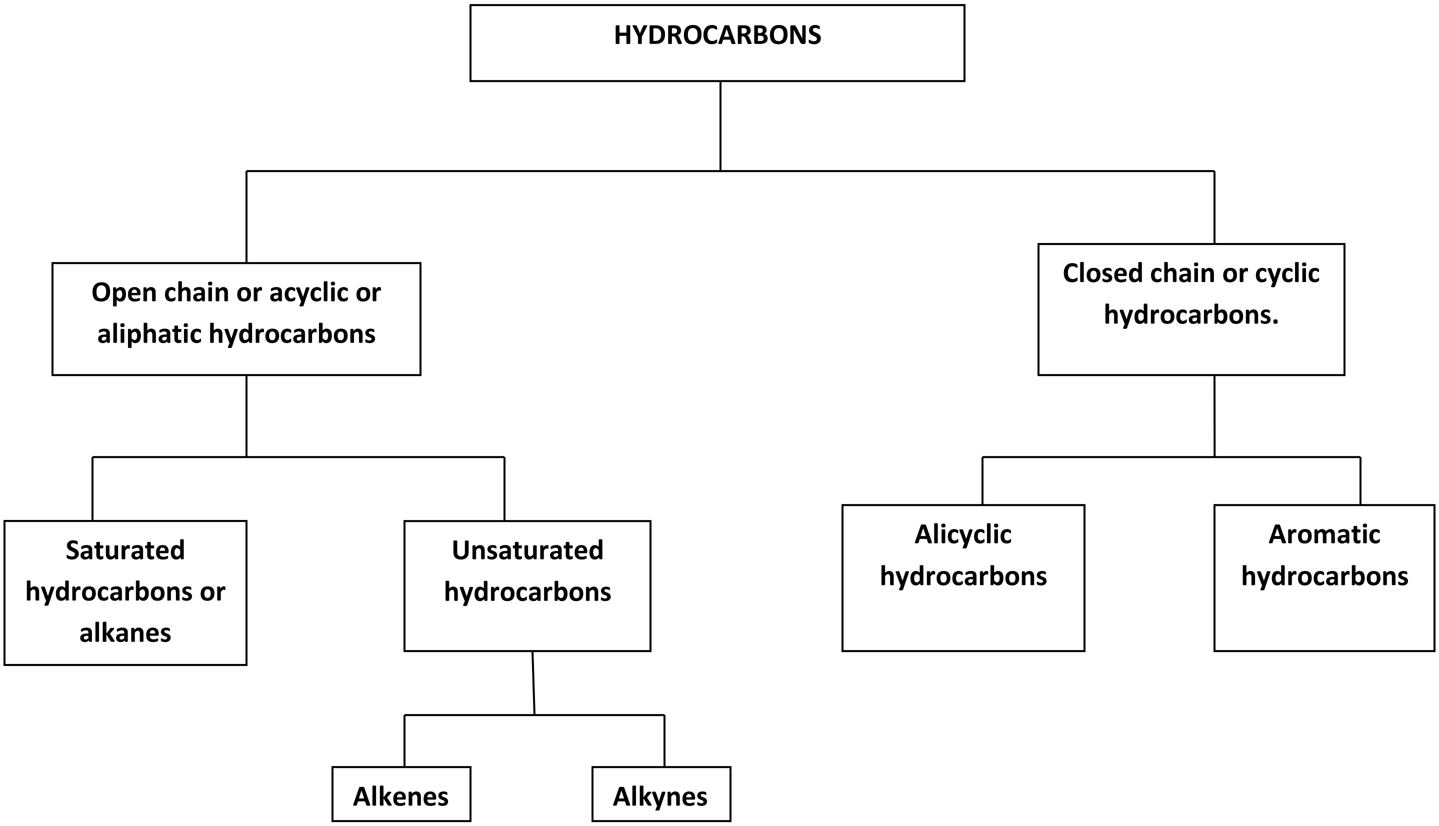
$$\underset{\text{(Ammonium cyanate)}}{NH_4CNO} \quad \overset{\Delta}{\leftrightarrow} \quad \underset{\text{(Urea)}}{NH_2CONH_2}$$

Later, Berthelot synthesized methane (CH_4) starting from the carbon and hydrogen. Again, Lavoisier synthesized acetic acid (CH_3COOH) starting from the constituent elements C, H & O. soon after these syntheses, the whole idea about organic chemistry has changed and the 'vital force theory' got a strong blow.

Hydrocarbons:

The compounds containing carbon and hydrogen are called hydrocarbons. For example: CH_4, C_2H_6, C_2H_4, C_2H_2, C_6H_6, etc.

Classification of hydrocarbons: -



SATURATED HYDROCARBONS: These are the hydrocarbons containing C – C single bonds only. Example: Alkanes (Methane, ethane, propane, butane, pentane, etc.).

UNSATURATED HYDROCARBONS: These are the hydrocarbons containing carbon-carbon multiple bonds (C = C, C ≡C).

Example: Alkenes (ethene, propene, butene, etc.) and alkynes (ethyne, propyne, butyne, etc.).

IUPAC SYSTEM OF NOMENCLATURE: -

IUPAC stands for "**I**nternational **U**nion of **P**ure and **A**pplied **C**hemistry". According to this system an organic compound may contain the following four parts.

1. Root Word
2. Prefix
3. Primary Suffix
4. Secondary Suffix

1. **ROOT WORD:** It refers to the number of carbon atoms present in the parent chain of an organic compound.

No. of C atom	Root word	No. of C atom	Root word
1	Meth	6	Hex
2	Eth	7	Hept
3	Prop	8	Oct
4	But	9	Non
5	Pent	10	Dec

2. **PREFIX:** It refers to the presence of substituent or side chain in the parent chain of an organic compound. Some groups that act as a substituent or side chain are:

Group	Prefix
─F	Fluoro
─Cl	Chloro
─Br	Bromo
─I	Iodo
─NO_2	Nitro
─R	Alkyl
─OR	Alkoxy

3. **PRIMARY SUFFIX:** It refers to the presence of (C─C), (C═C), (C≡C) in the compound.

Nature of Bond	Primary Suffix
All C─C bond	─ane
One C═C	─ene
Two C═C bond	─a------diene
Three C═C bond	─a------triene
One C≡C bond	─yne
Two C≡C bond	─a------diyne

4. **SECONDARY SUFFIX:** It refers to the presence of functional groups in the compounds.

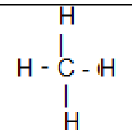
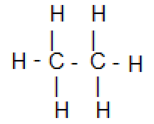
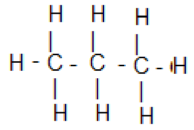
Functional Group	Secondary Suffix
Alcohol(─OH)	─ol
Aldehyde(─CHO)	─al
Ketone(─CO─)	─one
Carboxylic acid(─COOH)	─oic acid
Amine(─NH_2)	─amine
Acid amide(─$CONH_2$)	─amide
Acid chloride(─COCl)	─oylchloride

CLASS OF COMPOUNDS:

(i) Alkanes
(ii) Alkenes
(iii) Alkynes
(iv) Alkyl halides
(v) Alcohol

1. **Alkanes:** These are the saturated hydrocarbons in which the carbon atoms are linked by single bonds (C─C). These are also called Paraffins.

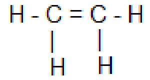
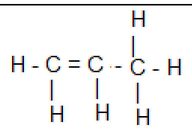
   General Formula: C_nH_{2n+2} where 'n' is the no. of carbon atoms.
   Primary Suffix: ane

n (No. of carbon atoms)	Molecular Formula	Structural formula	Common name	IUPAC name
1	CH_4	 $H-\underset{H}{\overset{H}{C}}-H$	Methane	Methane
2	C_2H_6	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$	Ethane	Ethane
3	C_3H_8	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$	Propane	Propane

2. **Alkenes:** These are the unsaturated hydrocarbons which have a carbon- carbon double bond (C═C) in their molecules. They are also called Olefins.

   General Formula: C_nH_{2n} where 'n' is the no. of carbon atoms.

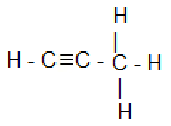
   Primary Suffix: ene

n (No. of carbon atoms)	Molecular Formula	Structural formula	Common name	IUPAC name
2	C_2H_4	 $H-\underset{H}{C}=\underset{H}{C}-H$	Ethylene	Ethene
3	C_3H_6	 $H-\underset{H}{C}=\underset{H}{C}-\underset{H}{\overset{H}{C}}-H$	Propylene	Propene

3. **Alkynes:** These are the unsaturated hydrocarbons which have a carbon-carbon triple bond (C≡C) in their molecules. These are also called Acetylenes.

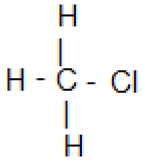
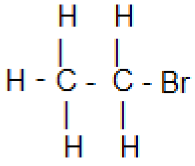
   General Formula: C_nH_{2n-2} where 'n' is the no. of carbon atoms.

   Primary Suffix: yne

n (No. of carbon atoms)	Molecular Formula	Structural formula	Common name	IUPAC name
2	C_2H_2	$H-C\equiv C-H$	Acetylene	Ethyne
3	C_3H_4	 $H-C\equiv C-\underset{H}{\overset{H}{C}}-H$	Methyl acetylene	Propyne

4. **Alkyl halides or Haloalkanes:** These are derived by replacing one H-atom of an alkane by a halogen atom.

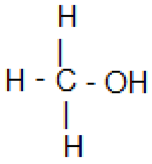
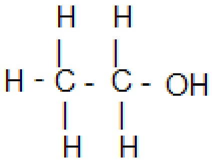
   General Formula: $C_nH_{2n+1}—X$ where 'n' is the no. of carbon atoms and 'X' refers to halogen atoms (F, Cl, Br, I).

n (No. of carbon atoms)	Molecular Formula	Structural formula	Common name	IUPAC name
1	$CH_3—Cl$	 $H-\underset{H}{\overset{H}{C}}-Cl$	Methyl Chloride	Chloromethane
2	$C_2H_5—Br$	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-Br$	Ethyl Bromide	Bromoethane

5. **Alcohol:** These are obtained by replacing one H-atom of an alkane by a hydroxyl group (—OH). The IUPAC name of an alcohol is obtained by replacing 'e' of the corresponding alkane by '**ol**'.

   General Formula: $C_nH_{2n+1}—OH$ where 'n' is the no. of carbon atoms.

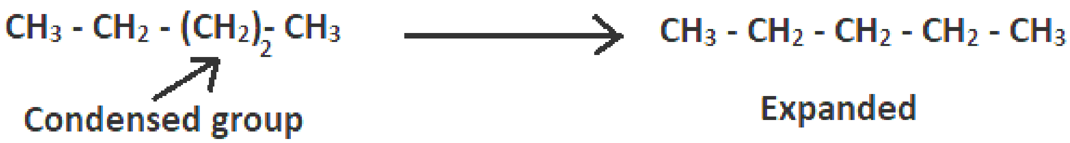
   Suffix: ol

n (No. of carbon atoms)	Molecular Formula	Structural formula	Common name	IUPAC name
1	$CH_3—OH$	 $H-\underset{H}{\overset{H}{C}}-OH$	Methyl alcohol	Methanol
2	$C_2H_5—OH$	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-OH$	Ethyl alcohol	Ethanol

RULES FOR IUPAC SYSTEM OF NOMENCLATURE:

1. **Expansion of chain:** Sometimes condensed groups are present in organic compounds. These condensed groups are to be separated.
   Examples:

(i)

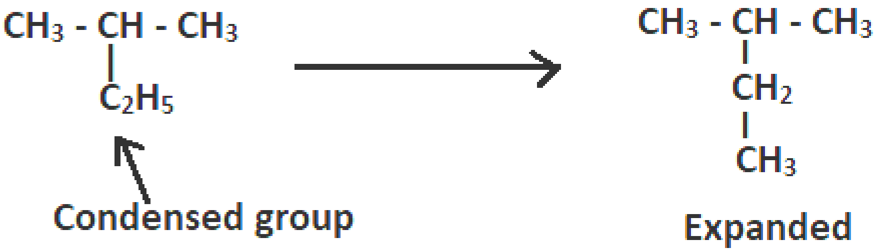


$$CH_3-CH_2-(CH_2)_2-CH_3 \longrightarrow CH_3-CH_2-CH_2-CH_2-CH_3$$

(ii)

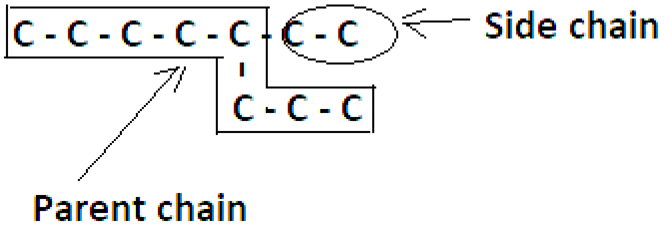
$$(CH_3)_2CH-CH_3 \longrightarrow CH_3-\underset{\begin{array}{c}|\\ CH_3\end{array}}{CH}-CH_3$$

(iii)



$$CH_3-\underset{\begin{array}{c}|\\ C_2H_5\end{array}}{CH}-CH_3 \longrightarrow CH_3-\underset{\begin{array}{c}|\\ CH_2\\ |\\ CH_3\end{array}}{CH}-CH_3$$

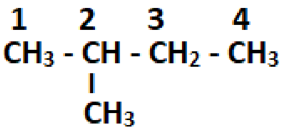
2. **Selection of Parent Chain:** The longest continuous carbon chain is called parent chain. The parent chain is selected and the groups which are outside the parent chain are called substituent or side chains.
   Example:



3. Numbering of Carbon atoms: (Lowest number rule or lowest sum rule).

a. Presence of one substituent or one side chain: The numbering of carbon atoms in the continuous carbon chain is done from one end to the other end, so that the carbon atom carrying the substituent get the lowest number.

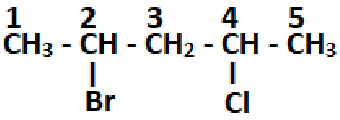
Examples:



$$\overset{1}{CH_3}-\overset{2}{\underset{\underset{CH_3}{|}}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_3}$$

b. Presence of 2 Substituents at the same position from either end: In this case minimum number is given to the carbon containing the substituent which comes first in alphabetical order.

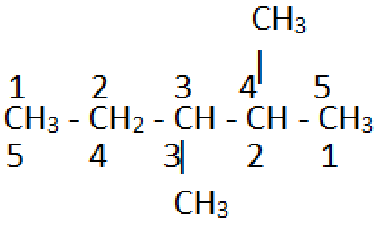
Example:



$$\overset{1}{CH_3}-\overset{2}{\underset{\underset{Br}{|}}{CH}}-\overset{3}{CH_2}-\overset{4}{\underset{\underset{Cl}{|}}{CH}}-\overset{5}{CH_3}$$

c. Presence of more than one substituents or side chains at any positions: In this case, number the parent chain from such an end so as to give lowest set of numbers possible to the substituents (**Lowest Sum Rule**).

Example:



$$\underset{5}{\overset{1}{CH_3}}-\underset{4}{\overset{2}{CH_2}}-\underset{\underset{CH_3}{|}}{\overset{3}{CH}}-\overset{\overset{CH_3}{|}}{\underset{2}{\overset{4}{CH}}}-\underset{1}{\overset{5}{CH_3}}$$

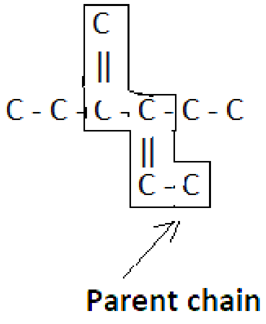
L → R: Sum = 3 + 4 = 7 X

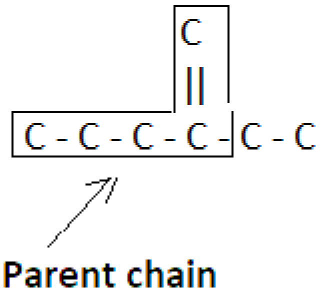
R → L : Sum = 2 + 3 = 5 √

4. Presence of Multiple bonds (double and triple bonds):

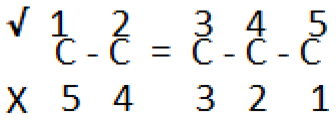
(i) Select the longest continuous carbon chain as the principal chain which contains the maximum number of multiple bonds.

Example:



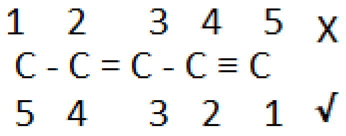


(ii) If a compound contains a multiple bond, then minimum number is given to the carbon containing the multiple bonds, irrespective of the position of the substituent or the side chain.
Example:



$$\begin{array}{lccccc} \surd & 1 & 2 & 3 & 4 & 5 \\ & C - & C = & C - & C - & C \\ X & 5 & 4 & 3 & 2 & 1 \end{array}$$

(iii) If the principal chain (parent chain) contains 2 or more multiple bonds, then number the principal chain from one end so that the multiple bonds get the lowest set of numbers.
Example:

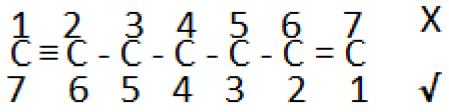


$$\begin{array}{cccccl} 1 & 2 & 3 & 4 & 5 & X \\ C - & C = & C - & C \equiv & C & \\ 5 & 4 & 3 & 2 & 1 & \surd \end{array}$$

L → R: Sum = 2 + 4 = 6

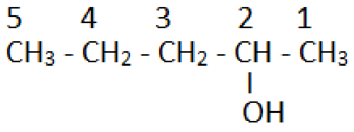
R → L : Sum = 1 + 3 = 4

(iv) If the numbering of principal chain from both the ends gives the same set of numbers to multiple bonds, then select the set which gives lower number to the double bond.
Example:



$$\begin{array}{cccccccl} 1 & 2 & 3 & 4 & 5 & 6 & 7 & X \\ C \equiv & C - & C - & C - & C - & C = & C & \\ 7 & 6 & 5 & 4 & 3 & 2 & 1 & \surd \end{array}$$

5. **Presence of Functional groups:** If a compound contains a functional group then, minimum number is given to the carbon containing the functional group irrespective of the position of the substituents, side chains or even multiple bonds.
Example:



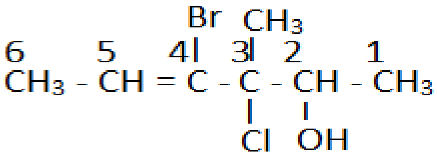
$$\overset{5}{CH_3} - \overset{4}{CH_2} - \overset{3}{CH_2} - \underset{\substack{| \\ OH}}{\overset{2}{CH}} - \overset{1}{CH_3}$$

6. **Arrangement of Prefixes:** In an organic compound the WR, Prefix, PS and SS are arranged in the following way.

( ) - Prefix---- Root Word ------( ) - Primary Suffix ----- ( ) - Secondary Suffix

Separate the number from the name of the substituent by a hyphen (-) and the numbers are separated by comma (,). If a particular substituent appears 2 or more times, then attach the prefix di, tri, tetra respectively to the name of the substituent and if there are 2 different substituents then they are written in alphabetical order. While following the rules for alphabetical order, the prefixes like di, tri, tetra etc. are ignored.

Example:

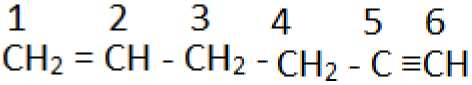


$$\overset{6}{CH_3} - \overset{5}{CH} = \overset{\overset{Br}{|}}{\overset{4}{C}} - \underset{\underset{Cl}{|}}{\overset{\overset{CH_3}{|}}{\overset{3}{C}}} - \underset{\underset{OH}{|}}{\overset{2}{CH}} - \overset{1}{CH_3}$$

IUPAC Name: 4-Bromo-3-chloro-3-methylhex-4-en-2-ol

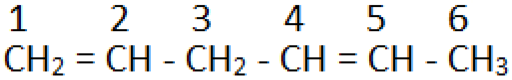
Note: The primary suffix for double bond is ene and for triple bond is yne. 'e' of ene is omitted if it is followed by a suffix starting with a, i, o, u, y. If the principal chain contains 2 double or two triple bonds, then suffix is diene or diyne respectively. In such cases 'a' is added to root word.

Examples:



$$\overset{1}{CH_2} = \overset{2}{CH} - \overset{3}{CH_2} - \overset{4}{CH_2} - \overset{5}{C} \equiv \overset{6}{CH}$$

Hex-1-en-5-yne



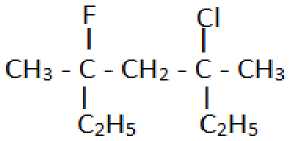
$$\overset{1}{CH_2} = \overset{2}{CH} - \overset{3}{CH_2} - \overset{4}{CH} = \overset{5}{CH} - \overset{6}{CH_3}$$

Hexa-1,4-diene

EXAMPLES:

Write the I.U.P.A.C names of the following organic compounds:

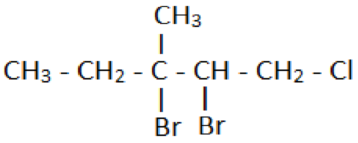
(i)



$$CH_3-\underset{C_2H_5}{\overset{F}{C}}-CH_2-\underset{C_2H_5}{\overset{Cl}{C}}-CH_3$$

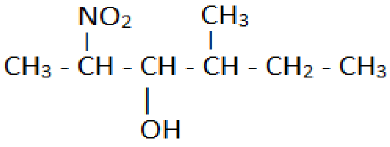
(ii) $(CH_3)_2CH - C \equiv CH$

(iii)



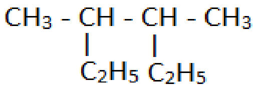
$$CH_3-CH_2-\underset{Br}{\overset{CH_3}{C}}-\underset{Br}{CH}-CH_2-Cl$$

(iv)



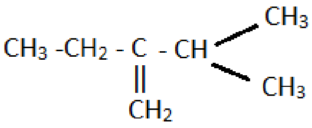
$$CH_3-\overset{NO_2}{CH}-\underset{OH}{CH}-\overset{CH_3}{CH}-CH_2-CH_3$$

(v)



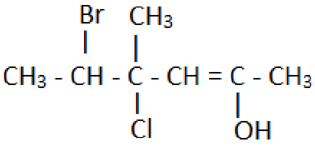
$$CH_3-\underset{C_2H_5}{CH}-\underset{C_2H_5}{CH}-CH_3$$

(vi)



$$CH_3-CH_2-\underset{CH_2}{\overset{\|}{C}}-CH(CH_3)_2$$

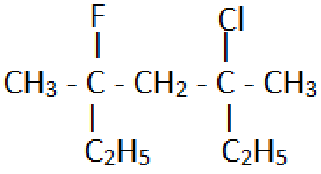
(vii)



$$CH_3-\overset{Br}{CH}-\underset{Cl}{\overset{CH_3}{C}}-CH=\underset{OH}{C}-CH_3$$

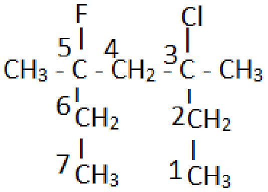
Solution:

(i)



$$CH_3-\underset{C_2H_5}{\overset{F}{C}}-CH_2-\underset{C_2H_5}{\overset{Cl}{C}}-CH_3$$

On expanding the condensed groups, we have

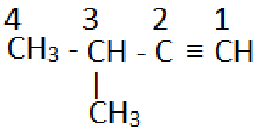


$$CH_3-\underset{\underset{{}^{7}CH_3}{|}{}^{6}CH_2}{\overset{F}{{}^{5}C}}-{}^{4}CH_2-\underset{\underset{{}^{1}CH_3}{|}{}^{2}CH_2}{\overset{Cl}{{}^{3}C}}-CH_3$$

3-Chloro-5-fluoro-3,5-dimethylheptane

(ii) $(CH_3)_2CH-C\equiv CH$

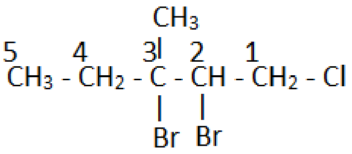
On expanding the condensed groups, we have



$$\overset{4}{CH_3}-\underset{\underset{CH_3}{|}}{\overset{3}{CH}}-\overset{2}{C}\equiv\overset{1}{CH}$$

3-Methylbut-1-yne

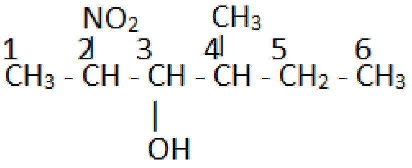
(iii)



$$\overset{5}{CH_3}-\overset{4}{CH_2}-\overset{\overset{CH_3}{|}}{\underset{\underset{Br}{|}}{\overset{3}{C}}}-\underset{\underset{Br}{|}}{\overset{2}{CH}}-\overset{1}{CH_2}-Cl$$

1-Chloro-2,3-dibromo-3-methylpentane

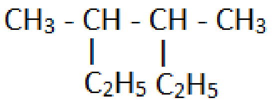
(iv)



$$\overset{1}{CH_3}-\overset{\overset{NO_2}{|}}{\overset{2}{CH}}-\underset{\underset{OH}{|}}{\overset{3}{CH}}-\overset{\overset{CH_3}{|}}{\overset{4}{CH}}-\overset{5}{CH_2}-\overset{6}{CH_3}$$

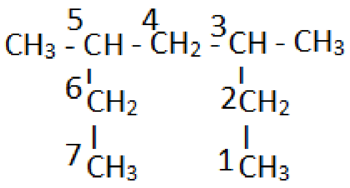
4-Methyl-2-nitrohexan-3-ol

(v)



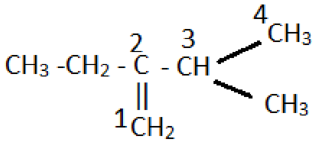
$$CH_3-\underset{\underset{C_2H_5}{|}}{CH}-\underset{\underset{C_2H_5}{|}}{CH}-CH_3$$

On expanding the condensed groups, we have



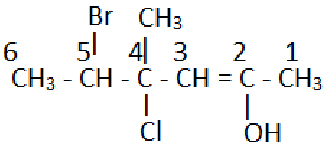
3,5-Dimethylheptane

(vi)



2-Ethyl-3-methylbut-1-ene

(vii)

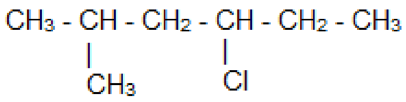


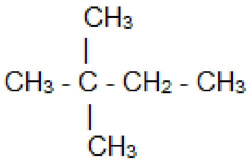
$$\overset{6}{CH_3}-\overset{\overset{Br}{|}}{\overset{5}{CH}}-\overset{\overset{CH_3}{|}}{\underset{\underset{Cl}{|}}{\overset{4}{C}}}-\overset{3}{CH}=\underset{\underset{OH}{|}}{\overset{2}{C}}-\overset{1}{CH_3}$$

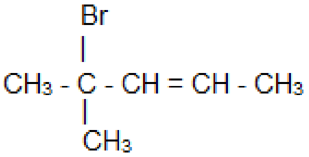
5-Bromo-4-chloro-4-methylhex-2-en-2ol

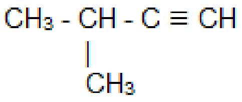
ASSIGNMENT:

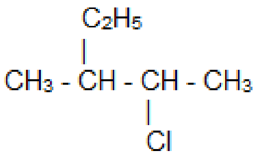
Write the IUPAC names of the following:

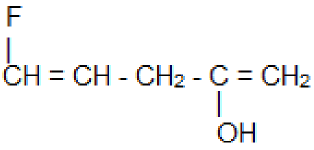
(i)

$CH_3-\underset{CH_3}{\underset{|}{CH}}-CH_2-\underset{Cl}{\underset{|}{CH}}-CH_2-CH_3$

(ii)

$CH_3-\overset{CH_3}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH_2-CH_3$

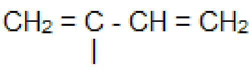
(iii)

$CH_3-\overset{Br}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH=CH-CH_3$

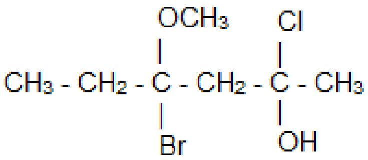
(iv)

$CH_3-\underset{CH_3}{\underset{|}{CH}}-C\equiv CH$

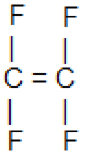
(v)

$CH_3-\overset{C_2H_5}{\overset{|}{CH}}-\underset{Cl}{\underset{|}{CH}}-CH_3$

(vi)

$\overset{F}{\overset{|}{CH}}=CH-CH_2-\underset{OH}{\underset{|}{C}}=CH_2$

(vii) $(CH_3)_2C(CH_3)_2$

(viii)

$CH_2=\underset{CH_3}{\underset{|}{C}}-CH=CH_2$

(ix)

$CH_3-CH_2-\overset{OCH_3}{\overset{|}{\underset{Br}{\underset{|}{C}}}}-CH_2-\overset{Cl}{\overset{|}{\underset{OH}{\underset{|}{C}}}}-CH_3$

(x)

$\overset{F}{\overset{|}{\underset{F}{\underset{|}{C}}}}=\overset{F}{\overset{|}{\underset{F}{\underset{|}{C}}}}$

WRITING STRUCTURAL FORMULA FROM IUPAC NAMES:

Steps to be followed:

1. Arrange the carbon atoms corresponding to the root word in a single line separated by single bonds.
2. Number the carbon atoms from any end.
3. Attach the side chains, substituents, multiple bonds and functional groups whichever is required at their respective positions.
4. Attach hydrogen atoms to satisfy the tetravalency of each carbon atom.

TYPES OF CARBON ATOMS IN ALKANES:

1. Primary (1º) carbon atom: It is the carbon atom attached to one carbon atom or all hydrogen atoms.
2. Secondary (2º) carbon atom: It is the carbon atom bonded to other carbon atoms on 2 different sides.
3. Tertiary (3º) carbon atom: It is the carbon atom bonded to other carbon atoms on 3 different sides.
4. Quaternary (4º) carbon atom: It is the carbon atom bonded to other carbon atoms on 4 different sides.

RULES FOR WRITING THE COMMON NAMES OF SOME SIMPLE ALKANES:

The simple branched chain alkanes can be assigned common names. According to common system of nomenclature, all the isomeric alkanes (having same molecular formula but different structural formula) have the same parent name but are distinguished by prefixes. The prefix indicates the type of branching in the molecule.

(i) The prefix **n** (normal) is used for all those alkanes in which all the carbon atoms form a continuous chain with no branching.

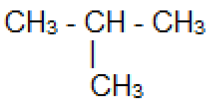
$CH_3 - CH_2 - CH_2 - CH_3$

n - butane

$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

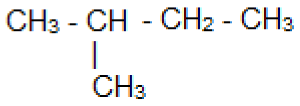
n - pentane

(ii) Prefix **iso** is used for those alkanes in which one methyl group (formed by removal of one H-atom from methane) is attached to the second last carbon atom of the continuous chain.
Examples:



$CH_3 - \underset{\underset{\displaystyle CH_3}{|}}{CH} - CH_3$

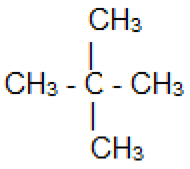
iso-butane



$CH_3 - \underset{\underset{\displaystyle CH_3}{|}}{CH} - CH_2 - CH_3$

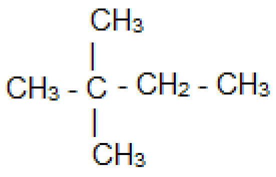
iso-pentane

(iii) Prefix **neo** is used for those alkanes which have 2 methyl groups attached to the second last carbon atom of the continuous chain.
Examples:



$CH_3 - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}} - CH_3$

neo-pentane

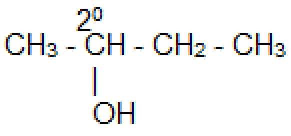


$CH_3 - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}} - CH_2 - CH_3$

neo-hexane

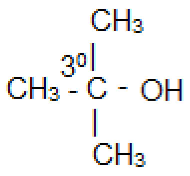
(If the branching occurs at any other position then these prefixes are not used.)

(iv) The prefixes **sec** and **tert** before the name of the alkyl group indicates the removal of H-atom from 2º and 3º carbon atoms respectively.
Examples:



$CH_3 - \overset{2^0}{\underset{\underset{\displaystyle OH}{|}}{CH}} - CH_2 - CH_3$

Sec-butyl alcohol



$CH_3 - \overset{\overset{\displaystyle CH_3}{3^0|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}} - OH$

Tert-butyl alcohol

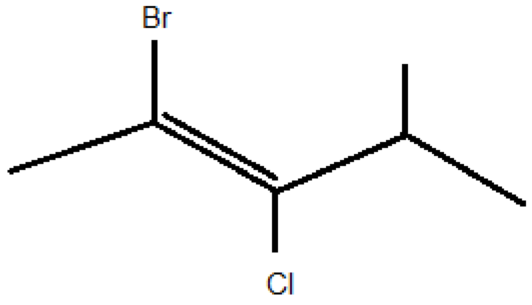
ASSIGNMENT:

Write the structural formulae of the following organic compounds:

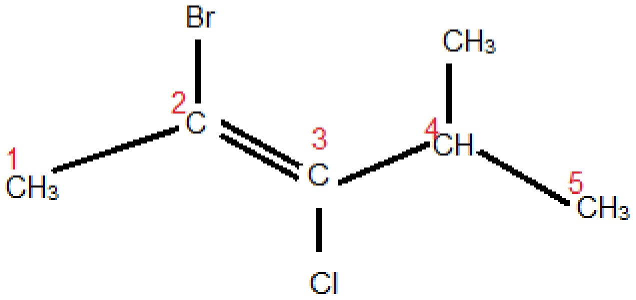
- (i) Tert-butyl alcohol
- (ii) But-1-en-3-yne
- (iii) 3,4-dimethyl pentan-2-ol
- (iv) 1,1,2,2-tetrafloro ethene
- (v) 2,3-dibromo-1,4-dichloro but-2-ene
- (vi) Iso-hexane
- (vii) n-propyl iodide
- (viii) n-butyl bromide
- (ix) iso-pentyl alcohol
- (x) 4,5-dimethoxy hex-2-ene
- (xi) Propylene
- (xii) 3-Ethyl penta-1,3-diene

BOND-LINE REPRESENTATION: In bond line representation, each corner and terminal is considered as a carbon atom and the rest are considered as hydrogen atoms to satisfy the tetra-covalency of each carbon atom.

Examples: I.U.P.A.C names of the following bond line notation:



Substituting the carbon hydrogen atoms, we have,

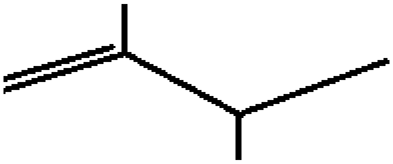


2-Bromo-3-chloro-4-methylpent-2-ene

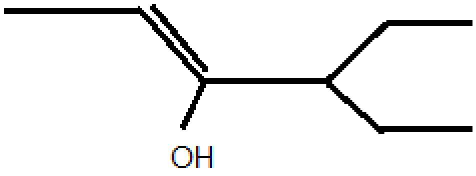
ASSIGNMENT:

Write the I.U.P.A.C names of the following:

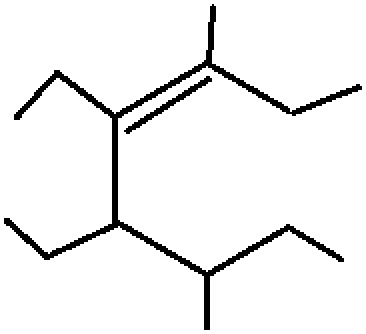
(i)



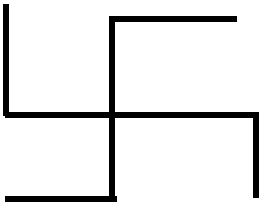
(ii)



(iii)



(iv)



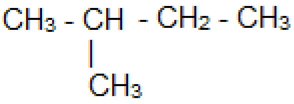
DISTINCTION BETWEEN SATURATED AND UNSATURATED HYDROCARBONS:

Sl. No.	Saturated hydrocarbons	Unsaturated hydrocarbons
1	Contain C─C single bonds and C─H bonds.	Contain carbon-carbon multiple bonds (C═C and C≡C).
2	Less reactive.	More reactive.
3	Burn with blue flame.	Burn with sooty flame.
4	Show substitution reaction.	Show addition reaction.
5	Contain only sigma bonds.	Contain both sigma and pi bonds.
6	Examples: Alkanes.	Examples: Alkenes and Alkynes.

Aliphatic hydrocarbons: The open-chained hydrocarbons are called aliphatic hydrocarbons or acyclic hydrocarbons**.** These may be straight chain or branched chain.
Example:

$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

n - pentane



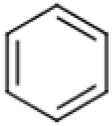
$$\underset{\displaystyle CH_3}{\underset{|}{CH_3 - CH}} - CH_2 - CH_3$$

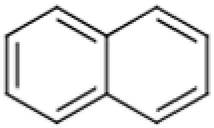
2-Methylbutane

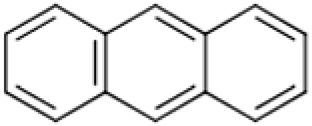
Aromatic hydrocarbons: These are the closed chain or cyclic hydrocarbons. They obey Huckel's rule of aromaticity.

Huckel's Rule of Aromaticity: The cyclic hydrocarbon containing (4n+2) π electrons in which single and double bonds are present in alternate positions is called an aromatic hydrocarbon. Where n = 0, 1, 2, 3, etc.

For example:


benzene


naphthalene


anthracene

DISTINCTION BETWEEN ALIPHATIC & AROMATIC HYDROCARBONS.

Sl. No.	Aliphatic hydrocarbons	Aromatic hydrocarbons
1	Open chain or Acyclic hydrocarbons.	Cyclic hydrocarbons containing (4n+2) □ electrons in which single and double bonds are present in alternate positions.
2	Do not obey Huckel's rule.	Obey Huckel's rule.
3	No pleasant odour.	Pleasant odour.
4	Alkanes burn with non-sooty flame.	Burn with sooty flame.
5	Examples: Alkanes, Alkenes, Alkynes.	Examples: Benzene, Napthalene, Toluene.

USE OF SOME IMPORTANT AROMATIC COMPOUNDS:

1. **Benzene:** It is used:
   (a) in manufacturing rubber, tyres.
   (b) in the printing industry for cleaning and maintaining printing equipment.
   (c) as an ingredient of a variety of painting products.
   (d) in manufacturing chemical and plastic products.
   (e) to clean parts such as hydraulic system, fuel system components and brakes.

2. **Toluene:** It is used:
   (a) as a solvent for paint, paint thinner, printer ink etc.
   (b) used in the synthesis of Trinitrotoluene (TNT) explosives.
   (c) in making elastic.
   (d) as a radiator fluid.
   (e) in breaking of RBC in order to extract the hemoglobin in biochemistry experiments.

3. **BHC (Benzene Hexachloride):** Also called gammaxene. It is used:
   (a) as an important insecticide.
   (b) as medication to remove head lice.

4. **Phenol:** It is used:
   (a) as disinfectant in household cleaners and in mouthwash when used in small quantity.

(b) as surgical antiseptic.
(c) in the manufacturing of cough syrups and other antiseptics.
(d) as a starting material to make plastics and drugs such as aspirin.
(e) in the study and extraction of biomolecules.

5. Naphthalene: It is used:
(a) in the form of mothballs and toilet deodorant blocks.
(b) in making dyes, resins, insecticides.
(c) in manufacturing of PVC (polyvinyl chloride).

6. Anthracene: It is used:
(a) in wood preservatives, insecticides.
(b) as a scintillator for detectors of high energy photons, electrons and alpha particles.

7. Benzoic acid: It is used:
(a) as a food preservative.
(b) in mouthwash, toothpaste, facial cleanser.
(c) in making dyes and insect repellents.
(d) a constituent of Whitfield’s ointment which is used for the treatment of fungal skin disease.

ASSIGNMENT:

1. Define Saturated and Unsaturated hydrocarbons with examples.
2. Differentiate between Aromatic and Aliphatic hydrocarbons.
3. State Huckel’s rule.
4. To which class the organic compound $C_8 H_{16}$ belong and how?
5. C_4H_8 belongs to which homologous series?
6. Distinguish between Saturated and Unsaturated hydrocarbons.

Exercise

(02 Marks Questions)

1. To which class of compound C_4H_{10} belongs and how?
2. To which class of compound C_5H_{10} belongs and how?
3. To which class of compound C_6H_{10} belongs and how?
4. What are saturated hydrocarbons?
5. What are unsaturated hydrocarbons?
6. How C_4H_8 is unsaturated?
7. What are aliphatic hydrocarbons? Give any two examples of it.
8. What is the IUPAC name of isopropyl alcohol?
9. What is the IUPAC name of tertiary butyl alcohol?
10. What is the IUPAC name of isobutyl chloride?
11. Give the structural formula of 4-Chloro-5-methylpent-2-en-2-ol.
12. Define Huckel's rule for aromativity.
13. How benzene is aromatic?
14. What is tertiary alkyl halide? Give an example of it.
15. What is the general formula of monohydric alcohols? Five a suitable example of it.

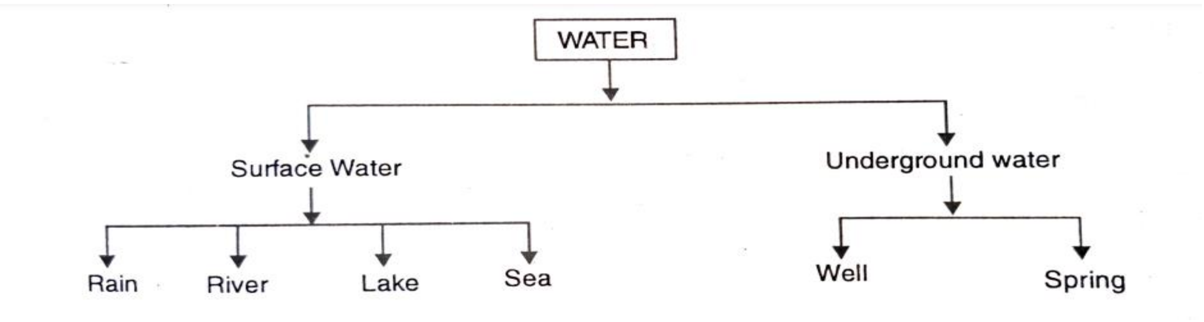
(05 Marks Questions)

1. What are saturated and unsaturated hydrocarbons? Is benzene saturated? Justify your answer.
2. Define and explain Huckel's rule of aromaticity with suitable examples.
3. What are aliphatic hydrocarbons? How can you classify them?
4. Define with example: Prefix, word root, primary suffix and secondary suffix.
5. What are the conditions of aromaticity?
6. Mention any two uses of benzene and toluene.
7. Mention any two uses of toluene and phenol
8. Mention any two uses of toluene naphthalene.
9. Mention any two uses of benzene and Anthracene
10. Mention any two uses of benzene and BHC.

CHAPTER – 10
WATER TREATMENT

Water: -Water is one of the most plentiful and readily available of all chemicals. Next to air, water is the important constituent of life-support systems. It is called Universal Solvent because it can dissolve more substances than any other liquid. Although it is most often perceived as a liquid at normal atmospheric pressure, water exists as a solid below 0^0C and as a gas above 100^0C.

Sources of water: - The sources of water can be classified as follows.



A. Surface water- Surface water is just what the name implies; it is water found in a river, lake or other surface cavity.

1. **Rainwater:**
   - Rainwater is considered to be the purest form of natural water as impurities and salts present in water on earth are left behind during vaporization by the sun.
   - But when the rain droplets fall, they dissolve gases like carbon dioxide, oxides of sulphur and nitrogen which make the rain slightly acidic.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$SO_2 + H_2O \rightarrow H_2SO_3$$

2. **River water:**
   - A river is a naturally flowing watercourse, usually freshwater, flowing towards a sea lake or another river.
   - Rivers are nourished by precipitation, by surface runoff, through springs or from melting of glaciers.
   - It contains high percentage of dissolved minerals like NaCl, KCl, $NaNO_3$, $CaCO_3$, $NaHCO_3$ etc.
3. **Lake water:**
   - Lake is a relatively large body of slowly moving or standing water that occupies an inland basin of appreciable size.
   - Lake water contains lesser amounts of dissolved minerals but considerable amount of suspended and organic matters.
4. **Sea water:**
   - Sea water is the water from sea or ocean and is the most impure form of natural water.

- It contains about 3.5% of dissolved minerals out of which about 2.5% is only NaCl. Sea water also contains a number of dissolved gases like nitrogen, oxygen, carbon dioxide and noble gases and biomaterials like carbohydrates, proteins, amino acids etc.

B. Underground Water:

- Groundwater is the water that occurs below the surface of Earth, where it occupies all or part of the void spaces in soils or geologic strata.
- It is naturally replenished by rain and snow melt that seeps down into the cracks and crevices beneath the land's surface.

Underground water is of two types.

1.Spring water:

- A spring is a natural outflow of water from an underground supply to the ground surface.
- It is a clearer form of natural water.
- It contains high percentage of minerals like magnesium, calcium, sodium and potassium & thus its hardness is very high.

2.Well water:

- A well is a hole drilled, dug, or driven into the earth to obtain groundwater.
- It is a clearer form of natural water.
- It contains many dissolved minerals and some organic matter.

Types of water

Water is of 02 types:
(1) Soft water & (2) Hard water.

1. Soft water: - Water which forms lather with soap solution is called soft water.

Ex: - Rainwater, demineralized water, distilled water etc.

2. Hard water: - Water which does not form lather with soap solution is called hard water. Instead, it forms a curdy white precipitate.

Ex: - Sea water, river water, Pond water etc.

Hardness of water:

It is the characteristic of water which prevents the lathering of soap due to the presence of bicarbonate, sulphate and chloride of calcium and magnesium in it.
Soap reacts with hard water as

$$2C_{17}H_{35}COONa + MgSO_4 \rightarrow (C_{17}H_{35}COO)_2Mg + Na_2SO_4$$

(Sodium stearate) soap (Impurity in hard water) (Magnesium stearate)

Types of hardness:

Hardness of water is of two types:
A. Temporary or Carbonate hardness
B. Permanent or Non-carbonate hardness

A. **Temporary hardness:** The temporary hardness of water arises due to the presence of bicarbonates of **Ca and Mg, [Ca (HCO3)2, Mg (HCO3)2]**.
It is named temporary hardness because the soluble bicarbonates decompose into insoluble carbonates simply on heating. Thus, water becomes soft. It is also called carbonate hardness.

B. **Permanent hardness: The** permanent hardness of water arises due to the presence of chlorides of Ca, Mg ($CaCl_2$, $MgCl_2$).It is named permanent hardness because such a hardness cannot be removed by simply boiling the water.

Unit of hardness

(1) PPM – Parts per million.
(2) mg/L – Milligrams per Litre.

Softening of water or removal of hardness:

Water softening is the process of removing the dissolved calcium and magnesium salts that cause hardness in water.

Removal of temporary hardness:

When temporary hard water is boiled, the soluble bicarbonates present in water decompose to give insoluble carbonates which settle down easily. Then the soft water is filtered off.

$$Ca(HCO_3)_2 \xrightarrow{Boil} CaCO_3 + H_2O + CO_2 \uparrow$$

Hard Water (insoluble)
(soluble)

$$Mg(HCO_3)_2 \xrightarrow{Boil} MgCO_3 + H_2O + CO_2 \uparrow$$

Hard Water (insoluble)
(Soluble)

Removal of permanent hardness:

A. **Lime Soda Process:** In this process hard water is treated with a calculated quantity of lime and soda. Lime and soda convert the soluble hardness causing chemicals present in hard water into insoluble substances called sludges.The precipitate or sludge formed is then removed by filtration to get soft water.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$

(soluble) soda (insoluble)

$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCl_2$$

(soluble) soda (Insoluble)

Lime-Soda process is of two types.

(a) Cold Lime soda process (b) Hot lime soda process

(a) Cold Lime Soda Process:

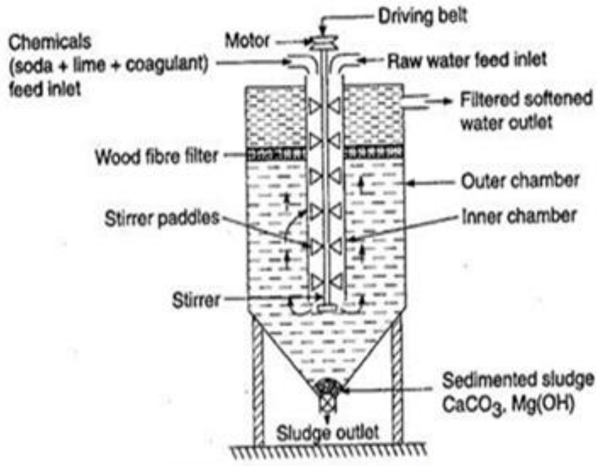
Principle: When hard water is treated with calculated amount of lime [$Ca(OH)_2$] and soda (Na_2CO_3) at room temperature 25ºC, the soluble Ca and Mg salt present in hard water are chemically converted into ppt. of calcium carbonate ($CaCO_3$) and magnesium hydroxide [$Mg(OH)_2$]. These ppts are removed by filtration. Thus, soft water is obtained.

$$\underset{\text{hard water}}{CaCl_2} + \underset{\text{soda}}{Na_2CO_3} \rightarrow \underset{\text{ppt}}{CaCO_3\downarrow} + 2NaCl$$

$$\underset{\text{hard water}}{MgCl_2} + \underset{\text{lime}}{Ca(OH)_2} \rightarrow \underset{\text{ppt}}{Mg(OH)_2\downarrow} + CaCl_2$$

Process:

The apparatus consists of a conical shaped steel tank (Fig. 10.1) Raw water, lime, soda and coagulants are added from the top inner vertical circular chamber which is fitted with rotating shaft carrying many paddles. The dissolved salts of Ca and Mg combine with lime soda and coagulants and form an insoluble precipitate as sludge. Softened water rises upwards and the heavy sludge settles down. Then the softened water passes through wood fibre filter and the filtered soft water is collected through the outlet. The sludge setting down at the bottom is removed. The residual hardness left in this process is about 50 - 60 ppm.



(Figure 10.1 Cold Lime-Soda Process)

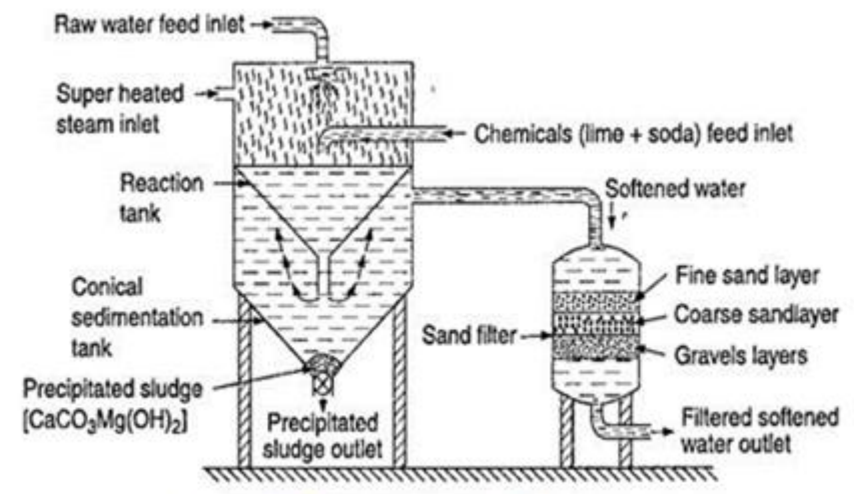
Dis-advantages:

- It is a slow process because reactions during water softening take place in very dilute solutions and room temp.
- It requires coagulant for setting particles of ppt. formed during reaction of water softening.
- Softening capacity of this process is less.
- Soft water obtained by this process consists of dissolved gases.

(b) Hot Lime Soda process:

Principle: This process involves treatment of hard water with lime and soda at a temp. of 80-150^{0}C.

Process: In the hot lime soda process, the reactions take place at higher temperature near about boiling point of water. The chemical mixing process is same as the cold lime soda process, but steam is applied in mixture tank. As a result, precipitation becomes almost complete very quickly.



(Figure 10.2 Hot Lime-soda Process)

Apparatus:

The apparatus consists of 3 main parts (Fig. 10.2).
(a) Reaction tank – in which hard water, lime & soda are mixed thoroughly.
(b)Conical sedimentation vessel – in which sludges settle down.
(c)Sand filter – where sludge is completely removed.

Advantages:

1. It is much economical.
2. The reaction is completed within a short period.
3. The reaction proceeds faster. Hence the softening capacity in increased.
4. No coagulant is required, as the sludge settles down easily.
5. Dissolved gasses like CO_2, air etc. are removed.
6. Under hot condition viscosity of water is lowered. Thus, filtration becomes easier.
7. Pathogenic bacterias are destroyed.
8. The residual hardness left in this process is much lower (15-30 ppm) as compared to that in the cold L-S process (50-60 ppm).

Dis-advantages:

- For efficient and economical softening careful operation and skilled supervision is required.
- Disposal of large amounts of sludge creates problem.
- This can remove hardness only up to 15ppm, which is not suitable for high pressure boilers.

Difference between cold lime soda process & hot lime soda process

Cold Lime soda process	Hot lime soda process
1. This process is conducted at room temp. (25^0C)	This process is conducted at 80^0 to 150^0 C.
2. It is costlier.	It is much economical.
3. The process takes longer time to complete.	It takes comparatively less time for completion.
4. The reaction is slower.	The reaction proceeds faster. Hence the softening capacity in increased.
5. Coagulant like alum is required.	No coagulant is required, as the sludge settles down easily.
6. Dissolved gases are not escaped.	Dissolved gasses like CO_2, air etc. are removed.
7. Filtration is comparatively slower.	Under hot condition viscosity of water is lowered. Thus, filtration becomes easier.
8. Pathogenic bacterias are not destroyed.	Pathogenic bacterias if any are destroyed.
9. The residual hardness left is more, i.e., 50 – 60 ppm.	The residual hardness left in this process is much lower (15-30 ppm) as compared to that in the cold L-S process (50-60 ppm).

Advantages of Hot soda lime process over cold soda lime process: -

(i) The precipitation reaction becomes almost complete.
(ii) The reaction takes place faster.
(iii) The sludge settles rapidly.
(iv) No coagulant is needed.
(v) Dissolved gases are removed.
(vi) Residual hardness is low as compared to the cold lime-soda process.

Ion – Exchange Process [Deionization or De-mineralization process]:

In this method, the ions responsible for hardness are exchanged with other ions which don’t make water hard.

Organic ion-exchangers (Ion-exchange resins): -

These are organic polymers having:
(i) high molecular weight.
(ii) Open and permeable molecular structure.
(iii) acidic (-COOH, $-SO_3H$) or basic groups ($-OH^-$, $-NH_2$) attached with them.

Ion-exchange resins are of two types:

(a) Cation-exchange resin(R-H^+): If the active ion in ion-exchanger is a cation, generally acidic functional groups, the resin is called cation-exchange resin, Ex – (Resin-H^+)

(b) Anion-exchange resin (R-H^-): If the active ion in ion-exchanger is an anion, generally basic functional groups, the resin is called anion-exchange resin Ex – (Resin-OH^-)

Process: The hard water is passed through a column of cation exchange resin called zero-carb. All the cations present in hard water get exchanged with H^+ ions of the resin (Fig. 10.3).

$$\underset{\text{(Cation-Exchange Resin)}}{2RH} + \underset{\text{hard water}}{Ca^{2+}} \rightarrow \underset{\text{Exhausted Resin}}{R_2Ca} + 2H^+$$

$$\underset{\text{(Cation-Exchange Resin)}}{2RH} + \underset{\text{hard water}}{Mg^{2+}} \rightarrow \underset{\text{Exhausted Resin}}{R_2Mg} + 2H^+$$

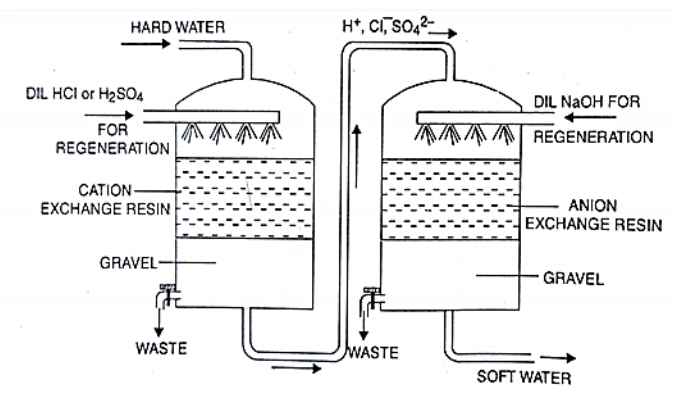
Then the hard water is passed through the column of anion exchange resin. All the anions present in water get exchanged with OH- ions of the resin.

$$\underset{\text{(Anion-Exchange Resin)}}{ROH} + \underset{\text{hard water}}{Cl^-} \rightarrow \underset{\text{Exhausted Resin}}{RCl} + OH^-$$

H^+ and OH^- ions released from the cation and anion exchange columns respectively get combined to produce water molecules.

$H^+ + OH^- \rightarrow H_2O$

Thus, the water coming out from the exchanger is free from cations as well as anion. Such water is known as deionized or demineralized water.



(Figure: 10.3 Organic Ion-Exchanger)

Regeneration of resins:

When all the H^+ and OH^- ions of the resins are exchanged by the cations and anions present in hard water, then the resins are said to be exhausted and regeneration can be done.

The cation-exchange resin can be regenerated by the treatment with dilute acids like dil. HCl or dil.H_2SO_4.

$$\underset{\text{(Exhausted resin)}}{R_2Ca} + 2HCl \rightarrow \underset{\text{(Regenerated resin)}}{2RH} + CaCl_2$$

Similarly, the anion-exchange resin can be regenerated by the treatment with dilute alkali like, dil NaOH solution.

$$\underset{\text{(Exhausted resin)}}{RCl} + NaOH \rightarrow \underset{\text{(Regenerated resin)}}{ROH} + NaCl$$

The regenerated resins may be used again.

Advantages of Ion – Exchange Process –

i. This process can be used to soften highly acidic or alkaline water.
ii. It produces water of very low hardness (up to 2 ppm). So, it is good for treating water for use in high pressure boilers.

Dis-advantages of Ion – Exchange Process:

- The equipment is costly and more expensive chemicals are needed.
- If water contains turbidity, then output of the process is reduced.

Exercise

(02 Marks Questions)

1.Define soft water and hard water.

2.What is hardness of water?

3.Why hard water does not produce lather with soap solution?

4.What do you mean by temporary and permanent hardness?

5.How temporary hardness can be removed?

6.What is the principle of Lime soda process?

7.What are the advantages of Hot Lime-Soda process?

8. What are the advantages of Ion-exchange process?

(05 Marks Questions)

1.Explain the softening of water by Lime-Soda process.

2.How hard water can be softened by Ion-exchange process?

3.Write the difference between cold lime-soda process and hot lime-soda process.

CHAPTER – 11
LUBRICANTS

Introduction:

Lubricant is a substance, usually organic, introduced to reduce frictional resistance between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. The property of reducing friction is known as lubricity.

In addition to industrial applications, lubricants are used for many other purposes. Other uses include cooking (oils and fats in use in frying pans, in baking to prevent food sticking), bio-applications on humans (e.g., lubricants for artificial joints), ultrasound examination, medical examination. It is mainly used to reduce friction and to contribute to a better and efficient functioning of a mechanism.

Definition of Lubricants: Lubricants are the chemical substances applied in between two moving or sliding surfaces with a view to reduce the frictional resistance between them.

Types of lubricants: Basing upon the physical states, lubricants can be classified into three categories.

1.Solid lubricants: The lubricants that exist in solid form are called solid lubricants. Solid lubricants are preferred where the working temperature is very high and where there is a chance of contamination of the products with the lubricant.

Examples: Layered Compounds like graphite, boron trinitride, molybdenum disulphide, mica etc. are used as solid lubricants.

Uses of graphite:

- It is used to lubricate air compressors, railway track joints, food stuff industries, IC engines, open gears etc.
- Graphite mixed with oil called oil dag is used in IC engines.
- Graphite mixed with water called aqua dag is used in food industries.

2.Liquid lubricants: These are also known as lubricating oils.

Examples: Petroleum oil, Animal and Vegetable oil, Blended oil etc.

Uses of liquid lubricants: Liquid lubricants are used when,

- The operating temperature is high.
- Speed of the roller is high.
- The sealing arrangement is perfect to prevent the loss of oil.

3.Semisolid lubricants: Semi-solid lubricants are gel-like substances which reduce friction between two moving surfaces.

Example-greases, Vaseline, waxes, etc.

Uses of Grease:

- Used where oil cannot remain in place due to high load, low speed, sudden jerks like rail axle.
- In bearings and gears which work at high temperature.

- ☞ Where dropping of oil affects the machine or products like production of paper, textile etc.

Purpose of lubrication or Functions of lubricants:

1. It reduces friction and minimizes were and tear.
2. It reduces loss of energy.
3. It reduces noise pollution.
4. It increases the efficiency of engines.
5. It enhances the durability of machinery parts.
6. It reduces expansion of metals.
7. It acts as a coolant by removing heat of friction.

Exercise

(02 Marks Questions)

1.Define lubricant. Give an example of a semi-solid lubricant.

2.Give example of solid lubricants. Write the uses of graphite.

3.What are liquid lubricants?

(05 Marks Questions)

1.What is a lubricant? Write the major functions of lubricants.

2.Define lubricant. Write the classification of lubricants with examples.

CHAPTER – 12

FUEL

Introduction:

Fuel is any material that can be made to react with other substances so that it releases energy as heat energy or to be used for work. The concept was originally applied solely to those materials capable of releasing chemical energy but has since also been applied to other sources of heat energy such as nuclear energy (via nuclear fission and nuclear fusion).

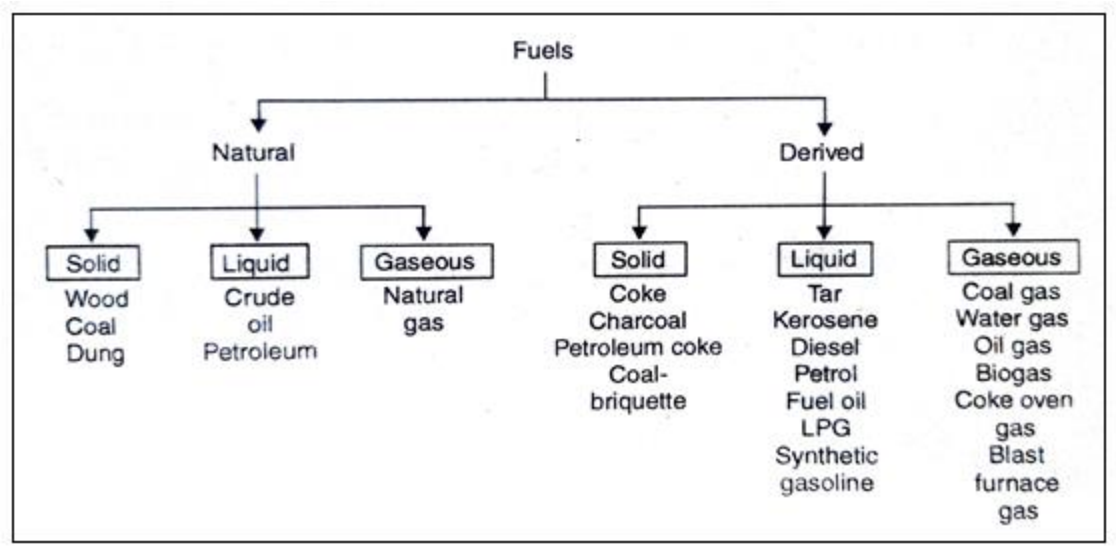
The heat energy released by reactions of fuels is converted into mechanical energy via a heat engine. Other times the heat itself is valued for warmth, cooking, or industrial processes, as well as the illumination that comes with combustion. Fuels are also used in the cells of organisms in a process known as cellular respiration, where organic molecules are oxidized to release usable energy. Hydrocarbons and related oxygen-containing molecules are by far the most common source of fuel used by humans, but other substances, including radioactive metals, are also utilized.

Fuels are contrasted with other substances or devices storing potential energy, such as those that directly release electrical energy (such as batteries and capacitors) or mechanical energy (such as flywheels, springs, compressed air, or water in a reservoir).

Definition: Fuel is defined as a combustible substance which on combustion produces a large amount of heat energy without producing excess by-products.

Fuel + O_2 → Products + Heat

Classification of Fuels:



A. On the basis of their occurrence, fuels may be classified into two categories: -

1. **Natural Fuels:** Such fuels are found in nature.

   Ex-Wood, coal, petroleum, natural gas etc.

2. **Artificial Fuels:** Such fuels are prepared from natural fuels.

   Ex-Coke, kerosene, petrol, water gas, producer gas etc.

B. Based on their physical state, fuels may be classified into three categories:

1. **Solid Fuels**: Fuels which are found in their solid state at room temperature are generally referred to as Solid Fuels.

   Ex-Wood, coal, charcoal, straw etc.

2. **Liquid Fuels:** Most liquid fuels are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.

   Ex-Petroleum, Kerosene, Petrol, Diesel, alcohol etc.

3. **Gaseous Fuels:** Most gaseous fuels are composed of hydrocarbons, carbon monoxide, hydrogen, or a mixture of them all.

   Ex- Natural gas, Coal gas, Producer Gas, Water Gas, Hydrogen etc.

Calorific value of fuel:

Calorific value may be defined as "the amount of heat energy produced by the complete combustion of a unit mass or unit volume of fuel in air."

Units of Calorific value are: Cal/gm, Kcal/Kg, KJ/Kg, B.Th./lb (British Thermal Unit/pound) etc.

Characteristics of good fuel:

1. It should have high calorific value.
2. It should be cheap and readily available.
3. It should leave only small amount of residue or ash when burnt.
4. It should have a controllable combustion rate.
5. It should not produce harmful combustion products.
6. It should not produce much smoke.
7. It should have moderate ignition temperature.
8. It should not be explosive in nature.
9. It should have low moisture content.
10. It should require low storage volume.
11. It should be easy to transport.

Composition and uses of some liquid fuels:

Diesel

- It contains a mixture of hydrocarbons between pentadecane to octadecane ($C_{15}H_{32}$ to $C_{18}H_{38}$).
- Average composition: C = 85%, H = 12%, Rest = 3%
- Calorific Value = 11,000 Kcal/kg

Uses: It is used as a fuel in diesel engine.

Petrol or Gasoline

- It contains a mixture of hydrocarbons between pentane to octane (C_5H_{12} to C_8H_{18}).
- It is volatile and inflammable.
- Average Composition C = 84%, H=15%, O+S+N =1%
- Calorific Value = 11,250 Kcal / Kg.

Uses:

- ☞ It is used as a fuel for internal combustion engines of automobiles.
- ☞ It is used as a dry-cleaning agent.

Kerosene

- ➢ It consists of hydrocarbons between decane to hexadecane ($C_{10}H_{22}$ to $C_{16}H_{34}$).
- ➢ Average Composition, C = 84 % , H = 16%, S < 0.1%
- ➢ Calorific value = 11,100 Kcal/ Kg

Uses:

- ☞ It is used as a domestic fuel in stoves.
- ☞ It is used as jet engine fuel for making oil gas.

Composition and uses of some gaseous fuels:

1. **Water Gas**
    - **(i)** It is a mixture of combustible gases CO and H_2 with a little quantity of non-combustible gases like CO_2 and N_2.
    - **(ii)** The average composition of water gas is H_2= 51 %, CO = 41 %, CO_2 = 4% & N_2 = 4%,
    - **(iii)** Its calorific value is 2800 Kcal / m^3 .

Uses: It is used:

- ☞ as a source of H_2 Gas.
- ☞ as a fuel.
- ☞ as an illuminating gas.
- ☞ for welding purposes.

2. **Producer Gas:**
    - **(i)** It is a mixture of combustible gases, CO and H_2 with large quantities of non-combustible gases CO_2 and N_2.
    - **(ii)** The avg. composition of producer gas is CO = 22-30%, H_2 = 8-12 %, N_2 = 52-55 % & CO_2 = 3%
    - **(iii)** Its calorific value is 1,300 Kcal /m^3.

Uses: It is used:

- ☞ For heating open-hearth furnaces in steel & glass manufacture, muffle furnace in coke & coal gas manufacture.
- ☞ As a reducing agent in metallurgical operations.

3. **Coal gas:**
    - **(i)** It is a mixture of a number of hydrocarbons along with N_2, H_2, CO & CO_2.
    - **(ii)** It is a colourless gas and burns with a sooty flame.
    - **(iii)** The average composition of coal gas is

H_2=40%, CH_4=32%, CO=7%, C_2H_2=2%, C_2H_4=3%, N_2=4%, CO_2=1% & rest=11%

    - **(iv)** Its calorific value is 4900 Kcal /m^3.

Uses: It is used:

- ☞ as a fuel.
- ☞ as a reducing agent in metallurgical operations.
- ☞ as an illuminant.

4. LPG (Liquified petroleum gas):

(i) It is mainly C3, C4 hydrocarbons of alkane & alkene.

(ii) It is highly inflammable.

(iii) It is colourless and odourless but a smelling agent called ethyl mercaptan(C_2H_5SH) is added to it to detect the leakage.

(iv) The average composition of LPG is

n-butane=27%, iso-butane=25%, butene=43%, propene=2.5% & propane=2.5%.

(v) Its calorific value is 27,800 Kcal /m^3.

Uses: It is used:

- As a domestic fuel.
- As an industrial fuel.
- As a vehicular fuel.

5. CNG (Compressed Natural Gas):

(i) It is a colourless, odourless gas and burns with a pale blue flame.

(ii) The average composition of CNG is:

CH_4=70-90%, C_2H_6=4-9% & traces of propane and butane.

(iii) Its calorific value is 12500 Kcal /m^3.

Uses: It is used:

- as a fuel in low emissive vehicles like ULEV (ultra-low emission vehicles).
- as a domestic and industrial fuel.
- as a source of carbon in tyre industry.
- for the production of H_2 gas needed in fertilizer industry.

Exercise

(02 Marks Questions)

1.Define fuel. Write the characteristics of a good fuel in terms of calorific value and moisture.

2.What is calorific value of fuel? Write its unit.

3.What is CNG?

4.Write the composition of coal gas.

5. Write the composition of producer gas.

6.What are derived fuels? Give two examples.

(05 Marks Questions)

1. Define fuel. What are the characteristics of a good fuel?

2.Write the composition and uses of water gas and producer gas.

3.Write short notes on LPG and CNG.

CHAPTER – 13
POLYMERS

Introduction:

Polymers are materials that are used in almost every material we encounter on a day-to-day basis. They have particular importance in today's increasingly industrial world. They are often found in the fields of science, technology and industry.

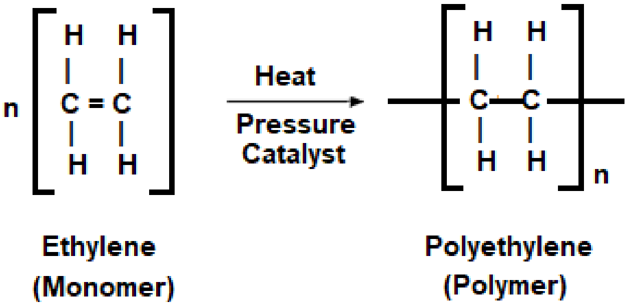
Product made from polymers are all around us: clothing made from synthetic fibers, polyethylene cups, fiberglass, nylon bearings, plastic bags, polymer-based paints, epoxy glue, polyurethane foam cushion, silicone heart valves, and Teflon-coated cookware. The list is almost endless.

Polymerization: The process of joining together a large number of simple small molecules to make large molecules of high molecular weight is called polymerization.

Polymers: Polymers are high molecular mass compounds whose structures are composed of a large number of simple molecules. For example: Polythene, PVC (polyvinyl chloride), Bakelite, Buna-S-rubber, Teflon, etc. are the examples of polymer.

The word "polymer" is derived from Greek word 'poly' meaning "many" and ' meres 'meaning "parts"

Monomer: Monomer is the single repeating unit which on polymerization gives a polymer. For example: Ethene is the monomer unit of polyethene.



(A) Depending upon the sources, polymers may basically be classified in to two types, they are:

- **(i) Natural Polymers:** These are the polymers which occur in the nature. Ex. Natural rubber, silk, polysaccharides, starch, cellulose, etc.
- **(ii) Synthetic Polymers:** These are the polymers which are manufactured in industries. Ex. Polythene, PVC, Bakelite, Teflon, Nylon, Buna-S, Buna-N, etc.

(B) Depending upon the nature of monomers present, polymers may be classified into the following types.

i. Homo-polymer:

The polymer containing monomer units of identical chemical composition is called a homo-polymer. In other words, the polymer formed from one type of monomer is called a homo-polymer. Example: polythene, PVC, Polystyrene etc.

----------M – M – M – M – M – -------- *where, "A" is the monomer unit.*

(homopolymer)

ii. Copolymer:

The polymer containing monomer units of different chemical composition is called co-polymer or mixed polymer. For example: Terylene is a polymer of two monomers ethylene glycol and terephthalic acid. Other examples of co-polymer are Bakelite, Nylon-6,6, Nylon-6,10, Buna-S, Buna-N etc.

$$\text{--------}M_1 - M_2 - M_1 - M_2 - M_1 - M_2 \text{-------}$$

(Copolymer)

(C) Depending upon the nature of the polymeric chain/structure polymers may be classified as:

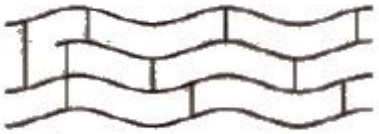
(i) **Linear polymers:** These are the polymers in which the monomer units are linked to one another to form long linear chains. These linear chains are closely packed in space. The close packing results in high densities, tensile strength and high melting and boiling points. e.g., high density polyethene, nylon and polyesters are linear polymers.


Linear chain polymer

(ii) **Branched chain polymers** In such polymers, the monomer units are linked to form long chains with some branched chains of different lengths with source. As a result of branching, these polymers are not closely packed in space. Thus, they have low densities, low tensile strength as well as low melting and boiling points. Some common Examples of such polymers are low density polyethene, starch, glycogen etc.


Branched chain polymer

(iii) **Cross-linked polymers or network polymers:** In such polymers, the monomer units are linked together to form three-dimensional network like structure. These are expected to be quite hard, rigid and brittle. Examples of cross-linked polymers are Bakelite, glyptal, melamine-formaldehyde polymer etc.


Cross linked polymer

Classification of Polymers Based on Mode of Polymerization

(i) Addition polymers: The polymers formed by the polymerization of monomers containing double or triple bonds (unsaturated compounds) without elimination of simple molecules are called addition polymers. Addition polymers have the same empirical formula as their monomers. Examples: Polythene, PVC, Polystyrene, etc.

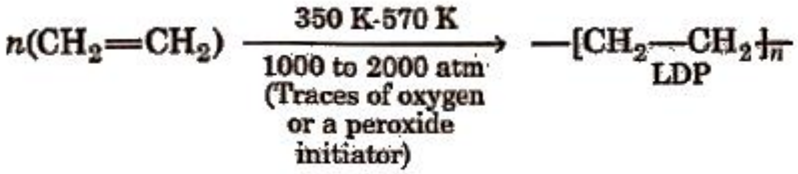
(ii) Condensation Polymers: The polymers which are formed by the combination of monomers with the elimination of small molecules such as water, alcohol, hydrogen chloride etc., are known as condensation polymers. Examples: Nylon-6,6 is formed by the condensation of hexamethylene diamine with adipic acid. Similarly, Bakelite is a condensation co-polymer of phenol and formaldehyde.

Distinction between Thermoplastics & Thermosetting.

	Thermoplastics	Thermosetting
1	These are formed by addition polymerization.	These are formed by condensation polymerization.
2	These are generally linear polymers.	These are three dimensional cross-linked polymers.
3	These are soft.	These are hard and rigid.
4	These are soluble in some solvents.	These are insoluble in any solvent.
5	These become soft on heating and become hard on cooling.	These burn to char on prolong heating.
6	These can be remoulded, reshaped and recycled.	These cannot be remoulded, reshaped and cannot recycled.
7	Examples: Polythene, PVC, Nylon, etc.	Examples: Bakelite, Urea-formaldehyde resin, Terylene, etc.

Polythene:

(i) Low density polythene (LDP)



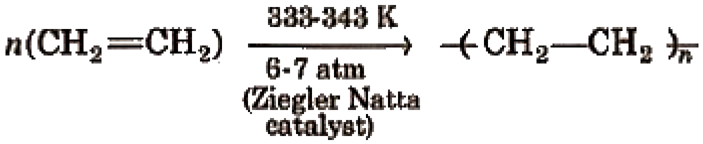
$$n(CH_2{=}CH_2) \xrightarrow[\text{1000 to 2000 atm (Traces of oxygen or a peroxide initiator)}]{\text{350 K-570 K}} \underset{\text{LDP}}{-[CH_2-CH_2]_n}$$

It is tough, flexible, transparent, chemically inert as well as poor conductor of electricity. It has moderate tensile strength but good tearing strength.

Uses: It is used

- in the insulation of electrical wires, cables.
- manufacture of bottles, toys and flexible pipes.

(ii) **High density polyethylene** (HDP)



$$n(CH_2{=}CH_2) \xrightarrow[\text{6-7 atm (Ziegler Natta catalyst)}]{\text{333-343 K}} -(CH_2-CH_2)_n$$

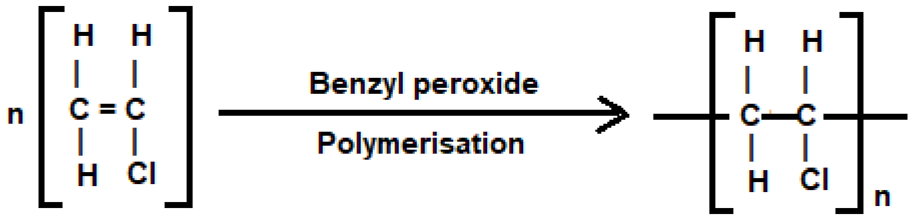
It has high density due to close packing. It is also chemically inert, tougher, and harder.

Uses: It is used

- in making containers,
- house wares,
- bottles,
- toys,
- electric insulation etc.

PVC (Poly Vinyl Chloride):

When vinyl-Chloride undergo polymerization in presence of a small quantity of benzyl peroxide, Poly Vinyl Chloride is formed



Vinyl chloride
(Monomer)

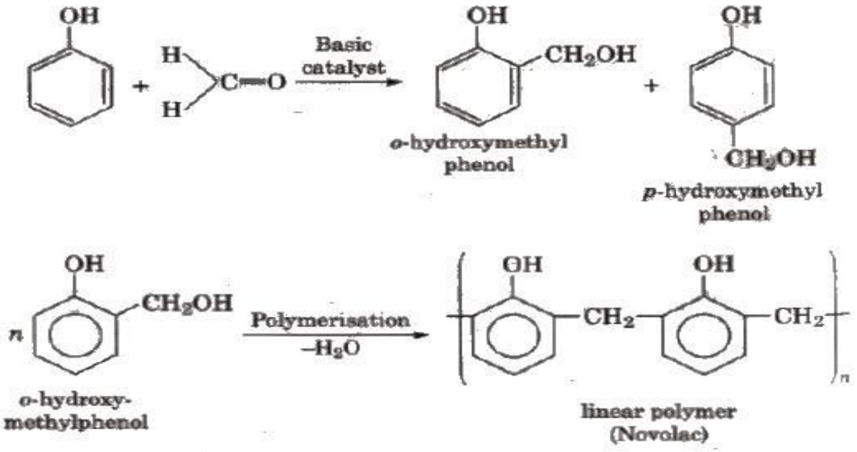
Polyvinyl chloride
(Polymer)

Uses: It is used for making:

- Sheets for tank lining
- Safely helmets.
- Refrigerator components
- Tyres, cycle and motorcycle mudguards
- Raincoat packing
- Tablecloths
- Electrical insulators
- Chemical containers, etc.

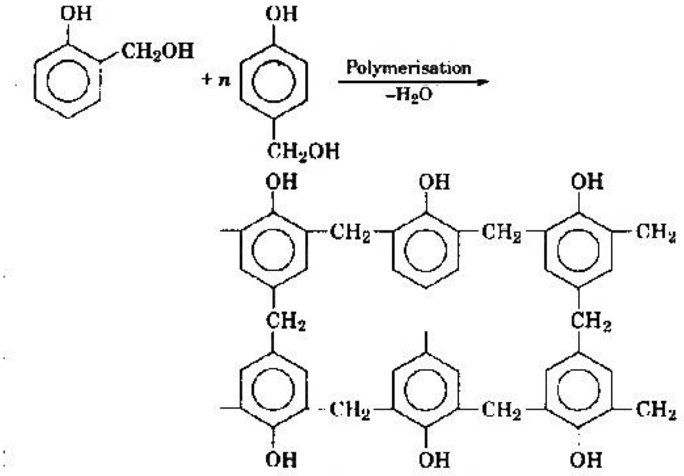
<u>Bakelite (Phenol-Formaldehyde Resin)</u>:

It is a co-polymer of **phenol and formaldehyde**. When phenol and formaldehyde are reacted together two isomeric compounds *O-hydroxy methylphenol and P-hydroxy methylphenol are obtained.*



The orthohydroxy methylphenol thus formed undergoes polymerization with phenol to form a linear polymer compound called **"NOVOLAC"**.

During the process of polymerization, a little quantity of hexamethylene tetraamine $[(CH_2)_6N_4]$ is added which converts 'novolac' into a hard resinous mass ***called Bakelite.***



cross linked polymer (bakelite)

Uses: *It is used in the manufacture of:*

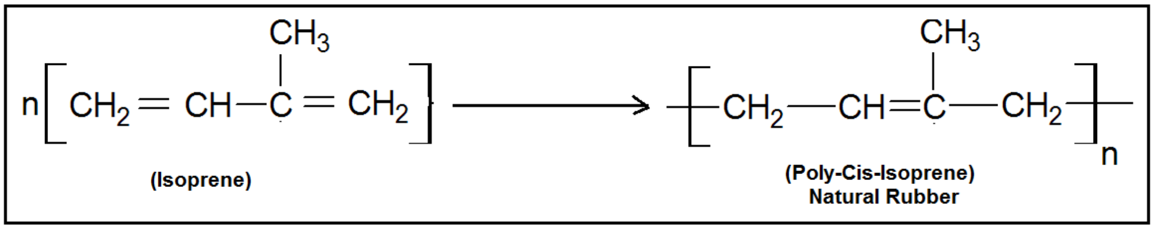
i. Electrical insulators like plug, switch etc.
ii. Cabinets for Radio and TV
iii. Telephone parts
iv. Paints, varnishes
v. Hydrogen exchange resin for softening of hard water.

RUBBER:

Rubber is a naturally occurring polymer. It is obtained as *latex* from rubber trees. It is highly elastic. It can be easily deformed but regains its original shape after the stress is relieved.

Rubber is obtained from rubber plants like '*Hevea brasiliensis'* generally found in the tropical regions of *Brazil, Indonesia, Malaysia* etc. Certain saps are cut on the rubber plants and the thick milky liquid *called* ***Latex*** is collected. It is then diluted with water and filtered to remove any impurities present in it. Then, the latex is treated with acetic acid (CH_3COOH) which coagulates the latex. The coagulated latex is then passed through a creeping machine to obtain sheets of rubber. These sheets of rubber are then put into moulding machine to get moulded articles.

Natural rubber consists of **"*isoprene*"** as the monomer units, which is in the form of the polymer polycis-isoprene. Thus, natural rubber is nothing but the polymer ***polycis-isoprene*****.**



$$n\left[CH_2=CH-\overset{CH_3}{\overset{|}{C}}=CH_2\right] \longrightarrow \left[-CH_2-CH=\overset{CH_3}{\overset{|}{C}}-CH_2-\right]_n$$

(Isoprene)

(Poly-Cis-Isoprene)
Natural Rubber

Draw backs of natural rubber:

Natural rubber or raw rubber has the following drawbacks:

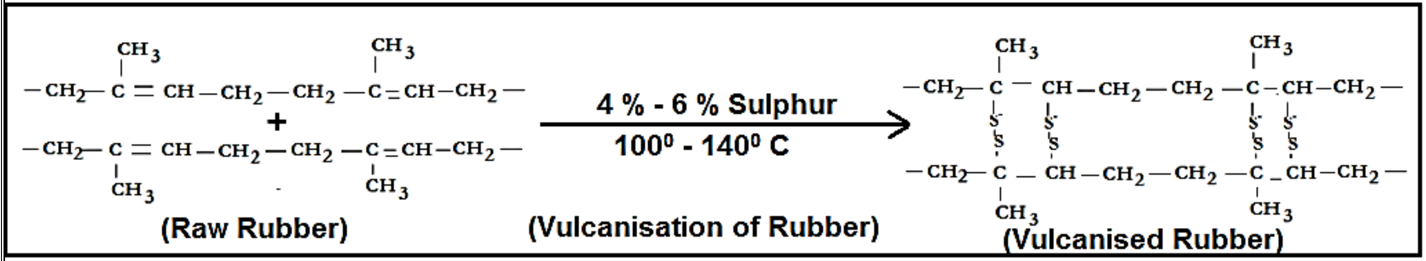
i. It has very low thermal stability
ii. It has very low tensile strength
iii. It has high water absorption capacity.
iv. It is attacked by atmospheric oxygen and ozone.

v. *It is attacked by acids and alkalis.*
vi. *It has the property of tackiness.*

Vulcanization of rubber:

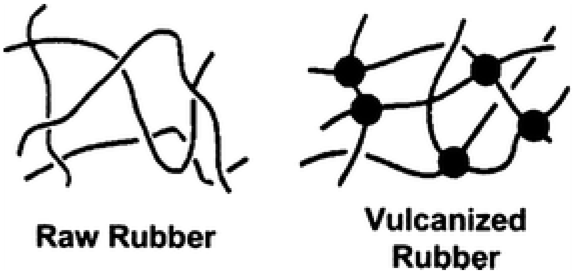
Natural rubber is a thermoplastic. There are no cross links between the polymer chains. It becomes soft and sticky when heated. It is not hard and tough. The properties of natural rubber can be modified and improved by the process of vulcanization. To improve the properties of natural rubber, it is heated with sulphur or sulphur containing compounds at a temperature of 100^0 -140^0 *C.*

The chemical process in which natural rubber is heated with 4 to 6% sulphur or sulphur containing compounds with a view to overcome the drawbacks of natural rubber are called vulcanization.



During vulcanization sulphur cross-links are formed in between the layers of polyisoprene at the carbon atoms containing double bond.

The formation of cross links makes *rubber hard, tough with greater tensile strength*. Although natural rubber is thermoplastic substance, yet on vulcanization, it is set into a given shape which is retained.



Advantages of Vulcanization:

After vulcanization, almost all the drawbacks of raw rubber are eliminated. Vulcanized rubber:

i. has higher thermal stability
ii. has comparatively lower tensile strength
iii. has low water absorption capacity.
iv. is not attacked by atmospheric oxygen and ozone.
v. is resistant to acids and alkalis.

Exercise

(02 Marks Questions)

1.Define monomer and polymer with example.

2.Define homopolymer and copolymer.

3.What is degree of polymerization?

4.Name the monomer of PVC. Write its two important applications.

5.Name the monomers of Bakelite. Write its two uses.

6.What is natural rubber?

7.Write two advantages of vulcanization.

(05 Marks Questions)

1.Explain the terms monomer, polymer, homopolymer, co-polymer & degree of polymerization with examples.

2.What is a polymer? Write the composition and uses of Bakelite.

3.Define polymer? Write the composition and uses of PVC.

4.What is vulcanization of rubber. Write the advantages of vulcanization.

5.What are the differences between thermoplastic and thermosetting polymers?

CHAPTER – 14

CHEMICALS IN AGRICULTURE

Pesticides: Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi, and unwanted plants (weeds).

The term pesticide includes all the following:

i. Insecticides
ii. Herbicides
iii. Fungicides.

Insecticides: Insecticides are substances used to kill insects.

Examples: - Chlorinated hydrocarbons like DDT, BHC (gammaxene), Aldrin, Dieldrin etc.

Uses- Insecticides are used in agriculture, medicine, industry and by consumers.

Herbicides: A herbicide is a chemical substance used to kill unwanted plants. These are commonly known as weedkillers.

Examples: Acetochlor, Amitrole, Arsenic acid, dinitrophenol, dipyridyl, carbamate, Propanil, Paraquat, etc.

Uses- Herbicides can be used to clear waste ground, industrial and construction sites, railways, and railway embankments as they kill all plant material with which they come into contact.

Also, these are applied in ponds and lakes to control algae & plants such as water grasses that can interfere with activities like swimming and fishing.

Fungicides: Fungicides are pesticides that prevent, kill, mitigate, or inhibit the growth of fungi on plants.

Ex- Bleaching powder, $CuSO_4$ solution, aluminium phosphide, Copper oxychloride, Carbendazim, Carboxin, Mancozeb, etc.

Uses-These are used to control fungi that damage plants.

Bio-fertilizers: Biofertilizers are the substance that contains living microorganism. Biofertilizers increase the nutrients of host plants when applied to their seeds, plant surface or soil by colonizing the rhizosphere of the plant. These are environment friendly substitute for harmful chemical fertilizers.

The microorganism in Biofertilizers restore the soil's natural nutrient cycle and build soil organic matter. These are extremely advantageous in enriching soil fertility & fulfilling plant nutrient requirements.

Ex-Rhizobium, Azotobacter, Azospirillum, Blue green algae etc.

Uses-

i. Rhizobium inoculant is used for leguminous crops.
ii. Azotobacter can be used with crops like wheat, maize. mustard etc.
iii. Blue green algae is used for paddy crops.
iv. Azospirillum is used for maize, sugarcane, millets etc.

Exercise

(02 Marks Questions)

1.What are insecticides? Give two examples.
2.What are fungicides? Write its uses.
3.What are herbicides? Write its uses.

(05 Marks Questions)

1. Define pesticide. Classify pesticides into different types with examples.
2. Define insecticide, herbicide and fungicide with suitable examples.
3. What are bio-fertilizers? Mention its different types with examples.

References:

1. Textbook of Intermediate Chemistry Part-1 and Part-2 by Nanda, Das, Sharma, Kalyani Publishers.