# LECTURE NOTES
# ON
# ENGINEERING CHEMISTRY

Prepared by

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# Chapter 8 – Alloys

**Definition** – Alloys are metallic materials consisting of 2 or more elements. They are mixture of metals with metals or non-metals.

**Features of Alloy** :

1. Alloys are homogeneous in molten state but they may be either homogeneous or heterogeneous in solid state.
2. Alloys containing mercury as one of the constituent are called amalgams.
3. An alloy must contain a metal.
4. In alloys, chemical properties of the component elements are retained, but certain physical properties are improved.

**Purpose of Making Alloys** :–

1. Enhance the hardness of metal
2. Lower the melting point
3. Enhance the tensile strength of parent metal
4. Enhance corrosion resistance
5. Provide better stability of castability.

**Types of Alloys** –

Ferro Alloy – Alloy containing (Fe) iron as main constituent.

Ex- Steel (General/Stainless), Manganese steel, Cast Iron

Non-Ferro Alloys- Alloys do not containing (Fe) iron as main constituent.

Ex- Bronze, Brass, Alnico, Duralumin, Solder, Gun metal, Bell metal etc.

Amalgam – Alloy containing Hg as main constituent

Ex- Hg+Sn+Cn+Zn – Dental fillings

| Type of Alloys | Composition | Uses |
|---|---|---|
| Brass | Cu : 65-90%<br>Zn : 35-10% | Door locks, Bolts, musical instruments, central hearing pipes, utensils, hardware items, screws, jewellery, Battery caps, tubes, nameplates |
| Bronze | Cu : 80-90%<br>Sn : 20-5% | Decorative statues, imitation jewellery, water fittings, medals, |

| | | |
|---|---|---|
| | | heavy load bearings, turbine blades, pump valves, coins |
| Alnico | Steel : 50%<br>Ni : 21%<br>Al : 20%<br>Co : 9% | Permanent magnets in loud speakers, microphones, pickups in electric guitars. |
| Duralumin | Al : 95%<br>Cu : 4%<br>Mn : 0.5%<br>Mg : 0.5% | Used in making air ships, air craft construction.<br>Surgical instruments, Automobile bodyparts, military equipment |

**Assignment:**

1. Define alloy. Write down the purposes of making alloy
2. What is the difference between ferro and non-ferro alloy. Explain with examples.
3. Write down the composition and uses of Brass, Bronze, Alnico and duralumin.

# Chapter 9 – Organic Chemistry

It is the chemistry of covalently bonded C-compounds except oxides, carbides and nitriles of carbon.

## Distinctive features of organic compounds:

1. **Vast Number:** Due to self linking property of C known as “catenation property”. it is the special nature of C-atom to combine with itself through covalent bonds forming long chains/rings of different sizes and shapes.

$_6C \rightarrow 1s^2\ 2s^2\ 2p^2$ (in ground state)

$^*{}_6C \rightarrow 1s^2\ 2s^1\ 2p^3$ (in excited stated)

Hence it shows tetracovalency

2. Complex nature with high molecular mass

3. Non-ionic and slow reversible nature of organic reaction

4. **Isomerism** : Organic compounds having the same molecular formula but different physical and chemical properties are called Isomers. The phenomena is called Isomerism.

5. **Homologous Series :** It is characterised by the presence of a functional group and can be represented by one general formula. One member of a particular homologous series differ from the consecutive member by a $-CH_2-$ group.

## Types of Bonds:

Single bond(C - C)-sigma bond

Double bond(C = C)-one sigma and one pi bond

Triple bond(C ≡ C)-one sigma and 2 pi bonds

# Classification of Organic Compunds

Based on C-skeleton

Acyclic/openchain/Aliphatic compounds

(Branched or straight chain)

Cyclic Compound or closed chain

Homocyclic/carbocyclic

Have 1/more rings composed

of C-atoms only

Heterocyclic

Closed ring compounds

containing 1/more

hetero atoms(N,S,O etc)

Acyclic rings(closed ring compounds

Containing C-atoms)

Aromatic compounds(closed ring compounds

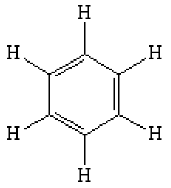
that obey Huckel's rule of aromaticity)

## Aromatic Compounds and Huckel's Rule of aromaticity or (4n + 2)π electron rule:

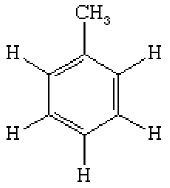
According to this rule , a cyclic, planar closed ring compound containing alternate single and double bond with (4n+2) no. Of π electrons is called an aromatic compound.

Where, n=1,2,3…etc

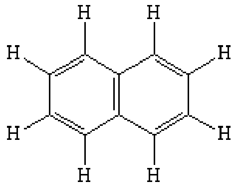
Ex: Benzene, Toluene, Naphthalene, Anthracene



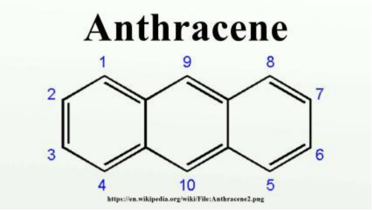
benzene



toluene



naphthalene



## Hydrocarbons:

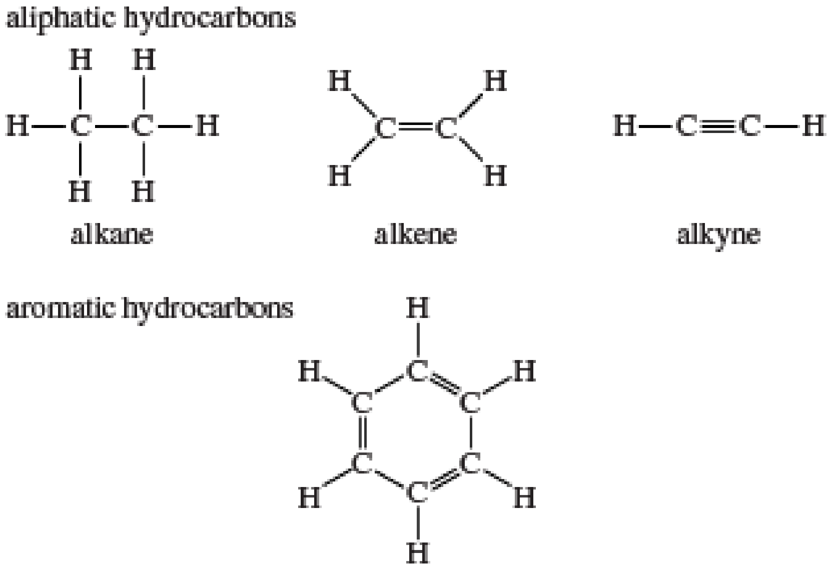
In organic chemistry, a hydrocarbon is an organic compound consisting entirely of hydrogen and carbon. Hydrocarbons are the principal constituents of petroleum and natural gas. They serve as fuels and lubricants as well as raw materials for the production of plastics, fibres, rubbers, solvents, explosives, and industrial chemicals.

Aliphatic hydrocarbons are divided into three main groups according to the types of bonds they contain: alkanes, alkenes, and alkynes.

1. Alkanes have only single bonds. These are called <u>saturated hydrocarbons</u>.
2. Alkenes contain a carbon-carbon double bond, and alkynes contain a carbon-carbon triple bond. These are called <u>Unsaturated hydrocarbons.</u>
3. Aromatic hydrocarbons are compounds with C and H only and they follow the Huckel's rule of aromaticity.

Ex:

**Structures of representative hydrocarbons**



Saturated hydrocarbons: $CH_4$(methane), $C_2H_6$(Ethane), $C_3H_8$(Propane) etc.

Unsaturated hydrocarbons: $C_2H_4$(Ethylene), $C_3H_6$(Propylene) etc. or $C_2H_2$(Acetylene), $C_3H_4$(Propyne) etc.

**<u>Difference between aliphatic and aromatic hydrocarbons:</u>**

| ALIPHATIC HYDROCARBONS | AROMATIC HYDROCARBONS |
|---|---|
| 1. Aliphatic hydrocarbons are organic compound composed of C, H and any other hetero atom like N,S,O etc arranged in straight chain or branched chain or cyclic structure . | 1. Aromatic hydrocarbons are organic compound composed of of C, H and any other hetero atom like N,S,O etc arranged in ring structure with delocalised pi electrons. |
| 2. Do not have a pleasant odour | 2. Have a pleasant odour. |
| 3. C to H ratio is high | 3. C to H ratio is low |
| 4. Burns with non-sooty flame | 4. Burns with sooty flame |
| 5. Some are saturated and others unsaturated | 5. All are unsaturated |

| | |
|---|---|
| 6. There are no delocalised pi electrons | 6. There are no delocalised pi electrons |
| 7. Do not obey Huckel’s rule of aromaticity | 7. Obey Huckel’s rule of aromaticity |
| 8. Majority of aliphatic compounds are not conjugated | 8. These are always conjugated due to presence of alternating single and double bonds. |
| 9. Ex: Butane and propane etc | 9. EX: Benzene and naphthalene etc |

## Assignments

1. Differentiate between aromatic and aliphatic compounds.
2. What are hydrocarbons? How many types of hydrocarbons are there? Explain with examples.
3. Classify organic compounds on the basis of their carbon skeleton.
4. Explain Huckel’s rule of aromaticity with examples.

# IUPAC Nomenclature of Organic Compounds:

A systematic naming system of organic compounds followed internationally. It consists of 4 parts basically:

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 the organic compound.

| NO. OF ‘C’ | ROOT WORD | NO. OF ‘C’ | 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 the organic compound. Some groups always act as substituent or side chain. They are:

| GROUP | PREFIX |
|---|---|
| -F | Fluoro- |
| -Cl | Chloro- |
| -Br | Bromo- |
| -I | Iodo- |
| $-NO_2$ | Nitro- |
| -R(side chains) | Alkyl- |
| -OR | Alkoxy- |

## 3. PRIMARY SUFFIX:

It refers to the presence of carbon-carbon single (C – C), double (C = C) or triple (C ≡ C) bond in the compound.

| NATURE OF THE BOND | PRIMARY SUFFIX |
|---|---|
| **Without functional group** | |
| All C - C bond | -ane |
| One C = C bond | -ene |
| Two C = C bond | -a-----diene |
| Three C = C bond | -a-----triene |
| One C ≡ C bond | -yne |
| Two C ≡ C bond | -a-----diyne |
| **With functional group** | |
| All C - C bond | -an- |
| One C = C bond | -en- |
| Two C = C bond | -a-----dien- |
| Three C = C bond | -a-----trien- |
| One C ≡ C bond | -yn- |
| Two C ≡ C bond | -a-----diyn- |
| Three C ≡ C bond | -a-----triyn- |

## 4. SECONDARY SUFFIX:

It refers to the presence of functional groups in the compound. Functional groups are the atoms or group of atoms which are responsible for the physical and chemical properties of the organic compounds.

| CLASS OF COMPOUND | FUNCTIONAL GROUP | SECONDARY SUFFIX |
|---|---|---|
| -OH | Alcohol | -ol |
| -CHO | Aldehyde | -al |
| >CO | Ketone | -one |
| -COOH | Carboxylic Acid | -oic acid |
| $-NH_2$ | Amine | -amine |
| $-CONH_2$ | Acid Amide | -amide |
| -COCl | Acid Chloride | -oylchloride |

* when using the secondary suffix, the C-atom of the functional group(if any) is normally included in the principal chain.

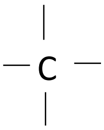
**Order of naming: Prefix-RW-P.S-S.S**

## IUPAC nomenclature of simple organic compounds:

## CLASS OF COMPOUNDS :

## 1. ALKANES:

General formula: $C_nH_{2n+2}$,: Representation:



Primary Suffix: -ane

IUPAC Name: Root Word +ane.

| **FORMULA** | **OPEN CHAIN STRUCTURE** | **IUPAC NAME** | **COMMON NAME** |
|---|---|---|---|
| $CH_4$ | - | Methane | Marsh gas |
| $C_2H_6$ | $CH_3CH_3$ | Ethane | |
| $C_3H_8$ | $CH_3CH_2CH_3$ | Propane | |
| $C_4H_{10}$ | $CH_3CH_2CH_2CH_3$ | Butane | |
| $C_5H_{12}$ | $CH_3CH_2CH_2CH_2CH_3$ | Pentane | |
| $C_6H_{14}$ | $CH_3CH_2CH_2CH_2CH_2CH_3$ | Hexane | |
| $C_7H_{16}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ | Heptane | |
| $C_8H_{18}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Octane | |
| $C_9H_{20}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Nonane | |
| $C_{10}H_{22}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Decane | |

## 2. ALKENES:

General formula: $C_nH_{2n}$, Representation: $>C = C<$

Primary Suffix: -ene

IUPAC Name: Root Word +ene.

| **FORMULA** | **OPEN CHAIN STRUCTURE** | **IUPAC NAME** | **COMMON NAME** |
|---|---|---|---|
| $C_2H_4$ | $CH_2 = CH_2$ | Ethene | Ethylene |
| $C_3H_6$ | $CH_2 = CHCH_3$ | Propene | Propylene |
| $C_4H_8$ | $CH_2 = CHCH_2CH_3$ | Butene | Butylene |
| $C_5H_{10}$ | $CH_2 = CHCH_2CH_2CH_3$ | Pentene | |
| $C_6H_{12}$ | $CH_2 = CHCH_2CH_2CH_2CH_3$ | Hexene | |
| $C_7H_{14}$ | $CH_2 = CHCH_2CH_2CH_2CH_2CH_3$ | Heptene | |
| $C_8H_{16}$ | $CH_2 = CHCH_2CH_2CH_2CH_2CH_2CH_3$ | Octene | |
| $C_9H_{18}$ | $CH_2 = CHCH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Nonene | |
| $C_{10}H_{20}$ | $CH_2 = CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Decene | |

**3. <u>ALKYNES:</u>** General formula: $C_nH_{2n-2}$, Representation: $-\ C \equiv C\ -$

Primary Suffix: -yne,

IUPAC Name: Root Word +yne. C2H2 Acetylene Ethyne C3H4 Propyne Propyne C4H6 Butyne Butyne

| **FORMULA** | **OPEN CHAIN STRUCTURE** | **IUPAC NAME** | **COMMON NAME** |
|---|---|---|---|
| $C_2H_2$ | $CH \equiv CH$ | Ethyne | Acetylene |
| $C_3H_4$ | $CH \equiv C - CH_3$ | Propyne | Allylene |
| $C_4H_6$ | $CH \equiv C - CH_2CH_3$ | Butyne | Crotonylene |
| $C_5H_8$ | $CH \equiv C - CH_2CH_2CH_3$ | Pentyne | |
| $C_6H_{10}$ | $CH \equiv C - CH_2CH_2CH_2CH_3$ | Hexyne | |

| | | | |
|---|---|---|---|
| $C_7H_{12}$ | $CH \equiv C–CH_2CH_2CH_2CH_2CH_3$ | Heptyne | |
| $C_8H_{14}$ | $CH \equiv C–CH_2CH_2CH_2CH_2CH_2CH_3$ | Octyne | |
| $C_9H_{16}$ | $CH \equiv C–CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Nonyne | |
| $C_{10}H_{18}$ | $CH \equiv C–CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | Decyne | |

## 4. ALKYL:

General formula: $C_nH_{2n+1}$ – or R – , Representation: R –

Common name: Alkyl, IUPAC Name: Root Word + yl

| FORMULA | OPEN CHAIN STRUCTURE | IUPAC NAME | COMMON NAME |
|---|---|---|---|
| $CH_3–$ | $CH_3–$ | Methyl- | |
| $C_2H_5–$ | $CH_3CH_2–$ | Ethyl- | |
| $C_3H_7–$ | $CH_3CH_2CH_2–$ | Propyl- | |
| $C_4H_9–$ | $CH_3CH_2CH_2CH_2–$ | Butyl- | |
| $C_5H_{11}–$ | $CH_3CH_2CH_2CH_2CH_2–$ | Pentyl- | |
| $C_6H_{13}–$ | $CH_3CH_2CH_2CH_2CH_2CH_2–$ | Hexyl- | |
| $C_7H_{15}–$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2–$ | Heptyl- | |
| $C_8H_{17}–$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2–$ | Octyl- | |
| $C_9H_{19}–$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2–$ | Nonyl- | |
| $C_{10}H_{21}–$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2–$ | Decyl- | |

## 5. ALKYL HALIDES OR HALOALKANES:

General formula: $C_nH_{2n+1}$ – X or R – X , where R= Alkyl, X= halogen (F, Cl, Br, I)

Representation: R – X , Common name: Alkyl halide

IUPAC Name: Halo +Root Word +ane.

X= Cl (Chloro-), Br(Bromo-), F(Fluoro-), I(Iodo)

| FORMULA (X=Cl) | OPEN CHAIN STRUCTURE | IUPAC NAME | COMMON NAME |
|---|---|---|---|
| $CH_3–Cl$ | $CH_3–Cl$ | Chloromethane | Methyl chloride |
| $C_2H_5–Cl$ | $CH_3CH_2–Cl$ | Chloroethane | Ethyl chloride |
| $C_3H_7–Cl$ | $CH_3CH_2CH_2–Cl$ | Chloropropane | Propyl chloride |
| $C_4H_9–Cl$ | $CH_3CH_2CH_2CH_2–Cl$ | Chlorobutane | Butyl chloride |
| $C_5H_{11}–Cl$ | $CH_3CH_2CH_2CH_2CH_2–Cl$ | Chloropentane | Pentyl chloride |

| | | | |
|---|---|---|---|
| $C_6H_{13}–Cl$ | $CH_3CH_2CH_2CH_2CH_2CH_2–Cl$ | Chlorohexane | Hexyl chloride |
| $C_7H_{15}–Cl$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2–Cl$ | Chloroheptane | Heptyl chloride |
| $C_8H_{17}–Cl$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2–Cl$ | Chlorooctane | Octyl chloride |
| $C_9H_{19}–Cl$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2–Cl$ | Chlorononane | Nonyl chloride |
| $C_{10}H_{21}–Cl$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2–Cl$ | Chlorodecane | Decyl chloride |

## 6. ALCOHOL:

General formula: $C_nH_{2n+1} – OH$ or $R – OH$ , where R= Alkyl, OH= functional group

Representation: R – OH , Common name: Alkyl alcohol

IUPAC Name: Root Word + an + ol.

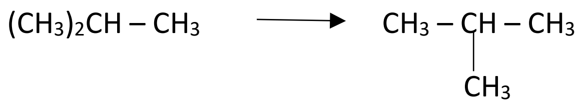
| FORMULA | OPEN CHAIN STRUCTURE | IUPAC NAME | COMMON NAME |
|---|---|---|---|
| $CH_3OH$ | $CH_3– OH$ | Methanol | Methyl alcohol |
| $C_2H_5$ OH | $CH_3CH_2– OH$ | Ethanol | Ethyl alcohol |
| $C_3H_7$ OH | $CH_3CH_2CH_2– OH$ | Propanol | Propyl alcohol |
| $C_4H_9OH$ | $CH_3CH_2CH_2CH_2– OH$ | Butanol | Butyl alcohol |
| $C_5H_{11}$ OH | $CH_3CH_2CH_2CH_2CH_2– OH$ | Pentanol | Pentyl alcohol |
| $C_6H_{13}$ OH | $CH_3CH_2CH_2CH_2CH_2CH_2– OH$ | Hexanol | Hexyl alcohol |
| $C_7H_{15}$ OH | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2– OH$ | Heptanol | Heptyl alcohol |
| $C_8H_{17}$ OH | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2– OH$ | Octanol | Octyl alcohol |
| $C_9H_{19}$ OH | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2– OH$ | Nonanol | Nonyl alcohol |
| $C_{10}H_{21}$ OH | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2–OH$ | Decanol | Decyl alcohol |

## RULES FOR IUPAC SYSTEM OF NOMENCLATURE FOR BRANCHED CHAIN COMPOUNDS:

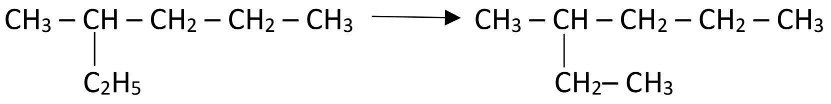
### 1. Expansion of chain:

Sometimes condensed groups are present in organic compounds. These condensed groups are to be separated.

Ex: $CH_3 – CH_2 – (CH_2)_2 – CH_3 \longrightarrow CH_3 – CH_2 – CH_2 – CH_2 – CH_3$



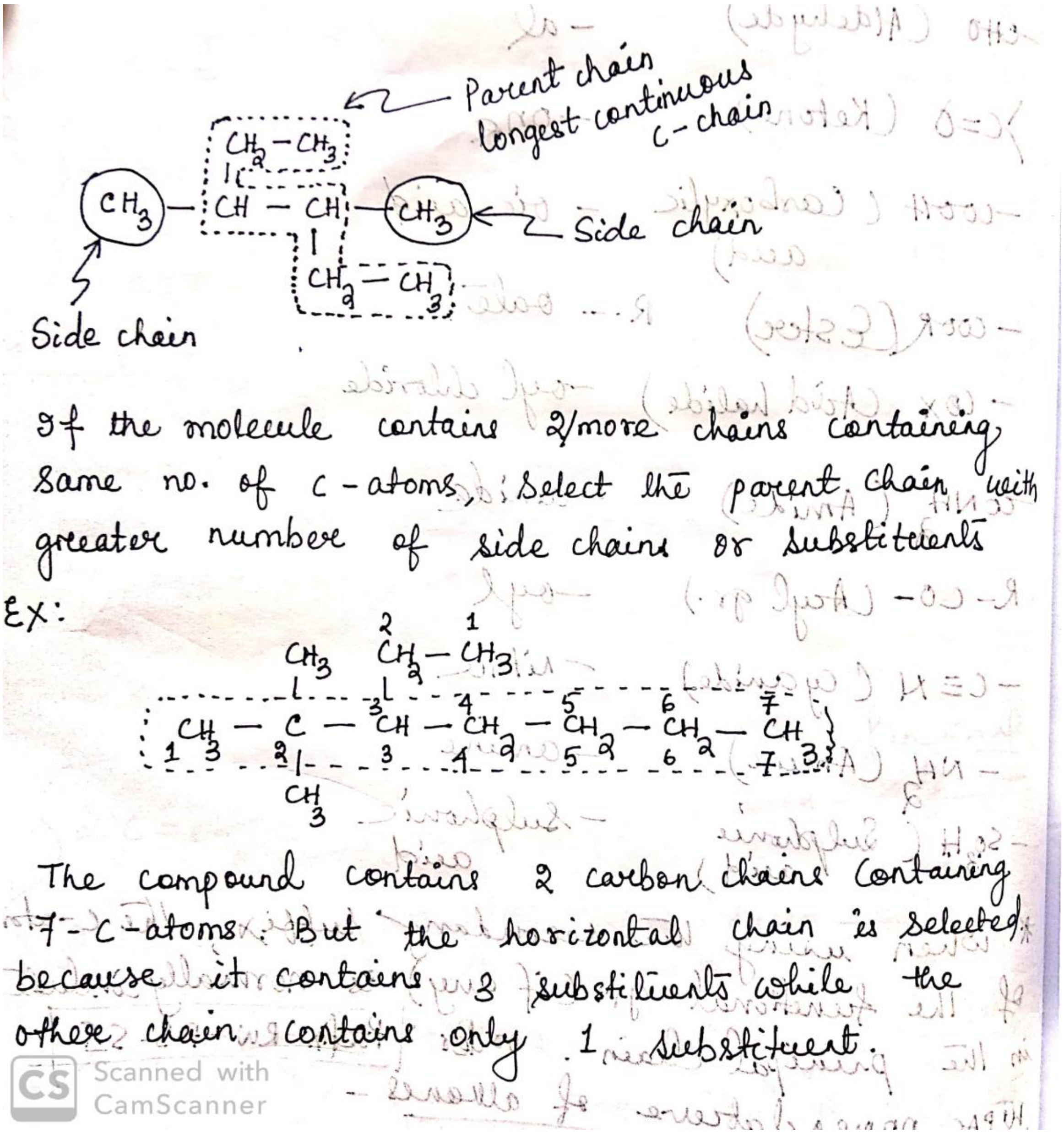
$$(CH_3)_2CH – CH_3 \longrightarrow CH_3 – \underset{\substack{|\\ CH_3}}{CH} – CH_3$$



$$CH_3 – \underset{\substack{|\\ C_2H_5}}{CH} – CH_2 – CH_2 – CH_3 \longrightarrow CH_3 – \underset{\substack{|\\ CH_2– CH_3}}{CH} – CH_2 – CH_2 – CH_3$$

## 2. Selection of Parent Chain:

The longest continuous carbon chain is called parent chain or Principal Chain. The parent chain is selected. The groups which are outside the parent chain are called substituents or side chains.



If the molecule contains 2/more chains containing same no. of C-atoms, Select the parent chain with greater number of side chains or substituents

Ex:

The compound contains 2 carbon chains containing 7-C-atoms. But the horizontal chain is selected because it contains 3 substituents while the other chain contains only 1 substituent.

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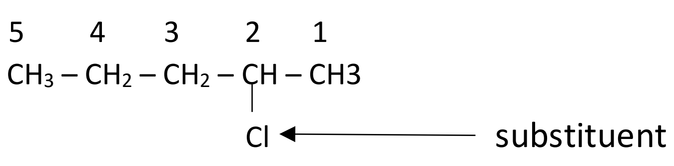
3. Numbering of Carbon:

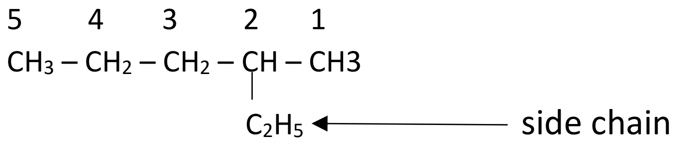
After selecting the parent chain, the carbon atoms of the parent chain are numbered. The numbering is always continuous and can be done either from left to right or right to left.

a. Presence of one Substituent (F, Cl, Br, I, $NO_2$, etc.) or one Side Chain(alkyl groups$CH_3$, $C_2H_5$, $C_3H_7$, etc.) :
 If a compound contains a substituent or a side chain then minimum number is given to the carbon containing the substituent or the side chain.

Ex:



$$\overset{5}{CH_3}-\overset{4}{CH_2}-\overset{3}{CH_2}-\underset{\underset{Cl}{|}}{\overset{2}{CH}}-\overset{1}{\mathrm{CH3}}$$

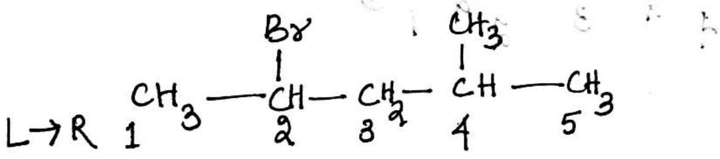


$$\overset{5}{\mathrm{CH_3}} - \overset{4}{\mathrm{CH_2}} - \overset{3}{\mathrm{CH_2}} - \overset{2}{\underset{\underset{\mathrm{C_2H_5}}{|}}{\mathrm{CH}}} - \overset{1}{\mathrm{CH3}}$$

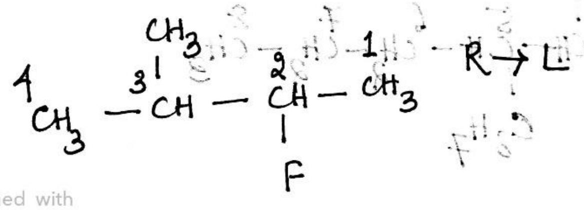
side chain

b. Presence of one Substituent and one Side chain at the same position from either end:

In such a case minimum number is given to the carbon containing the substituent.



C-containing Br is given minimum no. as it is a substituent



C-containing F is given minimum no. as it is a substituent

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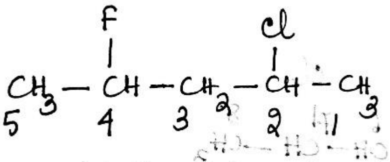
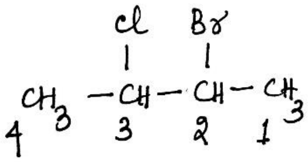
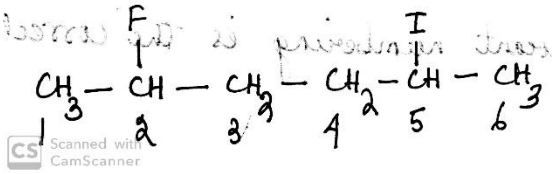
c. Presence of two substituents at the same position from either end:
In this case minimum number is given to the carbon containing the substituent which comes 1st in alphabetical order.



Chloro comes before fluoro in alphabetical order, hence C-containing Cl is given minimum no.



Bromo comes before Chloro in alphabetical order, hence C-containing Br is given minimum no.



Fluoro comes before iodo in alphabetical order, hence C-containing F is given minimum no.

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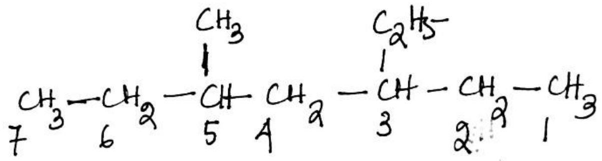
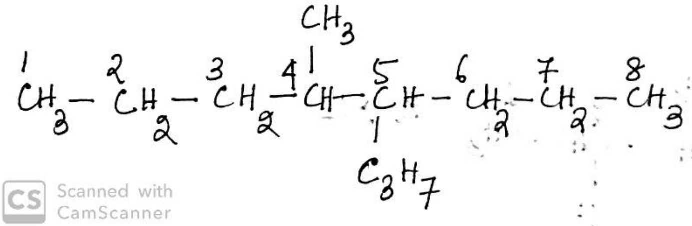
d. Presence of two side chains at the same position from either end:

In this case minimum number is given to the carbon containing the side chain which comes 1st in alphabetical order.



$CH_3-CH_2-CH(CH_3)-CH_2-CH(C_2H_5)-CH_2-CH_3$

C-containing ethyl group is given minimum no. as ethyl comes before methyl



$CH_3-CH_2-CH_2-CH(CH_3)-CH(C_3H_7)-CH_2-CH_2-CH_3$

C-containing methyl group is given minimum no. as methyl comes before propyl

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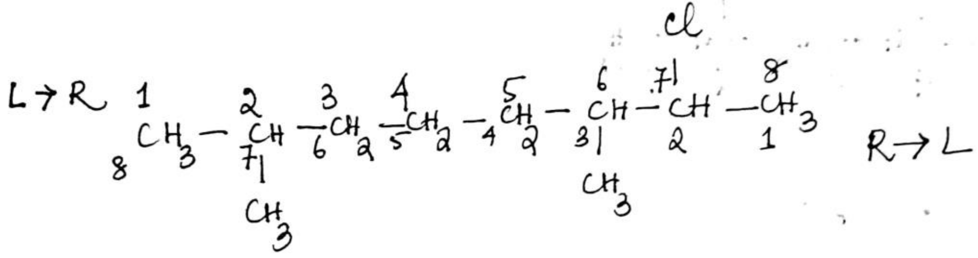
e. Presence of 2 or more than 2 substituents or side chains at any positions:

In this case Lowest locant rule is followed.



$CH_3-CH(CH_3)-CH_2-CH_2-CH_2-CH(CH_3)-CH(Cl)-CH_3$

L→R = 2 + 6 + 7 = 15

R→L = 2 + 3 + 7 = 12

So, Right to left locant numbering is the correct one.

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**Rules for alphabetical order:**

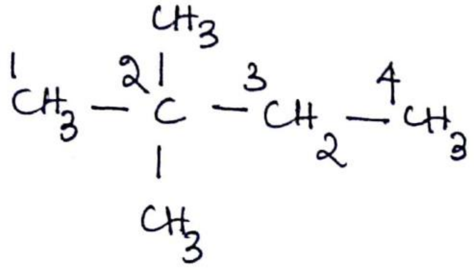
If a compound contains more than one substituent or side chain then, while naming the substituents / side chains are arranged alphabetically. While following the rules for alphabetical order the prefixes like di, tri, tetra, etc. are ignored

Arrangement of Root Word, Prefix, Primary Suffix and Secondary Suffix: In an organic compound the RW, Prefix, PS and SS are arranged in the following way.

**(-) – Prefix --------RW--------(-) – PS -----------(-) – SS**

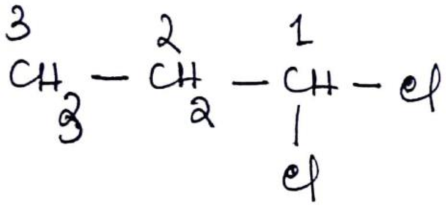
**Note: (-) are locant numbers**

**Examples:**



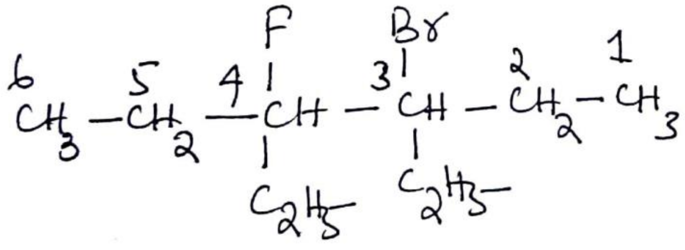
$$\overset{1}{CH_3}-\underset{CH_3}{\overset{CH_3}{\underset{|}{\overset{2\,|}{C}}}}-\overset{3}{CH_2}-\overset{4}{CH_3}$$

2,2-Dimethylbutane



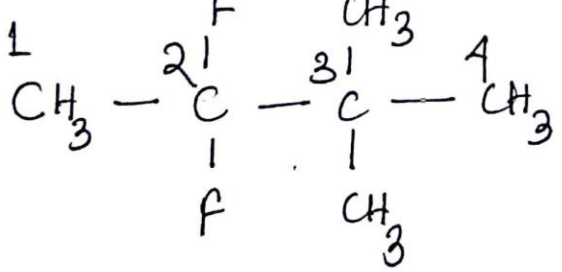
$$\overset{3}{CH_3}-\overset{2}{CH_2}-\underset{Cl}{\underset{|}{\overset{1}{CH}}}-Cl$$

1, 1-Dichloropropane



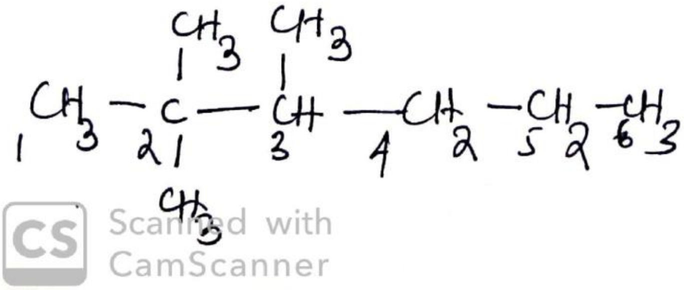
$$\overset{6}{CH_3}-\overset{5}{CH_2}-\underset{C_2H_5}{\underset{|}{\overset{F}{\overset{4\,|}{CH}}}}-\underset{C_2H_5}{\underset{|}{\overset{Br}{\overset{3\,|}{CH}}}}-\overset{2}{CH_2}-\overset{1}{CH_3}$$

3-Bromo-4-fluoro-3,4-dimethylhexane



$$\overset{1}{CH_3}-\underset{F}{\underset{|}{\overset{F}{\overset{2\,|}{C}}}}-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{3\,|}{C}}}}-\overset{4}{CH_3}$$

2,2-Difluoro-3,3-dimethyl butane



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

2,2,3-Trimethylhexane

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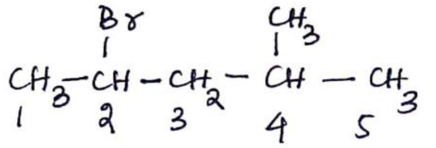
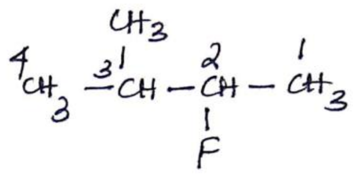
## Assignment:

**Write down the IUPAC names of the following compounds.**

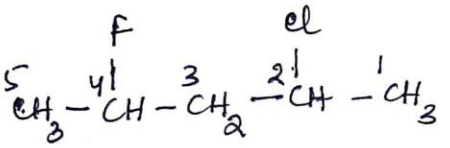
a)



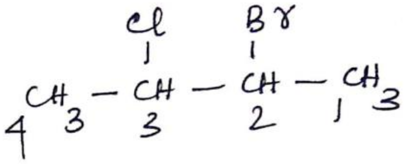
b)



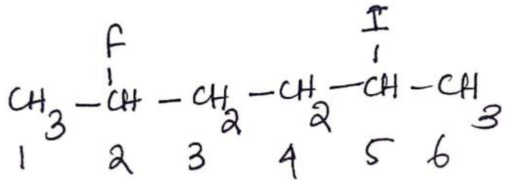
c)



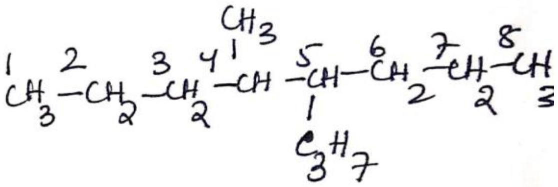
d)



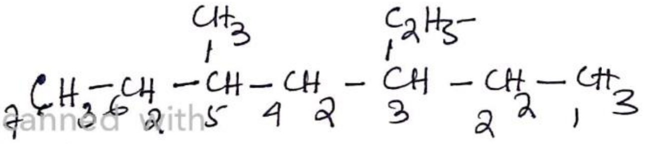
e)



f)



g)



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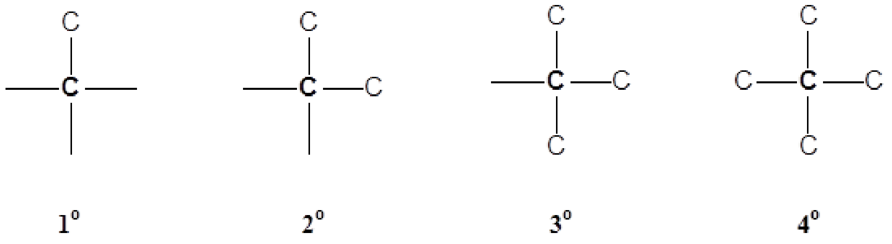
## Answers:

a) 2-Bromo-4-methylpentane
b) 2-Fluoro-3-methylbutane
c) 2-Chloro-4-fluoropentane
d) 2-Bromo-3-chlorobutane
e) 2-Fluoro-5-iodohexane
f) 4-Methyl-5-propyloctane
g) 3-Ethyl-5-methylheptane

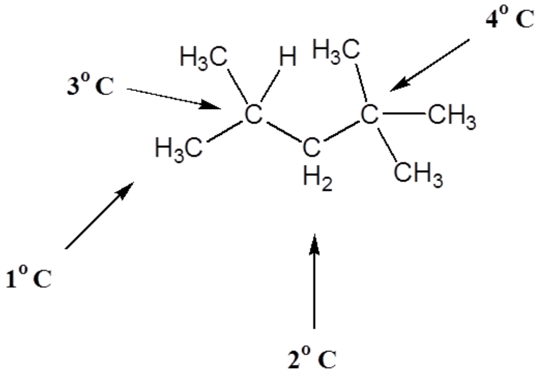
## Classification of carbon atoms

Carbons have a special terminology to describe how many other carbons they are attached to.

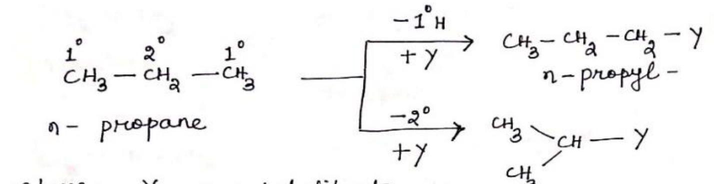


- Primary carbons (1°) attached to one other C atom
- Secondary carbons (2°) are attached to two other C’s
- Tertiary carbons (3°) are attached to three other C’s
- Quaternary carbons (4°) are attached to four C's

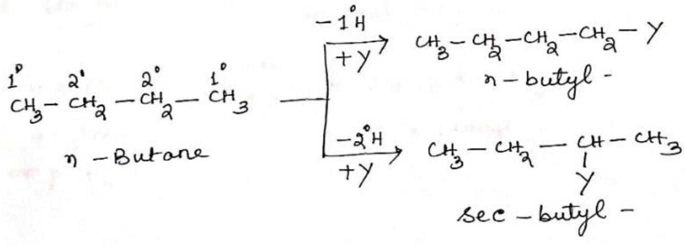
EX:

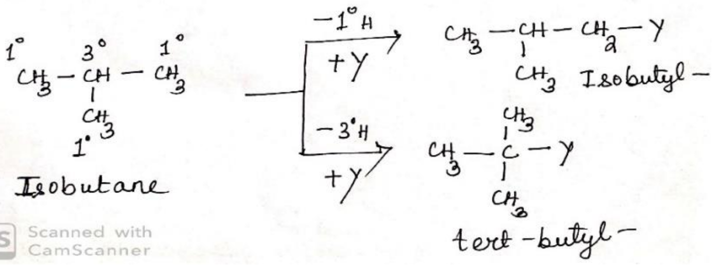


## Types of alkyl groups:



where; Y = any substituent (Cl, F, Br, I, NO₂ etc.) or functional group (−OH, −COOH, −CHO etc.)





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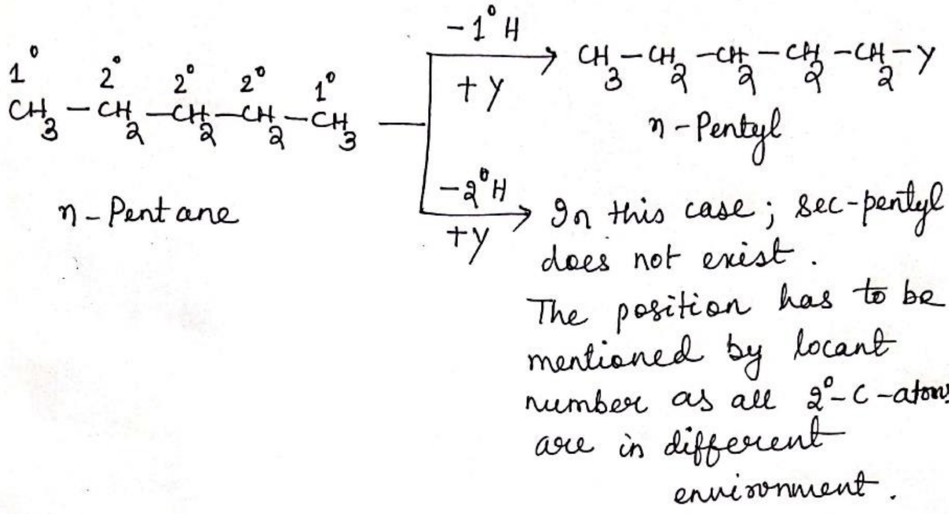
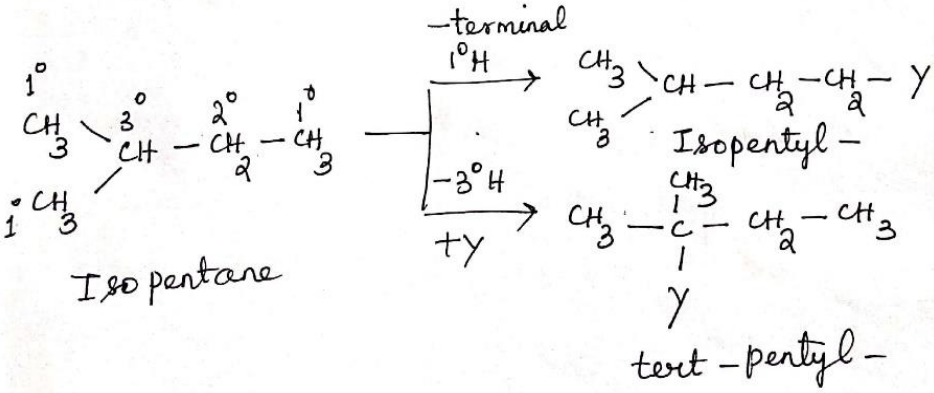
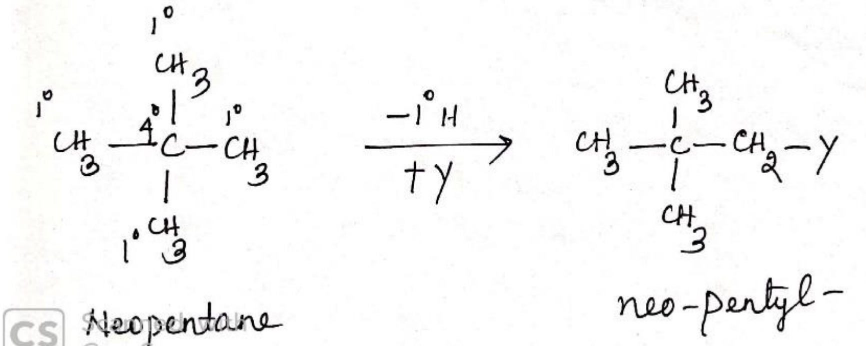
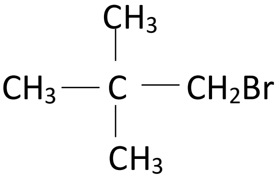


In this case; sec-pentyl does not exist. The position has to be mentioned by locant number as all 2°-C-atoms are in different environment.

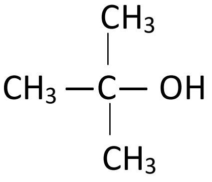




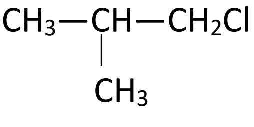
Ex:



$CH_3-C(CH_3)_2-CH_2Br$ neo-Pentyl bromide



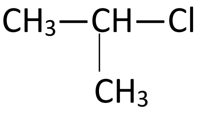
$CH_3-C(CH_3)_2-OH$ tert-Butyl alcohol



$CH_3-CH(CH_3)-CH_2Cl$ iso-Butyl chloride

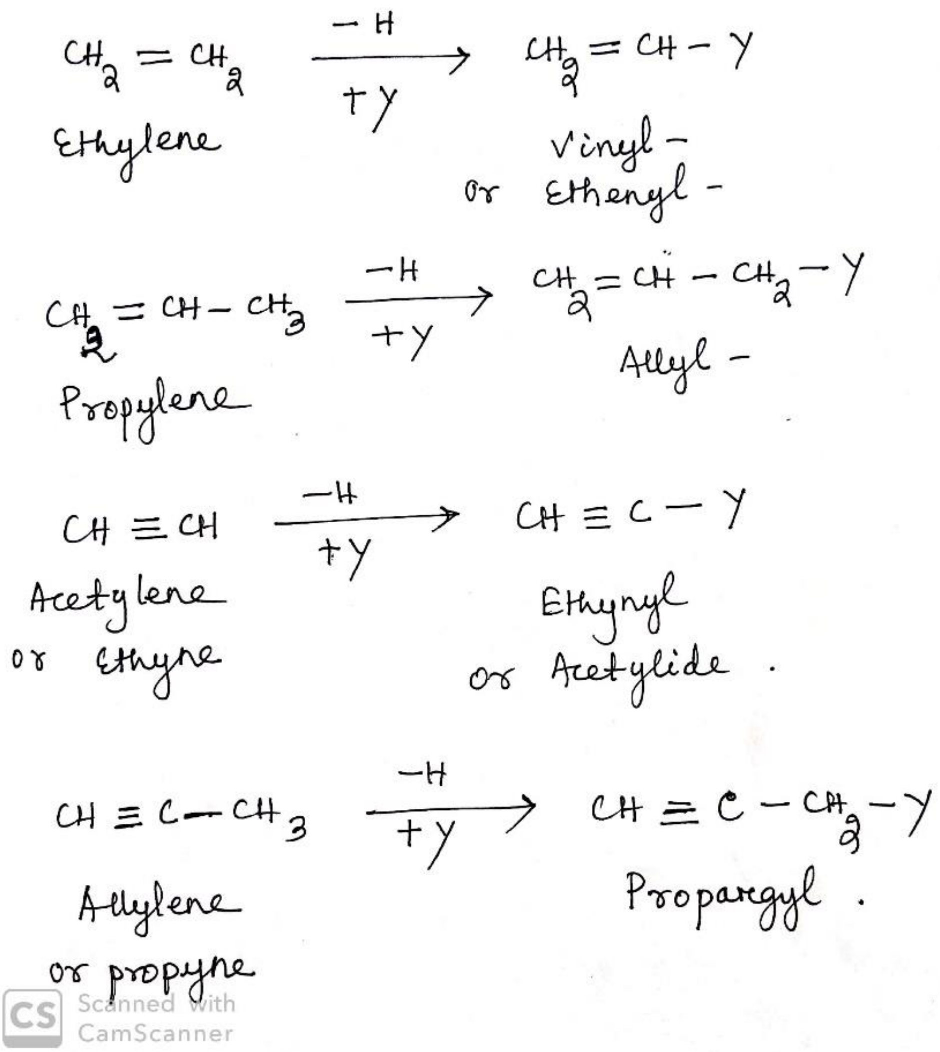
$CH_3-CH_2-CH_2-CH_2-CH_2F$

n-Pentyl fluoride



$CH_3-CH(CH_3)-Cl$ iso-propyl chloride

## Types of alkyl groups from unsaturated hydrocarbons:



$$CH_2=CH_2 \xrightarrow[+Y]{-H} CH_2=CH-Y$$

Ethylene — Vinyl - or Ethenyl -

$$CH_2=CH-CH_3 \xrightarrow[+Y]{-H} CH_2=CH-CH_2-Y$$

Propylene — Allyl -

$$CH\equiv CH \xrightarrow[+Y]{-H} CH\equiv C-Y$$

Acetylene or Ethyne — Ethynyl or Acetylide .

$$CH\equiv C-CH_3 \xrightarrow[+Y]{-H} CH\equiv C-CH_2-Y$$

Allylene or propyne — Propargyl .

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**Ex:**

$CH_2=CH—Cl$ Vinyl chloride

$CH\equiv C—Br$ Ethynyl bromide

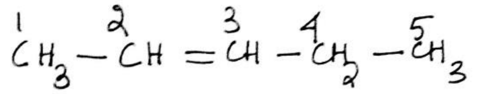
$CH_2=CH—CH_2Br$ Allyl bromide

## IUPAC nomenclature of compounds containing multiple bond:

## Numbering of C-atoms in principal chain:

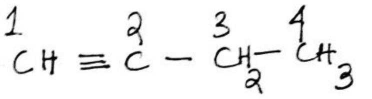
a. Presence of multiple bond:

If a compound contains a multiple bond (C = C or C ≡ C) then, minimum number is given to the carbon containing the multiple bond irrespective of the position of the substituents or side chains. Ex:



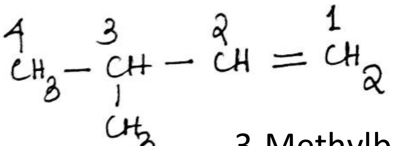
$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_2-\overset{5}{C}H_3$

Pent-2-ene



$\overset{1}{C}H\equiv\overset{2}{C}-\overset{3}{C}H_2-\overset{4}{C}H_3$

But-1-yne



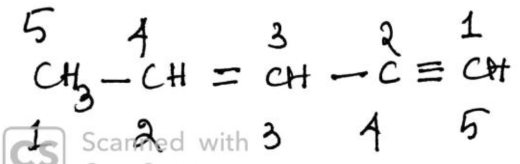
$\overset{4}{C}H_3-\underset{CH_3}{\overset{3}{C}H}-\overset{2}{C}H=\overset{1}{C}H_2$

3-Methylbut-1-ene

b. If the principal chain contains 2/more than 2 = and/or ≡ bond then number the principal chain from such an end so that the multiple bonds get the lowest set of locants.

Note: If a compound contains both = and ≡ bonds then the suffix is –en-yne.

Ex:



$\underset{1}{\overset{5}{C}H_3}-\underset{2}{\overset{4}{C}H}=\underset{3}{\overset{3}{C}H}-\underset{4}{\overset{2}{C}}\equiv\underset{5}{\overset{1}{C}H}$

L→R (Correct set 1,3)

R→L (incorrect set 2,4)

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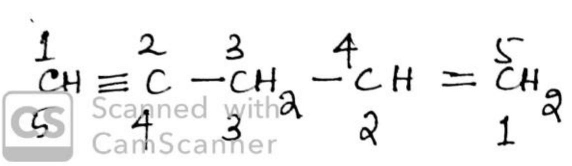
Pent-3-en-1-yne

c. If a double bond and a triple bond present at the same positions from either end then the carbon atom containing = bond is given the minimum number. Ex:



$\underset{5}{\overset{1}{C}H}\equiv\underset{4}{\overset{2}{C}}-\underset{3}{\overset{3}{C}H_2}-\underset{2}{\overset{4}{C}H}=\underset{1}{\overset{5}{C}H_2}$

(R→L incorrect set 1,4)

(L→R correct set 1,4)

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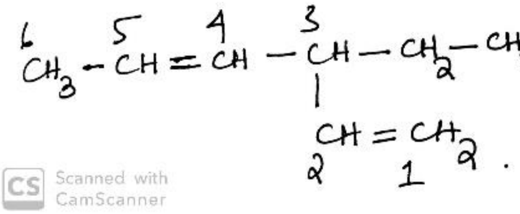
Pent-1-en-4-yne

d. If the principal chain contains 2 = bonds or 2 ≡ bonds, then the suffix is –diene or diyne respectively.



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

3-Propylhex-1,4-diene

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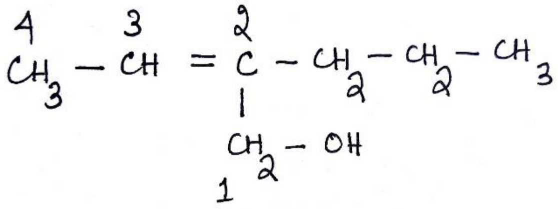
## IUPAC nomenclature of branched chain compounds containing functional group:

1. Selection of Principal Chain –

Select the longest continuous chain of c- atoms which will include the principal functional group and that will constitute the parent chain.

It multiple bonds are present; the principal/parent chain should include maximum number of multiple bonds. If there are 2/more chains containing equal number of c-atoms, select the one with maximum no. of substituents.

Ex:



$$\overset{4}{CH_3}-\overset{3}{CH}=\overset{2}{C}(\underset{1}{CH_2}-OH)-CH_2-CH_2-CH_3$$

2-propylbut-2-en-1-ol.

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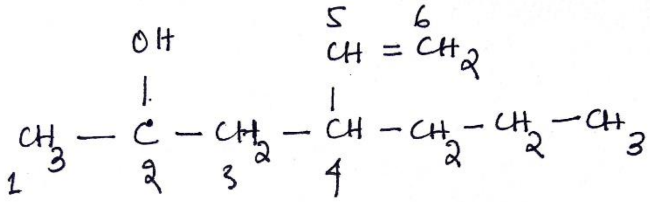
2. Number the principal chain in such a way that the principal functional group gets the lowest locant even if it violets the lowest set of locants rule.

Ex:



$$\underset{1}{CH_3}-\underset{2}{C}(OH)-\underset{3}{CH_2}-\underset{4}{CH}(\overset{5}{CH}=\overset{6}{CH_2})-CH_2-CH_2-CH_3$$

4-Propylhex-5-en-2-ol

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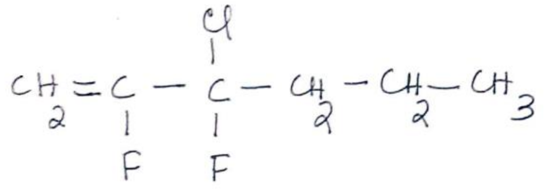
Assignment: Write down the IUPAC name of the following compounds.

i) $CH_3-C\equiv C-CH_2-OH$

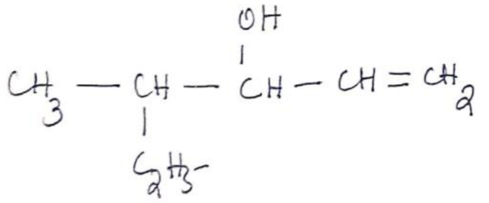
ii)



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

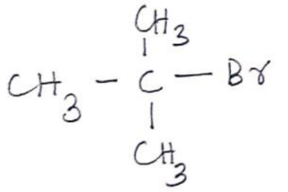
iii) $CH_2=CH-CH=CH-OH$

iv)



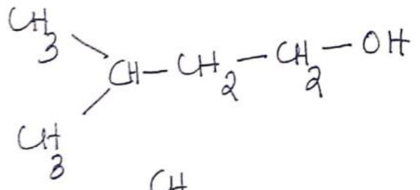
$CH_3-\underset{C_2H_5-}{CH}-\overset{OH}{CH}-CH=CH_2$

v)

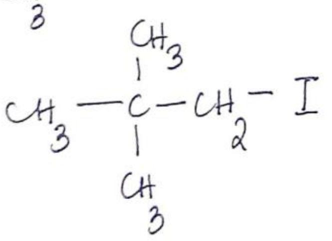


$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-Br$

vi)

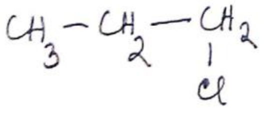


vii)



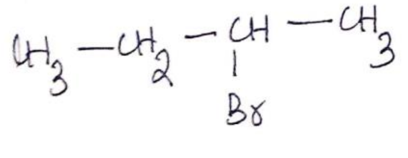
$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-CH_2-I$

viii)



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

ix)



$CH_3-CH_2-\underset{Br}{CH}-CH_3$

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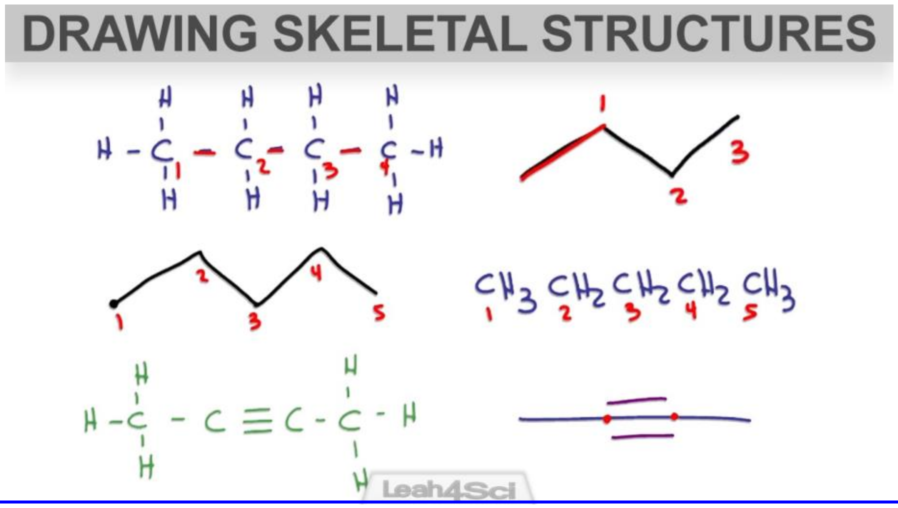
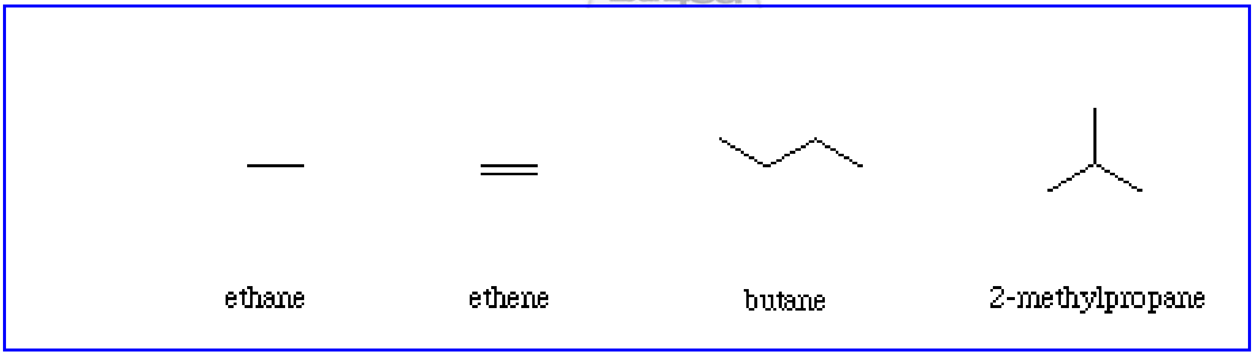
# IUPAC Nomenclature of Organic Compounds:

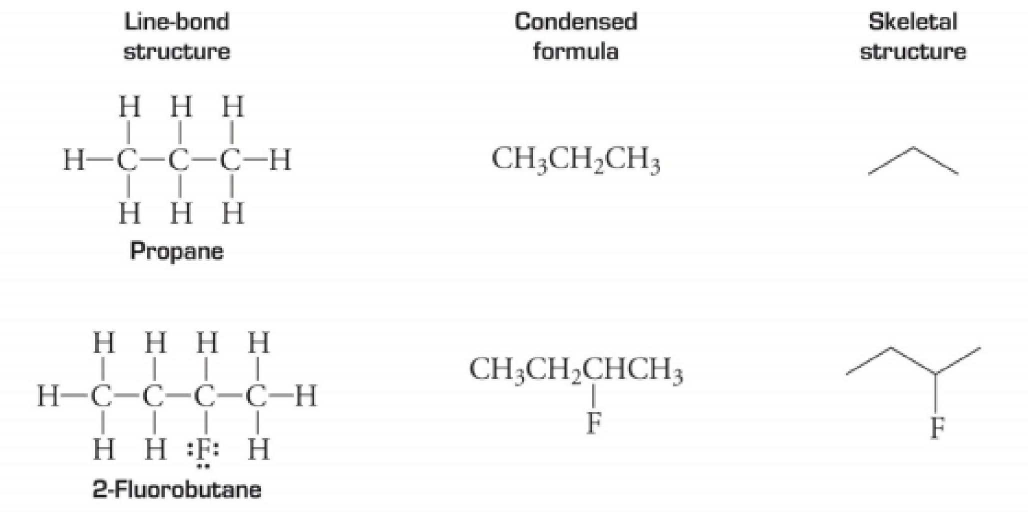
## Bond line Notation and name-to-structure conversion:

### Bond-line notation:

Generally organic chemists depict molecular structures using a convention known as bond line notation. According to this approach, a bond between two atoms is represented by a line. The ends of the line correspond to the positions of the bonded C-atoms. Only atoms other than carbon and hydrogen are shown clearly.

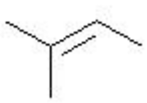


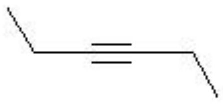




| Line-bond structure | Condensed formula | Skeletal structure |
|---|---|---|
| Propane | $CH_3CH_2CH_3$ | |
| 2-Fluorobutane | $CH_3CH_2\underset{\underset{F}{\vert}}{C}HCH_3$ | F |

Assignment: Write down the no. of C and H atoms in the following compounds.





## IUPAC Name-to-structure conversion:

### Steps:

1. Identify the Prefix, Root word, Primary suffix and secondary suffix in the given compound.
2. Write down the no. of C-atoms in the root word & it will constitute the parent chain.
3. Number the C-atoms in the parent chain either from left to right or from right to left(in any one direction only). It will constitute the locant numbers.
4. Then write down the prefix, primary suffix and secondary suffix accordingly at their respective position in the parent chain.
5. Finally balance the hydrogen so that all C- atoms are tetracovalent.

**Example: 3-Methylpent-2-en-1-ol**

**Step-1:** In this case Prefix= methyl at position 3

RW= pent => 5 C-atoms in the parent chain

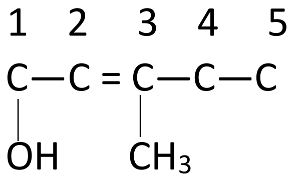
Primary suffix= en => double bond at position 2

Secondary suffix= ol => OH or alcohol group at position 1

**Step-2:** C—C—C—C—C

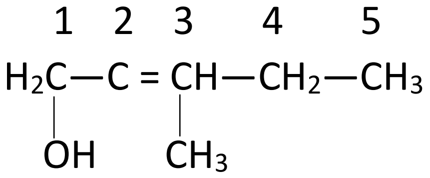
**Step-3:** C—C—C—C—C
1 2 3 4 5

**Step-4:**



$$\begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \\ C- & C= & C- & C- & C \\ | & & | & & \\ OH & & CH_3 & & \end{array}$$

**Step-5:**



$$\begin{array}{ccccccccc} 1 & & 2 & & 3 & & 4 & & 5 \\ H_2C & - & C & = & CH & - & CH_2 & - & CH_3 \\ | & & & & | & & & & \\ OH & & & & CH_3 & & & & \end{array}$$

Assignments:

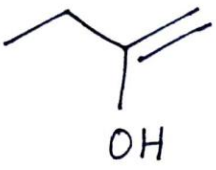
1. Write down the IUPAC structures of following compounds.

   i) 2,2-Dichloro-3,3-diiodobutane
   ii) 3-Chloro-3-methylpentan-1-ol
   iii) 3-Bromo-2-chloro-3-ethylpentan-2-ol
   iv) 2,3,4-trichlorohex-2-yne
   v) 2-Fluorobuta-1,3-diene
   vi) 2-Ethylhex-1-en-1-ol
   vii) 4,4-Dibromopent-2-yne

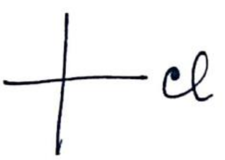
2. Write down the IUPAC name of the following compounds.

i)

ii)

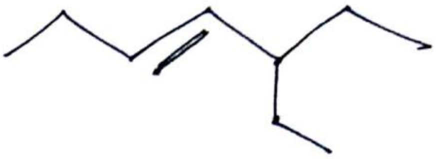


iii)



iv)

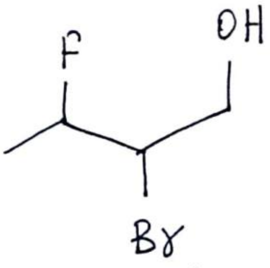
v)



vi)

vii)

viii)



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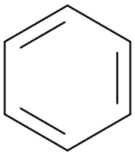
# Common Aromatic Compounds and uses in daily life

**Benzene:**

Benzene is an organic chemical compound with the molecular formula $C_6H_6$. The benzene molecule is composed of six carbon atoms joined in a ring with one hydrogen atom attached to each. As it contains only carbon and hydrogen atoms, benzene is classed as a hydrocarbon.



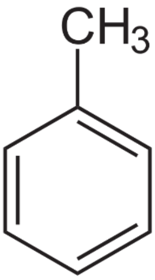
ChemEssen.com

**Application/uses:**

1. Benzene is used to make polymers and plastics like polystyrene.
2. Benzene is used to produce phenol and acetone for resins and adhesives.
3. Cyclohexane is synthesized from Benzene which is used in the manufacture of nylon fibers, which are processed into textiles and engineering plastics.
4. Smaller amounts of benzene are used to make some types of rubbers, lubricants, dyes, detergents, drugs, explosives, and pesticides.

**Toluene:**

It is also called methyl benzene

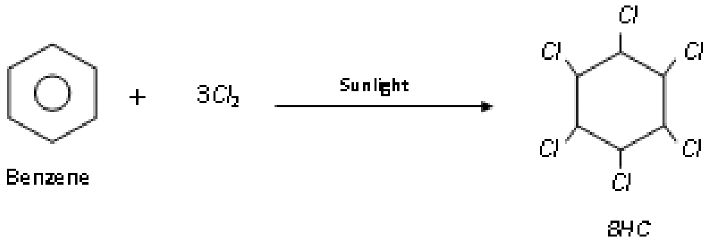


**Uses:**

1. Toluene has numerous commercial and industrial applications and is a solvent in paints, lacquers, thinners, glues, correction fluid and nail polish remover.
2. It is used in the printing and leather tanning processes.
3. It is used in making trinitrotoluene (the explosive, TNT)
4. It is also used as solvents for various compound and in preparation of a number of synthetic drugs.
5. Toluene can be used in gasoline fuels for internal combustion engines

## BHC(Benzene Hexachloride):

It is prepared from benzene in presence of chlorine and sunlight.

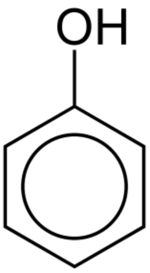


## Uses:

1. It is an important agricultural pesticide mainly used for exterminating white ants, leaf hopper, termite etc.
2. It is commercially available in market in the name of Gammaxene or Lindane and used as an insecticide.
3. It is used as an insecticide on crops, in forestry, for seed treatment.
4. It is used in the treatment of head and body lice.
5. It is used in pharmaceuticals.
6. It is used to treat scabies.

## Phenol:

It is the hydroxy derivative of benzene.

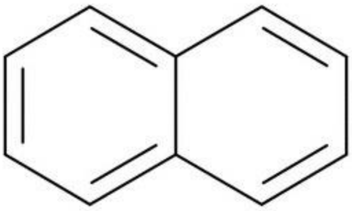


Uses:

1. Phenols are widely used in household products and as intermediates for industrial synthesis.
2. It is used as a disinfectant in household cleaners and in mouthwash.
3. Phenol may have been the first surgical antiseptic.
4. It is used in plastic manufacturing industries.
5. Phenol is also used in the study and extraction of bio-molecules.
6. Phenol is also used in the cosmetic industry in the manufacturing of sunscreens, skin lightening creams and hair colouring solutions.
7. It is also used to commercially prepare phenolic resins. The resulting resin is known as phenol-formaldehyde resin, commercially it is marketed by the name of bakelite. Bakelite is extensively used in electrical switches and automobiles due to its property of withstanding extreme conditions of heat and

resistance to electricity and other chemicals. The intermediate produced during the polymerization reaction is called novolac, this is a resin and is used as a binding agent or adhesive in many industries. Novolac is also used for protective coating purposes.

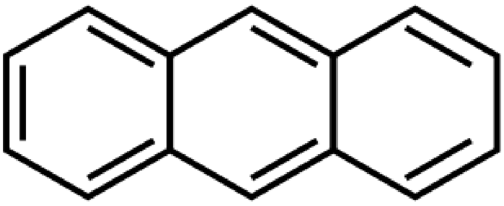
**Naphthalene:**



**Uses:**

1. Naphthalene is used to make mothballs, PVC, insecticides (insect killing chemicals), dyes, toilet deodorant blocks.
2. It is used to make pharmaceuticals and resins.
3. Naphthalene is used mainly as a precursor to other chemicals and also used in agriculture to make agrichemicals.
4. Naphthalene provides an excellent solubilizing medium for poorly soluble aromatic compounds.
5. In the past, naphthalene was administered orally to kill parasitic worms in livestock.

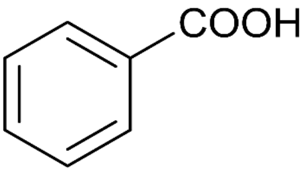
**Anthracene:**



**Uses:**

1. It is used as a preservative in wood and lumber
2. It is used as an insecticide for crops.
3. Anthraquinone, derived directly from anthracene, finds use as a precursor to a lot of dyes the fabrics and in textiles industries.
4. It is used as a coating material.

**Benzoic Acid:** It is the carboxylic acid derivative of benzene.



**Uses:**

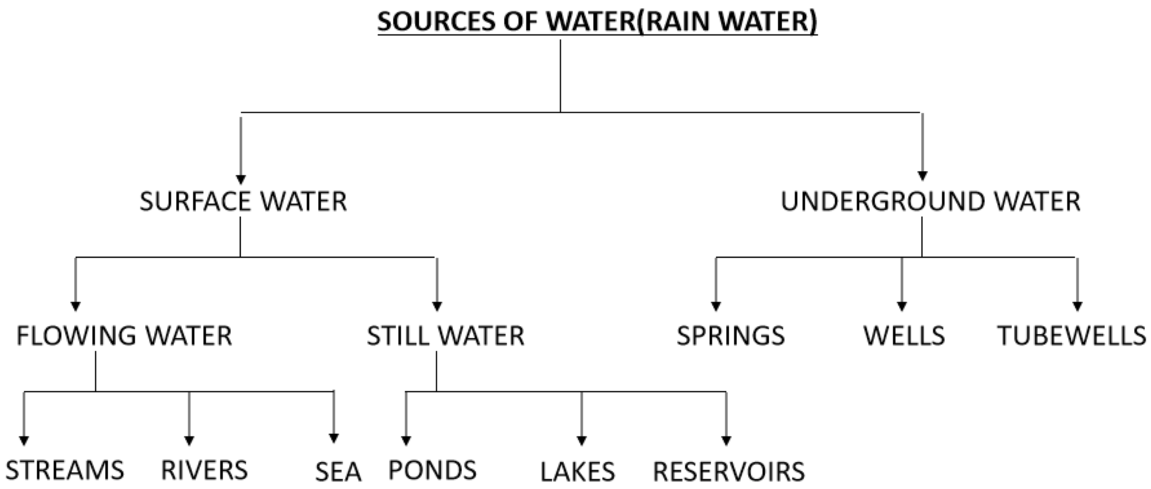
1. Benzoic acid is most commonly found in industrial settings to manufacture a wide variety of products such as perfumes, dyes, topical medications and insect repellents.
2. It is also used as a pH adjustor and preservative in food, preventing the growth of microbes to keep food safe. Usually processed food has benzoic acid to inhibit the growth of bacteria, mold and yeast.
3. It is used in toothpaste, jam, beverages, poultry, agriculture, perfume, dye etc.
4. It helps in the prevention of bacterial infection. It is used as an antifungal for treating diseases like ringworm and athlete's foot.
5. It is used in the treatment of skin irritation caused by insect bites, burns etc.
6. It is used in pharmaceuticals as a preservative in drugs. It is also present in baby products, skin products, cleansing products, hair and nail products, soaps, bath products, detergents etc.

## Assignments:

1. Write down 2 uses of Benzene and phenol in daily life
2. What are the important applications of benzoic acid, naphthalene and anthracene.
3. Write down the uses of BHC in agriculture.

# INDUSTRIAL CHEMISTRY

## CHAPTER-10- WATER TREATMENT



5. **Underground water.** The rainwater and other surface water percolate down through the soil and rocks and get filtered and finally collected on rocky surface or again come out as spring. Though it contains less suspended matter but the dissolved mineral content is quite high and is of high organic purity.

**TYPES OF WATER:**

**SOFT WATER:** which forms enough foam or lather with soap solution

ex: rain water,distilled water, demineralised water

**HARD WATER :** which does not form enough foam or lather with soap solution rather forms a curd white precipitate,

ex: sea water, river water, pond water

### Hardness of Water

*Hardness* of water is the characteristic of preventing lather formation of water with soap. Generally salts like chlorides, bicarbonates and sulfates of $Ca^{2+}$, $Mg^{2+}$ and $Fe^{2+}$ make water hard. This hard water on treatment with soap which is stearic or palmitic acid salts of sodium or potassium causes white precipitate formation of calcium or magnesium stearate or palmitate.

$$\underset{\substack{\text{Sodium stearate}\\ \text{(soap)}}}{2C_{17}H_{35}\,COONa} + CaCl_2 \longrightarrow \underset{\substack{\text{Calcium stearate}\\ \text{(insoluble)}}}{(C_{17}H_{35}COO)_2Ca} + 2NaCl$$

Thus the cause of hardness is the precipitation of the soap and hence prevents lathering at first. When the hardness causing ions are removed as insoluble soaps, water becomes soft and forms lather.

The hardness is of two types:

(*i*) *Temporary hardness* is due to the bicarbonates of $Ca^{2+}$ and $Mg^{2+}$ and carbonate of $Fe^{2+}$. Since bicarbonates readily get precipitated on boiling the water, the temporary hardness can be easily removed, *viz.*

$Ca(HCO_3)_2$

$Mg(HCO_3)_2$

$$Ca(HCO_3)_2 \xrightarrow{\text{heat}} \underset{\text{insoluble}}{CaCO_3\downarrow} + H_2O + CO_2$$

**By adding slaked lime:**

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow + MgCO_3\downarrow + 2H_2O$$

Excess lime may convert soft water to hard water again by absorbing $CO_2$ from air. So a calculated quantity of lime is used.

$$Ca(OH)_2 + CO_2 \longrightarrow Ca(HCO_3)_2$$

(*ii*) *Permanent hardness* is due to the presence of chlorides and sulfates of Ca, Mg, Fe, etc. Permanent hardness cannot be removed easily on boiling.

$CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$, $FeSO_4$

### *Units of Hardness*

Both temporary and permanent hardnesses are expressed in ppm as $CaCO_3$.

Hardness is principally expressed in ppm unit.

$$1 \text{ ppm} = \frac{1 \text{ part of hardness}}{10^6 \text{ parts of water}}$$

### Softening of Water

Softening of water means the removal of calcium, magnesium, iron salts and similar other metallic ions, which would form insoluble metallic soaps. The three important industrial methods employed for softening of water are:

1. Cold and hot lime-soda process.
2. Permutit or zeolite process.
3. Ion-exchange or demineralization process.

1. *Lime-soda process.* By this process, soluble calcium and magnesium salts are rendered insoluble by adding calculated amount of lime [$(CaOH)_2$] and soda [$Na_2CO_3$]. The insoluble precipitates of $CaCO_3$ and $Mg(OH)_2$ are removed by filtration. By this method, both temporary and permanent hardness are removed.

For the removal of temporary hardness the reactions are:

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$$
$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + MgCO_3 + 2H_2O$$
$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCO_3\downarrow$$

Hence, to remove equivalent quantities of Ca and Mg hardnesses the amount of lime necessary is in the ratio of 1:2.

Again for the removal of permanent hardness. The reactions are:

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + Na_2SO_4$$

$$MgSO_4 + Na_2CO_3 \longrightarrow MgCO_3 + Na_2SO_4$$

$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$$

$$MgSO_4 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$$

$$MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaSO_4$$

Hence, for the removal of permanent hardness due to Ca-salts, lime is not necessary, but it is necessary for Mg salts. Extra addition of $Ca(OH)_2$ causes hardness. So calculated quantities of lime and soda are to be added after the determination of actual hardness.

In the actual process the water is thoroughly mixed with the chemicals and allowed to react for sufficient time. Activated charcoal is added as activator, alum etc. are added as coagulants. To avoid after-precipitation of $CaCO_3$, sludge of the previous operation is added,

### *Cold Lime-Soda Process*

In this method, calculated quantity of chemicals and water, along with accelerators and coagulators are added to a tank fitted with a stirrer (Fig. 17.1). On vigorous stirring, thorough mixing takes place. After softening the soft water rises upwards and the heavy sludges settle down. The softened water passes through a filtering media ensuring complete removal of the sludge and finally the filtered water flows out through the top. Cold lime soda process is used for partial softening of municipal water, for softening of cooling water etc. In actual purpose, magnesium hardness is brought down to almost zero but calcium hardness remains about 40 ppm.

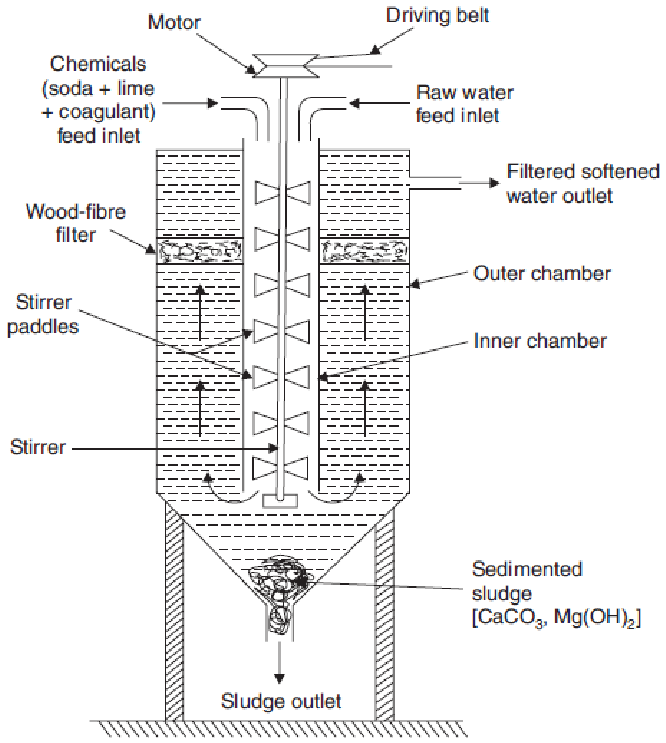


Fig. 17.1 Continuous cold lime-soda softener.

### *Hot Lime-Soda Process*

This process is similar to the cold lime-soda process. Here the chemicals alongwith the water are heated near about the boiling point of water by exhaust steam. As the reaction takes place at high temperature, there are the following advantages:

(*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 (which may cause corrosion) are removed.
(*vi*) viscosity of soft water is lower, hence filtered easily.
(*vii*) Residual hardness is low compared to the cold process.

Hot lime-soda process consists of three parts:

(*a*) 'Reaction tank' in which complete mixing of the ingredients takes place.
(*b*) 'Ionical sedimentation vessel' where the sludge settles down and
(*c*) 'Sand filter' where sludge is completely removed.

The soft water from this process is used for feeding the boilers (Fig. 17.2).

*Advantages Include:*

(*i*) Lime soda process is economical.
(*ii*) The process improves the corrosion resistance of the water.
(*iii*) Mineral content of the water is reduced.
(*iv*) pH of the water rises, which reduces the content of pathogenic bacteria.

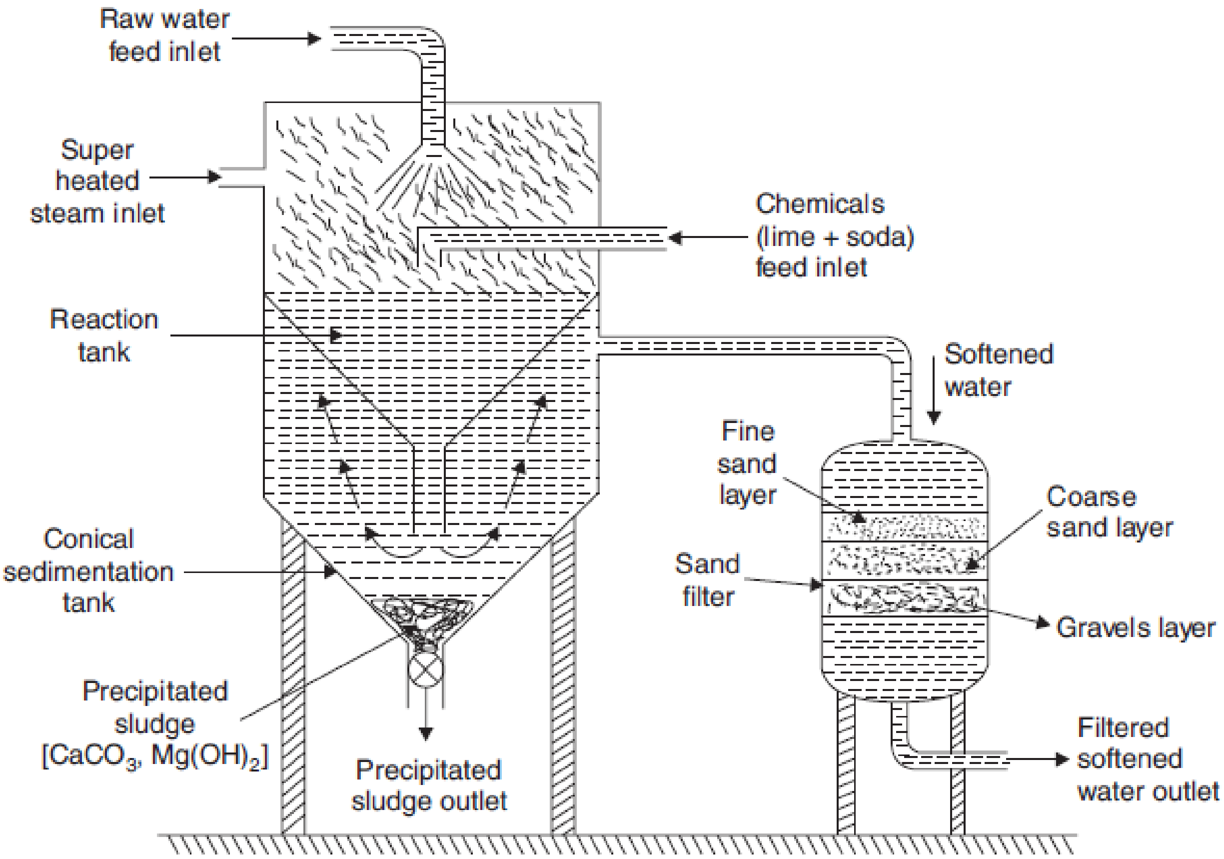


**Fig. 17.2** Continuous hot lime-soda softener.

*Disadvantages Include:*

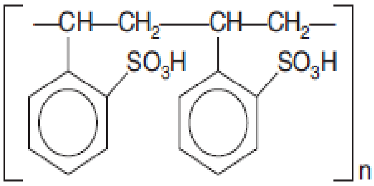
(*i*) Huge amount of sludge is formed and disposal is difficult.

(*ii*) Due to residual hardness, water is not suitable for high pressure boiler.

### Ion Exchange or Demineralization

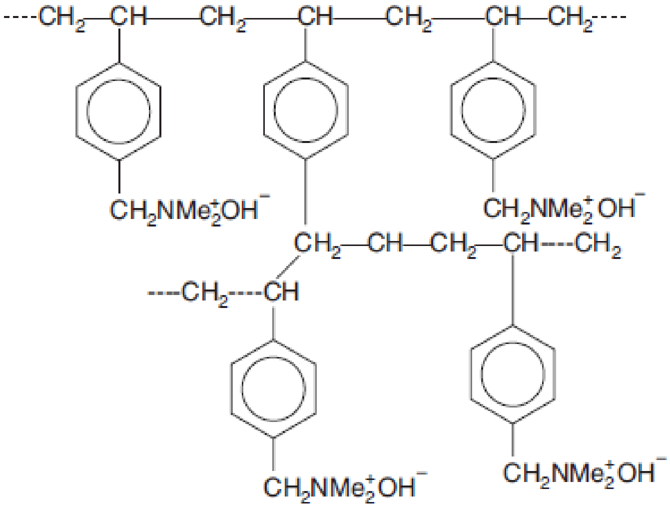
Ion exchange resins are organic polymers which are crosslinked having microporous structure and the functional groups are attached to the chains which are responsible for the ion exchange properties.

(*i*) *Cation exchange resins ($RH^+$)* are phenol-sulfonic acid-formaldehyde resin, styrene-divinyl benzene copolymers which exchange their $H^+$ ions with the cations present in the water *i.e.,* $Ca^{2+}$ and $Mg^{2+}$.



cation exchange resin

(*ii*) *Anion exchange resins ($ROH^-$):* The styrene divinyl benzene or amine formaldehyde copolymers contain quaternary ammonium tertiary sulphonium or amino group in the resin. The resin on treatment with NaOH solution is capable of exchanging the $OH^-$ with different anions of water *i.e.,* $Cl^-$, $SO_4^{2-}$ etc.



Anion exchange resin

***Method:*** The hard water is passed first through cation exchange resin similar to the permutit process whereby the cations like $Ca^{2+}$, $Mg^{2+}$ are removed from the hard water and exchanged with $H^+$ as follows:

$$2RH^+ + Ca^{2+}/Mg^{2+} \longrightarrow R_2Ca^{2+}/R_2Mg^{2+} + 2H^+$$

After this the hard water is again passed through anion exchange column, which exchanges all the anions like $SO_4^{2-}$, $Cl^-$ etc. present in the water with $OH^-$

$$ROH^- + Cl^- \longrightarrow R^+Cl^- + OH^-$$

These $H^+$ and $OH^-$ combine to form water molecule. Thus the water coming out finally from the two exchangers is ion free and called *deioinized* or *demineralized* water.

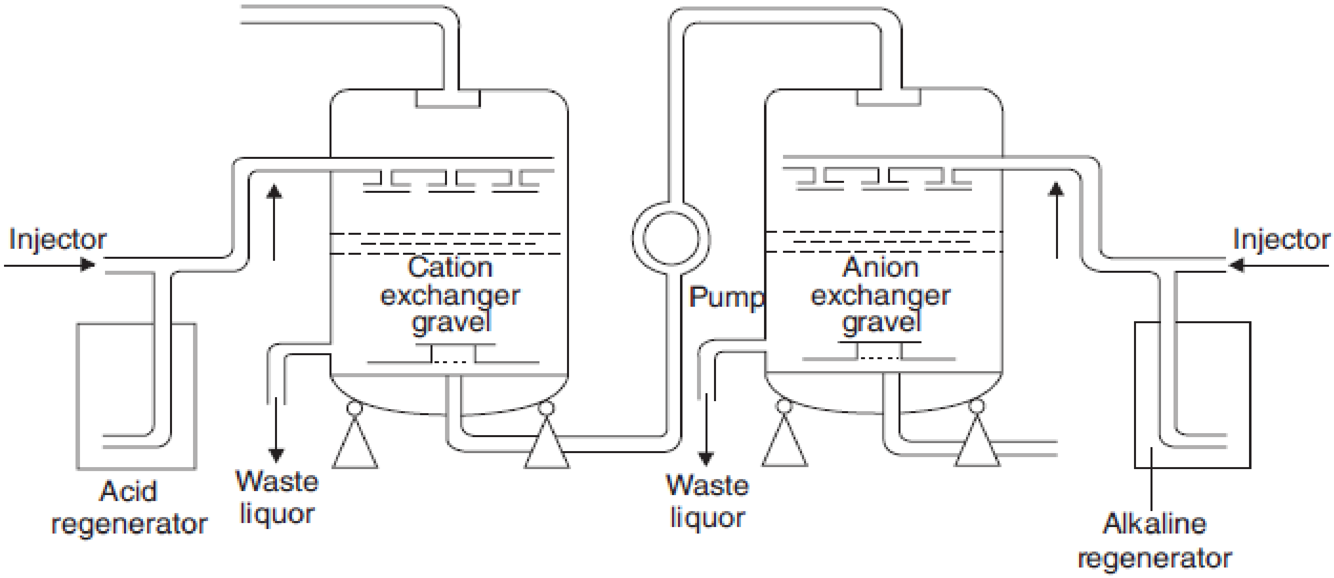
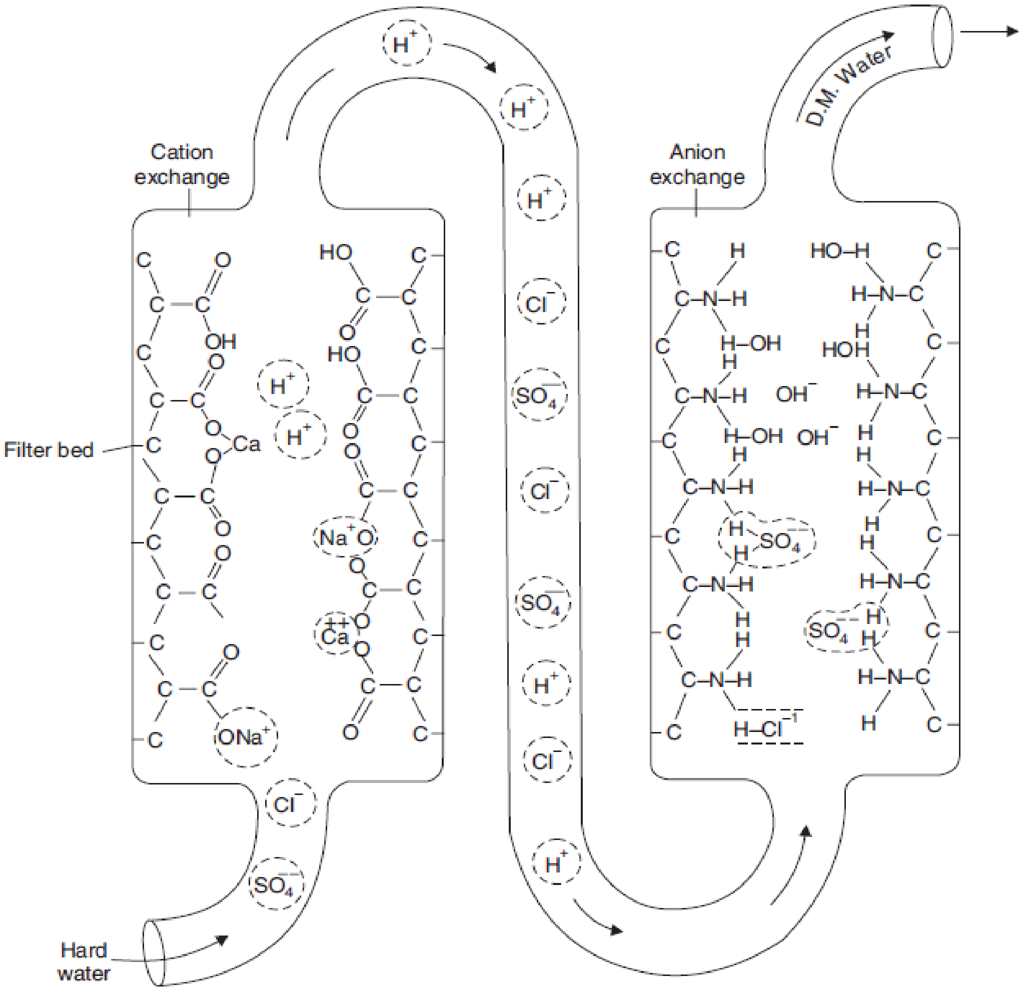


Fig. 17.4 Demineralisation of water.



Cation exchange reaction:

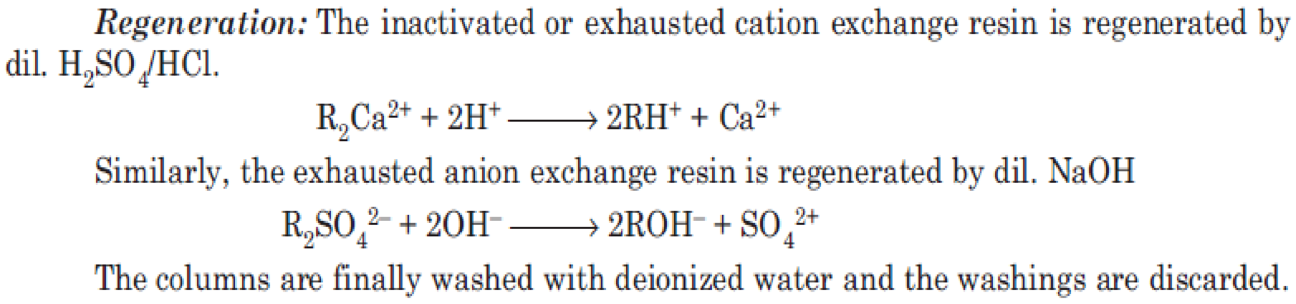
$2R^{-}H^{+} + Ca^{+2} \rightleftharpoons CaR_2 + 2H^{+}$

Anion exchange reaction:

$RNH_2 + H_2O \rightleftharpoons R\overset{+}{N}H_3OH^{-}$

$R\overset{+}{N}H_3OH^{-} + Cl^{-} \rightleftharpoons R\overset{+}{N}H_3Cl^{-} + OH^{-}$

Fig. 17.5 Demineralisation of water showing the ion exchanges.



*Regeneration:* The inactivated or exhausted cation exchange resin is regenerated by dil. $H_2SO_4$/HCl.

$$R_2Ca^{2+} + 2H^+ \longrightarrow 2RH^+ + Ca^{2+}$$

Similarly, the exhausted anion exchange resin is regenerated by dil. NaOH

$$R_2SO_4^{2-} + 2OH^- \longrightarrow 2ROH^- + SO_4^{2+}$$

The columns are finally washed with deionized water and the washings are discarded.

| Cold L-S Process | Hot L-S process |
|---|---|
| • Carried out in Room temperature<br>• Reaction proceeds at a slower rate<br>• Coagulants are added<br>• Takes some hours to complete<br>• Has low softening capacity<br>• Pathogenic bacteria may be present | • Carried out in higher temperature(80-150 $^0$C)<br>• Reaction proceeds at a faster rate<br>• Coagulants are not added<br>• Takes some minutes to complete<br>• Has high softening capacity<br>• Pathogenic bacteria are destroyed |

**ASSIGNMENTS:**

1. What is hardness of water? How many types of water are there according to the hardness of water? Explain with examples.
2. What is temporary hardness? How to remove it?
3. Explain the cold L-S method to remove permanent hardness with diagram.
4. How organic ion exchange method can remove permanent hardness?
5. What is the difference between cold and hot L-S process.
6. What are the advantages of hot L-S process over cold L-S process?

# CHAPTER-11: LUBRICANTS

## Lubricants:

Definition: Any substance introduced between the two moving and sliding surfaces with a view to reduce frictional resistance to know as lubricant.

### Functions of lubricants :

i. It reduces the frictional resistance between the sliding surfaces.
ii. It reduces wearing and tearing of machinery parts
iii. It reduces loss of heat energy there by increasing the efficiency of Engine and prevents corrosion.
iv. It enhances the durability of machinery parts.
v. It reduces expansion of metals
vi. It acts as a cooling medium.

### Type of lubricants :

Lubricants can be classified into three categories based upon their physical states. They are:

### Solid lubricants:

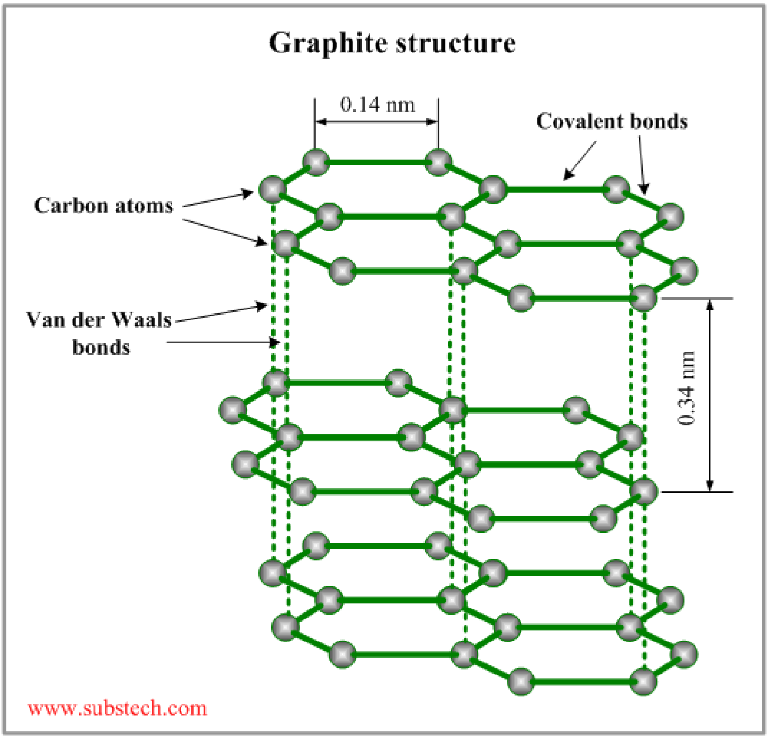
For example: Graphite, mica, molybdenum disulphide, boron trinitride, etc.

It is used where the working temperature or operating temperature or load is too high, even for grease to remain in position

It is used where there is a chance of contamination of the products with other lubricants (oils/greases)

### Graphite:

It is the most widely used of all the solid lubricants and can be used either in the powdered form or in suspension. It is soapy to touch; non-inflammable and stable upto a temperature of 375° C. Graphite has a flat plate like structure and the layers of graphite sheets are arranged one above the other and held together by weak forces of attraction. These parallel layers which can easily slide one over other make graphite an effective lubricant.



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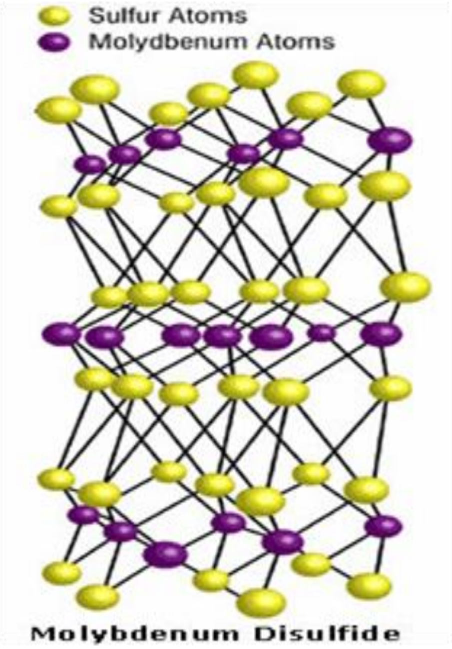
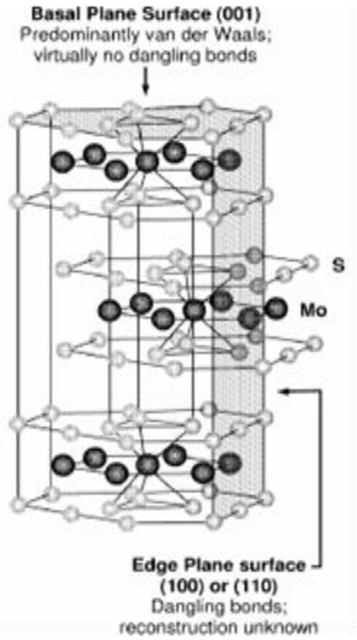
## USES OF GRAPHITE:

1. It is used in ICE(Internal combustion engine)
2. Used in railway track joints, open gears, chains, iron bearings etc.
3. Used in making lead pencils
4. Used in heavy machinary, general machine shop works, food stuff industries, in air compressor
5. Used between uneven surfaces

## Molybdenum Disulphide:

It has a sandwich- like structure with a layer of molybdenum atoms in between two layers of sulphur atoms. Poor interlaminar attraction helps these layers to slide over one another easily. It is stable upto a temperature of 400° C. The Metallic bond length , Mo-Mo is 3.08 $A^0$ , the covalent bond length S-S is 3.15 $A^0$ and the distance between two lamellas is 3.13 $A^0$ . It is stable up to 425$^o$C in presence of air and up to 800$^o$C in absence of air. It is chemically inert. It is used in space vehicles.





## Liquid lubricants or Lubricating oils:

Classified into three categories;

(i) Animal and Vegetables oils,

(ii) Mineral or Petroleum oils and

(iii) blended oils.

## Characteristic of good lubricating oils:

(1)high boiling point,
(2) low freezing point
(3) adequate viscosity for proper functioning
(4) high resistance to oxidation and heat
(5) non-corrosive properties
(6) stability to decomposition at the operating temperatures.

### (i) Animal and Vegetables oils:

These are extracted from the crude fat and vegetables oils such as cotton seed oil, olive oil, coconut oil, sunflower oil, whale oil, palm oil and caster oils. These oils possess good oiliness and hence they can stick on metal surfaces effectively even under elevated temperatures and heavy loads. they are costly, undergo easy oxidation to give gummy products and hydrolyze easily to acidic products.

### (ii) Mineral or Petroleum oils:

These are basically lower molecular weight hydrocarbons with about 12 to 50 carbon atoms. As they are cheap, available in abundance and stable under service conditions, hence they are widely used. But the oiliness of mineral oils is less, so the addition of higher molecular weight compounds like oleic acid and stearic acid increases the oiliness of mineral oil.

### (iii) Blended oils:

No single oil possesses all the properties required for a good lubricant and hence addition of proper additives is essential to make them perform well. Such additives added lubricating oils are called blended oils.

Examples: The addition of higher molecular weight compounds like oleic acid, stearic acid, palmetic acid, etc or vegetables oil like coconut oil, castor oil, etc increases the oiliness of mineral oil.

### Semi-solid Lubricants or Grease:

A semi-solid lubricant obtained by combining lubricating oil with thickening agents is termed as grease.

1. Lubricating oil is the principal component and it can be either petroleum oil or a synthetic hydrocarbon of low to high viscosity.
2. The thickeners consist primarily of special soaps of Li, Na, Ca, Ba, Al, etc.
3. Specific additives to improve the quality.

Grease can support much heavier load at lower speed. Internal resistance of grease is much higher than that of lubricating oils; therefore it is better to use oil instead of grease. Compared to lubricating oils, grease cannot effectively dissipate heat from the bearings, so work at relatively lower temp.

The main function of soap is thickening agent so that grease sticks firmly to the metal surfaces. However, the nature of the soap decides:

1. the temperature up to which the grease can be used
2. its consistency
3. Its water and oxidation resistance.

So, greases are classified after the soap used in their manufacture. Important greases are:

(i) Calcium-based greases or cup-greases
(ii) Soda-base greases
(iii) Lithium-based greases
(iv) Axle greases

**(i) Calcium-based greases or cup-greases**:

These are emulsions of petroleum oils with calcium soaps. They are, generally, prepared by adding requisite amount of calcium hydroxide to hot oil while under agitation. These greases are the cheapest and most commonly used. They are insoluble in water, so water resistant. However, they are satisfactory for use at low temperatures, because above 80oC, oil and soap begins to separate out.

**(ii) Soda-base greases:**

These are petroleum oils, thickened by mixing sodium soaps. They are not water resistant, because the sodium soap content is soluble in water. However, they can be used up to $175^{o}C$. They are suitable for use in ball bearings, where the lubricant gets heated due to friction.

**(iii) Lithium-based greases**:

These are petroleum oils, thickened by mixing lithium soaps. They are water-resistant and suitable for use at very low temperatures. Used in aircraft application($-55^{0}C$).

**(iv) Axle greases:**

These are very cheap resin greases, prepared by adding lime (or any heavy metal hydroxide) to resin and fatty oils. The mixture is thoroughly mixed and allowed to stand, when grease floats as stiff mass. Filters (like talc and mica) are also added to them. They are water-resistant and suitable for less delicate equipments working under high loads and at low speeds. Besides the above, there are greases prepared by dispersing solids (like graphite) in mineral oil. These are mostly used in rail axle boxes, machine bearings, tractors rollers, wires ropes etc.

**ASSIGNMENTS:**

1. Define Lubricants.
2. What are the function of lubricants?
3. What are the operating condition of solid and liquid lubricants?
4. What is semi solid lubricant?
5. How many types of semisolid lubricants are there?

# CHAPTER-12 - FUEL

**Definition**:

Fuel is a carbonaceous combustible substance, which on combustion liberates a large amount of energy in the form of heat which can be useful industrially and domestically.

$$\text{Fuel} + O_2 \longrightarrow \text{Products} + \text{Large amount of heat}$$

**Classification**:

(A) Classification based on the occurance:

(i) Primary or natural fuels: The fuels which occur in nature as such. Example: wood, coal, peat, lignite, anthracite, petroleum, natural gas etc.

(ii) Secondary or artificial fuels: The fuels which are derived from the primary fuels. Example: coke, kerosene oil, petrol, coal gas, pulverized coal, liquefied petroleum gas (LPG), CNG etc.

(B) Classification based on the physical state:

(i) Solid fuels- wood, coal, peat, lignite, anthracite

(ii) Liquid fuels- petroleum, kerosene oil, petrol, Diesel

(iii) Gaseous fuels-LPG,CNG, coal gas, Water gas, Producer gas

**CALORIFIC VALUE**:

Calorific value is defined as the total amount of heat liberated when a unit mass/volume of fuel is burnt completely in presence of air or oxygen.

Calorific value is of two types as follows:-

1) Higher calorific value. (HCV) or Gross calorific value. (GCV)

2) Lower calorific value. (LCV) or Net calorific value. (NCV)

1) HCV: - It is the amount of heat liberated when a unit mass of fuels burnt completely in the presence of air or oxygen and the products of combustion are cooled to room temperature. Here it includes the heat liberated during combustion and the latent heat of steam. Hence its value is always higher than lower calorific value.

2) LCV: - It is amount of heat liberated when a unit mass of fuel is burnt completely in the presence of air or oxygen and the product of combustion are let off completely into air. It does not include the latent heat of steam. Therefore it is always lesser than HCV.

| **FUELS AND THEIR UNIT** | | |
|---|---|---|
| **SYSTEM** | **SOLID/LIQUID FUEL** | **GASEOUS FUEL** |
| MKS | kcal/kg | Kcal/m3 |
| GGS | Cal/g | Cal/cm3 |

**Characteristics of a Good Fuel**:

(1) High calorific value: The calorific value of a fuel is the direct measure of its efficiency of a fuel. If the calorific value of the fuel is high, the fuel is said to be more efficient. Therefore, a good fuel must have high calorific value.

(2) Moderate ignition temperature: Ignition temperature is the minimum temperature to which the fuel is to be heated to start combustion. The fuel having very low ignition temperature causes fire hazards during handling, applications, storage and transportation. It is very difficult to ignite the fuel with ignition temperature. Hence moderate ignition temperature is the most desired property of the fuel.

(3) Low moisture content: The presence of high percentage of moisture in the fuel reduces the efficiency of a fuel. It also increases the ignition temperature and fuel cost. It decreases the calorific value since some of the heat produced is utilized to vaporize the moisture. Hence the moisture content in a good must be at negligible level.

(4) Low ash content: Formation of ash during combustion is due to the presence of inorganic matter in the fuel. High ash content in the fuel causes the following problems.

(a) lowering the calorific value.

(b) problems in disposal.

Hence, a good fuel must be free from ash content.

(5) Combustion control: A large wastage of valuable fuel can be avoided by

(a) regulating the combustion rate properly and

(b) stopping the process immediately as when desired.

(6) Ease of availability: Fuel must be readily available in abundant and its cost must be minimum.

(7) Harmless combustion products: A good fuel must not produce harmful combustion products like CO, SO2, NO, H2S, smoke and clinkers during combustion. Therefore, a good fuel must burn with clean flame without producing undesirable by products.

(8) Low cost.

(9) Easy to transport.

(10) Low storage cost.

(11) Uniform size: In the case of a solid fuel, the size should be uniform so that the combustion is regular.

(12) A fuel must burn in air with efficiency without much smoke and ash.

**Liquid Fuels-Petroleum:**

Petroleum is the principle source of aliphatic organic compounds. It is a dark greenish brown highly viscous oil found in deep in the earth’s crust. Usually oil is floating upon a layer of brine and has a layer of gas on the top of it.

It contains various hydrocarbons together with small amounts of organic compounds having oxygen, nitrogen and sulfur.

**The average composition of petroleum is**

Carbon : 79.5 - 87.1% Hydrogen: 11.5 - 14.8% Sulfur: 0.1 - 3.5%;
Nitrogen and Oxygen: 0.1-0.5%.

**Refining of Petroleum:**

The process of separation of crude oil or petroleum into different fractions on the basis of their boiling points is known as refining or fractionation of petroleum. The refining process mainly involves 3 steps.

(1) Separation of water
(2) Removal of harmful sulfur compounds
(3) Fractional distillation.

(1) **Separation of water (Cottrell's process)**:

The crude oil is an extremely stable emulsion of oil and salt water. To separate water from crude oil, the crude oil is allowed to flow between two highly charged electrodes. The colloidal water droplets combine to form large drops and get separated from oil.

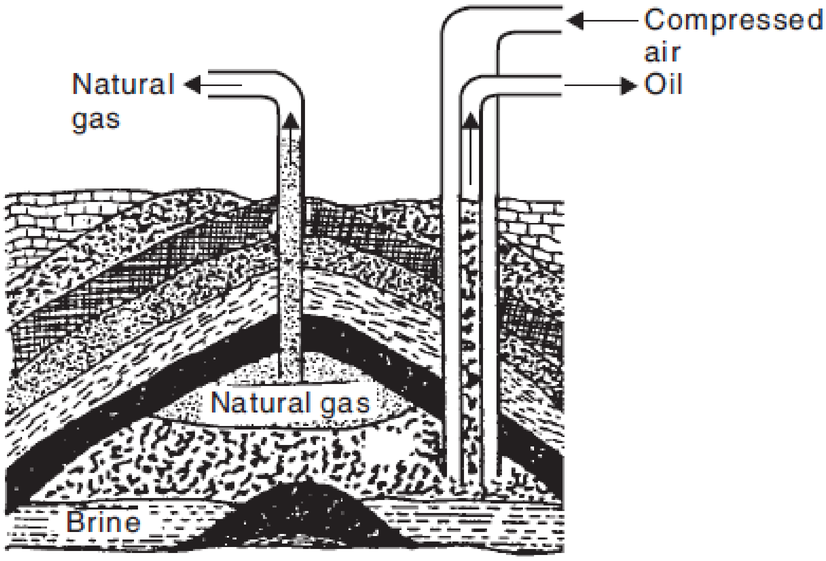


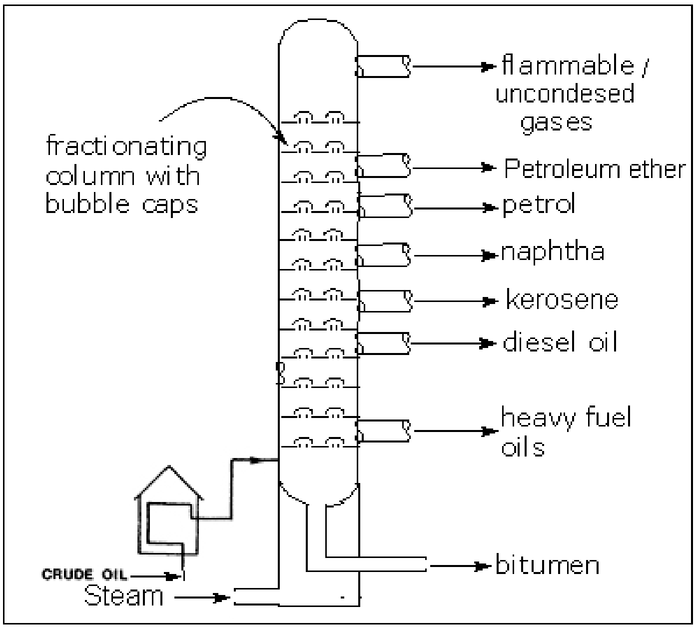
**Fig. 18.5** Mining of crude oil and use of air-lift pump.

(2) **Removal of sulfur compounds**:

To remove sulfur from the crude oil or petroleum, the crude oil is treated with copper oxide. The sulfur gets precipitated as copper sulfide and is separated by filtration.

(3) **Fractional distillation**:

The crude oil is heated to about 4000C in an iron retort. All volatile constituents get evaporated. The hot vapors are passed up through a fractionating column. Fractionating column is a tall cylindrical tower having number of horizontal stainless steel trays at short distances. Each tray is provided with small chimney covered with a loose cap. As vapors go up, they become gradually cooler and fractional condensation takes place at different heights of column.



**Petrol or Gasoline**:

i. The fraction obtained between $40^0$ - $120^0$C, chiefly contains petrol.

ii. It consist of hydrocarbons between pentane to octane ($C_5H_{12}$ to $C_8H_{18}$)

iii. It is volatile and inflammable.

iv. Average Composition C = 84%, H=15%, O+S+N =1%

v. Calorific Value = 11,250 Kcal / Kg.

**Uses**:

1. It is used as a fuel in the petrol engine.
2. It is used as a dry cleaning agent.

**Kerosene**

i. It is obtained between $180^0$C – $250^0$C

ii. It consists of hydrocarbons between decane to hexadecane ($C_{10}H_{22}$ to $C_{16}H_{34}$).

iii. Average Composition, C = 84 % , H = 16%, S < 0.1%

iv. Calorific value = 11, 100 Kcal/ Kg

**Uses**:

1. It is used as a fuel in the kitchen for domestic.
2. It is used as a fuel in jet planes.
3. It is used in making oil gas.

**Diesel**

i. It is obtained between $250^0$C – $320^0$C

ii. It contains a mixture of hydrocarbons between pentadecane to octadecane ($C_{15}H_{32}$ to $C_{18}H_{38}$).

iii. Average composition: C = 85%, H = 12%, Rest = 3%

iv. Calorific Value = 11000Kcal/kg

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

**Light Diesel Oil (LDO) and High Speed Diesel (HSD)**: Light diesel oil and High speed diesel are produced from crude petroleum oil. The fraction obtained between $150^0$C – $400^0$C contains LDO and HSD. These contain hydrocarbons having C12 – C18 and comprise of paraffins, olefins and aromatics. LDO is normally used for the generation of electricity, in stationary & marine engines and diesel generators. HSD is normally used in automobiles like buses, lorries, etc.

Low Sulphur Heavy Stock (LSHS): When heavy oil or gas oil stock is cracked at the temperature range 475$^0$C -530$^0$C under pressure of 100 kg/cm3, high grade petrol is obtained which contains very low quantity of sulphur and is called LSHS. These are rich in aromatics and iso-paraffins. These are mainly used in locomotives as diesel engine fuel.

**Gaseous Fuels-**

The gaseous fuels are most preferred because of their ease of storage, transport, handling and ignition. These are classified into two types.

a) Primary fuels Ex:- Natural gas

b) Secondary fuels ex: - Coal gas, producer gas, water gas.

**CNG: Compressed Natural Gas:**

The natural gas is obtained from the wells dug in the earth during mining of petroleum. It is mainly composed of methane and small quantities of ethane along with other hydrocarbons. If the lower hydrocarbons are present, the gas is called dry gas or lean gas but if the hydrocarbons having the higher molecules are present, the gas is known as rich or wet gas.

The average composition of natural gas is as follows.

Methane – 88.5%
Ethane – 5.5%,
Propane – 3.7%
Butane – 1.8%,
Pentane, hydrogen and higher hydrocarbons – 0.5%

Calorific Value of natural gas varies from 12000-14000 Kcal/m3.

**Applications:-**

It is an excellent domestic fuel and industrial fuel.

It is also used as raw material for the manufacture of carbon-black, methanol, formaldehyde etc.

For synthetic protein(animal feed) preparation from CH4

**LPG (Liquefied Petroleum Gas) :**

The gas is obtained from natural gas or as a byproduct in refineries during cracking of heavy petroleum products. Nowadays LPG has been a common fuel for domestic work and also in most of the industries. The main components of LPG are n-butane, isobutane, butylenes and propane (traces of propene and ethane). The hydrocarbons are in gaseous state at room temperature and 1 atmospheric pressure but can be liquefied under higher pressure.

**Composition:**

n-butane-27%
Isobutane-25%
Butane-43%
Propane-2.5%

Propene-2.5%

It has high calorific value (27,800 kcal/m3)

**USES:**

It is mainly used as a domestic fuel & industrial fuel

Also used as motor fuel

## Water Gas:

Water gas is essentially a mixture of combustible gases CO and $H_2$ with a little fraction of non-combustible gases. It is made by passing alternatively steam and little air through a bed of red hot coal or coke maintained at about 900 to 1000oC in a rector, which consists of a steel vessel about 3 m wide and 4 m in height. It is lined inside with fire-bricks. It has a cup and cone feeder at the top and an opening at the top for the exit of water gas. At the base, it is provided with inlet pipes for passing air and steam.

### Reactions

Supplied steam reacts with red hot coke (or coal) at 900-1000°C to form CO and $H_2$.

$C + H_2O \longrightarrow CO + H_2 - 29\ kcal$

$C + O_2 \longrightarrow CO_2 + 97\ kcal$

### Composition

The average composition of water gas is :

$H_2 = 51\%$;

$CO = 41\%$;

$N_2 = 4\%$;

$CO_2 = 4\%$.

Its calorific value is about 2,800 kcal/m3.

### Uses:

It is used as

(a) a source of hydrogen gas,

(b) an illuminating gas, and

(c) a fuel gas.

## Producer Gas

Producer gas is essentially a mixture of combustible gases carbon monoxide and hydrogen associated with non-combustible gases $N_2$, $CO_2$, etc. It is prepared by passing air mixed with little steam over a red hot coal or coke bed maintained at about 1100°C in a special reactor called gas producer. It consists of a steel vessel about 3 m in diameter and 4 m in height. The vessel is lined inside with fire bricks. It is provided with a cup and cone feeder at the top and a side opening for the exit of producer gas. At the base it has an inlet for passing air and steam. The producer at the base is also provided with an exit for the ash formed.

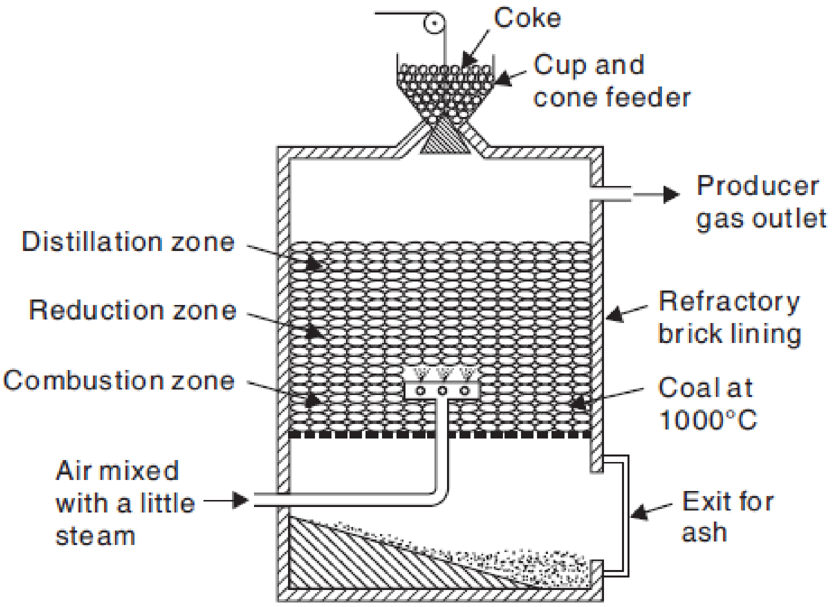


**Fig. 18.12** Gas producer.

It is a mixture of combustible gases, CO and $H_2$ with large quantities of non-combustible gases $CO_2$ and $N_2$

**The average composition of producer gas is**

CO = 22- 30%
$H_2$ = 8 - 12 %
$CO_2$ = 3%
$N_2$ = 52 - 55 %
Its calorific value is 1300 Kcal /m3.

**Uses:**

It is used:
i. In heating furnace in metallurgical operations.
ii. As a reducing agent.

**Coal gas -**

It is obtained when coal is carbonized or heated in absence of air at about 1300°C in either coke ovens or gas-making retorts. In gas making retort process coal is fed in closed silica retorts, which are then heated to about 1300oC by burning producer gas and air mixture.

$$C + ½ O_2 \longrightarrow CO + 29.5 \text{ kcal}$$

Coal gas is a colourless gas having a characteristic odour. It is lighter than air and burns with a long smoky flame.

**Its average composition is :**

$H_2$ = 47%    $CH_4$ = 32%
CO = 7%    $C_2H_2$ = 2%
$C_2H_4$ = 3%    $N_2$ = 4%
$CO_2$ = 1%    Rest = 4%.

Its calorific value is about 4,900 kcal/m3.

**It is used as**

a)illuminant in cities and town

b)a fuel, and

c)in metallurgical operations for providing reducing atmosphere.

d)In Smelting of metals & alloys

**ASSIGNMENTS:**

1. Define and classify Fuels with examples.
2. What is calorific value of fuel.
3. What are the characteristics of a good fuel
4. Write down the composition, uses and calorific value of Petrol, diesel and kerosene.
5. Write down the composition, uses and calorific value of water gas, producer gas and coal gas.
6. Write down the composition and uses of HSD and LDO.
7. Write down the composition, uses and calorific value of LPG and CNG.

# CHAPTER-13: POLYMER

## Polymer – Definition:

Polymers are the substances consisting of giant or macromolecules of high molecular weight formed by linking a large number of smaller molecules (monomers). For example: Polythene, PVC (polyvinyl chloride), Bakelite, Buna-S, Buna –N, Teflon, etc. are the examples of polymer. In Greek, ‘poly’ means many

$$n(CH_2 = CH_2) \xrightarrow{\text{polymerization}} (-CH_2 - CH_2-)n$$

Ethylene (monomer) Polyethylene (polymer)

and ‘meros’ means units or parts.

Monomer: Monomer is the single repeating unit which on polymerization gives a polymer.

For example: Ethene is the monomer unit of polyethene.

## Classification of Polymers

Polymers may basically be classified in to two types, they are:

i. Homo-polymer ii. Co-polymer

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, “M" is the monomer unit.

(homopolymer)

## Copolymer :

A 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.

--------M1 – M2 – M1 – M2 – M1 –M2 ------- where, “M1” & “M2” are
(Copolymer) the monomer units

Degree of polymerization(n): The number of repeat units (or) monomeric units available in the polymer is known as degree of polymerization.

**Differences between thermoplastics and thermosettings polymers:**

| Thermoplastics | Thermosettings |
|---|---|
| 1. Formed either by addition or by condensation polymerisation reactions | 1.Formed by condensation polymerisation reactions. |
| 2.They have either linear or branched structures | 2. They have 3-dimensional crosslinked network structure. |
| 3.Adjacent polymer chains are held together by either vander waals forces, by dipole-dipole forces or by H-bonds. | 3.Adjacent polymer chains are held together by strong covalent bonds called crossed-links. |
| 4.They soften on heating and stiffen on cooling | 4. They do not soften on heating. |
| 5.They can be remoulded, reshaped and re-used. | 5.They cannot be remoulded and hence cannot be used. |
| 6.They are soft , flexible and less britte | 6.They are hard, rigid, infusible and more brittle. |
| 7.They swell or dissolve in organic solvents. | 7.They neither dissolve nor swell in organic solvents. |
| 8.They undergo reversible changes, on the application of heat. These are liner polymers which are hard at room temperature become soft on heating again hard on cooling. | 8.They undergo irreversible changes on the application of heat. So these type of polymers can’t be moulded again and again as on heating once it permanently sets into a solid which cannot be remelted and reworked |
| 9.The moulded articles are to be cooled to room temperature before taking out from the moulds to avoid deformation. | 9.The moulded articles can be taken out of the moulds even when they are still hot without any deformations. |
| 10.Examples:Polyethylene(PE),Polypropylene(PP),PolyVinylChloride(PVC), Polystyrene(PS),Poly tetrafluoroethylene (PTFE or Teflon), Polymethyl methacrylate (PMMA) nylons, Polyesters. | 10.Examples: Phenol-formaldehyde resin (PF), urea-formaldehyde resin(UF), Melamine – formaldehyde resin (MF), epoxy resins, bakelite. |

## Polyethylene:

Ethene is the monomer unit of polyethene.

$$\underset{\substack{\text{Ethylene}\\\text{(monomer)}}}{n(CH_2 = CH_2)} \xrightarrow{\text{polymerization}} \underset{\substack{\text{Polyethylene}\\\text{(polymer)}}}{(-CH_2 - CH_2-)n}$$

Ethylene is a colourless gas at ordinary temperature. It is polymerised by compressing to 1500 atm pressure and passed through a reactor maintained at 2000 C in presence of O2 or peroxide as catalyst.

Properties:

Polythenes are rigid, waxy, transparent solids having high symmetrical chain structure. They are classified according to their densities:

i)LDPE

ii)HDPE

It has good chemical resistance against acids, alkalis and salt solutions, good insulating property but susceptible to organic solvents, particularly kerosene.

**USES:**

i)Polythene sheets, tubes - domestic appliances

ii)Toys, pipes, coated wires and cables

iii)Carry bag, packing material, flexible bottles, caps, insulator parts

## Polyvinylchloride(PVC):

Vinyl chloride is the monomer unit of PVC. The monomer is produced by direct addition of HCl to acetylene at $60^0$-$80^0$C. Then it is polymerized to PVC at high T & P.

$$CH \equiv CH + HCl \xrightarrow{HgCl} CH_2 = CHCl$$

$$nCH_2 = CHCl \xrightarrow{\text{Polymerize}} \underset{\text{PVC}}{-(CH_2CHCl)_n-}$$

**Properties:**

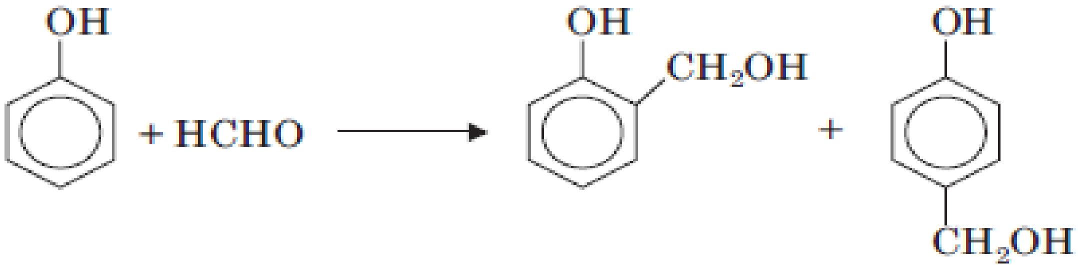
1. It is a colourless, odourless, non-flammable, chemically inert material
2. Resistant to water, light, $O_2$, inorganic acids, alkali, oil, petrol etc.
3. Soluble in hot chlorinated hydrocarbons

**USES:**

1. Insulating material-electric cables
2. Safety helmets, seat cover, motorcycle mudguards
3. Refrigerator components, raincoats, plastic dolls, handbags, belts, table cloths
4. Drainage pipes, conveyor belts
5. Water hoses, tyres, floor coverings etc

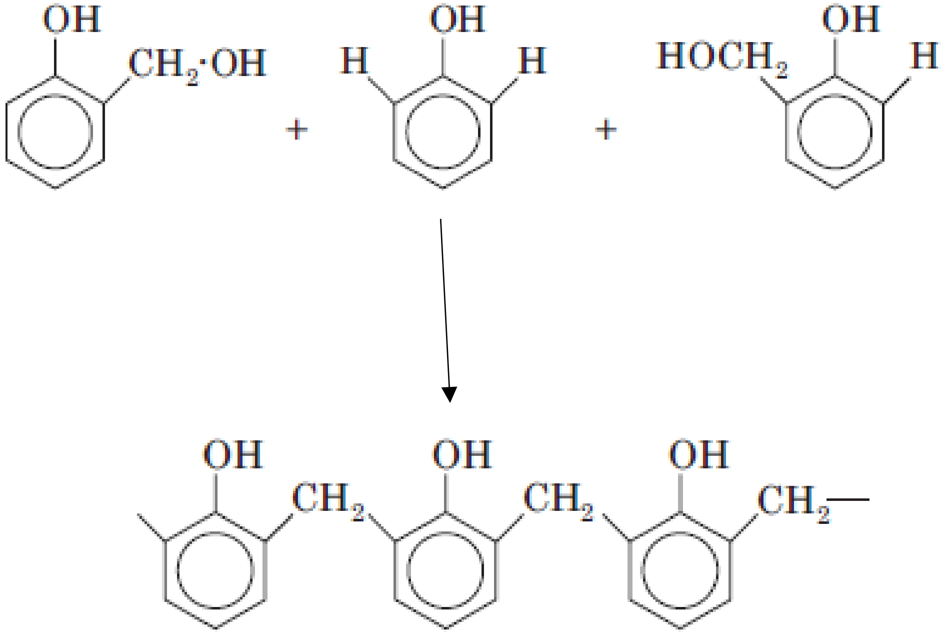
**Bakelite-(Phenol-formaldehyde resin):**

It is prepared by condensation polymerization of phenol and formaldehyde in presence of acid/alkali ne catalyst in aqueous solution. In presence of acid catalyst, the1st step leads to formation of ortho- and para-hydroxymethyl phenol.



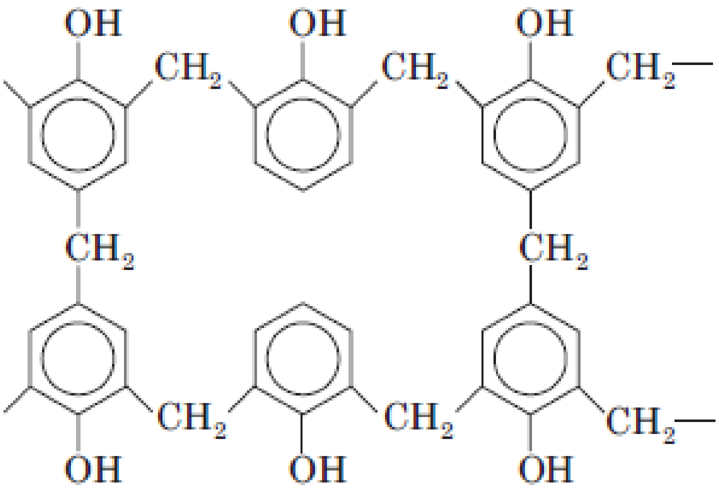
Phenol formaldehyde o-hydroxymethyl phenol p-hydroxymethyl phenol

In the 2nd step the ortho-hydroxymethyl phenol condense with phenol to form a linear polymer known as "NOVOLAC" .



Novolac

In the next step, the "NOVOLAC" is further heated in presence of hexamethylenetetramine [$(CH_2)_6N_4$] to give a hard, insoluble, infusible cross-linked polymer known as "Bakelite".



bakelite

**Properties:**

1. Rigid, hard, water-resistant
2. Resistant to non-oxidising acids, organic solvents but are susceptible to alkali.
3. Possess excellent electrical insulating properties.

**USES:**

1. Electrical Insulation parts, switches, plugs etc
2. Telephone parts, radio and TV cabinets
3. As a binder for grinding wheels
4. As an ion-exchange resin for water softening
5. For making bearings in paper industry and rolling mills

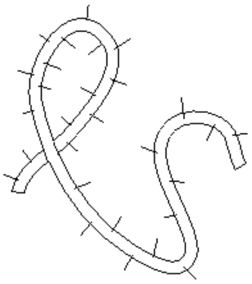
**Rubbers(ELASTOMERS):-**

These are high polymers having elastic properties in excess of 300%. The property lies between those of thermosetting and thermoplastic polymers.

Elasticity:

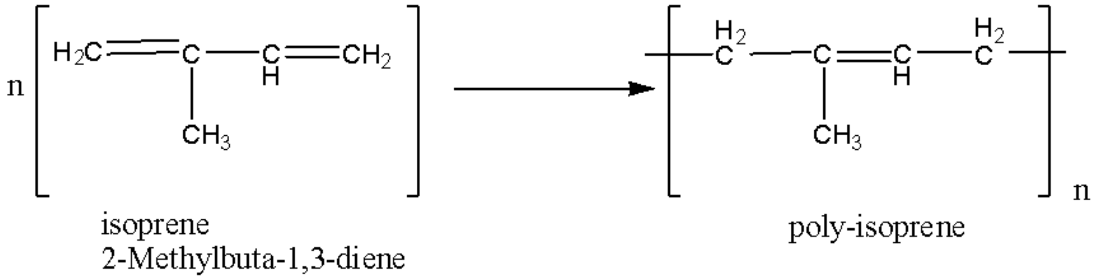
It is the most important property of rubber. On stretching it elongates to 200% of its length and quickly returns to its original length when the stretching force is removed. It is called resilience property.(ex-rubber band)

The elastic deformation arises from the fact that in the unstressed condition, an elastomer molecule is not straight chain but in form of a coil and consequently it can be stretched like a spring.



**Natural Rubber:-**

It is produced from latex - milky emulsion drawn from the rubber tree (Hevea brasiliensis). When coagulated latex transforms into soft, plastic and sticky substance i.e crude rubber. The natural rubber is composed of polyisoprene molecules.



It is of 2 types

1. Cis-polyisoprene
2. Trans-polyisoprene

Trans-polyisoprene is another variety of natural rubber obtained from matured leaves of Palagum gutta and Dichopsis guttae used for manufacture of golf ball covers, submarine cables, adheisves etc.

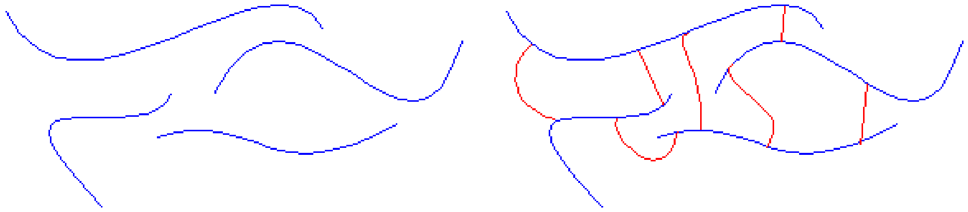
**Drawbacks of Natural Rubber/Raw rubber:-**

1. It is plastic in nature: soft at high temp., too brittle at low temp. Hence can be used in the temp. range of 10-60$^0$C only.
2. Weak, less tensile strength
3. Large water absorption capacity
4. Non-resistant to non-polar solvents like oil, benzene, mineral, gasoline etc.
5. Attacked by oxidising agent
6. Little durability
7. When stretched to a greater extent, it suffers permanent deformation, r because of the sliding/slippage of some molecular chain over one another.
8. Swells in organic solvents and gradually disintegrates.

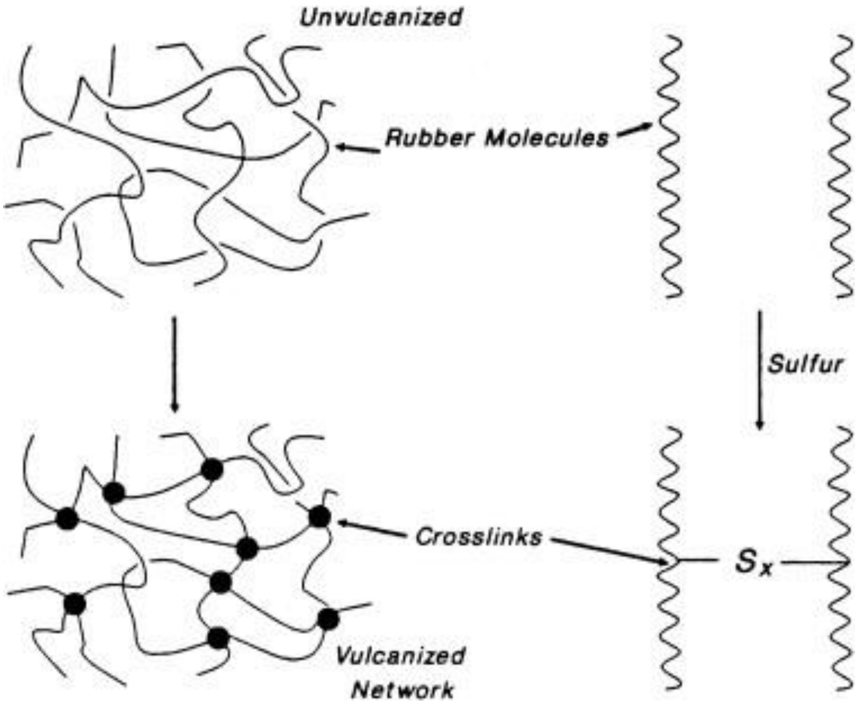
**Vulcanisation of Rubber:**

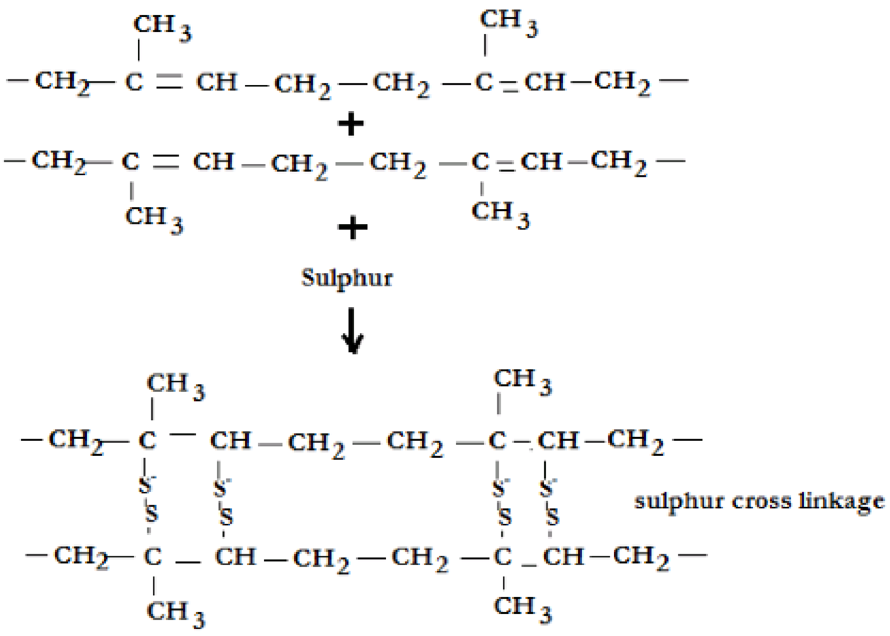
It is the process of heating raw rubber with compounding agents like S or $H_2S$ at a temperature 100-140$^0$C to improve the property of rubber. The process consists of heating raw rubber with S at 100-140$^0$C. The added S combines chemically at the double bonds at different rubber springs. Vulcanisation thus stiffens the material by preventing intermolecular movement of rubber springs. The extent of stiffness depends on the amount of S added.

For ex; tyre rubber: 3-5% S, Battery case rubber: 30% S



uncrosslinked rubber crosslinked rubber





## Advantages of vulcanised rubber over Raw rubber:-

1. Has good tensile strength and extensibility
2. Has excellent resilience i.e article made from it return to original shape when deforming force is removed.
3. Possess low water absorption tendency
4. Higher resistance to oxidation & oxidising agents
5. Higher resistance to wear and tear
6. Better electrical insulator
7. Resistant to organic solvents
8. Has useful temp. range -400C to 1000C

## Uses of vulcanised rubber:

1. Vehicle tyres
2. Water hoses
3. Conveyer belt
4. Electrical insulation

## ASSIGNMENTS:

1. Define Polymer.
2. Classify polymers with examples.
3. What are the difference between thermosetting and thermoplastic polymers?
4. Write down the properties and uses of polythene and PVC along with their monomers.
5. Write down the monomers of Bakelite. How it is prepared? Draw its structure and write down its properties and uses.
6. Define elastomer and explain its property.
7. What is natural rubber? Write down the drawbacks of raw rubber.
8. What is vulcanisation of rubber? Give 2 examples of vulcanised rubber.
9. Write down the advantage of vulcanised rubber over raw rubber.

# CHAPTER-14- CHEMICALS IN AGRICULTURE

## PESTICIDES:

Pesticides are chemical compounds used to kill pests & protect seeds, leaves & roots of plants from insects & bacteria. Pests include insects, fungi, rodents, bacteria, larvae, unwanted plants and herbs etc.

Types of pesticides:

1. Insecticide
2. Herbicide
3. Fungicide
4. Rodenticide
5. Bactericide
6. Larvicide

These are used in agriculture to kill pests and protect crops.

## INSECTICIDES:

Insecticides are pesticides that are formulated to kill, harm, repel or mitigate one or more species of insect. Such substances are used primarily to control pests that infest cultivated plants or to eliminate disease-carrying insects in specific areas.

Insecticides work in different ways. Some insecticides disrupt the nervous system, whereas others may damage their exoskeletons, repel them or control them by some other means. They can also be packaged in various forms including sprays, dusts, gels, and baits. Because of these factors, each insecticide can pose a different level of risk to non-target insects, people, pets and the environment.

Examples: DDT, Gammaxene(BHC), aldrin, chlordane, dieldrin, endrin, heptachlor, mirex and toxaphene, p-Dichlorobenzene

**USES:**

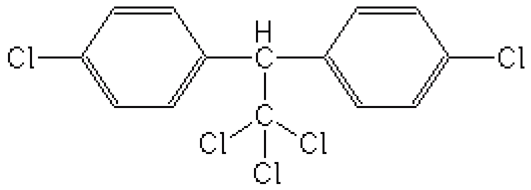
(1) increased yields of crops because of protection from defoliation and diseases

(2) prevention of much spoilage of stored foods; and

(3) prevention of certain diseases, which conserves health and has saved the lives of millions of people and domestic animals.

## DDT(dichloro-diphenyl-trichloroethane)-

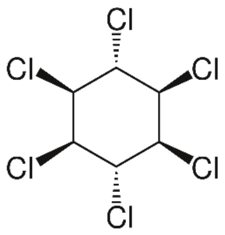
It is the most common and effective of all the commercial insecticides.



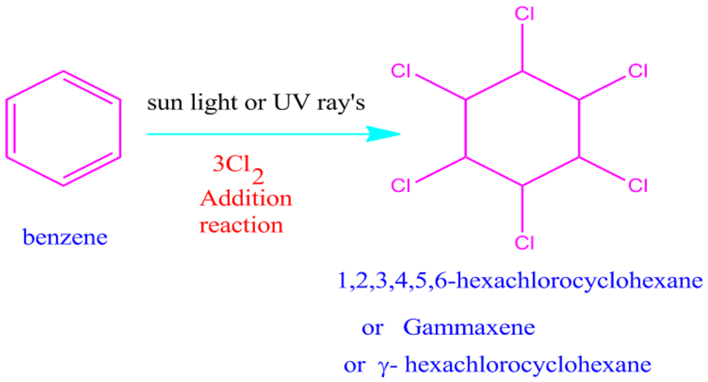
**USES:**

1. It affects the pests by attacking their exoskeleton and nervous system.
   .
2. It also kills mosquitoes and their larvae and helps in controlling malaria
3. Application of excess DDT can cause poor egg formation in birds.
4. It also affects the aquatic animals.

**Gammaxene(Benzene hexachloride)-**



It is commercially available in market in the name of “Lindane”. It acts more effectively than DDT. When benzene reacts with chlorine in presence of sunlight , BHC results.



**USES:**

1. It is used in house, factories and in pet animal living areas to get rid of insects like ants and cockroaches.
2. BHC is an important agricultural pesticide mainly used for exterminating white ants, leaf hopper, termite etc.

## HERBICIDE:

A herbicide is a pesticide used to kill unwanted plants. Selective herbicides kill certain targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often based on plant hormones.

1. Plant pests, or weeds, compete with desired crop plants for light, water, nutrients, and space. This ecological interaction may decrease the productivity and yield of crop plants, thereby resulting in economic damage. Plants may also be judged to be weeds if they interfere with some desired aesthetic effect, as is the case of weeds in lawns.

2. To reduce the intensity of the negative effects of weeds on the productivity of desired agricultural or forestry crops, fields may be sprayed with a herbicide that is toxic to the weeds, but not to the crop species.
3. To reduce negative influences of weeds on agricultural productivity, herbicides are commonly applied to agricultural fields.
4. Most herbicides are applied as water-based sprays using ground equipment.

**Ex:** 2,4-D (2,4-Dichlorophenoxyacetic acid)

2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)

MCPA (2-Methyl-4-chlorophenoxyacetic acid)

silvex [2-(2,4,5-Trichlorophenoxy)-propionic acid].

Atrazine, cynazine, hexazinone,Glyphosphate

## FUNGICIDE:

Fungicides also called antimycotic are biological organisms used to kill parasitic fungi or their spores. A fungicide inhibits their growth. Fungicides kill pathogenic or parasitic fungi by disrupting their critical cellular processes. For example, many fungicides bind with specific enzymes to interrupt the metabolic pathways involved with cellular respiration

Fungi can cause serious damage in agriculture, resulting in critical losses of yield, quality, and profit. Fungicides can be used to control fungi that damage plants, including rusts, molds, mildews and blights. Fungicides are generally used to control parasitic fungi that either cause economic damage to crop or ornamental plants or endanger the health of domestic animals or humans. Most agricultural and horticultural fungicides are applied as sprays or dusts

Fungicides work in a variety of ways, but most of them damage fungal cell membranes or interfere with energy production within fungal cells.

**Examples:**

chloropicrin, methyl bromide, and formaldehyde, copper sulphate solution, Aluminium Phosphide, Ethylene dibromide

Broadly, there are three main reasons fungicides are used:

(a) To control a disease during the establishment and development of a crop.

(b) To increase productivity of a crop and to reduce blemishes. Diseased food crops may produce less because their leaves, which are needed for photosynthesis, are affected by the disease. Blemishes can affect the edible part of the crop or, in the case of ornamentals, their attractiveness, which both can affect the market value of the crop.

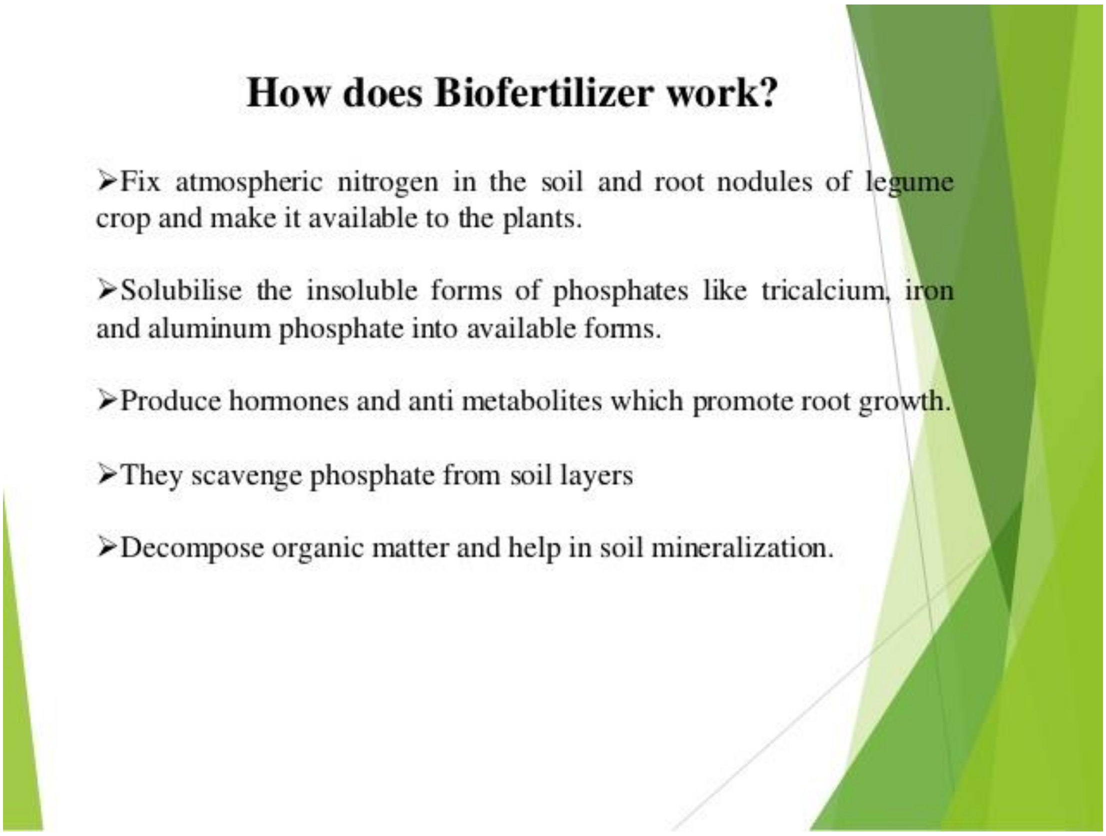
(c) To improve the storage life and quality of harvested plants and produce. Fungi often spoil (render unusable) stored fruits, vegetables, tubers, and seeds. A few which infect grains produce toxins (mycotoxins) capable of causing severe illness or even death in humans and animals when consumed. Fungicides have been used to reduce mycotoxin contamination in wheat

## Bio-fertilizer:

‘Bio’ means ‘life’. Therefore, by definition biofertilizers are living organisms that enrich the nutrient quality of the soil.Biofertilizers are defined as preparation containing living cells of efficient strains of microorganismsthat help crop plants for the uptake of nutrients. It refers to the use of microbes instead of chemicals to enhance the nutrition of the soil. Biofertilizers are more cost-effective and pollution free as compared to chemical fertilizers.

Importance of biofertilizer:

1. Increasing harvest yields
2. Improving soil structure
3. Better water relation
4. Lowering production cost
5. Fortifying the soil
6. Improving sustainability



**How does Biofertilizer work?**

➢Fix atmospheric nitrogen in the soil and root nodules of legume crop and make it available to the plants.

➢Solubilise the insoluble forms of phosphates like tricalcium, iron and aluminum phosphate into available forms.

➢Produce hormones and anti metabolites which promote root growth.

➢They scavenge phosphate from soil layers

➢Decompose organic matter and help in soil mineralization.

Types of Bio-fertilizers:

1. Bacterias
2. Fungi
3. Cyanobacteria

**Bacteria;** There are nitrogen-fixing nodules on the roots of legumes plants. This a great example of biofertilizers. The nodules are formed by the association of the bacterium '*Rhizobium'* with the roots of these plants. This association is beneficial and is, therefore, called 'symbiotic'.

**Fungi;** Symbiotic associations exist between plants and fungi too. These associations are called 'Mycorrhizae'. The fungus in this association absorbs phosphorus from the soil and provides it to the plant. Plants that grow with these associations also show other advantageous characteristics such as:

1. Tolerance to drought conditions and salinity.
2. Resistance to root-borne pathogens.
3. An overall increase in plant growth and development
4. Enhance the uptake of P,Zn, S and water leading to uniform crop growth and increased yield
5. Liberate growth promoting substances and vitamins and help to maintain soil fertility.

**Cyanobacteria;** These are blue-green bacteria found in water and on land. They also help fix atmospheric nitrogen. Examples are *Oscillatoria, Nostoc, Anabaena* etc. The symbiotic association between the aquatic fern Azolla and *Anabaena* is very important for rice fields. In this association, *Anabaena* receives carbon and nitrogen from the plant in exchange for fixed nitrogen. This adds organic matter to the soil enhancing the fertility of rice fields.

There are many benefits to using this safe and relatively inexpensive product. It produces a healthier crop and promotes subsistence farming.

Biofertilizers are an environmentally friendly substitute for harmful chemical fertilizers. The major advantages of Biofertilizers over Chemical fertilzers are;

1. They can increase the output of food to be used.
2. They have a low production cost because they make use of leftover vegetables and easily obtained organic products like Manure.
3. It produces a healthier crop and promotes subsistence farming.
4. They supplement chemical fertilizers for meeting the integrated nutrient demand of crops
5. Results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation.

6. Act as antagonists and suppress the incidence of soil borne plant pathogens and hence help in bio control of disease.
7. $N_2$ fixing, phosphorous mobilizing and cellulolytic microorganisms in biofertilizer enhance the availability of plant nutrients in the soil and thus sustain the agricultural production and farming system.
8. They are cheaper, renewable, pollution free energy sources
9. BGA like Nostoc, Anabaena are often employed in reclamation of alkaline soil

## ASSIGNMENTS:

1. Define pesticides. Write down different types of pesticides.
2. Define Insecticides. Write down two examples and uses of insecticides.
3. Define herbicides. Write down the importance of herbicides in agriculture.
4. What are Fungicides? Write down two examples and uses of fungicides.
5. What is biofertilizer? Write down its advantages and explain with examples.