Module III- CHEMISTRY OF MATERIALS AND POLYMERS

1) What are the differences between organic and inorganic compounds?

Organic	Inorganic
Found in living organisms	Found in non-living matter
Main component element is carbon	Composed of one or more known elements
Covalent compounds	Ionic compounds
Volatile and flammable	Generally non-volatile and non-flammable
Generally insoluble in water	Soluble in water
Reactions are slow	Reactions are fast
Non-conductor of electricity	Most of them are conductors in fused state
Very large in number	Small in number

2) Explain uniqueness of Carbon

a. High Catenation capacity: - The tendency of an element to form chain of identical atoms is called catenation. It is maximum for carbon.
b. Tetra-covalency: - Carbon atom can make four covalent bonds and thus form large variety of compounds.
c. High strength of C-C bond.
d. Capacity to combine with other non-metals.
e. Capacity to form multiple; double or triple bonds
f. Isomerism: - It is the phenomenon in which compounds with different structure and properties have same molecular formula.

3) Distinguish between saturated and unsaturated organic compounds

Saturated	Unsaturated
Single C-C covalent bonds	At least one C-C multiple bond
Less reactive	More reactive
Do not decolourise bromine water	Decolourise bromine water
Do not decolourise Baeyer's reagent	Decolourise Baeyer's reagent
Eg. Methane CH_3-CH_3	Eg. Ethene CH_2=CH_2

4) Write a note on functional groups

Functional group is defined as an atom or group of atoms which determines the properties of an organic compound.

Functional group	Formula	Class of compound	Example
Hydroxyl	-OH	Alcohol	Methyl alcohol CH_3-OH
Aldehydic	-CHO	Aldehyde	Acetaldehyde CH_3-CHO
Carboxyl	-COOH	Carboxylic Acid	Acetic acid CH_3-COOH
Amino	$-NH_2$	Amine	Methyl Amine CH_3-NH_2
Ketonic	-CO-	Ketone	Dimethyl ketone CH_3-CO-CH_3
Ester (Carboxylate)	-COOR	Ester	Methyl acetate CH_3-$COOCH_3$
Ether	-O-	Ether	Diethyl ether C_2H_5-O-C_2H_5

5) What are refractories? Classify them. Give their general properties and uses

A refractory substance is defined as a material that can withstand high temperatures without softening, melting or deformation.

Classification

a. Acid refractories- These are not attacked by acids. Eg. Silica, Alumina.
b. Basic refractories- These are not attacked by bases. Eg. Magnesite, Dolomite.
c. Neutral refractories- These are not attacked by slightly acidic or basic substances. Eg. Graphite, Silicon carbide.

General properties

a. Refractoriness- It is the property by which a material can withstand high temperatures without softening.
b. Low porosity
c. Minimum thermal spalling
d. High mechanical strength
e. Chemical inertness
f. Low thermal expansion
g. Low electrical conductivity

Uses

a. Used as internal lining for furnaces, tanks, kilns, crucibles, etc.
b. Used as thermal insulating walls

6) What are the general properties of glass?

a. Amorphous
b. No definite melting point
c. Good electrical insulator
d. Can be moulded into desired shapes
e. Not affected by air, water or acids (except HF acid)
f. Affected by alkalis
g. Absorb, reflect or transmit light
h. Very brittle

7) Give a not on different types of glasses

i. Soda glass or soft glass- It is a mixture of sodium and calcium silicates. It is soft and brittle. Used for making window glass, bottles, bulbs, etc.

ii. Pyrex or Borosilicate glass- It is a mixture of sodium aluminium borosilicate. It can withstand high temperature. It is resistant to chemicals. Used to make laboratory glassware, pipelines, kitchen ware, etc.

iii. Safety glass- It does not allow its broken parts to fly apart. It is obtained by placing a thin layer of plastic sheet with an adhesive between two sheets of glasses. Used in automobile and aero plane wind shields.

iv. Insulating glass- It is prepared by two or more plates of glass separated by a small gap (6-13mm) filled with dehydrated air and sealing around the edges which gives a heat insulation. Used for separating rooms, and used as window glass.

8) What are optical fibres? Give their advantages and uses.

An optical fibre is a transparent flexible fibre made by drawing glass into very small diameter and include a transparent core surrounded by a transparent material with lower index of refraction.

Advantages

a. Optical fibre is immune to electromagnetic interference.
b. Light can be transmitted by the phenomenon ‘Total internal reflection’.
c. Multi-mode propagations are possible for communication

Uses

a. Used in communication over long distances
b. Used as optic sensor of temperature, pressure, strain, etc
c. Used in photovoltaic cells
d. Used as light guide in medical applications (eg. Endoscopy)
e. Used in decorative illuminations
f. Used in imaging optics

9) Define polymer, monomer and polymerization

Polymer is a very large molecule having high molecular weight and formed by joining of repeating structural units using covalent bonds.

The simple molecule from which the repeating structural units are derived is called a monomer.

The process of converting monomers into a polymer is called polymerization

10) What are the different types of polymers based on nature of monomer?

a. Homo polymers- Here the repeating structural units are derived from only one type of monomers. Eg. Polyethene obtained from Ethene, Poly Vinyl Chloride (PVC) from vinyl chloride.
b. Co-polymers- These are polymers whose repeating structural units are derived from two or more types of monomers. Eg. Nylon -66 is obtained from hexamethylene diamine and adipic acid, Bakelite obtained from phenol and formaldehyde

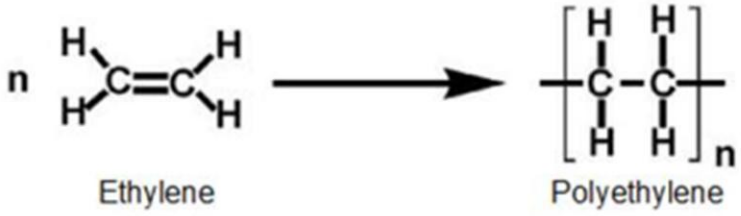
11) Classify polymers based on source of availability

a. Natural polymers which are found in nature. Eg. Starch, Rubber, Protein
b. Semi Synthetic polymers which are derived from naturally occurring polymers by chemical modifications. Eg. Cellulose acetate, Cellulose trinitrate
c. Synthetic polymers which are man-made. Eg. Polyethene, Nylon 6

12) Classify polymers based on mode of polymerization

a. Addition polymerization- In this type of polymerization, polymers are formed by simple addition reaction between small molecules containing double or triple bonds.

Example: Formation of polyethylene or polythene.

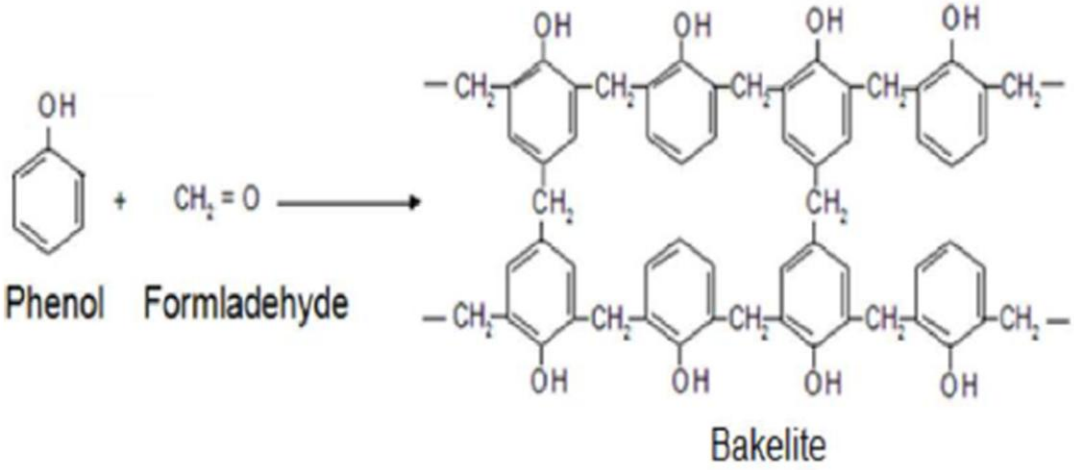


Formation of Poly Vinyl Chloride (PVC)

$$n\ CH_2\text{-}CHCl \rightarrow (\text{-}CH_2\text{-}CHCl\text{-})_n$$

Vinyl Chloride PVC

b. Condensation polymerisation- In this type of polymerization, polymers are formed by the condensation reaction between small molecules of monmer with elimination of molecules like H_2O, H_2S, NH_3, etc.
Example- Formation of Bakelite



Formation of Nylon- 6,6

$$COOH\text{-}(CH_2)_4\text{-}COOH + NH_2\text{-}(CH_2)_6\text{-}NH_2 \rightarrow [\text{-}CO\text{-}(CH_2)_4\text{-}CO\text{-}\ NH\text{-}(CH_2)_6\text{-}NH]_n$$

Adipic acid Hexamethylene diamine Nylon-6,6

13) Classify polymers based on molecular forces

a. **Elastomers** in which the intermolecular forces of attraction between the polymer chains are the weakest. Eg. Rubber, Neoprene
b. **Fibres** in which the intermolecular forces of attraction are the strongest. Eg. Terylene, Nylon-6,6
c. **Thermoplastic polymers** in which the intermolecular forces of attraction are in between those of elastomers and fibres. Eg. Polyethene, PVC

d. **Thermosetting polymers** which changes into a hard and infusible mass when heated, due to the formation of extensive crosslinking between polymer chains. Eg. Bakelite, Urea-Formaldehyde resin.

14) Distinguish between thermoplastics and thermosetting plastics

Sl. N	Property	Thermoplastics	Thermosetting plastics
1	Action of heat	They soften on heating and set on cooling every time	They set on heating and cannot be resoftened
2	Type of bonding between adjacent polymer chains	The polymer chains are held together by weak force called Vander Waal's force of attraction	The polymer chains are linked by strong chemical bonds (covalent bonds)
3	Solubility	They are soluble in organic solvents	They are insoluble in organic solvents
4	Expansion due to heating	They expand very much on heating	Their expansion is only marginally on heating
5	Type of polymerization	They are formed by addition polymerization	They are formed by Condensation polymerization
6	Type of moulding	They are processed by injection moulding	They are processed by compression moulding.
7	Scrap recovery	Scrap can be reused	Scrap cannot be reused
8	Example	Polythene, PVC, nylon	Bakelite

15) Classify polymers based on structure

a. Linear polymers consisting of long and straight chains of polymer molecules. They have high density and high tensile strength. Eg. Nylon-6,6, High Density Polyethene (HDPE)
b. Branched chain polymers having some branches in molecule. They have low density and low tensile strength. Eg. LDPE, Glycogen

c. Three-dimensional network or cross-linked polymers having strong bonding between various linear polymer chains. They are hard, rigid and brittle. Eg. Bakelite, Urea-Formaldehyde resin.

16) Write a note on rubber and give its properties

Rubber is a natural polymer obtained from rubber latex. It is a linear polymer of Isoprene monomer and possesses elastic properties.

Properties

i) Rubber is an elastomer with weak intermolecular forces
ii) It stretches like a spring
iii) It becomes soft at high temperature (>335 K)
iv) It becomes brittle at low temperature (<283 K)
v) It has low tensile strength
vi) It has low resistance to abrasion
vii) It is easily attacked by organic solvents and oxidising agents
viii) It has large water absorption capacity

17) Define vulcanisation. What are its advantages?

Vulcanisation is the process of heating rubber with sulphur at 400 K in the presence of Zinc oxide. On vulcanisation, sulphur forms cross links and thus rubber gets hardened.

Advantages

i) It prevents slippage
ii) It makes rubber less temperature sensitive
iii) Increases elasticity, tensile strength and extensibility
iv) Increases resistance to oxidation, wear and tear, water and organic solvents
v) Vulcanised rubber is a better electrical insulator

18) Give some commonly used polymers, their monomers and uses

Name of polymer	Monomer	Uses
Polyethene	Ethene	Packaging material, Insulation for wires, Material for bottles, toys, etc
Poly Propene	Propene	Ropes, Toys, Fibres, etc
Poly Vinyl Chloride (PVC)	Vinyl Chloride	Rain coats, Water pipes, Vinyl floorings, etc

Polystyrene	Styrene	Wrapping material, Toys, Radio/TV cabinets, etc
Neoprene	Chloroprene	Hoses, Belts, Shoe heels, straps, etc
Teflon	Tetrafluoro ethene	Non stick utensils, Pump packings, Valves, gaskets, etc
Buna-S (SBR)	Styrene and Butadiene	Auto tyres, Floor tiles, bubble gum, Foot wear, etc
Buna- N	Butadiene and Acrylonitrile	Oil seals, tank linings, Hoses, etc
Nylon-6	Caprolactam	Fabrics, Tyre cords, Mountaineering ropes, etc
Nylon-6,6	Adipic acid and hexamethylene diamine	Carpets, Textile fibres, Bristles of brushes, Bearings, Gear wheels, etc
Bakelite	Phenol and Formaldehyde	Switches, Handles of utensils, Combs, Computer discs, etc