ENGINEERING CHEMISTRY – I

UNIT II

POLYMERS AND COMPOSITES

PART A

1. Define polymers and monomers.

Polymers are macro molecules (giant molecules of higher molecular weight) formed by the repeated linking of large number of small molecules called monomers.

Monomer is a micro molecules (small molecule) which combines with each other to form a polymer.

2. What is degree of polymerization?

The number of repeating units (n) in a polymer chain is known as the degree of polymerization. It is represented by the following relationship.

Degree of polymerization (n) = $\frac{\text{Molecular weight of the polymeric network}}{\text{Molecular weight of the repeating unit}}$

3. Explain functionality of monomer with suitable example.

The number of bonding sites or reactive sites or functional groups present in a monomer is known as its functionality.

$CH_2=CH_2$ (ethylene) – 2 (Two bonding sites are due to the presence of one double bond in the monomer. Therefore ethylene is a bifunctional monomer.)

$H_2N-(CH_2)_6-NH_2$ (Hexa methylene diamine) - 2 (This monomer contains two functional groups, hence it is a bifunctional monomer.)

4. Explain condensation polymerization with a suitable example.

It is a reaction between simple polar groups containing monomers with the formation of a polymer and elimination of small molecules like H_2O, HCl, etc.

Example: Hexamethylene diamine and adipic acid condense to form a polymer, Nylon6:6 (polyamide).

5. What are additional polymers? Give one example.

It is a reaction that yields a polymer, which is an exact multiple of the original monomeric molecule. The original monomeric molecule, usually, contains one or more double bonds. In addition polymerization there is no elimination of any molecule.

Example: Polyethylene is produced from ethylene.

$$n CH_2=CH_2 \xrightarrow[\text{catalyst}]{\text{Heat/pressure}} n\ldots CH_2\text{-}CH_2\text{-}\ldots. \rightarrow \ldots.(CH_2\text{-}CH_2)\ldots\ldots$$

Ethylene — catalyst — Bifunctional monomer — Polyethylene (PE)

6. What is polymerization?

Polymerization is a process in which large numbers of small molecules (called monomers) combine to give a big molecule (called a polymer) with or without elimination of small molecules like water.

7. Name the various polymerizations.

1. Addition polymerization.
2. Condensation polymerization.
3. Co- polymerization.

8. What are the various steps of free radical mechanism?

Free radical mechanisms occur in three major steps namely, (i) Initiation. (ii) Propagation, and (iii) Termination.

9. What is dead polymer?

The product of addition polymerization is known as dead polymer.

10. What is copolymerization? Give an example.

It is the joint polymerization in which two (or) more different monomers combine to give a polymer.

Example: Butadiene and styrene copolymerize to give GR-S rubber.

11. How is polymerization classified? Give one example for each class.

Polymerization is classified into three types

1. Addition polymerization.
   Example: Polyethylene is produced form ethylene.
2. Condensation polymerization.
   Example: Nylon6:6 is produced form hexametylene diamine and adipic acid
3. Co- polymerization.
   Example: GR-S rubber is produced from butadiene and styrene

12. Distinguish between additional polymerization and condensation polymerization.

S.no	Additional polymerization	Condensation polymerization
1	The monomer must have atleast one multiple bond	The monomer must have atleast two identical or different functional groups.
2	Monomers add on to give a polymer and no by products are formed.	Monomers condense to give a polymer and byproducts are formed.
3	Homo-chain polymers obtained.	Hetero-chain polymers obtained.

13. What do you understand by disproportionation of polymer chains?

Disproportionation is splitting of a polymer chain into two new compounds.

Example: It involves transfer of a hydrogen atom of one radical centre from one polymer chain to another polymer chain's radical centre, forming two macromolecules, one saturated and another unsaturated.

14. How is nylon 6:6 formed? Bring out its important properties and uses.

$nH_2N - (CH_2)_6 - NH_2 + n\ HOOC - (CH_2)_4 - COOH \rightarrow -[HN-(CH_2)_6 - NH-CO-CH_2- CO -]n$

Hexamethylene diamine Adipic acid (Nylon 6:6)

15. What are plastics?

Plastics are higher molecular weight organic materials, that can be moulded into any desired shape by the application of heat and pressure in the presence of a catalyst.

16. What are the disadvantages of plastics?

- Softness.
- Embrittlement at low temperature
- Deformation under load.
- Low heat-resistant and poor ductility.
- Combustibility.
- Polymers tend to degrade upon exposure to heat and uv radiation.

17. List out the various ways by which polymers can be classified.

I. Classification based on structure

- Thermoplastics.
- Thermosetting plastics

II. Classification based on usage

- General purpose plastics.
- Engineering plastics.
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18. What are engineering plastics?

Engineering plastics are a group of materials obtained from high polymer resins. They posses high mechanical strength, toughness and higher use temperature. They are mainly used in load bearing applications, generally to replace conventional materials like metal, wood, glass and ceramics.

19. What are the important applications of high performance plastics?

i) They can be used alone or in conjunction with metals, ceramics Or glasses, etc.
ii) They find applications in demanding areas like automobiles, defence, electrical and electronics, telecommunications, textiles, satellite robts, computer components, etc.

20. Differentiate thermoplastics and thermosetting plastics.

S.No	Thermoplastics resins	Thermosetting resins
1	They are formed by addition polymerization.	They are formed by condensation polymerisation.
2	They consist of linear long chain polymers.	They consist of three dimensional network structures.
3	All the polymer chains are held together by weak Vander Waals forces. e.g. polyethylene.	All the polymer chains are held together by weak strong covalent bonds. e.g. Bakelite

21. Distinguish between commodity and engineering plastics.

(or)

Bring out the differences of general purpose plastics and engineering plastics.

S.No	Commodity	Engineering plastics
1	It possesses low abrasion resistance.	It possesses high abrasion resistance.
2	It possesses low dimensional stability.	It possesses good dimensional stability.
3	It possesses loe mechanical properties	It possesses high mechanical strength.
4	It cannot be used at high temperature.	It can be used at high temperature.
5	It is general purpose plastics.	It is high performance plastics.

22. Mention preparation and uses of PVC. (or) Write ant two uses of PVC.

Preparation of PVC involves the following two steps

I-step: Vinyl chloride is prepared by treating acetylene with HCl at 60-80oC in the presence of metal chloride as catalyst.

$CH{=}CH + HCl \rightarrow CH_2{=}CHCl$

Vinyl chloride

II-step: PVC is obtained by heating water emulsion of vinyl chloride in the presence of H2O2 under pressure.

$N\ CH_2{=}CHCl \rightarrow -[-CH_2-CH(Cl)-]-_n$

PVC

Uses

- It is used in the production of pipes, cable insulations, table covers and rain coats, etc.,
- It is also used for making sheets, which are employed for tank-linings, light fittings, refrigerator components, etc.,

23. What is fluon? Mention its uses?

Teflon or Fluon is polytetrafluoroethane, obtained by polymerisation of water emulsion of tetrafluoroethylene in presence of benzoyl peroxide under pressure.

$$nCF_2=CF_2 \xrightarrow{(C_6H_5)_2O_2} -[-CF_2-CF_2-]-_n$$

Uses:

1. It is used as a very good electrical insulating material in motors, cables, transformers, electrical fittings.
2. It is also used for making non-lubricating bearings, chemical carrying pipes, etc.,
3. It is also used for making gaskets, packings, pumpparts,tank linings, etc.,
4. It is used in making non-sticking stop cocks for burettes.

24. Mention some important applications of polycarbonate.

They are used for making electrical insulators, housing apparatus, plugs, sockets, Switches, sterilizable transparent containers, cameras, photographic films, hair-drier bodies, baby bottles, safety windows in prison and jewellery shops, etc.,

25. Give two properties and uses of Perlon-U.

i) It posses excellent flexibility, toughness even at sub-zero temperature.
ii) It is less stable than polyamies.

Uses:

i) Polyurethanes are used as coatings, films, foams adhesives and elastomers.
ii) They are also used in defence, oceanographic research, mountaineering

26. How is Perlon-U prepared?

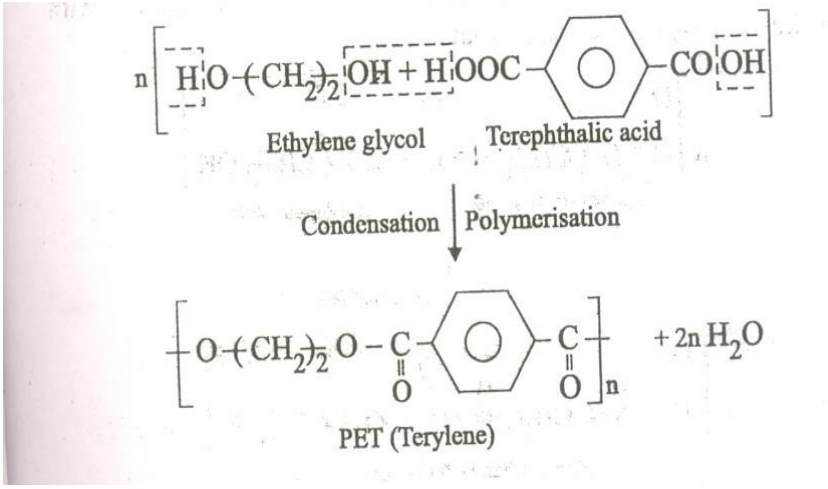
It is obtained by the reaction of 1,4-butane diol with 1,6di-isocyanate.

$$O=C=N-(CH2)-N=C=O + HO-(CH2)4-OH \xrightarrow{\text{polymerisation}} n\,[-O=C-HN-(CH2)6-NH-COO-(CH2)4-OH]$$

1,6Hexamethylene di-isocyanate — 1,4butane diol — Polyurethane (perlon-U)

27. How is PET prepared?

It is saturated polyester, prepared by condensation of ethylene glycol and terephthalic acid.



28. Why is Teflon highly chemical resistant? (or) Why is Teflon behaving non-sticky?
Since the fluorine atoms are the strong electronegative elements, they tightly bonds with carbon atoms in Teflon. As C-F bond is stonger ti is non-reactive and hence it is not wetted by oil and water. So, Teflon is highly chemical resistant and non-sticky.

29. What are elastomers?
Rubbers9or) elastomers are non-crystaline high polymers(linears polymers),having elastic and other rubber-like properties.

30. Raw rubber cannot be used why?

1. It is plastic in nature, ie., it becomes soft at high temperature and is too brittle at low temperature.
2. It has poor strength.
3. It has non-resistant to non-polar solvents like benzene and vegetable and mineral oil
4. It is attacked by oxidizing agents like HNO_3,H_2SO_4.
5. It swells and disintegrates gradually in organic solvents.
6. It has little durability.
7. It has large water-absorption capacity.

31. What is meant by vulcanization of rubber?
The process of vulcanization consists of heating the raw rubber with sulphur to about 100-140^oC.

32. What are the characteristics of FRP.

1. It possess superior properties like higher yield strength, fracture strength and fatigue life.
2. Since fibre prevents slip and crack propagation, the mechanical properties of FRP gets increased.
3. It possess high corrosion resistance and heat resistance property.

33. How is natural rubber obtained?

Natural rubber is obtained from the tree as latex, which is a dispersion of isoprene.

34. Draw the general structure of rubber.

CH3 CH3 CH3

C CH2 C CH2 C

CH2 C CH2 C CH2 C
H H H

35. What are Composites?

A composites material may be defined as ,"a material system consisting a mixture of two or more macro constituents, which are mutually insoluble, differing in form or composition and forming distinct phases". Such a combination possesses properties different from those of any of its constituents.

36. Write the characteristics of Composites.

1. They possess higher specific strength and lower specific gravity.
2. They possess lower electrical conductivity and thermal expansion.
3. They possess better creep, fatigue strength, corrosion and oxidation resistance.
4. They maintain very good strength, even upto high temperatures.

37. How are composites classified?

Composites are classified into three major types

1. Metal Matrix Composites(MMC)
2. Ceramic Matrix Composites(CMC)
3. Polymer Matrix Composites(PMC)

38. What are FRPs?

FRPs are fibre reinforced plastics obtained by reinforcing plastics with high strength fibre materials.

39. Explain the properties of FRP.

1. It possess superior properties like higher yield strength, fracture strength and fatigue life.
2. Since fibre prevents slip and rack propagation, the mechanical properties of FRP gets increased.
3. It possess high corrosion resistance and heat resistance property.

40. Name any two resins used as matrix forming materials in the manufacture of composites.

1. Polyester resin 2. Epoxy resin 3. Phenolic resin

41. Name some important FRPs.

1. Carbon fibre-reinforced plastics.
2. Glass fibre-reinforced plastics.
3. Aramid fibre-reinforced plastics.
4. Alumina fibre-reinforced plastics.
5. Boron fibre-reinforced plastics.

42. Mention some important applications of FRPs.

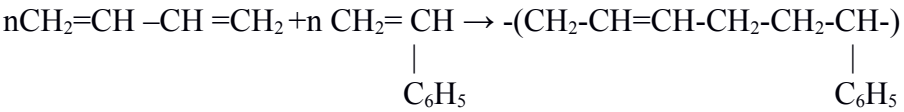
1. Since FRPs are very good corrosion resistants, they are used for making acid and alkali storage tanks, cloth washing tanks,etc.
2. FRPs are used in mining Industries for making digesters, solvent extraction tanks and filtration tanks.
3. FRPs are also used in making sports equipments like boots, sports cars, gold clubs, etc.

43. What is GR-S or SBR rubber?

SBR is styrene-butadiene rubber consisting 75% butadiene and 25% styrene.

44. How is SBR prepared?

SBR is obtained by copolymerizing an aqueous emulsion of the mixture containing 75% butadiene, 25% styrene and an emulsifying agent (cumene hydro peroxide).



45. Mention some important uses of SBR.

SBR is used mainly for making light duty tyres, belts, floor tiles, gaskets, gum, hoses, adhesives and electrical insulation.

46. What is GR-I rubber?

It is a butyl rubber obtained by copolymerizing isobutylene with 1.5 to 4.5% isoprene in methyl chloride.

47. List the properties of Composites.

i. They possess higher specific strength and lower specific gravity.
ii. They possess lower electrical conductivity and thermal expansion.
iii. They possess better creep, fatigue strength, corrosion and oxidation resistance.
iv. They maintain very good strength, even up to high temperatures.

48. Why thermosetting plastics cannot be remoulded.

They are prepared by condensation polymerization. The polymer chains are held together by strong covalent bonds (cross links).

49. What is the role of sulphur in the vulcanization of rubber?

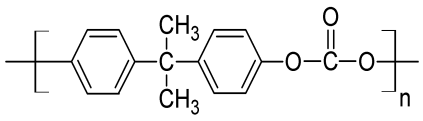
The added sulphur combines chemically at the double bonds of different long chain rubber springs. Thus the vulcanization prevents intermolecular movement of rubber springs. The extent of stiffness of vulcanized rubber depends on the amount of sulphur added.

50. What are resins? Give some examples.

Resins are the basics binding material consisting of long chain organic polymer. Resins undergo cross linking, during curing process, form three dimensional, rigid, water resistant polymers.

51. Give the chemical structure of polycarbonate and polyurethane.

i) Polycarbonate



ii) Polyuretane

- [-O=C-HN-(CH2)6-NH-COO-(CH2)4-O-]-n

52. What is Polymerization?

Polymerization is a process in which large no.of small molecules combine to form a big molecule with (or) without elimination of small molecules like water.

53. What are high polymers and oligo polymers?

(i) Oligo Polymers

Polymers with low degree of polymerization are known as oligo polymers, their molecular weight ranges from 500-5000.

(ii) High Polymers

Polymers with high degree of polymerization are known as high polymers, their molecular weight ranges from 10,000-2,00,000.

PART B

1. Explain with examples the terms addition and condensation polymerization?
2. Explain condensation polymerization taking one example .Give any three important properties of condensation polymers.
3. What are the differences between addition and condensation polymerization.
4. Describe the copolymerization with example.
5. Discuss the mechanism of free radical polymerization with suitable example.
6. What are plastics? Distinguish thermoplastics and thermosetting plastics.
7. What are the advantages of plastics over other engineering materials?
8. Name any three engineering plastics and discuss about them?
9. Bring out the difference between commodity plastics & high performance plastics?
10. Explain the method of manufacture and applications of PVC?
11. Describe the method of preparation, properties and uses of following i) Teflon ii) polycarbonate iii) polyurethanes.
12. Describe the preparation properties and applications of polyamide (nylon:6,6).
13. What are the drawbacks of raw rubber? How to improve the properties of rubber?
14. Why is rubber vulcanized? Give the mechanism of vulcanization?
15. Compare raw rubber with vulcanized rubber.
16. Give preparation, properties and uses of SBR (styrene rubber), butyl rubber.
17. What are composites? Explain the different types of polymer matrix composites
18. How are fibre reinforced plastics made? What are their industrial applications?
    (Or) Name any two fibres used in FRP and give detail about them.
19. Give an account of vulcanization of rubber.
20. Give the preparation, properties and uses of the following: 1. Teflon 2. Butyl rubber.
21. How are composites classified? Explain.