

**Question 15.1:**

Explain the terms polymer and monomer.

Answer

Polymers are high molecular mass macromolecules composed of repeating structural units derived from monomers. Polymers have a high molecular mass ($10^3 - 10^7 u$). In a polymer, various monomer units are joined by strong covalent bonds. Polymers can be natural as well as synthetic. Polythene, rubber, and nylon 6, 6 are examples of polymers.

Monomers are simple, reactive molecules that combine with each other in large numbers through covalent bonds to give rise to polymers. For example, ethene, propene, styrene, vinyl chloride.

Question 15.2:

What are natural and synthetic polymers? Give two examples of each type.

Answer

Natural polymers are polymers that are found in nature. They are formed by plants and animals. Examples include protein, cellulose, starch, etc.

Synthetic polymers are polymers made by human beings. Examples include plastic (polythene), synthetic fibres (nylon 6, 6), synthetic rubbers (Buna – S).

Question 15.3:

Distinguish between the terms homopolymer and copolymer and give an example of each.

Answer

Homopolymer	Copolymer
The polymers that are formed by the polymerization of a single monomer are known as homopolymers. In other words, the repeating units of homopolymers are derived only from one monomer. For example, polythene is a homopolymer of ethane.	The polymers whose repeating units are derived from two types of monomers are known as copolymers. For example, Buna-S is a copolymer of 1, 3-butadiene and styrene.

**Question 15.4:**

How do you explain the functionality of a monomer?

Answer

The functionality of a monomer is the number of binding sites that is/are present in that monomer.

For example, the functionality of monomers such as ethene and propene is one and that of 1, 3-butadiene and adipic acid is two.

Question 15.5:

Define the term polymerisation.

Answer

Polymerization is the process of forming high molecular mass ($10^3 - 10^7$ u) macromolecules, which consist of repeating structural units derived from monomers. In a polymer, various monomer units are joined by strong covalent bonds.

Question 15.6:

Is -(NH-CHR-CO)_n , a homopolymer or copolymer?

Answer

-(NH-CHR-CO)_n is a homopolymer because it is obtained from a single monomer unit, $\text{NH}_2\text{-CHR-COOH}$.

Question 15.7:

In which classes, the polymers are classified on the basis of molecular forces?

Answer

On the basis of magnitude of intermolecular forces present in polymers, they are classified into the following groups:

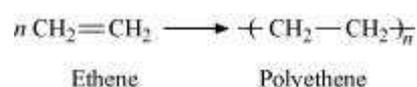
- (i) Elastomers
- (ii) Fibres
- (iii) Thermoplastic polymers
- (iv) Thermosetting polymers

**Question 15.8:**

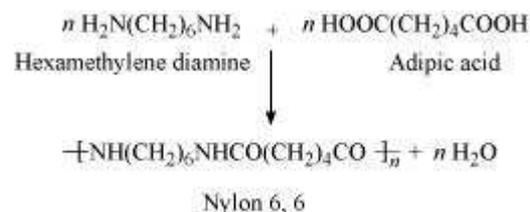
How can you differentiate between addition and condensation polymerisation?

Answer

Addition polymerization is the process of repeated addition of monomers, possessing double or triple bonds to form polymers. For example, polythene is formed by addition polymerization of ethene.



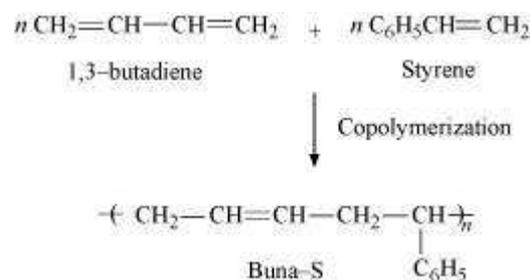
Condensation polymerization is the process of formation of polymers by repeated condensation reactions between two different bi-functional or tri-functional monomers. A small molecule such as water or hydrochloric acid is eliminated in each condensation. For example, nylon 6, 6 is formed by condensation polymerization of hexamethylenediamine and adipic acid.

**Question 15.9:**

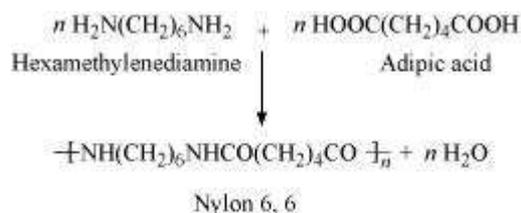
Explain the term copolymerisation and give two examples.

Answer

Polymers from two or more different monomeric units is called copolymerization. Multiple units of each monomer are present in a copolymer. The process of forming polymer Buna-S from 1, 3-butadiene and styrene is an example of copolymerization



Nylon 6, 6 is also a copolymer formed by hexamethylenediamine and adipic acid.



Question 15.10:

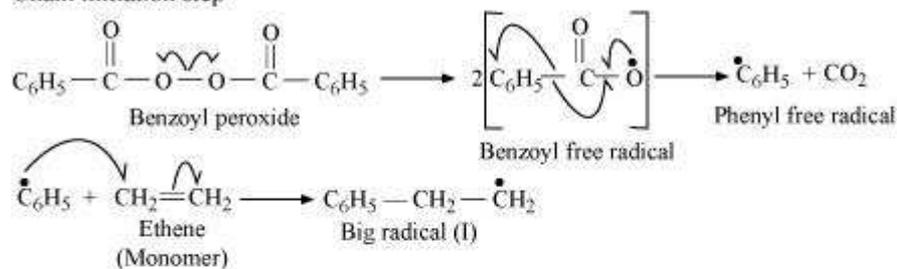
Write the free radical mechanism for the polymerisation of ethene.

Answer

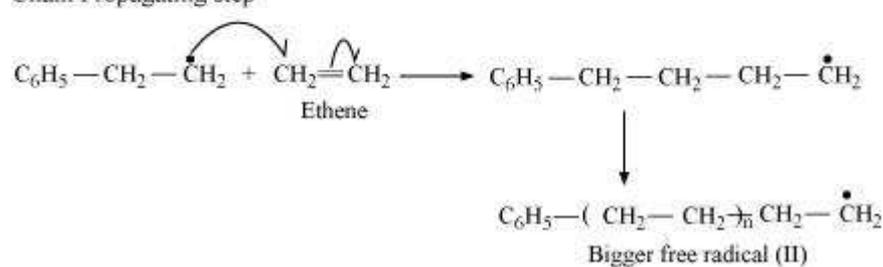
Polymerization of ethene to polythene consists of heating or exposing to light a mixture of ethene with a small amount of benzoyl peroxide as the initiator.

The reaction involved in this process is given below:

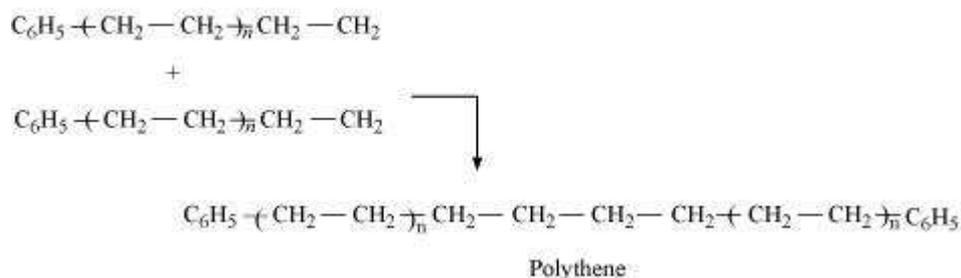
Chain initiation step



Chain Propagating step



Chain Terminating step



**Question 15.11:**

Define thermoplastics and thermosetting polymers with two examples of each.

Answer

Thermoplastic polymers are linear (slightly branched) long chain polymers, which can be repeatedly softened and hardened on heating. Hence, they can be modified again and again. Examples include polythene, polystyrene.

Thermosetting polymers are cross-linked or heavily branched polymers which get hardened during the molding process. These plastics cannot be softened again on heating. Examples of thermosetting plastics include bakelite, urea-formaldehyde resins.

Question 15.12:

Write the monomers used for getting the following polymers.

(i) Polyvinyl chloride **(ii)** Teflon **(iii)** Bakelite

Answer

(i) Vinyl chloride ($\text{CH}_2=\text{CHCl}$)

(ii) Tetrafluoroethylene ($\text{CF}_2 = \text{CF}_2$)

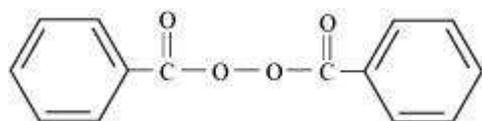
(iii) Formaldehyde (HCHO) and phenol ($\text{C}_6\text{H}_5\text{OH}$)

Question 15.13:

Write the name and structure of one of the common initiators used in free radical addition polymerisation.

Answer

One common initiator used in free radical addition polymerization is benzoyl peroxide. Its structure is given below.

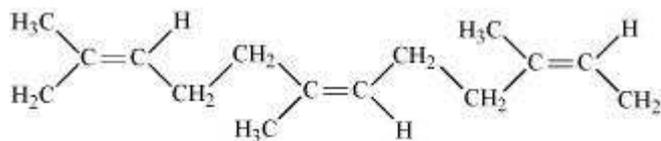
**Question 15.14:**

How does the presence of double bonds in rubber molecules influence their structure and reactivity?

Answer



Natural rubber is a linear cis-polyisoprene in which the double bonds are present between C₂ and C₃ of the isoprene units.



Natural rubber

Because of this cis-configuration, intermolecular interactions between the various strands of isoprene are quite weak. As a result, various strands in natural rubber are arranged randomly. Hence, it shows elasticity.

Question 15.15:

Discuss the main purpose of vulcanisation of rubber.

Answer

Natural rubber though useful has some problems associated with its use. These limitations are discussed below:

1. Natural rubber is quite soft and sticky at room temperature. At elevated temperatures (> 335 K), it becomes even softer. At low temperatures (< 283 K), it becomes brittle. Thus, to maintain its elasticity, natural rubber is generally used in the temperature range of 283 K-335 K.
2. It has the capacity to absorb large amounts of water.
3. It has low tensile strength and low resistance to abrasion.
4. It is soluble in non-polar solvents.
5. It is easily attacked by oxidizing agents.

Vulcanization of natural rubber is done to improve upon all these properties. In this process, a mixture of raw rubber with sulphur and appropriate additive is heated at a temperature range between 373 K and 415 K.

Question 15.16:

What are the monomeric repeating units of Nylon-6 and Nylon-6, 6?

Answer

The monomeric repeating unit of nylon 6 is $[\text{NH}-(\text{CH}_2)_5-\text{CO}]$, which is derived from Caprolactam.



The monomeric repeating unit of nylon 6, 6 is $\left[\text{NH}-(\text{CH}_2)_6-\text{NH}-\text{CO}-(\text{CH}_2)_4-\text{CO} \right]_n$, which is derived from hexamethylene diamine and adipic acid.

Question 15.17:

Write the names and structures of the monomers of the following polymers:

- (i) Buna-S (ii) Buna-N
(iii) Dacron (iv) Neoprene

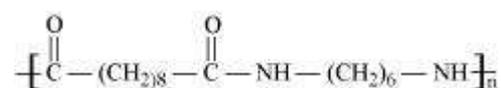
Answer

Polymer		Monomer	Structure of monomer
i	Buna-S	1, 3-butadiene	$\text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2$
		Styrene	$\text{C}_6\text{H}_5\text{CH} = \text{CH}_2$
ii	Buna-N	1, 3-butadiene	$\text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2$
		Acrylonitrile	$\text{CH}_2 = \text{CH} - \text{CN}$
iii	Neoprene	Chloroprene	$\begin{array}{c} \text{Cl} \\ \\ \text{CH}_2 = \text{C} - \text{CH} = \text{CH}_2 \end{array}$
iv	Dacron	Ethylene glycol	$\text{HOH}_2\text{C} - \text{CH}_2\text{OH}$
		Terephthalic acid	$\text{COOH} - \text{C}_6\text{H}_4 - \text{COOH}$

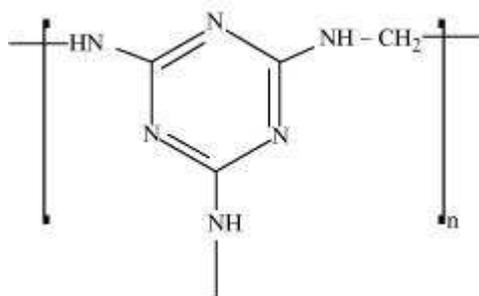
Question 15.18:

Identify the monomer in the following polymeric structures.

(i)



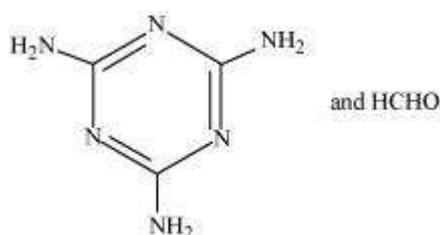
(ii)



Answer

(i) The monomers of the given polymeric structure are decanoic acid $[\text{HOOC}-(\text{CH}_2)_8-\text{COOH}]$ and hexamethylene diamine $[\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2]$.

(ii) The monomers of the given polymeric structure are

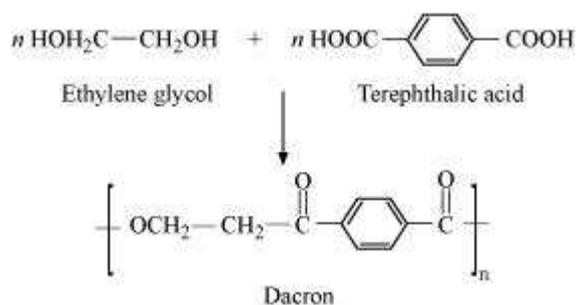


Question 15.19:

How is dacron obtained from ethylene glycol and terephthalic acid?

Answer

The condensation polymerisation of ethylene glycol and terephthalic acid leads to the formation of dacron.



Question 15.20:

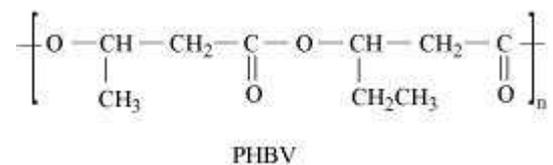
What is a biodegradable polymer? Give an example of a biodegradable aliphatic polyester.



Answer

A polymer that can be decomposed by bacteria is called a biodegradable polymer.

Poly- β -hydroxybutyrate-CO- β -hydroxyvalerate (PHBV) is a biodegradable aliphatic polyester.



**Question 15.1:**

What are polymers?

Answer

Polymers are high molecular mass macromolecules, which consist of repeating structural units derived from monomers. Polymers have a high molecular mass ($10^3 - 10^7 u$). In a polymer, various monomer units are joined by strong covalent bonds. These polymers can be natural as well as synthetic. Polythene, rubber, and nylon 6, 6 are examples of polymers.

**Question 15.2:**

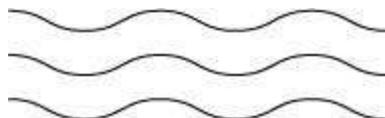
How are polymers classified on the basis of structure?

Answer

Polymers are classified on the basis of structure as follows:

1. Linear polymers:

These polymers are formed of long straight chains. They can be depicted as:



For e.g., high density polythene (HDP), polyvinyl chloride, etc.

2. Branched chain polymers:

These polymers are basically linear chain polymers with some branches. These polymers are represented as:



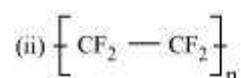
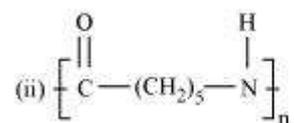
For e.g., low density polythene (LDP), amylopectin, etc.

3. Cross-linked or Network polymers:

These polymers have many cross-linking bonds that give rise to a network-like structure. These polymers contain bi-functional and tri-functional monomers and strong covalent bonds between various linear polymer chains. Examples of such polymers include bakelite and melmac.

**Question 15.3:**

Write the names of monomers of the following polymers:



Answer

(i) Hexamethylenediamine $[\text{H}_2\text{N} - (\text{CH}_2)_6 - \text{NH}_2]$ and adipic acid
 $[\text{HOOC} - (\text{CH}_2)_4 - \text{COOH}]$

(ii)



(iii) Tetrafluoroethene $(\text{CF}_2 = \text{CF}_2)$

Question 15.4:

Classify the following as addition and condensation polymers: Terylene, Bakelite, Polyvinyl chloride, Polythene.

Answer

Addition polymers:

Polyvinyl chloride, polythene

Condensation polymers:

Terylene, bakelite

Question 15.5:

Explain the difference between Buna-N and Buna-S.

Answer

Buna – N is a copolymer of 1, 3–butadiene and acrylonitrile.



Buna – S is a copolymer of 1, 3–butadiene and styrene.

Question 15.6:

Arrange the following polymers in increasing order of their intermolecular forces.

(i) Nylon 6, 6, Buna-S, Polythene.

(ii) Nylon 6, Neoprene, Polyvinyl chloride.

Answer

Different types of polymers have different intermolecular forces of attraction. Elastomers or rubbers have the weakest while fibres have the strongest intermolecular forces of attraction. Plastics have intermediate intermolecular forces of attraction. Hence, the increasing order of the intermolecular forces of the given polymers is as follows:

(i) Buna – S < polythene < Nylon 6, 6

(ii) Neoprene < polyvinyl chloride < Nylon 6

CHAPTER-15 POLYMERS

3 Marks Chapter

Key Points

Polymer:

It is a very large molecule having molecular mass $10^3 - 10^7 \text{ g mol}^{-1}$. They are formed by joining together repeating structural units called monomers.

Classification of Polymers:

(a) Based On Source:

- (i) Natural: Found in plants and animals, e.g. Proteins, cellulose, natural rubber, silk, wool.
- (ii) Synthetic: Man-made e.g. Nylon, polyester, neoprene, Bakelite, Teflon, PVC, polystyrene.

(b) Based On Structure:

- (i) Linear Polymers: This consist of long and straight chain repeating units e.g. Polythene (HDPE), PVC, nylon, polyester.
- (ii) Branched Polymers: This contain linear chains having some branches e.g. amylopectin, glycogen etc.
- (iii) Cross Linked Polymers: Strong covalent bonds are present between various linear polymer chains. E.g. Bakelite, urea- formaldehyde polymer, melamine, formaldehyde polymer etc.

(c) Based On Mode Of Polymerization:

- (i) Addition Polymers: These are formed by the repeated addition of monomer molecules possessing multiple bonds, e.g., polythene, polypropene, polystyrene, PMMA (polymethyl metha crylate)
- (ii) Condensation Polymers: These are formed by the repeated condensation reaction of different bifunctional or trifunctional monomers, with the elimination of small molecules like water, HCl, NH₃, alcohol etc. e.g. Bakelite, nylon, polyester, urea- formaldehyde resin.

(d) Based On Molecular Forces:

- (i) Elastomers: Forces of interaction between polymer chains is weakest, e.g. natural rubber, neoprene, vulcanized rubber.
- (ii) Fibers: Strong hydrogen bonds are present between the polymer chains. They have high tensile strength e.g., nylon, polyester, silk, wool, orlon, rayon etc.
- (iii) Thermoplastics: They are linear/slightly branched chains molecules capable of repeated softening on heating and hardening on cooling, e.g., polythene, PVC, polystyrene, polypropene.

(iv) Thermosetting Plastics: They are cross-linked or heavily branched molecules, which on heating undergo extensive cross-linkages and become infusible, e.g., bakelite, urea formaldehyde resin.

(e) Based On Growth Of Polymerization: Depending upon the mechanism of Polymerization, polymers are classified as

(i) Addition Polymers Or Chain Growth Polymers:

They follow mostly free radical mechanism.

(ii) Condensation Polymers or Step Growth Polymers because they are formed in gradual steps.

Polymer	Monomer	Uses
(i) Polyethene	Ethene	Insulation of wires, toys, manufacture of dustbins etc.
(ii) Polytetra Fluoroethene (Teflon)	Tetrafluoroethene	Oil seal and Gasket and non Stick kitchen wares
(iii) Polyacrylonitrile	Acrylonitrile	Substitute for wool
(iv) Terylene or Decron	Glycol + Terephthalic Acid	Ropes, safety belts, tyre -cord , sails of boats, saree and dress material
(v) Nylon-6,6	Hexamethylenediamine + Adipic acid	Stocking, socks, ropes, Parachutes, fabrics, bristles of tooth brush
(vi) Nylon-6	Caprolactum	Tyre-cords, Ropes, fabrics
(vii) Novolac	Phenol + Formaldehyde	Used for binding glue, laminated wooden planks
(viii) Phenol Formaldehyde resin	Formaldehyde + Phenol	Combs, records, switches boards
(ix) Melamine polymers	Melamine + Formaldehyde	Manufacture of unbreakable crockery
(x) Buna-S Copolymer	1,3-Butadiene + Styrene	Autotyres floor, tiles foot-wear components
(xi) Natural rubber	2-methyl-1,3-butadiene (Isoprene)	Used for tyres
(xii) Neoprene	2-chloro-1,3-butadiene (chloroprene)	Conveyor belts, gasket , hoses
(xiii) Buna-N	1,3-butadiene + acrylonitrile	Resistance to action of petrol. Make oil seals, tank linings etc.

(xiv) (PHBV) hydroxybutyrateco- β- hydroxyl valerate (biodegradable)	3-hydroxybutanoic acid + 3-hydroxypantanoic acid	Packaging orthopaedic devices
(xv) Nylon-2-nylon-6	Glycine + aminocaproic acid	It is biodegradable step growth Polymer
(xvi) Poly(glycolic acid) Poly(lactic acid) (dexton) (biodegradable)	Glycolic acid + lactic acid	Sutures ,ie,for stitching wounds after operation. Biodegradables

Very short Answer Questions - 1 Mark

1. Name a natural elastomer.

Ans . Natural rubber.

2. Write name of a synthetic polymer which is an amide.

Ans. Nylon 6 or Nylon 6,6.

3. Write the monomer units of Bakelite.

Ans. Phenol and formaldehyde.

4. Name of monomer of Nylon 6.

Ans. 6- Aminocaproic acid

5. Define a copolymer.

Ans.The polymers made by addition polymerisation from two different monomers are termed as **copolymers**, *e.g.*, Buna-S, Buna-N, etc.

6. Write one use of PVC.

Ans: In manufacture of rain coats& vinyl flooring.

7. Give an example of thermoplastics.

Ans: Thermoplastics are polythene, polystyrene, polyvinyls, etc.

8. To which class of polymers does Nylon-66 belong?

Ans: Polyamides

9. Name the type of monomers in terylene?

Ans: Ethylene glycol and terephthalic acid.

10. What is the function of sulphur in vulcanisation of rubber?

Ans: Sulphur introduces sulphur bridges.So it is become more tensile strength,elasticity and resistance to abrasion etc.

Short Answer Questions - 2 Marks

1. Arrange the following polymers in increasing order of their intermolecular forces.

(i) Nylon 6,6, Buna-S, Polythene.

(ii) Nylon 6, Neoprene, Polyvinyl chloride.

Ans. (i) Buna-S < Polythene < Nylon 6,6

(ii) Neoprene < Polyvinyl chloride < Nylon 6.

2. Classify the following as addition and condensation polymers: Terylene, Bakelite, Polyvinyl chloride, Polythene.

Ans. (i) addition polymers : Polyvinyl chloride, Polythene.

(ii) condensation polymers: Terylene , Bakelite.

3. What is a biodegradable polymer ? Give an example of a biodegradable aliphatic polyester.

Ans. Polymers which disintegrate by themselves over a period of time due to environmental degradation by bacteria, etc. are called biodegradable polymers. e.g. PHBV

4. How can you differentiate between addition and condensation polymerization

Ans. In addition polymerization the molecules of the same monomer or different monomers add together on a large scale to form a polymer. The monomers used are unsaturated compounds, e.g., alkenes, alkadienes and their derivatives.

Condensation polymerisation generally involves a repetitive condensation reaction between two bi-functional monomers. These polycondensation reactions may result in the loss of some simple molecules as water, alcohol, etc., and lead to the formation of high molecular mass condensation polymers. e.g. , Nylon 6,6.

5. What is meant by PTFE ? Give its popular name.

Ans. Polytetrafluoroethylene. It is called Teflon.

6. Write chemical name of (Ziegler-Natta catalyst).

Ans: Triethylaluminium and titanium tetrachloride

7. Write down the two differences between thermoplastic and thermosetting plastic and examples.

Ans: Thermoplastic are the linear or slightly branched long chain molecules

capable of repeatedly softening on heating and hardening on cooling. These polymers possess intermolecular forces of attraction intermediate between elastomers and fibres. Some common thermoplastics are polythene, polystyrene, polyvinyls, etc.

Thermosetting plastic polymers are cross linked or heavily branched molecules, which on heating undergo extensive cross linking in moulds and again become infusible. These cannot be reused. Some common

examples are bakelite, urea-formaldehyde resins, etc.

8. Differentiate Novolac and Bakelite on the basis of structure.

Ans: A linear product of *Phenol - formaldehyde polymer* is Novolac, used in paints.

Novolac on heating with formaldehyde undergoes cross linking to form an infusible solid mass called **bakelite**. It is used for making combs, phonograph records, electrical switches and handles of various utensils.

9. Distinguish between the terms homopolymer and copolymer and give an example of each.

Ans: the addition polymers formed by the polymerisation of a single monomeric species are known as **homopolymers**, e.g., polythene.

The polymers made by addition polymerisation from two different monomers are termed as **copolymers**, e.g., Buna-S, Buna-N, etc.

10. How will you differentiate between LDP and HDP?

Ans: *Low density polythene*: It is obtained by the polymerisation of ethene under high pressure of 1000 to 2000 atmospheres at a temperature of 350 K to 570 K in the presence of traces of dioxygen or a peroxide initiator (catalyst).

Low density polythene is chemically inert and tough but flexible and a poor conductor of electricity. e.g., squeeze bottles, toys and flexible pipes.

High density polythene: It is formed when addition polymerisation of ethene takes place in a hydrocarbon solvent in the presence of a catalyst Ziegler-Natta catalyst at a temperature of 333 K to 343 K and under a pressure of 6-7 atmospheres.

HDP consists of linear molecules and has a high density due to close packing. It is more tougher and harder. It is used for manufacturing buckets, dustbins, bottles, pipes, etc.

Short Answer Questions - 3Marks

1. Write the names of monomers of the following polymers:

(i) Nylon 6,6 (ii) Neoprene (iii) Buna -N

Ans. (i) hexamethylenediamine and adipic acid.

(ii) chloroprene.

(iii) 1, 3 - butadiene and acrylonitrile.

2. Write the monomers of the following polymers:

(i) Buna-N (ii) Teflon (iii) Neoprene.

Ans. (i) 1, 3 – butadiene and acrylonitrile (ii) *tetrafluoroethene* (iii) chloroprene.

3. Write use of each orlon and Nylon-6.

Ans: use of orlon is clothing as a substitute for wool & for Nylon-6.

use of Nylon-6 is as fabrics

10. Write Important uses of following Polymers

(1) Polypropene (2) Polystyrene (3) Glyptal

Ans: (1) Manufacture of ropes, toys, pipes, fibres, etc.

(2) As insulator, wrapping material, manufacture of toys, radio and television cabinets.

(3) Manufacture of paints and lacquers.

HOTS QUESTIONS

1. What is the main constituent of bubble gum?

Ans - Styrene - butadiene copolymer (SBR).

2. What is a plasticizer?

Ans; The substances which are added to increase the softness of hard polymers.

3. Draw the structures of the monomer of PAN.

Ans: $\text{CH}_2=\text{CH}-\text{CN}$

4. Give the name of polymer which is used for making non-stick utensils.

Ans: Teflon ($\text{CF}_2=\text{CF}_2$)

5. What is the % of sulphur used during vulcanization of rubber?

Ans: 3% to 5%

6. Give the common and the IUPAC name of the monomer of natural rubber.

Ans: cis-Isoprene & 2-methyl-1,3-butadiene

7. Discuss the two main purposes of vulcanization of rubber.

Ans: (i) It makes the rubber hard.

(ii) It is more elastic.

(iii) It has more wear and tear resistance.

8. Why should one always use purest monomer in free radical polymerisation?

Ans: Impurities of other substances if present, may inhibit or hinder the chain propagation.

9. How is dacron obtained from ethylene glycol and terephthalic acid?

Ans: It is the condensation product of ethylene glycol and terephthalic acid carried out at 420 to 460K in the presence of catalyst mixture of zinc acetate and antimony trioxide.

10. . Why is Bakelite a thermosetting polymer?

Ans: It is a cross-linked polymer. On heating it sets permanently into a solid. It can not be remoulded by heating again.

11. A regular copolymer of ethylene and vinyl chloride contains alternate monomers of each type. What is the weight percent of ethylene in this copolymer?

Ans: the weight percent of ethylene in this copolymer

$$[28/(28+62.5)]*100$$

30.93%

Acid polymerisation

12. $C_6H_{10}NOH \rightarrow A \rightarrow B$ Give the products A & B.

A = 6 - Aminocaproic acid

B = nylon-6

13. .(i) Give an example of a synthetic rubber.

(ii) Mention main advantage of synthetic rubber.

(iii) Arrange the polymers in the increasing order of tensile strength,

Nylon-6, Buna-S, Polythene.

Ans: (i) synthetic rubber is Buna-S

(ii) It is used for making oil seals, tank linings.

(iii) Buna-S < Polythene < Nylon-6