NCERT TEXTUAL EXERCISE (SOLVED)

1. Explain the term polymer and monomers.

Sol. **Polymers** are high molecular mass (10^3–10^7u) substances consisting of a very large number of simple repeating structural units joined together through covalent bonds in a linear fashion. Polymers are also called macromolecules. Some examples are polythene, nylon-6,6, bakelite, rubber, etc.

Monomers are the simple and reactive molecules from which the polymers are prepared either by addition or condensation some examples are ethene, vinyl chloride, acrylonitrile phenol and formaldehyde.

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

Sol. **Natural polymers:** Polymers which are found in nature (i.e. animals and plants) are called natural polymers e.g. proteins, starch, cellulose, nucleic acids, resins and rubber.

Synthetic polymers: Man-made polymers are called synthetic polymers e.g. plastics (polythene, PVC, synthetic fibres (polyester, nylon-6,6) and synthetic rubber (neoprene, Buna-S)).

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

Sol. Polymers whose repeating structural units are derived from only one type of monomer units are called homopolymers e.g. PVC polyethene, PAN, Teflon, polystyrene and nylon-6.

Polymers whose repeating structural units are derived from two or more types of monomer molecules are copolymers e.g. Buna-S, Buna-N, nylon-66, polyester and bakelite.

4. How do you explain the functionality of a monomer?

Sol. Functionality means the number of binding sites in a molecule. For example, the functionality of ethene, propene, styrene, acrylonitrile is one while that of 1, 3-butadiene, adipic acid, terephthalic acid, hexamethylenediamine is two.

5. Define the term polymerisation?

Sol. It is a process of formation of a high molecular mass polymer from one or more monomers by linking together a large number of repeating structural units through covalent bonds.

6. Is $\left(\text{NH} - \text{CHR} - \text{CO}\right)_n$ a homopolymer or a copolymer?

Sol. It is a homopolymer because the repeating structural unit has only one type of monomer (i.e. NH_2–CHR–COOH).

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

Sol. (a) Elastomers (b) Fibres
(c) Thermoplastics plastics (d) Thermosetting plastics

8. How can you differentiate between addition and condensation polymerisation?

Sol. In addition to polymerisation, the molecules of the same or different monomers simply add on one another leading to the formation of a macromolecules. Addition polymerisation generally occurs among molecules containing double and triple bonds. For example, formation of polythene from ethene and neoprene from chloroprene, etc.

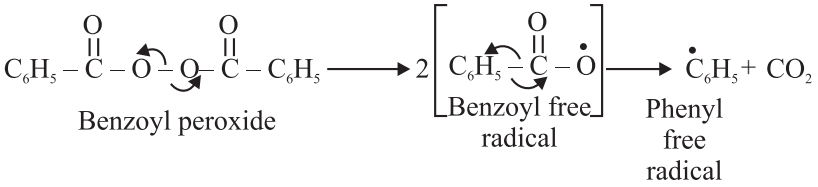
In condensation polymerisation, two or more bifunctional molecules undergo a series of independent condensation reactions usually with the elimination of simple molecules like water, alcohol, ammonia, carbon dioxide and hydrogen chloride to form a macromolecule. For example, nylon-6, 6 is a condensation polymer of hexamethylenediamine and adipic acid formed by elimination of water molecules.

9. Explain the term copolymerisation with two examples.

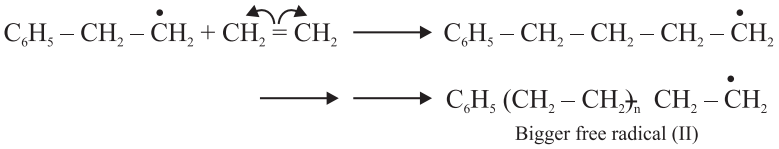
Sol. When two or more different monomers are allowed to polymerise together the product formed is called a copolymer, and the process in called copolymerisation. Thus, a copolymer contains a large number of units of each example, Buna-S and Buna-N. Buna- S is a copolymer of 1, 3-butadiene and styrene while Buna-N is a copolymer of 1,3-butadiene and acrylonitrile.

10. Write the free radical mechanism for the polymerisation of ethene.

Sol. (a) Chain initiation steps:



(b) Chain propagating steps:



(c) Chain termination steps:

(i) By combination of free radicals (II):

$$H_5\text{-}(CH_2-CH_2)_n-CH_2-\dot{C}H_2 + \dot{C}H_2-CH_2-(CH_2-CH_2)_n-C_6H_5 \longrightarrow$$

(II) (II)

$$C_6H_5-(CH_2-CH_2)_n-CH_2CH_2CH_2CH_2-(CH_2-CH_2)_n-C_6H_5$$

Polythene (polymer)

(ii) By disproportionation of free radicals :

$$C_6H_5-(CH_2-CH_2)_n-CH_2-\dot{C}H_2 + C_6H_5-(CH_2-CH_2)_n-\dot{C}H_2-CH_2$$

(II)

$$\xrightarrow{\text{Disproportionation}} C_6H_5-(CH_2-CH_2)_n-CH_2CH_3 + C_6H_5-(CH_2-CH_2)_n-CH=CH_2$$

Polyethene (polymer)

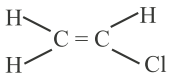
11. Define thermoplastic and thermosetting polymers with two example of each.

Sol. Thermoplastic polymers are linear polymers which can be repeatedly used again and again without any change in chemical composition and mechanical strength. Examples are polythene and polypropylene.

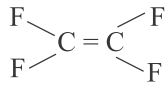
Thermosetting polymers, on the other hand, are permanently setting polymers. On heating in a mould, they get hardened and set, and cannot be softened again. This hardening on heating is due to cross-linking between different polymer chains to give a three-dimensional network solid. Examples are bakelite, melamine-formaldehyde polymer.

12. Write the monomers used for getting the following polymers:

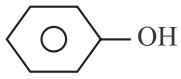
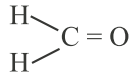
(a) Polyvinyl chloride (b) Teflon (c) Bakelite

Sol. (a) 

Vinyl chloride

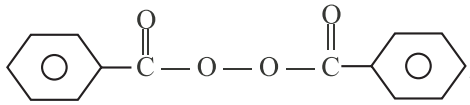
(b) 

Tetrafluoro ethene

(c)  and 

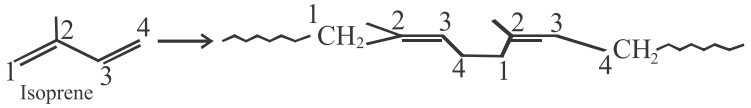
Pnenol Formaldehyde

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

Sol. Benzoyl peroxide,  .

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

Sol. Natural rubber is cis-polyisoprene and is obtained by 1, 4-polymerisation of isoprene units. In this polymer, double bonds are located between C_2 and C_3 of each isoprene unit. These cis-double bonds do not allow the polymer chains to come closer for effective interactions and hence intermolecular forces are quite weak. As a result, natural rubber (i.e. cis-polyisoprene) has a randomly coiled structure and hence show elasticity.



15. Discuss the main purpose of vulcanisation of rubber.

Sol. Natural rubber has the following disadvantages:

(a) It is soft and sticky and becomes even more so at high temperatures and brittle at low temperatures. Therefore, rubber is generally used in a narrow temperature range (283–335K) where its elasticity is maintained.

(b) It has large water absorption capacity, has low tensile strength and low resistance to abrasion.

(c) It is not resistant to the action of organic solvents.

(d) It is easily attacked by oxygen and other oxidising agents. To improve all these properties, natural rubber is vulcanised by heating it with about 5% sulphur at 373–415K. The vulcanised rubber thus obtained has excellent elasticity over a larger range of temperature, has low water solubility and resistant to oxidising agents.

16. What are the monomeric repeating units of nylon-6 and nylon 6, 6?

Sol. The monomeric repeating unit of nylon-6 is $\left[\mathrm{NH-(CH_2)_5-\overset{O}{\overset{\|}{C}}}\right]_n$ which is derived from caprolactam.

The monomeric repeating unit of nylon 6, 6 is derived from two monomers, hexamethylenediamine and adipic acid and has the following structure:

$$\left[\mathrm{NH-(CH_2)_6-NH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}}\right]_n$$

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

(i) Buna-S (ii) Buna-N

(iii) Dacron (iv) Neoprene

Sol. (a) Buna-S: $CH_2 = CH - CH = CH_2$ (1,3–Butadiene) and $C_6H_5 - CH = CH_2$ (Styrene)

(b) Buna-N: $CH_2 = CH - CH = CH_2$ (1,3–Butadiene) and $CH_2 = CH - CN$ (Acrylonitrite)

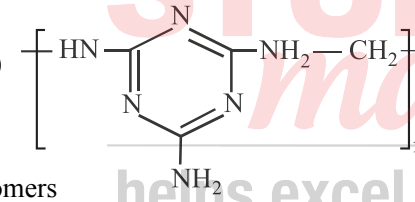
(c) Dacron: $HO - CH_2 - CH_2 - OH$ (Ethylene glycol) and HOOC–C$_6$H$_4$–COOH (Terephthalic acid)

(d) Neoprene: $CH_2 = \underset{\displaystyle Cl}{\underset{|}{C}} - CH = CH_2$ and

Chloroprene or 2-chloro-1,3-butadiene.

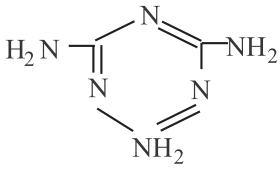
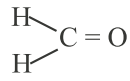
18. Identify the monomer in the following polymeric structures:

(i) $\left[-\overset{O}{\overset{\|}{C}} - (CH_2)_8 - \overset{O}{\overset{\|}{C}} - NH - (CH_2)_6 - NH - \right]_n$

(ii) 

Sol. Monomers

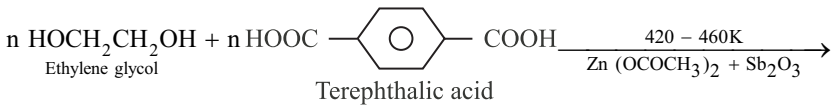
(a) $HOOC - (CH_2)_8 COOH$ (Decanoic acid) and $H_2N - (CH_2)_6 - NH_2$ (Hexamethylenediamine)

(b)  and  (Formaldehyde.)

2, 4, 6-Triamine - 1, 3, 5-triazine.

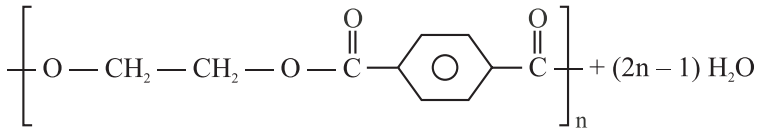
19. How is dacron obtained from ethylene glycol and terephthalic acid?

Sol. Dacron is obtained by condensation polymerisation of ethylene glycol and terephthalic acid with the elimination of water molecules. The reaction is carried out at 420–460K in presence of a catalyst consisting of a mixture of zinc acetate and antimony trioxide.



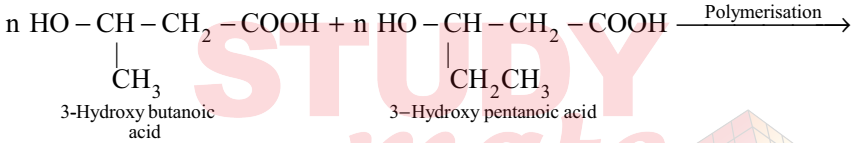
Ethylene glycol

Terephthalic acid



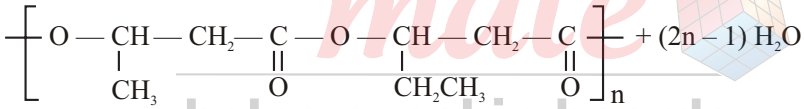
20. What is a biodegradable polymer? Give an example of a biodegradable aliphatic polyester.

Sol. Polymers which disintegrate by themselves over a period of time due to environment degradation by bacteria and other reasons are called biodegradable polymers. Examples is PHBV (i.e. poly-β-hydroxy butyrate-co-β-hydroxyvalerate).



3-Hydroxy butanoic acid

3–Hydroxy pentanoic acid



PHBV

Polyester