

Polymer is defined as very large molecule having high molecular mass $(10^3 - 10^7 \mu)$. They are also referred to as macromolecules, which are formed by joining repeating structural units on a large scale. The repeating structural units are derived from some simple and reactive molecules known as monomers and are linked to each other by covalent bonds. This process of formation of polymers from respective monomers is called polymerisation.

CLASSIFICATION OF POLYMERS

Based on Source

Natural polymers :

Found in nature and generally obtained from plants and animals. For examples : proteins, cellulose, starch, resins, rubber, etc.

Semi-synthetic polymers

These are mostly derived from naturally occuring polymers by chemical modifications.

For examples : cellulose acetate (rayon) and cellulose nitrate

Synthetic polymers

Polymers prepared by synthesis (man made), are known as synthetic polymers.

For examples : plastics like polyethene, synthetic fibres like nylon 6, 6 and synthetic rubbers like Buna–S

Based on Structure of Polymers

Linear polymers

These polymers consist of long and straight chains. As a result of close packing of polymer chains, linear polymers have high melting points densities and tensile strength.

For examples : HDPE, PVC, etc.

Branched chain polymers

These polymers contain linear chains having some branches As a result of branching these polymers do not pack well thus have low melting points, densities and tensile strength.

For examples : LPDE, etc.

Cross-linked or Network polymers

These polymers are formed from bi-functional and tri-functional monomers and contain strong covalent bonds between various linear polymer chains. Because of presence of crosslinks these polymers are hard, rigid and brittle.

For examples : bakelite, melamine, etc.

Based on Mode of Polymerisation

Addition polymers

- These polymers are formed by repeated addition of monomer molecules possessing double or triple bond.
 For examples : polyethene, polypropene, Buna–S, Buna–N, etc.
- (ii) If only one type of monomeric species are present, the addition polymer is called **homopolymer**.
 ex: polythene, polyvinylchloride, etc.

n
$$CH_2 = CH_2 \longrightarrow (CH_2 - CH_2)_n$$

ethene Polyethene

(iii) If the monomers are different, the addition polymer is called **copolymer**.

 $ex: Buna - N \ etc.$

n
$$CH_2 = CH - CH = CH_2 + nC_6H_5CH = CH_2$$

1, 3-Butadiene \downarrow Styrene C_6H_5
 \downarrow $(CH_2 - CH = CH - CH_2 - CH_2 - CH_2)_n$
Buna-S

Note: In addition polymerisation a small amount of an organic peroxide is normally used as a free radical initiator.

Condensation polymers

These polymers are formed by repeated condensation reaction between two different bi- functional or tri-functional monomeric units.

In this, elimination of small molecules such as water, alcohol, HCl, etc., takes place.

Ex: Nylon 6, 6, terylene, nylon-6, etc.

n H₂N (CH₂)₆ NH₂ + n HOOC(CH₂)₄COOH

$$\downarrow$$

 $($ NH(CH₂)₆NHCO(CH₂)₄CO $)_n$ + n H₂O
Nvlon 6, 6

Condensation is also known as step growth polymerisation.

Based on Inter Molecular Forces

Elastomers

These polymers are rubber-like solids with elastic properties. Polymers having weakest inter-molecular forces between polymer chains.

These polymer can be stretched ten times their normal length and they return to original position when force is withdrawn.

For examples : Buna – S, Buna – N, neoprene etc.

Fibres

Polymers in which the intermolecular force of attraction are the strongest are called fibres. These forces are either due to Hbonding or dipole-dipole interaction.

They are thread forming solids possessing high tensile strength, high modulus and least elasticity. In these polymers strong bonding results in close packing of chains and crystalline structure Example : nylon 6, 6; terylene etc.

Thermoplastics

In these polymers intermolecular forces of attraction are intermediate between elastomers and fibers. They are linear or slightly branched chain molecules.

They can repeatedly soften on heating and gets harden on cooling. Some important examples of this class of polymers are polyvinyl chloride, polythene, polypropylene, polystyrene etc.

Thermosetting

They are semi-fluid substances with low molecular masses which when heated become hard and infusible, because of sufficiently large number of cross links. They acquire a shape of threedimensional network. Important examples of this class of polymers are bakelite. urea formaldehyde resin, etc.

TYPES OF POLYMERISATION REACTIONS

Addition or Chain Growth Polymerisation

In this, monomers of same or different type add together on a large scale to form polymer. Monomers used are unsaturated compounds, like alkenes, alkadienes, and their derivatives. For example : polythene, HDPE, Teflon, PAN, etc

SOME IMPORTANT COMMERCIAL POLYMERS

Condensation or step growth polymerisation

It involves repetitive condensation reaction between two bifunctional monomers. These reactions result in the loss of some simple molecules like water, alcohol, HCl, NH₂, etc.

For example : nylon, polyesters, bakelite, etc.

Mechanism for addition polymerization

Addition polymerisation proceeds via free radical addition polymerization. Free radical mechanism of addition polymerization is given as follows :

(i) Chain initiation step:

$$\xrightarrow{O}_{2} \underbrace{C_{6}H_{5}}_{0} \underbrace{C_{-O}}_{0} \xrightarrow{O}_{2} \underbrace{C_{6}H_{5}}_{0} + CO_{2}$$

Benzyl free radical Phenyl radical

$$\overset{\bullet}{\underset{C_6H_5 + CH_2 = CH_2}{\longrightarrow}} C_6H_5 - CH_2 - CH_2$$

$$C_{6}H_{5}CH_{2}CH_{2} + CH_{2} = CH_{2}$$

$$\longrightarrow C_{6}H_{5} - CH_{2} - CH_{2} - CH_{2} - CH_{2}$$

$$\downarrow$$

$$C_{6}H_{5} - (CH_{2} - CH_{2})CH_{2} - CH_{2}$$

3. Chain terminating step:

$$C_{6}H_{5}\left(CH_{2}-CH_{2}\right)_{n}CH_{2}-CH_{2}+C_{6}H_{5}\left(CH_{2}-CH_{2}\right)_{n}CH_{2}-CH_{2}$$

$$\longrightarrow C_{6}H_{5}\left(CH_{2}-CH_{2}\right)_{n}CH_{2}-CH_{2}-CH_{2}-CH_{2}-CH_{2}\left(CH_{2}-CH_{2}\right)_{n}C_{6}H_{5}$$
Polyethene

Name of polymer	Monomer	Structure of repeating unit	Preparation Reaction	Uses	
I. Addition polymers					
1. (a) LDPE (Low Density Polyethene)	ethene	-(CH ₂ - CH ₂) _n	Polymerisation of ethene under high pressure of $1000 - 2000$ atm at a temperature of 350 - 570 K in presence of traces of O ₂ or peroxide initiator. It has highly branched structure.	It is used in insulation of electricity carrying wires and manufacture of squeeze bottles, toys, flexible pipes (it is chemically inert, tough, flexible and poor conductor of electricity)	

1. (b) HDPE (High density polyethene)	ethene	-(CH ₂ - CH ₂) _n	Polymerisation of ethene in hydrocarbon solvent in presence of zeigler-Natta catalyst at $333-343$ K and 6-7 atm. It consists of linear chains which undergoes to close packing. Thus it possesses high density.	It is used for making buckets, dustbins, bottles, pipes, etc. (it is compara- tively more chemically inert, tougher and harder)
2. Polytetrafluoro ethene (Teflon)	Tetrafluoro ethene	$-(CF_2 - CF_2)_n$	$nCF_{2} = CF_{2}$ $\int_{n}^{catalyst} high pressure$ $(CF_{2} - CF_{2})_{n}$	It is used in making oil seals and gaskets and also used for non-stick surface coated utensils as it is chemically inert and resistant to attack by corrosive reagents.
3. Polyacrylonitrile (PAN)	Acrylonitrile	$-(CF_2 - CF)_n$	nCH ₂ = CHCN \downarrow Peroxide catalyst $(CH_2 - CH)_n$ CN	It is used as a substitute for wool in making commercial fibres as orlon or acrilan.
4. Polypropene	propene	$(CH_3 - CH_3)$	CH_{3} $nCH = CH_{2}$ Propylene $\xrightarrow{Ziegler Natta Catalyst}{Al(C_{2}H_{5})_{3} + TiCl_{3}}$ $\begin{bmatrix} CH_{3} \\ \\ -CH - CH_{2} - \\ Polypropylene \end{bmatrix}_{n}$	It is used in manufacture of ropes, toys, pipes, fibres, etc.
5. Polystyrene	Styrene	C_6H_5 + $CH_2 - CH_n$	$C_{6}H_{5}$ $nCH = CH_{2}$ Styrene $\underbrace{Benzoyl Peroxide}_{C_{6}H_{5}}$ $\begin{bmatrix} C_{6}H_{5} \\ -CH - CH_{2} - \\ Polystyrene \end{bmatrix}_{n}$	It is used as an insulator, wrapping material in manufacture of toys, radio and television cabinets.
6. Polyvinyl chloride (PVC)	Vinyl chloride	$-(CH_2 - CH)_n$	$nCH_{2} = CH \longrightarrow $ Cl Vinyl chloride $[-CH_{2} - CH -]_{n}$ Cl Polyvinyl chloride	It is used in manufacture of rain coats, hand bags, vinyl flooring, water pipes, etc.

II. Condensation polymers				
1. Polyamides (a) Nylon 6, 6	hexamethylene diamine and adipic acid	-{NH(CH ₂) ₆ NHCO(CH ₂) ₄ CO) _n	nHOOC(CH ₂) ₄ COOH + nH ₂ N(CH ₂) ₆ NH ₂ $\int_{\text{pressure}}^{553 \text{ K}} O$ # -(NH(CH ₂) ₆ NH - C - (CH ₂) ₄ - C) _n # O	It is used in making sheets, bristles for brushes and in textile industry
(b) Nylon 6	caprolactum	$\begin{array}{c} O & H \\ \parallel & \parallel \\ (C - (CH_2)_5 - N)_n \end{array}$	$H_{2}C$ H	It is used in manufacture of tyre cords, fabrics and ropes
2. Polyesters Terylene or Dacron	ethylene glycol and terephthalic acid	$(O - CH_2CH_2 - O - C - C)_n$	$nHO - CH_2 - CH_2 - OH$ $+ O$ $nHO - CO C - OH$ $420-460 \text{ K} \downarrow Zn(OCOCH_3)_2$ $- O O$ $O O$ $(O - CH_2 - CH_2 - O - C$	It is used in manufacture of wear fabrics, tyre cords and seat belts it is used in blending cotton and wool fibres and also used as glass reinforcing materials in safety helmets
 Phenol formaldehyde polymer (a) Novalac 	o -Hydroxy- methylphenol	$\begin{bmatrix} OH & OH \\ \downarrow & CH_2 & CH_2 \\ \downarrow & & CH_2 \end{bmatrix}_n$	$\begin{array}{c} OH \\ n \downarrow CH_2OH \\ \downarrow polymerisation \\ \hline OH OH \\ \downarrow CH_2 \downarrow CH_2 \\ \hline \end{bmatrix}_n$	
(b) Bakelite	Novalac + formaldehyde (Phenol and formaldehyde)	$ \begin{array}{c} OH & OH \\ \downarrow & CH_2 & CH_2 \\ \downarrow & CH_2 & n \end{array} $	Novalac (linear polymer) $\begin{pmatrix} & & & \\ & & & & \\ & & & \\ & & & & \\ $	It is used in making combs, phonograph records, electrical switches and handles of various utensils, etc.



COPOLYMERISATION

It is a polymerisation reaction in which a mixture of more than one monomeric species is allowed to polymerise and form a copolymer. It can be made by chain as well as step growth polymerisation. Ex: Buna–S



Properties of copolymers are different from homopolymers. Actually, copolymers have better physical and mechanical properties. For example : Buna–S is tough and a good substitute for natural rubber.

RUBBER

Natural rubber

It is manufactured from rubber latex which is a colloidal dispersion of rubber in water.

It is a linear polymer of isoprene (2-methyl-1, 3-butadiene) and is also called cis -1, 4 – polyisoprene. Cis-polyisoprene molecule consists of various chains held together by weak Van der waals interactions and has a coiled structure. Thus, it can be stretched like a spring and exhibits elastic properties.

Vulcanization of rubber:

Natural rubber becomes soft at high temperature and brittle at low temperatures and shows high water absorption capacity. It is soluble in non-polar solvents and is non-resistant to attack by oxidising agents. To improve upon these physical properties, vulcanization is carried out. It consists of heating a mixture of raw rubber with sulphur and an appropriate additive at a temperature range between 373K to 415K. On vulcanization, sulphur forms cross-links at reactive sites of double bonds and thus rubber gets stiffened.

Note : (i) About 5% sulphur is used for making tyre rubber, 20-25% sulphur for making ebonite and 30% sulphur for making battery case rubber.

(ii) Natural rubber is cis-polyisoprene whereas gutta parcha is trans-polyisoprene.

Synthetic rubbers

They are either homopolymers of 1, 3-butadiene derivatives or copolymers of 1, 3-butadiene or its derivatives with another unsaturated monomer.

Preparation:

(i) Neoprene (or polychloroprene) It is prepared by free radical polymerisation of chloroprene.

n CH₂ = C - CH = CH₂
$$\xrightarrow{\text{polymerisation}}$$

Chloroprene $\begin{array}{c} Cl \\ \downarrow \\ CH_2 - C = CH - CH_2 \\ \downarrow \\ Neoprene \end{array}$

It is resistant to vegetable and mineral oils. It is used for manufacturing conveyor belts, gaskets and hoses.

(ii) Buna-N

It is obtained by copolymerisation of 1, 3-butadiene and acrylonitrile in presence of peroxide catalyst.

$$n CH_2 = CH - CH = CH_2 + n CH_2 = CH$$

$$\begin{array}{c} \begin{array}{c} \text{copolymeri-} \\ \hline \text{sation} \end{array} \quad \left[\begin{array}{c} \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH} \\ \begin{matrix} \text{I} \\ \text{CN} \end{matrix} \right]_n \\ \end{array}$$

It is resistant to action of petrol, lubricating oil and organic solvents. It is used in making oil seals, tank lining, etc.

MOLECULAR MASS OF POLYMERS

Polymer sample contains chains of varying lengths and hence its molecular mass is always expressed as an average and can be determined by chemical and physical methods.

Number Average Molecular Weight ($\bar{\mathrm{M}}_{n}$)

$$\overline{M}_n = \frac{\text{Total weight of the molecules}}{\text{Total number of molecules}}$$

$$\overline{M}_n = \frac{N_1 M_1 + N_2 M_2 + N_3 M_3 + - - -}{N_1 + N_2 + N_3 + - - -}$$

 $\overline{M}_n = \frac{\Sigma N_i M_i}{\Sigma N_i}$

 \overline{M}_n is generally determined by osmotic pressure method.

Weight Average Molecular Weight ($\overline{\mathrm{M}}_{\mathrm{n}}$)

$$\overline{M}_{w} = \frac{w_{1}M_{1} + w_{2}M_{2} + w_{3}M_{3} + \dots}{w_{1} + w_{2} + w_{3} + \dots} = \sum \frac{w_{i}M_{i}}{\sum w_{i}}$$

or
$$\overline{M}w = \frac{N_1M_1^2 + N_2M_2^2 + N_3M_3^2 + \dots}{N_1M_1 + N_2M_2 + N_3M_3 + \dots} = \frac{\Sigma N_iM_i^2}{\Sigma N_iM_i}$$

[weight (w) = no. of molecules (N) \times molecular weight (M)]

 $\bar{M}^{}_{w}\,$ is generally determined by the light scattering method.

PDI (POLY DISPERSITY INDEX)

The ratio of the \overline{M}_{w} and \overline{M}_{n} is called PDI

$$PDI = \frac{\overline{M}_{w}}{\overline{M}_{n}}$$

In natural polymers, which are generally mono dispersed, the PDI is unity ($\overline{M}_w = \overline{M}_n$)

In synthetic polymers which are poly dispersed, PDI is greater than unity because \overline{M}_w is always higher than \overline{M}_n .

BIODEGRADABLE POLYMERS

A large number of polymers are resistant to environmental degradation processes and are thus responsible for accumulation of polymeric solid waste materials. To overcome this problem, new biodegradable synthetic polymers have been designed and developed.

Aliphatic polyesters are one of the important classes of biodegradable polymers. Some important examples are:

(i) Poly β -hydroxy buty rate - co- β -hydroxy valerate (PHBV) It is obtained by following reaction:

$$\begin{array}{c} OH & OH \\ | \\ CH_3 - CH - CH_2 - COOH + \\ 3-Hydroxy \ butanoic \ acid \end{array} \begin{array}{c} OH \\ | \\ Hydroxy \ butanoic \ acid \end{array}$$

$$\xrightarrow{(O-CH-CH_2-C-O-CH-CH_2-C)}_{CH_3 O} \xrightarrow{(O-CH-CH_2-C)}_{CH_2CH_3 O} \xrightarrow{(CH_2CH_3 O)}_{PHBV}$$

It undergoes bacterial decomposition in environment.

It is used in speciality packaging, orthopaedic devices and in controlled release of drugs.

(ii) Nylon-2-nylon-6

It is an alternating copolymer of glycine (H $_2$ N-CH $_2$ -COOH) and amino caproic acid (H $_2$ N(CH $_2$) $_5$ COOH) It is biodegradable





- (c) $COOH(CH_2)_6 COOH + NH_2(CH_2)_4 NH_2$
- (d) $COOHC_6H_4^{T}COOH_(p) + \tilde{NH}_2(\tilde{CH}_2)_6 \tilde{NH}_2$

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Codes:

- (b) I-E, II-A, III-C, IV-B (a) I-E, II-A, III-B, IV-C (d) I-D, II-C, III-A, IV-B
- (c) I-D, II-C, III-A, IV-B
- 25. The monomer of the polymer;





- (c) $CH_3CH = CH_2$
- **26.** Orlon is a polymer of
 - (a) styrene (b) tetrafluoroethylene
 - (c) vinyl chloride (d) acrylonitrile
- 27. P.V.C. is formed by polymerisation of
 - (a) ethene (b) 1-chloropropene
 - (c) propene (d) 1-chloroethene
- **28.** Caprolactam polymerises to give

(a) terylene (b) teflon (c) glyptal (d) nylon-6

(d) $(CH_3)_2C = C(CH_3)_2$

- 29. The process involving heating of rubber with sulphur is called
 - (a) galvanisation (b) vulcanization
 - (c) bessemerisaion (d) sulphonation
- Which of the following is used in paints? 30.
 - (a) Terylene (b) Nylon
 - (d) Chloroprene (c) Glyptal
- **31.** Which of the following polymers do not involve cross linkages?
 - (a) Melmac (b) Bakelite
 - (c) Polythene (d) Vulcanised rubber
- Number average molecular mass, \overline{M}_n and weight average 32. molecular mass (\overline{M}_w) of synthetic polymers are related as
 - (a) $\overline{M}_n = (\overline{M}_w)^{1/2}$ (b) $\overline{M}_n = \overline{M}_w$
 - (d) $\overline{M}_w < \overline{M}_n$ (c) $\overline{M}_W > \overline{M}_n$
- 33. Select the correct statement.
 - (a) Vinyon is a copolymer of vinyl chloride and vinyl acetate
 - (b) Saran is a copolymer of vinyl chloride and vinylidine chloride
 - (c) Butyl rubber is a copolymer of isobutylene and isoprene
 - (d) All of the above are correct
- 34. The polymer used in the manufacture of lacquers is (a) bakelite (b) glyptal (c) PVC (d) PHBV
- 35. Low density polythene is prepared by
 - (a) Free radical polymerisation
 - (b) cationic polymerisation
 - (c) anionic polymerisation
 - (d) Ziegler-Natta polymerisation

36. Head-to-tail addition takes place in chain-growth polymerisation when monomer is

(a)
$$CH_2 = CH - CH = CH_2$$
 (b) $CH_2 = CH - CH = CH_2$

- (c) $CH_2 = C COCH_3$ (d) $CH_2 = CH C \equiv N$ | | | CH_3 O
- **37.** Polymer used in bullet proof glass is
 - (a) lexan (b) PMMA (c) nomex (d) kevlar
- The monomer(s) used in the preparation of Orlon, a substitute 38. for wool is/are
 - (a) caprolactam
 - (b) tetrafluoroethene
 - (c) styrene and 1, 3-butadiene
 - (d) acrylonitrile
- **39.** Glyptals are chiefly employed in
 - (a) toy making (b) surface coating
 - (c) photofilm making (d) electrical insulators
- **40.** The polymer used for making contact lenses for eyes is
 - (a) polymethylmethacrylate(b) polyethylene
 - (c) polyethylacrylate (d) nylon-6
- 41. Which polymer is used for making magnetic recording tapes?
 - (a) Dacron (b) Acrilan (c) Glyptal (d) Bakelite
- 42. The polymer used in making synthetic hair wigs is made up of
 - (a) $CH_2 = CHCl$ (b) $CH_2 = CHCOOCH_3$
 - (c) $\tilde{C_6H_5CH} = CH_2$ (d) $CH_2 = CH - CH = CH_2$
- 43. The monomer of polystyrene is
 - (a) $C_2H_5 CH = CH_2$
 - (b) $CH_2 = CHCl$
 - (c) $C_6H_5 CH = CH_2$
 - (d) $CH_2 = CHCHO$
- 44. Which of the following has been used in the manufacture of non-inflammable photographic films?
 - (a) Cellulose nitrate (b) Cellulose xanthate
 - (c) Cellulose perchlorate (d) Cellulose acetate
- 45. Which of the following is currently used as a tyre cord?
 - (a) Terylene (b) Polyethylene
 - (d) Nylon 6 (c) Polypropylene
- The plastic household crockery is prepared by using **46**.
 - (a) melamine and tetrafluoroethane
 - (b) malonic acid and hexamethyleneamine
 - (c) melamine and vinyl acetate
 - (d) melamine and formaldehyde
- 47. The polymer used in orthopaedic devices and in controlled drug release is
 - (a) Orlon (b) PTFE (c) SBR (d) PHBV
- Which one of the following polymers is prepared by **48**. condensation polymerisation?
 - (a) Teflon

(c) Styrene

- (b) Natural rubber
- (d) Nylon-66

- **49.** Which one of the following statement is *not true*?
 - (a) In vulcanization the formation of sulphur bridges between different chains make rubber harder and stronger.
 - (b) Natural rubber has the *trans* -configuration at every double bond
 - (c) Buna-S is a copolymer of butadiene and styrene
 - (d) Natural rubber is a 1, 4 polymer of isoprene
- 50. Which of the following structures represents neoprene polymer?

(a)
$$(CH_2 - C = CH - CH_2)_n$$
 (b) $(CH_2 - CH)_n$
(c) $(CH_2 - CH)_n$ (c) $(CH_2 - CH)_n$
(c) $(CH_2 - CH)_n$ (c) $(CH - CH_2)_n$
(c) $(CH_2 - CH)_n$ (c) $(CH - CH_2)_n$

- 51. Of the following which one is classified as polyester polymer?
 - (a) Terylene (b) Bakelite (c) Melamine (d) Nylon-66
- Which one of the following is not a condensation polymer? 52.
 - (a) Melamine (b) Glyptal
 - (c) Dacron (d) Neoprene
- Which of the following statements is false? 53.
 - (a) Artificial silk is derived from cellulose.
 - (b) Nylon-66 is an example of elastomer.
 - (c) The repeat unit in natural rubber is isoprene.
 - (d) Both starch and cellulose are polymers of glucose.
- 54. Bakelite is obtained from phenol by reacting with
 - (a) $(CH_2OH)_2$ (b) CH₂CHO
 - (c) CH₂ COCH₂ (d) HCHO
- Vinyl chloride can be converted into PVC. In this reaction, 55. the catalyst used is
 - (b) cuprous chloride (a) peroxides
 - (c) anhydrous zinc chloride (d) anhydrous AlCl₃
- The mass average molecular mass & number average 56. molecular mass of a polymer are 40,000 and 30,000 respectively. The polydispersity index of polymer will be (a) <1 (b) >1(c) 1 (d) 0

57. Ethylene-propylene rubber (EPR) is

- (a) unsaturated and stereoregular
- (b) saturated and stereoregular
- (c) atactic and unsaturated
- (d) syndiotactic and unsaturated
- 58. The monomeric units of terylene are glycol and which of the following



- The synthetic polymer which resembles natural rubber is 59. (a) neoprene (b) chloroprene
 - (d) nylon (c) glyptal
- 60. Characteristic property of Teflon is
 - (a) 2000 poise viscosity
 - (b) high surface tension
 - (c) non-inflammable and resistant to heat
 - (d) highly reactive
- Which of the following is used in vulcanization of rubber? 61.
- (a) SF_6 (b) CF₄ (c) Cl_2F_2 (d) C_2F_2
- What is the percentage of sulphur used in vulcanization of **62**. rubber
 - (a) 05% to 30% (b) 03% to 25%
 - (c) 10% to 20%(d) 05% to 25%
- **63.** Perlon is

(a) Rubber (b) Nylon-6 (c) Terylene (d) Orlon

- 64. Plexiglas (PMMA) is a polymer of
 - (a) acrylic acid (b) methyl acrylate
 - (d) None of these (c) methyl methacrylate
- 65. Which one of the following sets forms the biodegradable polymer?

 - (a) $CH_2 = CH CN$ and $CH_2 = CH CH = CH_2$ (b) $H_2N CH_2 COOH$ and $H_2N (CH_2)_5 COOH$
 - (c) $HO CH_2 CH_2 OH$ and

(d)
$$\bigcirc$$
 CH=CH₂ and CH₂=CH-CH=CH₂

66. Buna-N synthetic rubber is a copolymer of :

- (a) $H_2C = CH CH = CH_2$ and $H_5C_6 CH = CH_2$ (b) $H_2C = CH CN$ and $H_2C = CH CH = CH_2$

(c)
$$H_2C = CH - CN$$
 and $H_2C = CH - C = CH_2$
 $\downarrow CH_3$

(d)
$$H_2C = CH - C = CH_2$$
 and $H_2C = CH - CH = CH_2$

- 67. The polymer containing strong intermolecular forces e.g. hydrogen bonding, is
 - (a) teflon (b) nylon 6, 6
 - (c) polystyrene (d) natural rubber
- **68**. Among cellulose, polyvinyl chloride, nylon and natural rubber, the polymer in which the intermolecular force of attraction is weakest is
 - (a) nylon (b) polyvinyl chloride
 - (c) cellulose (d) natural Rubber
- The monomer(s) used to prepare polyvinyl polythene is 69.
 - (a) vinyl chloride and ethene
 - (b) ethene
 - isoprene (c)
 - (d) 1, 3-butadiene

- **70.** The polymer used in orthopaedic devices and in controlled drug release is
 - (a) Orlon (b) PTFE
 - (c) SBR (d) PHBV
- 71. The monomer of polystyrene is
 - (a) $C_2H_5 CH = CH_2$
 - (b) $CH_2 = CHCl$
 - (c) $C_6H_5 CH = CH_2$
 - (d) $CH_2 = CHCHO$
- 72. A network polymer among the following is
 - (a) teflon (b) polythene
 - (c) bakelite (d) PVC

- **73.** The monomer(s) used in the preparation of Orlon, a substitute for wool is/are
 - (a) caprolactam
 - (b) tetrafluoroethene
 - (c) styrene and 1, 3-butadiene
 - (d) acrylonitrile
- 74. The polymer used in the manufacture of lacquers is
 - (a) bakelite (b) glyptal
 - (c) PVC (d) PHBV
- **75.** Teflon, styron and neoprene are all
 - (a) Copolymers (b) Condensation polymers
 - (c) Homopolymers (d) Monomers

EXERCISE - 2 Applied Questions

- 1. The monomers used for the preparation of nylon- 2-nylon-6 is/are
 - (a) caprolactam
 - (b) alanine and amino caproic acid
 - (c) glycine and amino caproic acid
 - (d) hexamethylenediamine and adipic acid
- 2. Polymer formation from monomers starts by
 - (a) condensation or addition reaction between monomers
 - (b) coordinate reaction between monomers
 - (c) conversion of monomer to monomer ions
 - (d) hydrolysis of monomers.
- **3.** Nylon threads are made of
 - (a) polyester polymer (b) polyamide polymer
 - (c) polyethylene polymer (d) polyvinyl polymer
 - The polymer containing strong intermolecular forces *e.g.* hydrogen bonding, is
 - (a) teflon (b) nylon 6, 6
 - (c) polystyrene (d) natural rubber

5.
$$n(CF_2 = CF_2) \xrightarrow{\text{Benzoyl peroxide or}} X$$

Here, X is :

4.

6.

(a)	RMMA	(b) PVC
		(

- (c) PAN (d) None of these
- Which pair of polymers have similar properties ?(a) Nylon, PVC(b) PAN, PTFE
 - (a) Nyton, PVC (b) PAN, PTPE (c) PCTFE, PTFE (d) Bakelite, alkyl resin
- 7. Which compound/set of compounds is used in the manufacture of nylon 6?

(a)
$$\bigvee_{CH = CH_2}$$

(b) $HOOC(CH_2)_4COOH + NH_2(CH_2)_6 NH_2$
 CH_3
(c) $CH_2 = CH - C = CH_2$ (d)

- 8. Among the following, the wrong statement is
 - (a) PMMA is plexiglass
 - (b) SBR is natural rubber
 - (c) PTFE is teflon
 - (d) LDPE is low density polythene
- **9.** If a polythene sample contains two monodisperse fractions in the ratio 2 : 3 with degree of polymerization 100 and 200, respectively, then its weight average molecular weight will be :
 - (a) 4900 (b) 4600 (c) 4300 (d) 5200
- **10.** When condensation product of hexamethylenediamine and adipic acid is heated to 525K in an atmosphere of nitrogen for about 4-5 hours, the product obtained is
 - (a) solid polymer of nylon 66
 - (b) liquid polymer of nylon 66
 - (c) gaseous polymer of nylon 66
 - (d) liquid polymer of nylon 6
- 11. The polymer used for optical lenses is :
 - (a) polypropylene
 - (b) polyvinyl chloride
 - (c) polythene
 - (d) polymethyl methacrylate
- 12. The compound which cannot be used as a plasticizer, is
 - (a) di-*n*-butylphthalate (b) tricresyl phosphate
 - (c) di-*n*-octyphthalate (d) diethyl phthalate
- **13.** In which of the following polymers, empirical formula resembles with monomer ?
 - (a) Bakelite (b) Teflon
 - (c) Nylon-6, 6 (d) Dacron
- 14. Which is a polymer of three different monomers ?
 - (a) ABS (b) SBR
 - (c) NBR (d) Nylon-2-Nylon-6
- **15.** Which of the following fibres is made of polyamide ?
- (a) Dacron (b) Orlon (c) Nylon (d) Rayon16. The polymer which has conducting power is
 - (a) polyethylene (b) polybutadiene
 - (c) polystyrene (d) polyacetylene

- **17.** Orlon is a
 - (a) homopolymer and addition polymer
 - (b) copolymer and addition polymer
 - (c) homopolymer and condensation polymer
 - (d) copolymer and condensation polymer
- **18.** Dacron is a –

19.

- (a) crease resistant
- (b) polyamide
- (c) addition polymer
- (d) polymer of ethylene glycol and phthalic acid
- Which of the following is a branched polymer?
- (a) Low density polymer (b) Polyester
- (c) High density polymer (d) Nylon
- **20.** Given the polymers (i) Nylon-66; (ii) Buna-S; (iii) Polythene, arrange these in increasing order of their inter-molecular forces (lower to higher)
 - (a) (i) > (ii) > (iii) (b) (ii) > (iii) > (i)
 - (c) (ii) \leq (iii) \leq (i) (d) (iii) \leq (i) \leq (ii)
- **21.** Structures of some common polymers are given. Which one is **not** correctly presented?

(a) Neoprene;
$$\begin{pmatrix} -CH_2 - C = CH - CH_2 - CH$$

(b) Terylene;

$$(-OC - OC - OC - COOCH_2 - CH_2 - O)$$

- (c) Nylon 66; $\left[-NH(CH_2)_6 NHCO(CH_2)_4 CO \right]_n$
- (d) Teflon; $(-CF_2 CF_2 -)_n$

DIRECTIONS for Qs. 22 to 25 : These are Assertion-Reason type questions. Each of these question contains two statements : Statement-1 (Assertion) and Statement-2 (Reason). Answer these questions from the following four options.

- (a) Statement-1 is true, Statement-2 is true, Statement-2 is a correct explanation for Statement -1
- (b) Statement-1 is true, Statement-2 is true; Statement-2 is NOT a correct explanation for Statement-1
- (c) Statement-1 is true, Statement-2 is false
- (d) Statement-1 is false, Statement-2 is true
- 22. Statement-1 : In vulcanisation of rubber, sulphur cross links are introduced.

Statement-2: Vulcanisation is a free radical initiated chain reaction.

- **23.** Statement-1 : Bakelite is a thermosetting polymer. Statement-2 : Bakelite can be melted again and again without any change.
- **24.** Statement-1 : The time of vulcanisation and temperature is increased by adding accelerators.

Statement-2: By vulcanising, a material of high tensile strength can be obtained.

25. Statement-1 : Teflon has high thermal stability and chemical inertness.

Statement-2: Teflon is a thermoplastic.

EXERCISE - 3 Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

- **1.** Which of the following polymers of glucose is stored by animals?
 - (a) Cellulose (b) Amylose
 - (c) Amylopectin (d) Glycogen
- 2. Which of the following is not a semisynthetic polymer?
 - (a) cis-polyisoprene (b) Cellulose nitrate
 - (c) Cellulose acetate (d) Vulcanised rubber
- 3. The commercial name of polyacrylonitrile is
 - (a) dacron (b) orlon (acrilan)
 - (c) PVC (d) bakelite
- 4. Which of the following polymer is biodegradable?

(a)
$$(CH_2 - C = CH - CH_2)_n$$

 $|_{Cl}$

(b)
$$(CH_2 - CH = CH - CH_2 - CH_2 - CH_2)$$

CN |



5. In which of the following polymers ethylene glycol is one of the monomer units?

(a)
$$(OCH_2 - CH_2OOC)$$

(b)
$$(CH_2 - CH_2)_n$$



- 6. Which of the following statements is not true about low density polyethene?
 - Tough (a)
 - (b) Hard
 - Poor conductor of electricity (c)
 - (d) Highly branched structure

7.
$$(O - C - CH_3 - CH_3)$$

 $| - CH_2 - CH_2 - CH_n$ is a polymer having monomer
 $| - CH_3 - CH_3$

units



8. Which of the following polymer can be formed by using the following monomer unit?



Nylon-6, 6 (a)

(c)

(b) Nylon-2-nylon-6 Melamine polymer (d) Nylon-6

NEET/AIPMT (2013-2017) Questions

Which is the monomer of Neoprene in the following? 9.

(a)
$$CH_2 = C - CH = CH_2$$
 [2013]
 CH_3

- (b) $CH_2 = C CH = CH_2$
- (c) $CH_2 = CH C = CH$
- (d) $CH_2 = CH CH = CH_2$

- Nylon is an example of: 10.
 - (a) Polysaccharide (b) Polyamide
 - (c) Polythene (d) Polyester
- 11. Which one of the following is an example of a thermosetting polymer? [2014]

(a)
$$(CH_2 - C = CH - CH_2)_n$$

(b)
$$(CH_2 - CH)_n$$

(c)
$$\begin{array}{c} H & H & O & O \\ | & | & | & | \\ (N-(CH_2)_6 - N - C - (CH_2)_4 - C)_n \end{array}$$

- Which of the following organic compounds polymerizes to 12. form the polyester Dacron? [2014]
 - (a) Propylene and para $HO-(C_6H_4)-OH$
 - (b) Benzoic acid and ethanol
 - (c) Terephthalic acid and ethylene glycol
 - (d) Benzoic acid and para $HO-(C_6H_4)-OH$
- Biodegradable polymer which can be produced from glycine 13. and aminocaproic acid is : [2015]
 - (a) PHBV (b) Buna - N
 - (d) Nylon 2- nylon 6 (c) Nylon 6, 6
- Caprolactum is used for the manufacture of : [2015 RS] 14.
 - (a) Nylon 6 (b) Teflon

- Natural rubber has 15.
 - all cis-configuration (a)
 - all trans-configuration (b)
 - alternate cis-and trans-configuration (c)
 - random cis-and trans-configuration (d)

[2016]

Hints & Solutions

EXERCISE - 1

1. (c) Nylon is a polymer of adipic acid and hexamethylenediamine thus it contains nitrogen. Polyvinyl chloride is a polymer of vinyl chloride. It does not contain nitrogen. Bakelite is a resin of formaldehyde and phenol. It does

not contain nitrogen. Terylene is a polymer of ethylene glycol and terephthalic acid. It does not contain nitrogen. It is also called dacron.

2. (b) Elastomers are the polymers having very weak intermolecular forces of attraction between the polymeric chains. The weak forces permit the polymer to be streched.



- (d) The given compound is a copolymer of hexamethylene 4. diamine and adipic acid. It is actually Nylon-66.
- (d) Bakelite is a thermosetting polymer. On heating it becomes 5. hard and infusible thus cannot be remoulded.
- 6. (a) Polymers which form from condensation polymerisation are called condensation polymers dacron is a condensation polymer of terepthalic acid and ethylene glycol.
- (b) Glyptal is not a polyamide 7.

A polyamide has amide linkage
$$-C - N - ||$$

H

Example

n(HO –

$$\begin{pmatrix} H & H & O \\ | & | & \| \\ -N - (CH_2)_6 - N - C - (CH_2)_4 - C - \\ \| \\ O \\ \end{pmatrix}$$

- Nylon 6,6
- (c) Ebonite is a hard highly vulcanized rubber, containing 8. 20-25%, sulphur.
- 9. (b) Nylon is a condensation polymer
- 10. (a) The polymer of ethylene glycol and tere-phthalic acid is known as terylene or dacron.

$$-CH_2 - CH_2 - OH) +$$

Ethylene glycol
$$n\left(HOOC - O - COOH\right) -$$

Terephthalic acid

It is a condensation polymer.

[Note: Now a days dimethyl terepthalate is used instead of terephthalic acid. This is due to the fact that terephthalic acid is non-volatile and very slightly soluble in most of the solvents. Dimethyl terepthalate on the other hand, can be purified by distillation very easily]. Thus, option (a) is correct.

- 11. (c) Nylon is a general name for all synthetic fibres forming polvamides.
- 12. (a) PVC is an example of thermoplastic polymer.
- 13. (a) The synthetic polymer neoprene (polychloroprene) is prepared by polymerisation of chloroprene.

This is inferior to natural rubber but is more resistant to aerial oxidation and to other solvents.

 \cap

14. (c)
$$H_2N - (CH_2 -)_6 NH_2 + Cl - C - (CH_2)_8 - C - Cl$$

Hexamethylene diamine Sebacovl chloride

$$\xrightarrow{\Delta} -HN - (CH_2)_6 - (NH - C - (CH_2)_8 - C -)_n$$
Nylon 6, 10

- 15. (b) Since proteins, cellulose and RNA control various activities of plants and animals, they are called biopolymers.
- 17. (b) 16. (d)
- 18. (d) Urotropine is used as antibiotic for urinary tract infection.
- 19. (b) $nHOOC(CH_2)_4COOH+nH_2N(CH_2)_6NH_2$ adipic acid Hexamethylene diamine

$$\xrightarrow{525K}_{\text{Polymerisation}} \begin{bmatrix} O & O \\ II \\ C - (CH_{2})_{4} - C \\ Nylon 6, 6 \end{bmatrix}_{n} O \\ H = (CH_{2})_{6} - NH = [n]_{n}$$

20. (d) Terylene is prepared by condensing terephthalic acid and ethylene glycol



21. (d)

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22. (a) Monomer of
$$\begin{bmatrix} CH_3 \\ C \\ CH_3 \end{bmatrix}_n$$
 polymer is

2-methylpropene.

- 23. (b) Acrilan is a polyacrylonitrile (PAN).
- 24. (b)
- 25. (a) Addition of monomers follows isoprene rule



- 26. (d) Orlon is a trade name of polyacrylonitrile
- 27. (d) P.V.C. (Polyvinyl chloride) is formed by polymerisation of vinyl chloride, CH₂=CHCl, whose IUPAC name is 1-chloroethene

31. (c) Polythene is a linear polymer

32. (c) PDI =
$$\frac{M_w}{\overline{M}_n}$$

For synthetic polymer, PDI > 1

 $\therefore \overline{M}_{W} > \overline{M}_{n}$

33. (d)

- 34. (b) Glyptal is used in preparation of lacquers.
- 35. (a) Ethene on free radical polymerisation gives low density polythene.
- 36. (a)
- 37. (b) PMMA and polycarbonate is used in bullet proof glass
- (d) Acrylonitrile is the monomer used in the preparation of orlon.
- (b) Glyptal is an alkyd resin obtained from polyhydric alcohols and polybasic organic acids or their anhydrides. They are used for surface coatings.
- 40. (a) Also known as PMMA. It is a transparent, excellent light transmitter and its optical clarity is better than glass so it is used in the preparation of lenses for eyes.

41. (d)

42. (a) SARAN, a polymer of vinyl chloride (CH₂=CHCl) and vinylidene chloride, is used for making synthetic hair wigs.

 (c) Polystyrene is manufactured by polymerization of styrene in presence of benzoyl peroxide.



- 44. (d) Cellulose acetate has been used in the manufacture of non inflammable photographic films.
- 45. (d) Nylon tyre cord is made from high tenacity continuous filament yarn by twisting and plying.
- 46. (d) The unbreakable plastic household crockery is made from copolymer of formaldehyde (HCHO) and melamine.



 (d) Polyhydroxybutyrate-co-β-hydroxyvalerate or PHBV is a biodegradable polymer and thus it can be used as biomaterials in orthopaedic devices and in controlled drug release.

$$\begin{array}{c} \mathrm{CH}_3 - \mathrm{CH}\mathrm{CH}_2\mathrm{COOH} + \mathrm{CH}_3\mathrm{CH}_2 - \begin{array}{c} \mathrm{CH} - \mathrm{CH}_2\mathrm{COOH} \\ | \\ \mathrm{OH} \end{array} \\ \end{array} \\ \begin{array}{c} \mathrm{OH} \end{array}$$



48. (d) Copolymer of adipic acid (6C) and hexamethylene diamine (6C).

n HOOC(CH₂)₄COOH+nH₂N(CH₂)₆NH₂
$$\rightarrow$$

Adipic acid Hexamethylene diamine

$$\underbrace{\stackrel{O}{\stackrel{}_{\parallel}}_{\leftarrow} \stackrel{O}{(C-(CH_2)_4} - \underbrace{\stackrel{O}{C-NH}_{\leftarrow} (CH_2)_6 - NH}_{Nylon 66} }_{Nylon 66}$$

It has high tenacity and elasticity. It is resistant to abrasion and not affected by sea water. It is used for reinforcement of rubber tyres, manufacture of parachute, safety belts, carpets and fabrics.

49. (b)

47



(All cis configuration)



- 50. (a) Neoprene is a polymer of chloroprene (2 chloro 1, 3 butadiene).
- 51. (a) Polyesters are condensation polymers of a dibasic acid and a diol. e.g., Terylene

HO.CH₂CH₂OH+n HOOC
$$\checkmark$$
 COOH \checkmark
Ethylene glycol Terephthalic acid

 $(O CH_2CH_2-O-C) \xrightarrow{O} (C) \xrightarrow{O} (C)$

Terylene

52. (d) Neoprene is an addition polymer of isoprene.



Neonrene

- 53. (b) Nylon (polyamides) are fibres.
- 54. (d) Phenol and formaldehyde undergo condensation polymerisation under two different conditions to give a cross linked polymer called bakelite.



56. (b) Average number molecular weight $\overline{M_n} = 30,000$ Average mass molecular weight $\overline{M_w} = 40,000$

Polydispersity index (PDI) =
$$\frac{\overline{M_w}}{\overline{M_n}} = \frac{40,000}{30,000} = 1.33$$

57. (b)

58. (c) Terylene is made from glycol and Terephthalic acid

$$HO - CH_2 - CH_2 - OH and HOOC - COOH$$

(Glycol) (Terephthalic acid)

59. (a) The synthetic polymer neoprene is prepared by polymerisation of chloroprene.

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Polychloroprene of Neoprene

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This is inferior to natural rubber but is more resistant to aerial oxidation and to other solvents.

- 60. (c) Teflon is non-inflammable and resistant to heat so it is used in coating, particularly in non-sticking frying pans.
- 61. (a) SF_6 is used in the vulcanisation of rubber. Sulphur is heated with polymer to introduce cross-linking and thus, form tough polymer.
- 62. (a) Vulcanization is a process in which natural rubber is treated with sulphur and certain organic compounds which accelerate the reaction between the rubber and sulphur. Thus about 5% S is used for making tyre rubber, 20-25% S for making ebonite and 30% S for making battery case rubber.
- 63. (b) Perlon is Nylon-6. It is prepared from a single monomer having a potential amino group at one end and a potential carbonyl group at other end.
- 64. (c)
- 65. (b) Biodegradable polymer is Nylon-2- Nylon-6 which is copolymer of glycine ($H_2N CH_2 COOH$) and amino caproic acid ($H_2N-(CH_2)_5 COOH$).

$$nH_2N-CH_2-COOH+nH_2N-(CH_2)_5-COOH$$

$$nylon - 2 - nylon -$$

66. (b) Buna – N is a copolymer of butadiene $(CH_2=CH-CH=CH_2)$ and acrylonitrile $(CH_2=CHCN)$.

- 67. (b) Nylon 6, 6 has amide linkage capable of forming hydrogen bonding.
- 68. (d) Nylon and cellulose, both have intermolecular hydrogen bonding, polyvinyl chloride has dipole-dipole interactions, while natural rubber has van der Waal forces which are weakest.
- 69. (d)

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 (d) Polyhydroxybutyrate-co-β-hydroxyvalerate or PHBV is a biodegradable polymer and thus it can be used as biomaterials in orthopaedic devices and in controlled drug release.



71. (c) Polystyrene is manufactured by polymerization of styrene in presence of benzoyl peroxide.



- 72. (c) Bakelite is a cross linked polymer.
- 73. (d) Acrylonitrile is the monomer used in the preparation of orlon.
- 74. (b) Glyptal is used in preparation of lacquers.
- 75. (c)

EXERCISE - 2

- 1. (c) Glycine and amino caproic acid are the monomers used for the preparation of nylon-2-nylon-6.
- 2. (a) Polymerisation starts either by condensation or addition reactions between monomers
- 3. (b) Nylon is a polyamide polymer
- 4. (b) Nylon 6, 6 has amide linkage capable of forming hydrogen bonding.

5. (d)
$$n(CF_2 = CF_2) \xrightarrow{\text{Benzoyl peroxide or}} (CF_2 - CF_2) \xrightarrow{\text{PTFE}} (X)$$

Here X is polytetrafluoroethylene. So, none of these i.e., option (d) is correct choice.

6. (c) PCTFE and PTFE both have same carbon backbone.

 $\label{eq:cifc_cifc_ci} \begin{array}{c} {}_{t}CIFC-CF_{2} \\ \\ {}_{n} \end{array} \\ \mbox{PCTFE (polymonochloro trifluoroethylene)} \end{array}$

 $F_2C - CF_2$ PTFE (poly tetrafluoro ethylene) (d) Nylon–6 can be manufactured from



- 8. (b) SBR (styrene-butadiene) is a synthetic rubber.
- 9. (b)

7.

 (b) The condensation polymerisation of hexamethylene diamine and adipic acid is done in solution form by interface technique. In this liquid nylon polymer is obtained.

$$n.H_2N - (CH_2)_6 - NH_2 +$$

+nHOOC – (CH₂)₄ – COOH
$$\xrightarrow{\text{Polymerisation}}$$
 – nH₂O

$$[-HN - (CH_2)_6 - \underset{Nylon}{NHCO} - (CH_2)_4 - CO -]_n$$

- 11. (d) Polymethyl methacrylate is hard, fairly rigid. It is used for optical lenses.
- 12. (d) Generally high boiling esters or haloalkanes act as plasticizer.
- 13. (b) In addition homopolymers such as teflon, empirical formula resembles with monomer.
- 14. (a) ABS is acrylonitrile-butadiene-styrene rubber which is obtained by copolymerisation of acrylonitrile, 1, 3-butadiene and styrene.

$$\begin{array}{c} \mathrm{CH}_{2} = \mathrm{CH} + \mathrm{CH}_{2} = \mathrm{CH} \\ | \\ \mathrm{CN} \\ \mathrm{acrylonitrile} \\ 1,3-\mathrm{butadiene} \end{array} + \begin{array}{c} \mathrm{CH}_{2} = \mathrm{CHC}_{6}\mathrm{H}_{5} \longrightarrow \\ \mathrm{styrene} \\ \mathrm{styrene} \end{array}$$

$$\begin{array}{c} - CH_2 - CH - CH_2 CH = CHCH_2 - CH_2 - CH_1 \\ | \\ CN \\ \end{array}$$

ABS rubber

- (c) Nylon fibres are made up of polyamides. Dacron and orlon are made up of polyester. Rayon is artificial silk made up of polysaccharides.
- 16. (d) Polyacetylene, due to presence of double bonds, is a conducting polymer.

17. (a) Orlon is polymer of acrylonitrile
$$\begin{pmatrix} CH_2 = CH \\ | \\ CN \end{pmatrix}$$

$$nCH_2 = \begin{array}{c} CH \longrightarrow CH_2 - CH \\ \downarrow \\ CN \end{array} \xrightarrow{} \left(\begin{array}{c} CH_2 - CH \\ \downarrow \\ CN \end{array} \right)_n$$

- 18. (a) Dacron is a polyester and is the condensation polymer of ethylene glycol and terephthalic acid. It is crease resistant
- 19. (a)
- 20. (c) Nylon 6, 6 is a fibre with hydrogen bonds thus have strongest intermolecular forces. Buna-S is a elastomer whereas polythene is thermoplastic. the intermolecular forces of attraction in thermoplastics is intermediate between elastomer and fibres. Therefore forces in elastomers are weakest.
- 21. (a) Neoprene is a polymer of chloroprene. Hence, correct representation is

nCH₂ = CH — Cl
Chloroprene CH₂ — O₂ or peroxides
Chloroprene (
$$\begin{pmatrix}
-CH_2 - C = CH - CH_2 - \\
Cl
Neoprene
\end{pmatrix}$$

- 22. (b) Vulcanisation is a process of treating natural rubber with sulphur or some compounds of sulphur under heat so as to modify its properties. This cross-linking give mechanical strength to the rubber.
- 23. (c) Bakelite can be heated only once.
- 24. (d) The time of vulcanisation is reduced by adding accelerators and activators.
- 25. (b) Due to the presence of strong C–F bonds, teflon has high thermal stability and chemical inertness.

EXERCISE -3

Exemplar Questions

- 1. (d) Glycogen is a polymer of glucose found in liver, brain and muscles of animals.
- 2. (a) cis-polyisoprene is a synthetic polymer.
- 3. (b) The commercial name of polyacrylonitrile is orlon (acrilan).



(c) PHBV is an example of biodergradable polymer.(a)

4.

5.

n

9.





6. (d) Low density polythene has slightly branched structure.

7. (a)
$$n \operatorname{CH}_{2} = C \underbrace{CH_{3}}_{\text{Monomer}}$$

 $\xrightarrow{\text{Polymerisation}} \operatorname{CH}_{3} \xrightarrow{CH_{3}} \underbrace{CH_{3}}_{\text{H}_{2} \to CH_{2} \to CH_{2} \to CH_{3}}_{\text{CH}_{3} \to CH_{3}}$
8. (d) $\underbrace{\bigcup_{\text{Caprolactum}}^{H} \underbrace{O}_{\text{Caprolactum}} \underbrace{A, \operatorname{Polymerisation}}_{-(n-1)\operatorname{H}_{2}\operatorname{O}} \underbrace{H}_{NH} - (\operatorname{CH}_{2})_{5} - \underbrace{C}_{n}^{H}_{Nylon-6}$
NEET/AIPMT (2013-2017) Ouestions

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- (b) $CH_2 = \dot{C} CH = CH_2$ (chloroprene) is the monomer of neoprene.
- 10. (b) Nylon is a synthetic polyamide polymer.
- (d) Thermosetting polymers undergo chemical changes when heated and set to hard mass when cooled e.g. Bakelite.



n HO.CH₂CH₂OH+n HOOC
$$\longrightarrow$$
 COOH $\xrightarrow{\Delta}$ 14.

Ethylene glycol

Terephthalic acid

Terylene

It is resistant to mineral and organic acids. It is used for blending with wool to provide better crease, in safety helmets and aircraft battery boxes.

(d) $H_2 N - CH_2 - COOH + H_2 N - (CH_2)_5 - COOH \rightarrow$ (HN - CH₂ - CO - NH - (CH₂)₅ - CO) -13. Aminocapric acid

Glycine

Nylon-2-nylon-6



(a) Natural rubber is found to be a polymer of cis-isoprene 15. i.e. it is cis-polyisoprene

$$H_2C = C - CH = CH_2 \xrightarrow{polymerisation} CH_3$$
 cis-polyisoprene



Isoprene