

3. POLYMERS

SYNOPSIS

I. CLASSIFICATION & POLYMERIZATION PROCESS

- (i) On the basis of source, polymers are classified into the following three categories :
1. Natural polymers are found in nature, i.e., animals and plants – starch, cellulose, proteins nucleic acids, natural rubber, etc. Natural polymers which control the various life processes are called **biopolymers**. For example, polysaccharides (starch, cellulose), proteins and nucleic acids.
 2. Semi-synthetic polymers are obtained from naturally occurring polymers by chemical modification. For example, cellulose on acetylation with acetic anhydride in presence of little conc, H_2SO_4 gives cellulose triacetate. Partial hydrolysis removes some of the acetate groups and degrades the chains to smaller fragments (200-300 unit each) and gives roughly cellulose diacetate which are used for making threads of acetate rayon. Rayon is similar to cotton fibre but has shine like silk. Other examples of semi-synthetic polymers are : vulcanized rubber (which is superior to natural rubber and is extensively used for making tyres) and **gun cotton** (which is superior to natural rubber and is extensively used for making tyres) and **gun cotton** (which is cellulose trinitrate and is extensively used for making explosives and smokeless powders).
 3. Synthetic polymers are man-made polymers – Polythene, polypropylene, poly-styrene, PVC neoprene, teflon, nylon, dacron, backlite, melamine-formaldehyde resin, etc.
- (ii) On the basis of structures polymers are divided into the following three types :
1. Linear Polymers consist of long straight chains of polymers – High density polythene, nylon and polyester.
 2. Branched chain polymers have branches along the main chain – low density polythene, amylopectin, glycogen, etc.
 3. Cross-linked polymers consist of a large number of linear polymer chains joined together by at least two cross-links per polymer chain to form three dimensional giant network structure – Bakelite, urea-formaldehyde, melamine-formaldehyde polymer, etc.
- (iii) On the basis of molecular forces of attraction polymers have been divided into the following four categories :
1. Elastomers have the weakest (van der waals') intermolecular forces of attraction between the polymer chains – Natural rubber, vulcanized rubber, Buna-S.etc.
 2. Fibres are polymers in which the inter molecular forces of attraction are the strongest. These intermolecular forces may be either H-bonding between N-H and C=O groups or *dipole – dipole interactions* between the polar carbonyl groups in polyesters or cyano group in orlon, acrilan, etc.
 3. Thermoplastics are polymers in which intermolecular forces are in between those of -"s elastomers and fibres. Polythene, poly propylene, polystyrene, PVC, teflon, polyvinyl acetate, polyacrylonitrile, polymethacrylate, etc. Plastivizers. Substances such as *di-n-butyl phthalate or cresyl phosphates* which when added to plastics make them soft and readily workable on heating are called **plasticizers**
 - (iv) Thermosetting polymers. Low molecular weight semifluid substances which when heated in a mould undergo change in chemical composition to give a hard, infusible and insoluble mass are called thermosetting polymers. – Bakelite, urea – formaldehyde, melamine-formaldehyde, etc. whereas a **thermoplastic polymer** can be melted time and again without any changes, ads thermosetting polymer can be heated only once when it permanently sets into a solid which cannot be remelted and reworked.

- v) On the basis of mechanism or mode of formation, polymers have been divided into the following two categories :
1. **Addition polymers or Chain growth polymers** are formed by addition of a large number of monomer molecules containing multiple bonds. These are usually formed by *free radical polymerization* – Low density polythene, polypropylene, teflon, PVC, *cis*-polyisoprene (natural rubber).etc.
 2. **Condensation or step growth polymers** are between two difunctional molecules with the loss of simple molecules like H_2O , NH_3 , $\text{C}_2\text{H}_5\text{OH}$, HCl etc. – Nylon-6, nylon-6,6 bakelite, alkyd resins, polyester, etc.

This type of polymerization involves successive addition of monomer units to a growing chain carrying a reactive intermediate such as free radical, a carbocation or a carbanion.

Free radical addition polymerization. A variety of unsaturated compounds such as alkenes, alkadienes and their derivatives readily undergo polymerization in presence of a radical initiator such as oxygen benzoyl peroxide, acetyl peroxide, tert-butyl peroxide, etc. All free radical polymerization reactions occur in three steps : (i) *chain initiating* (ii) *chain propagating* and (iii) *chain termination*.

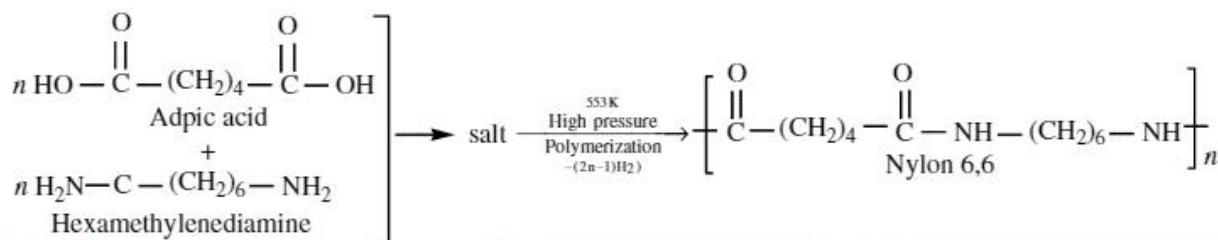
Some important addition polymers are :

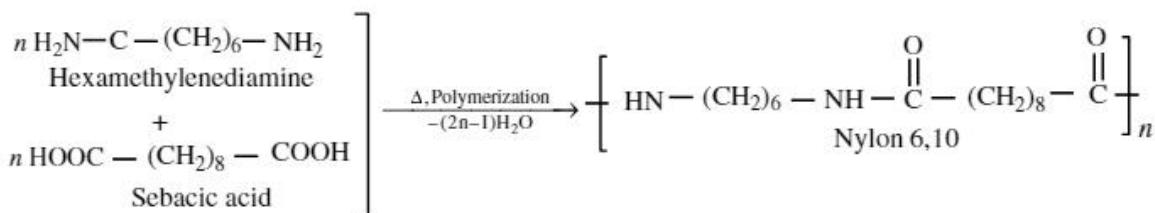
1. Low density-polythene(LDP) is obtained by *free-radical polymerization of ethylene*, i.e., by heating ethylene to 350-370 K under a pressure of 1000-2000 atm and in presence of a trace of oxygen. It has *branched chain structure*. It is a transparent polymer of moderate tensile strength and high toughness. It is chemically inert, slightly flexible and is a poor conductor of electricity. It is chemically inert, slightly flexible and is a poor conductor of electricity. It is mainly used as a packaging material in form of thin plastic **films**, bags, etc.), as insulation for electrical wires and cables, in manufacturing of squeeze bottles, **toys** and flexible pipes.
2. **High density polythene (HDP)** is obtained by *coordination polymerization* of ethylene in a hydrocarbon solvent at 333-343 K under a pressure of 6-7 atmospheres in presence of a catalyst consisting of $(\text{CH}_3\text{CH}_2)_2\text{Al} + \text{TiCl}_4$ (**Ziegler Natta catalyst**). It has linear structure and packs well in lattice. As a result, it has higher density, higher tensile strength and greater toughness than LDP. It is a translucent polymer and is used in the manufacture of containers (buckets, tubs, mugs, etc.) housewares, pipes, **button** and toys.

Condensation Polymerization or Step Growth Polymerizations

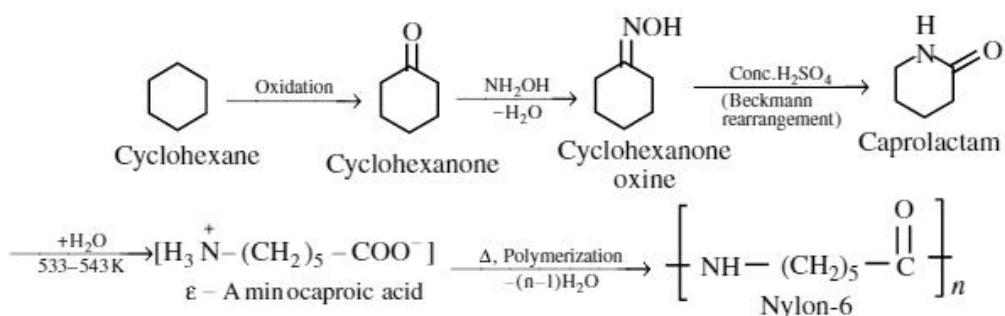
This type of polymerization occurs in steps involving loss of small molecules like water, alcohol, etc. Some important step-growth polymers are :

1. **Polyamides or Nylons** : (a) Nylong-6,6 is a condensation copolymer of adipic acid and hexamethylenediamine. On the other hand, Nylon-6,10 is a condensation polymer of sebacic acid and hexamethylene diamine. Nylons are used in the manufacture of carpets, textile fibres and bristles of brushes.

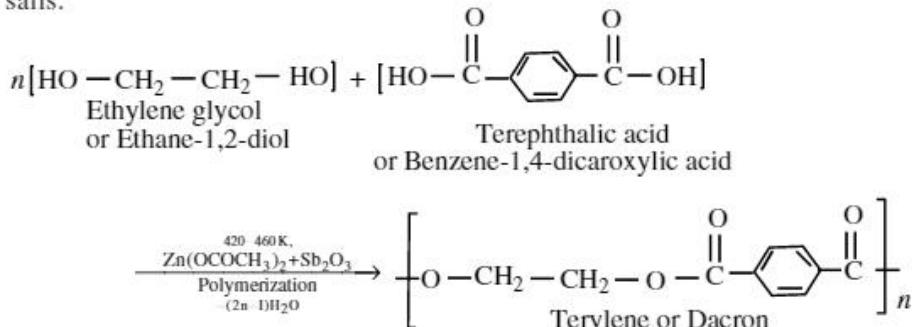




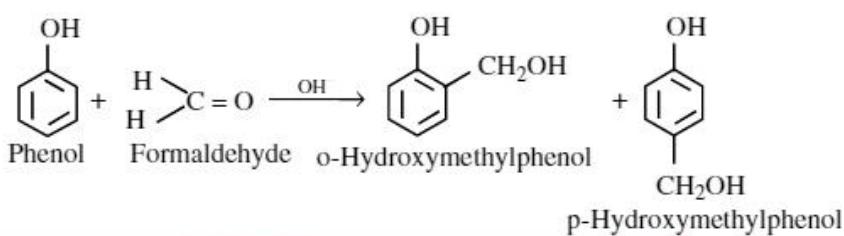
- b) Nylon-6 or Perlon is a condensation polymer of *caprolactam* which is obtained from cyclohexanone-oxime by *Beckmann rearrangement*. Unlike cotton fibres, nylong fibres do not rot, have high tensile strength, are tough, abrasion resistnat and somewhat elastic. Therefore, these are used for making tyre : cords, fabrics and Mountaineering ropes.

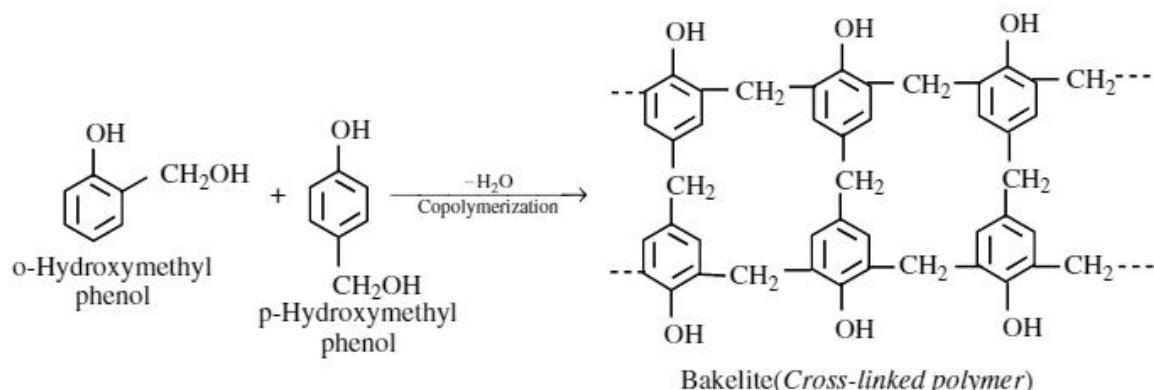
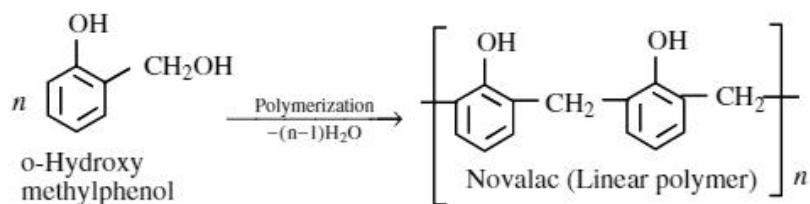


1. Polyester of Terylene or Dacron is a condensation copolymer of ethylene glycol and terephthalic acid or its dimethyl ester. It is used to manufacture wash and wear fabrics, tyre-cords, seat belts and sails.

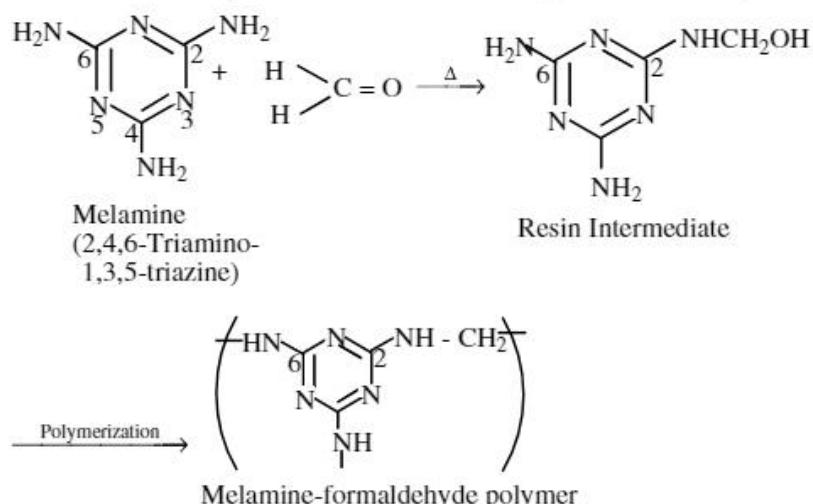


2. **Phenol-formaldehyde polymers** are obtained by condensation of phenol with formaldehyde in presence of either an acid or a base catalyst. First a linear product called **novolac** is obtained which is used in paints. Novolac on further heating with formaldehyde undergoes cross-linking to form **bakelite**. Thus, bakelite is a condensation copolymer of phenol and fucinaldehyde. It is a *thermosetting*, scratch and water-resistant polymer. It is used in the manufacture of combs, formica table tops, fountain pen barrels, electrical goods (switches and plugs), gramophone records, etc.





3. Melamine-formaldehyde resin is a condensation copolymer of melamine (2, 4,6-triamino-1, 3, 5-triazine) formaldehyde and is used for making non-breakable plastic crockery)



4. Urea-formaldehyde resin is a condensation polymer of urea and formaldehyde and is used for making unbreakable cups and laminated sheets.
5. Glyptal or Alkyd resins are condensation copolymers of dibasic acids (i.e., phthalic acid) or their anhydrides with polyhydric alcohols such as ethylene glycol, glycerol, etc. These are used in the manufacture of paints and lacquers.

II. NATURAL RUBBER & SYNTHETIC RUBBER :

Rubbers

1. Natural rubber is prepared from latex which is obtained from rubber trees. Chemically natural rubber is a polymer of isoprene, i.e., 2-methyl-1, 3-butadiene. Since each repeating unit in

Polyisoprene contains a double bond, it may have either *cis*-or *trans*-orientation. Actually, natural rubber is *cis*-polyisoprene while synthetic rubber (*gutta-percha*) obtained by free radical polymerization of isoprene is *trans*-polyisoprene.

Natural rubber is soft and tacky and becomes even more so in hot weather. Its tensile strength, resistance to abrasion are low and elasticity is maintained over a low range of temperature. All these properties can be improved by a process called vulcanization. It involves heating of rubber with 3.5% sulphur. It introduces sulphur bridges between polymer chains thereby increasing its tensile strength: elasticity and resistance to abrasion.

2. Synthetic rubber : To meet the ever-increasing demands of mankind, a number of synthetic rubber such as polybutadiene neoprene and Buna-S have been prepared
 - (i) **cis-Polybutadiene** is obtained by polymerization of 1, 3-butadiene in presence of $(C_2H_5)_3Al + TiCl_3$ or $TiCl_4$ (Zeigler-Natta catalyst). Its properties are similar to that of natural rubber.
 - (ii) **Buna-S or SBR (Styrene, Butadiene, Rubber)** is obtained by copolymerization of 1, 3-butadiene and styrene in the ratio 3 : 1 in presence of sodium. It is used in the manufacture of tyres, rubber soles, water-proof shoes, etc.
 - (iii) **Neoprene** is an addition polymer of chloroprene (2-chloro-1, 3-butadiene). It is superior to natural rubber in its stability to aerial oxidation and resistance to oils, gasoline and solvents.
 - (iv) **Buna-N or nitrile rubber.** Buna-N is obtained by copolymerization of 1, 3-butadiene and acrylonitrile in presence of a peroxide catalyst. Since it is resistant to the action of petrol, lubricating oils and organic solvents, it is used for making oil seals, hoses and tank linings, etc.
 - (v) **Thiokol or Polysulphide rubber** is prepared by copolymerization of 1, 2-dichloroethane with sodium tetrasulphide in presence of $Mg(OH)_2$. It has slightly less tensile strength but is exceptionally resistant to the action of mineral oils, solvents, oxygen and ozone.

III. MOLECULAR WEIGHT OF POLYMERS

Types of Average Molecular Mass of Polymers. There are two types of average molecular masses of polymers, i.e.,

Number average molecular mass (\bar{M}_n)

Weight average molecular mass \bar{M}_w

1. Number average molecular mass (\bar{M}_n)

If $N_1, N_2, N_3 \dots$ are the number of macro-molecules with molecular masses $M_1, M_2, M_3 \dots$ respectively then the number average molecular mass of the polymer is given by

$$\bar{M}_n = \frac{N_1 M_1 + N_2 M_2 + N_3 M_3 + \dots}{N_1 + N_2 + N_3} = \frac{\sum N_i M_i}{\sum N_i}$$

where N_i is the number of macromolecules i th type with molecular mass M_i .

The number average molecular mass (\bar{M}_n) is determined by using methods which depend upon the number of molecules present in the polymer sample, viz., colligative properties such as osmotic pressure, depression in freezing point and elevation in boiling point. The latter two methods are usually not used since the depression in freezing point and elevation in boiling point are too small to be measured accurately.

2. Weight average molecular mass (\bar{M}_w)

If $m_1, m_2, m_3 \dots$ are the masses of macro molecules with molecular masses $M_1, M_2, M_3 \dots$ respectively, then the weight average molecular mass of the polymer is given by

$$\bar{M}_w = \frac{m_1 M_1 + m_2 M_2 + m_3 M_3 + \dots}{m_1 + m_2 + m_3} = \frac{\sum m_i M_i}{\sum m_i}$$

But $m_i = N_i M_i$ where N_i is the number of macromolecules of i th type with molecular mass M_i

$$\frac{\sum N_i M_i \times M_i}{\sum N_i M_i} = \frac{\sum N_i M_i^2}{\sum N_i M_i}$$

Weight average molecular mass (\bar{M}_w) is determined by using methods which depend upon the masses of individual molecules, viz., light scattering, ultracentrifuge, sedimentation, etc.

Poly Dispersity'Index (PDI). The ratio of weight average molecular mass to number average molecular mass is called poly dispersity index (PDI), e.g., $PDI = \bar{M}_w / \bar{M}_n$ is used to determine the homogeneity of a polymer. On the basis of values of PDI, polymers have been classified into two categories : Monodisperse polymers. Polymers whose molecules have same or narrow range of molecular masses are called monodisperse polymers. For these polymers, \bar{M}_w / \bar{M}_n and hence their $PDI = 1$ (unity). Natural polymers usually have PDI equal to one and hence are more homogeneous.

Polydisperse polymers. Polymers whose molecules have a wide range of molecular masses are called polydisperse polymers. For these polymers, \bar{M}_w / \bar{M}_n and hence their $PDI > 1$. Synthetic polymers usually have $PDI > 1$ and hence are less homogeneous.

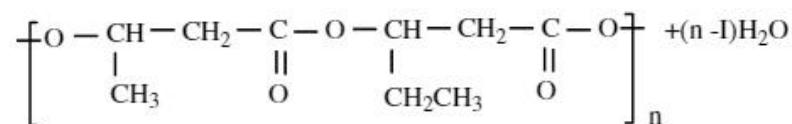
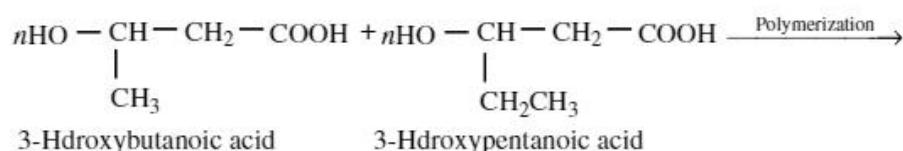
Thus, in general, monodisperse (natural) polymers are more homogeneous than polydisperse (synthetic) polymers.

IV. BIODEGRADABLE POLYMERS

Natural polymers (cellulose, starch, proteins, nuclei acids, etc.) disintegrate by themselves over a certain period of time and hence are called biodegradable. Synthetic polymers, however, do not, disintegrate by themselves over a period of time and hence are called non-biodegradable.

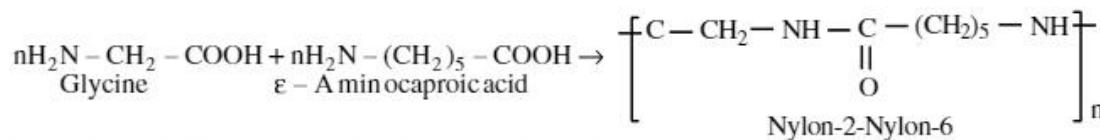
The durability of polymers is not altogether an advantage but has serious waste disposal problems. Therefore, to reduce polymer waste disposal problem, biodegradable synthetic polymers have been developed. These are based upon aliphatic polyesters and polyamides. Some of these are :

1. **Poly- β -hydroxybutyrate-Co- β hydroxyvalerate (PHBV).** It is a copolymer of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid in which the two monomer units are connected by ester linkages. It is used in speciality packing, orthopaedic devices and in controlled drug release.



Poly (glycolic acid) poly(lactic acid). It is also called dextron. It is used as sutures i.e., for stitching of wounds after operation.

Nylon-2 Nylon-6. It is an alternating polyamide of glycine (containing two carbon atoms) and ϵ -aminocaproic acid or 6-amino hexanoic acid (containing six carbon atoms. It is a step-growth copolymer)



V. COMMERCIAL IMPORTANCE OF POLYMERS

Polypropene is prepared by free radical polymerization of propene. It is used in the manufacture of carpet fibres, ropes, stronger pipes, toys and bottles.

1. **Polystyrene** is prepared by free radical polymerization of styrene. It is used as an insulator and as a wrapping material. It is used for making soft drink and baby feeding bottles, plastic toys, telephone, radio and television bodies, refrigerator linings, etc.
2. **Plycrylonitrile (PAN)** is prepared by free radical polymerization (i.e., in presence of peroxide catalyst) of acrylonitrile. It is used as a substitute for wool in the manufacture of orlon and acrilan fibres which are used for making clothes, carpets and blankets.
3. **Teflon** is an addition polymer and is obtained by free-radical polymerization of tetrafluoroethylene. It is flexible and inert to solvents and to boiling acids even to aqua regia and stable upto 598 K. It is used for preparing non-stick utensils, gaskets, pump packings, valves, seals, etc.
4. Poly (vinyl chloride), PVC is an addition polymer and is obtained by free radical polymerization of vinyl chloride. It is used as an electrical insulator for coating wires, cables and other electrical goods.
5. **Poly (methyl methacrylate), PMMA (Plexiglas, Lucite, Acryline and Perspex)** is an addition polymer obtained by free radical polymerization of methyl methacrylate. It has better light transmission properties than even glass and hence is widely used in transparent domes and skyights, aircrafts windows, dentures and plastic jewellery.
6. **Kevlar** is a polyamide and is obtained by condensation copolymerization of terephthalic acid with 1, 4-diaminobenzene (p-phenylene-diamine). *The fibres of this polymer are so strong that they are user! to make bullet -Proof vests.*
7. **Nomex** is a polyamide made by condensation polymerization of isophthalic acid and m-diaminobenzene. *It is known for its fire-resistant properties and is used in protective clothing for firefighters, astronauts, and race-car drivers*
8. **Lexan** is a polycarbonate (polyester) and is prepared by condensation copolymerization of diethyl carbonate and bisphenol A. *It has unusually high impact strength and hence is used in making bullet proof windows and safety or crash helmets.*
9. **Epoxy resin** is a condensation polymer of bisphenol-A and epichlorohydrin. It has strong adhesive properties and is used to join glass, porcelain wood and metal pieces.
10. Polyurethanes forms are obtained by condensation of toluene m-diisocyanate with ethylene glycol. During polymerization low boiling liquids such as freon II are added to the reaction mixture. The heat of polymerization volatilises the volatile liquid producing bubbles. Which convert the viscous polymer to a frothy mass of polyurethane foam. Polyurethane foams are quite rigid but very light and are extensively used for making washable and long lasting mattresses, cushions and pillows. They are also used as thermal insulation in building construction and for making ice chests.

 LECTURE SHEET 

EXERCISE-I

(Classification & Polymerisation process)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Which is an example of thermo setting polymer
1) Polythene 2) PVC 3) Neoprene 4) Bakelite
2. Which of the following is a chain growth polymer
1) Nucleic acid 2) Polystyrene 3) Protein 4) Styrene
3. A co polymer is one in which
1) two monomers undergo condensation 2) there is excessive cross linking
3) extensive hydrogen bonding 4) repeating unit contains two different monomers
4. Thermoplastic polymer among the following is
1) Bakelite 2) Urea formaldehyde resin
3) Polysiloxanes 4) PVC
5. Polymerization of iso butene is mostly initiated by
1) a cation 2) an anion 3) a free radical 4) Zwitter ion
6. Monomers are converted to polymers by
1) Hydrolysis of monomers 2) Condensation reaction between monomers
3) Protonation of monomers 4) None of these
7. Which of the following is an example of condensation polymer (or) Which of the following is not an example of addition polymer
1) Polythene 2) PVC 3) Orlon 4) Terylene
8. Which among the following is a semi synthetic polymer.
1) Cellulose rayon 2) Acrylonitrile 3) Cellulose nitrate 4) Both (1) & (3)
9. Linear polymer among the following is
1) Melamine 2) Starch 3) Bakelite 4) Polyvinylchloride
10. Which among the following is a branched chain polymer.
1) LDPE 2) Phenol formaldehyde resin
3) Nylon 4) Terylene
11. Cross linked polymer among the following is
1) Polythene 2) LDPE
3) Melamine formaldehyde resin 4) Nylon 6,6
12. Correct statement among the following is
1) All macromolecules are polymers
2) Physical and mechanical properties of a polymer are similar to its monomer
3) Majority of bonds in polymer molecule are covalent
4) Vitamins are polymers

13. In the polymerization of acrylonitrile, most commonly used initiator is
 1) a cation 2) an anion 3) a free radical 4) Zwitter ion
14. Initiators that can be used in anionic polymerisation is/are
 a) Potassium amide b) n-buthyl lithium c) AlCl_3 d) H_2SO_4
- The correct answer is*
 1) only a 2) only a and b 3) only c and d 4) all
15. Which one of the following types of monomers, mostly undergo cationic polymerization
 1) Vinyl monomers with electron donating group
 2) Vinyl monomers with electron with drawing group
 3) Poly functional group monomers 4) Saturated hydrocarbons
16. Terylene and Nylon-6,6 are
 1) Random co-polymers 2) Alternating co-polymers
 3) Block copolymers 4) Graft copolymers
17. In Elastomer, intermolecular forces are
 1) Nil 2) Weak 3) Strong 4) Very strong

LEVEL-II (ADVANCED)***Straight Objective Type Questions***

1. The example of a homopolymer is
 a) Bakelite b) Nylon-66 c) Terylene d) Neoprene
2. Which is not true about polymers?
 a) Polymer donot carry any charge b) Polymers have high viscosity
 c) Polymers scatter light d) Polymers have low molecular weight
3. Which one of the following is obtained by step growth polymerization ?
 a) Nylon, 6, 6 b) Neoprene c) polyvinylchloride d) polyvinylpyrrolidene
4. Bakelite is made from phenol and formaldehyde. The initial reaction between two compounds is an example of
 a) Aromatic nucleophilic substitution b) Aromatic electrophilic substitution
 c) Free radical substitution reaction d) Free radical addition reaction

More than One correct answer Type Questions

5. Which of the following is/are example of natural polymer
 a) Wool b) Silk c) Leather d) Nylon
6. Synthetic fibres manufactured from cellulose are termed as
 a) Rayon b) Nylon c) Dacron d) Artificial silk
7. Which of the following are copolymers
 a) Bakelite b) Melamine c) Buna-S d) Nylon-6,6
8. Which of the following is/are not an elastomer ?
 a) Bakelite b) Polyethylene c) Nylon-6 d) Natural rubber

9. Which of following is/are not a thermoplastic ?
 a) Bakelite b) Polyethylene c) Nylon-6 d) Natural rubber
10. Which of the following is/are a homopolymer ?
 a) Natural rubber b) Synthetic rubber
 c) Gutta-percha d) Saran
11. Which of the following are linear polymer
 a) Polypeptide b) Poly ethylene terephthalate
 c) Starch d) Phenol- formaldehyde resin
12. The man made polymers that are esters include
 a) Terylene b) Dacron c) Glyptal d) Nylon

Linked Comprehension Type Questions

Passage-I :

Polymerization involves various mechanisms depending upon the initiator. If initiator generates free radical, addition polymerization takes place through free radical mechanism. If H^+ is initiator and electron releasing group is present, cationic polymerization takes place. If electron withdrawing group is present and KNH_2 is initiator, anionic polymerization takes place.

13. Which of the following will induce anionic polymerization
 a) KNH_2 b) n – Butyllithium c) KOH d) All of these
14. Which of the following will undergo cationic polymerization in presence of H^+
 a) $CH_2 = CH$
 |
 Cl b) $CH_2 = CH$
 |
 CN c) $CH_2 = CH_2$ d) $CH_2 = CH$
 |
 CH_3
15. Which of the following will undergo anionic polymerization in presence of KNH_2



Passage-II :

The utility of the polymers in various fields is due to their mechanical properties like tensile strength elasticity, toughness etc. These properties mainly depend upon intermolecular forces like van der Waal's forces and hydrogen bonding operating in polymer molecules. Polymers have been classified on this basis.

16. The molecular forces of attraction are weakest in
 a) Elastomers b) Fibres
 c) Thermoplastics d) Thermosetting polymers
17. Which of the following is hard
 a) Elastomer b) Fibre
 c) Thermoplastic d) Thermosetting polymers

Matrix Matching Type Questions**18. Column-I**

- A) Melamine
B) Glyptal
C) Polytetrafluoro ethylene
D) Buna-S

Column-II

- p) Non-breakable plastic formaldehyde cookery
q) Nonstick utensil coating
r) Water proof shoes
s) Paints and lacquers

19. Column-I

- A) Starch
B) Rubber
C) Neoprene
D) Nylon - 6

Column-II

- p) Natural polymers
q) synthetic polymer
r) addition polymer
s) condensation polymer
t) homo polymer

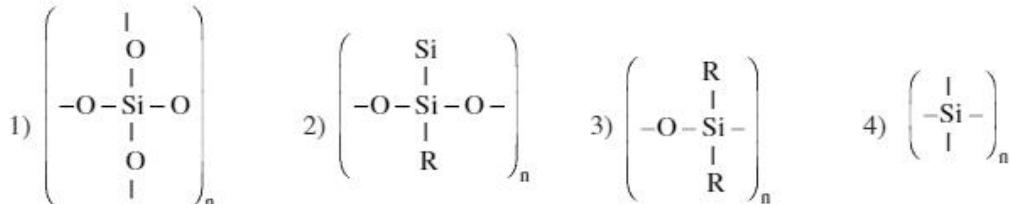
Integer Type Questions

20. Number of polymers containing ester linkages in the following are, Nylon, glyptal, Dacron, PVC.
21. The number of carbon items present in the monomer of Teflon is
22. Sum of nitrogen atoms in the monomers of nylon-6, and nylon-6,6 is x and sum of carbon atoms in them is 'y'. Then $\frac{y}{x}$ is
23. How many of the following are natural polymers?
Cellulose, Cellulose acetate, Cellulose nitrate, starch, proteins, plastic, bakelite, melamine, teflon
24. How many of the following polymers with ester linkage ?
Dacron, Teflon, Gyptal, PHBV, PMMA poly lactic acid, polyglycolic acid, nylon – 6,6, nylon-6

EXERCISE-II**(Natural Rubber & Synthetic Rubber)****LEVEL-I (MAIN)*****Straight Objective Type Questions***

1. Natural rubber is which type of polymer
1) Condensation polymer 2) Addition polymer
3) Coordination polymer 4) None of these
2. The percentage of rubber in rubber latex is
1) 20% 2) 25% 3) 35% 4) 65%
3. Natural rubber is a
1) Polydiyne 2) Polyamide 3) Polyester 4) Polyene
4. Gutta percha is
1) Cis - 1, 4 - polyisoprene 2) Trans - 1, 2 - polyisoprene
3) Cis - 1, 2 - polyisoprene 4) Trans - 1, 4 - polyisoprene

5. Natural rubber is a polymer of (or) the monomer of natural polymer rubber is
 1) Butadiene 2) Ethyne 3) Isoprene 4) Styrene
6. The role of zinc stearate in the process of vulcanisation is
 1) to accelerate the process 2) to slow down the process
 3) to stop the process 4) to initiate the process
7. The vulcanized rubber has
 1) high water absorbing tendency 2) low elasticity
 3) high sensitivity to heat treatment 4) high resistance to chemical oxidation
8. Natural rubber is a
 1) Trans isomer 2) cis isomer
 3) contains equal amounts of cis and trans isomers 4) racemic mixture
9. Empirical formula and molecular formula of monomer of natural rubber are respectively
 1) C_5H_8 , C_5H_8 2) C_5H_8 , $(C_5H_8)_n$ 3) C_4H_8, C_4H_6 4) C_5H_{12} , C_5H_8
10. Which of the following monomers gives the polymer neoprene on polymerisation?
 1) $CH_2 = CHCl$ 2) $Cl_2C = CCl_2$ 3) $CH_2 = C - \underset{Cl}{\overset{|}{CH}} = CH_2$ 4) $CF_2 = CF_2$
11. Buna - N is a polymer of
 1) Butadiene 2) Butadiene and sodium acetanilide
 3) Butadiene and styrene 4) Butadiene and vinyl cyanide
12. Structure of Silicone polymer is



LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Which of the following polymers has molecular mass an integral multiple of molecular mass of its monomer ?
 a) Buna rubber b) Glyptal c) Tereylene d) Nylon-6, 6
2. GR – S rubber is a copolymer of
 a) Butadiene & Acrylonitrile b) Butadiene & Styrene
 c) Ethylene & Styrene d) Ethylene & Vinyl cyanide
3. Which of the following is called nitrile rubber
 a) Butyl rubber b) Buna – N c) Buna – S d) All the above
4. IUPAC name of isoprene is
 a) 1 – Methyl – 1, 3 – butadiene b) 2 – Methyl – 1, 2 – butadiene
 c) 2 – Methyl – 1, 3 – butadiene d) 1 – Methyl – 1, 2 – butadiene

More than One correct answer Type Questions

5. Which of the following is/are a homopolymer ?
 a) Natural rubber b) Synthetic rubber c) Gutta-percha d) Saran
6. Cationic polymerisation is initiated by
 a) BF_3 b) NaNH_2 c) BuLi d) SnCl_4
7. Which of the following polymer contain 1, 3 – butadiene as one of the monomers ?
 a) SBR b) nitrile rubber c) butyl rubber d) ABS plastic
8. Which of the following is a biodegradable polymer
 a) PHBV b) Polyglycolic acid c) PMMA d) Nylon -2-Nylon-6
9. Correct statement about BuNa - N is
 a) it is copolymer b) 'N' stands for propenenitrile
 c) its structure is $\left(-\text{CH}_2 - \text{CH} = \text{CH} - \text{CH} = \text{CH} - \text{CH} - \text{CN} \right)_n$ d) it is an addition polymer

Linked Comprehension Type QuestionsPassage :

Natural rubber or raw rubber consists of basic material latex which is a dispersion of isoprene. Natural rubber can treatment this isoprene polymers to form a high molecular weight polymer of isoprene. Natural rubber can be obtained from five hundred different species of plants.

10. In the isoprene polymer all the isoprenes have
 a) Trans 1,4 configuration b) Cis 1,4 configuration
 c) Both cis & trans 1,4 configuration d) Cis 1,2 configuration
11. (i) Tensile strength of vulcanized rubber is almost ten times more than raw rubber.
 (ii) Elasticity of raw rubber is very high.
 a) (i) is true (ii) is false b) (i) is flase (ii) is true
 c) Both (i) & (ii) are true d) Both (i) & (ii) are false
12. The molecular weight of the raw rubber is about
 a) 1,00,000-1,50,000 b) 5,000-10,000 c) 2,00,000-5,00,000 d) 50,000-1,00,000

Matrix Matching Type Questions

- | 13. Column-I | Column-II |
|-------------------|--------------------|
| A) Gyptal | p) 1,3 – butadiene |
| B) Buna – N | q) Styrene |
| C) Buna – S | r) Acrylonitrile |
| D) Terylene | s) Ethylene glycol |
| | t) Phthalic acid |

Integer Type Questions

14. If a natural rubber has a molecular weight of 20,400 then the no.of repeating units in the polymer is $x \times 10^y$. ($x + y$) is equal to

EXERCISE-III

(Molecular weight of polymers)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Number average molecular weight (\bar{M}_n) of polymers is determined by

a) Osmotic pressure method	b) End group analysis method		
c) Light scattering method	d) Ultra centrifuge method		
1) only a	2) only a and b	3) only c and d	4) all
2. For most of the synthetic polymers

1) $\bar{M}_w > \bar{M}_n$	2) $\bar{M}_n > \bar{M}_w$	3) $\bar{M}_n = \bar{M}_w$	4) $\bar{M}_n = 2\bar{M}_w$
----------------------------	----------------------------	----------------------------	-----------------------------
3. If \bar{M}_w is the weight-average molecular weight and \bar{M}_n is the number-average molecular weight of a polymer, the polydispersity index (PDI) of the polymer is given by

1) $\frac{\bar{M}_n}{\bar{M}_w}$	2) $\frac{\bar{M}_w}{\bar{M}_n}$	3) $\bar{M}_w \times \bar{M}_n$	4) $\frac{1}{\bar{M}_w \times \bar{M}_n}$
----------------------------------	----------------------------------	---------------------------------	---
4. \bar{M}_n of a polymer containing 30% molecules with molecular mass 20,000, 40% have 30,000 and the rest have 60,000 is

1) 36×10^5	2) 36×10^3	3) 18×10^3	4) 18×10^5
---------------------	---------------------	---------------------	---------------------
5. The correct formula to calculate the weight average molecular weight of polymers is

1) $\frac{\sum N_i M_i}{\sum N_i}$	2) $\frac{\sum N_i M_i^2}{\sum N_i}$	3) $\frac{\sum N_i M_i}{\sum N_i M_i^2}$	4) $\frac{\sum N_i M_i^2}{\sum N_i M_i}$
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6. In the determination of number average molecular weight of polymers by osmotic pressure experiment, $(\pi/C)_0$ along Y-axis 'c' along X-axis graph, Y intercept i.e., $(\pi/C)_0$ is equal to

1) $RT\bar{M}_n$	2) $\frac{\bar{M}_n}{RT}$	3) $\frac{RT}{\bar{M}_n}$	4) $\frac{R}{\bar{M}_n T}$
------------------	---------------------------	---------------------------	----------------------------
7. 1 kg of ethylene undergo polymerization completely, then the weight of polyethylene obtained is

1) 1000 gm	2) < 1000 gm	3) > 1000 gm	4) 500 gm
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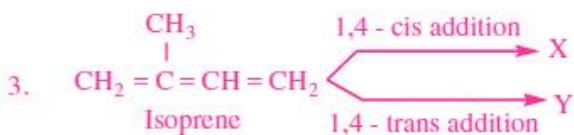
LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The mass average molecular mass and number average molecular mass of a polymer are respectively 40,000 and 30,000. The polydispersity index of polymer will be

a) < 1	b) > 1	c) 1	d) 0
----------	----------	------	------
2. Buna – s is a'

a) addition polymer	b) condensation polymer
c) both a & b	d) none of these

More than One correct answer Type Questions

X and Y are :

- a) X is Natural rubber
 - b) Y is Gutta percha
 - c) X & Y are Natural rubber
 - d) X & Y are Gutta percha
4. Which of the following is correct ?
- a) $\overline{M_w}$ of a polymer is greater than $\overline{M_n}$
 - b) $\overline{M_n}$ of a polymer is greater than $\overline{M_w}$
 - c) For synthetic polymers PDI is greater than 1
 - d) During vulcanization rubber becomes cross linked with zinc oxide
5. Average molecular weight of a polymer can be determined by
- a) Colligative property osmotic pressure
 - b) End group analysis
 - c) Viscosity measurements
 - d) Scattering of light
6. A sample of a polymer contains 200 molecules of molecular mass 10^3 each, 300 molecules of molecular mass 10^4 each and 500 molecules each having 10^5 as a molecular mass . M_n is
- a) 94553
 - b) 53200
 - c) 25,200
 - d) 26,000

Matrix Matching Type Questions7. **Column-I****Molecular mass of Polymer and PDI**

- A) Number avg molecular mass ($\overline{M_n}$)
- B) Weight avg molecular mass ($\overline{M_w}$)
- C) PDI of natural polymer
- D) PDI of synthetic polymer

Column-II**Method of determination of molecular mass of polymer**

- p) Light scattering and ultracentrifuge methods
- q) osmotic pressure method
- r) PDI = 1
- s) PDI > 1

Integer Type Questions

8. A polymer contains 30% molecules with molecular mass 20,000, 40% have 30,000 and rest have 60,000. Its $\overline{M_n}$ is 36×10^x . What is x.
9. In a sample of a polymer, 100 molecules have molecular mass 10^3 each and 200 molecules have molecular mass 10^4 each, the Number average molecular weight of polymer is $x \times 10^3$ then 'x' is
10. Osmotic pressure measurements of a polymer solution at 27°C gave a value for $(\pi/c)_0$ as $2.463 \times 10^{-4} \text{ L atm g}^{-1}$. The $\overline{M_n}$ of the polymer 10^x , x is

EXERCISE-IV

(Bio degradable polymers)

LEVEL-I (MAIN)

Straight Objective Type Questions

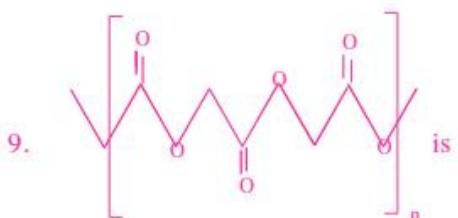
1. Proteins are polyamides of
 - 1) β -amino acids
 - 2) α -amino acids
 - 3) α -hydroxy acids
 - 4) β -keto acids
2. Glucose is stored in our body as
 - 1) Fats
 - 2) Glycogen
 - 3) Lipids
 - 4) Sucrose
3. Which one of the following is not a biopolymer
 - 1) Cellulose
 - 2) Proteins
 - 3) DNA
 - 4) Nylon-6,6
4. Keratin is present in
 - 1) Blood
 - 2) Hair
 - 3) Milk
 - 4) Muscles
5. In which one of polysaccharide, D-glucose units are joined same as in starch
 - 1) Dextron
 - 2) Dextrin
 - 3) Cellulose
 - 4) Lactose
6. Which of the following is not a polymer
 - 1) Silk
 - 2) DNA
 - 3) DDT
 - 4) Dextrin
7. Fibrous and globular proteins are formed due to ----- structure of protein
 - 1) Primary
 - 2) Secondary
 - 3) Tertiary
 - 4) Quaternary
8. Natural starch is a mixture of
 - 1) 10-20% amylopectin and 80-90% amylose
 - 2) 10-20% amylose and 80-90% amylopectin
 - 3) 50% amylose and 50% amylopectin
 - 4) 75% amylose and 25% amylopectin
9. Partial hydrolysis of starch gives
 - 1) Dextrose
 - 2) Dextrin
 - 3) Sucrose
 - 4) Raffinose

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The polymer used for post-operative stitches
 - a) PHBV
 - b) Nylon-2-Nylon-6
 - c) Polylactic acid
 - d) Buna-S
2. Which of the following monomer in excess makes PHBV more flexible
 - a) β -hydroxy butanoic acid
 - b) α -hydroxy butanoic acid
 - c) β -hydroxy pentanoic acid
 - d) α -hydroxy pentanoic acid
3. The first polymer used as biodegradable material is
 - a) Dextrose
 - b) Dextrin
 - c) Dextron
 - d) Dacron
4. Which of the following is a biodegradable polymer
 - a) Cellulose
 - b) Polythene
 - c) PVC
 - d) Nylon 6
5. Polymer used in making capsules
 - a) Poly glycolic acid
 - b) Poly lactic acid
 - c) Nylon-2-Nylon-6
 - d) PHBV
6. Monomers of which one of the following biodegradable polymer are amino acids
 - a) polyglycolic acid
 - b) PHBV
 - c) Nylon - 6
 - d) Nylon - 2- Nylon-6

7. Incorrect statement about PHBV is
- it is co-polymer of 3- hydroxybutanoic acid and 3 - hydroxypentanoic acid
 - it has ester linkage
 - excess of hydroxy pentanoic acid makes the polymer more tougher
 - it undergo degradation by bacteria
8. By which one of the following enzymatic chemical reaction biopolymers undergo degradation
- | | |
|---------------------|------------------------------|
| a) Hydrolysis only | b) Oxidation only |
| c) Dehydration only | d) Oxidation (or) hydrolysis |



- a) polyglycolic acid b) polylactic acid c) PHBV d) Nylon-2-Nylon - 6
10. Which of the following is a bio degradable polymer
- | | | | |
|--------------|-------------|---------|--------|
| a) Polythene | b) Bakelite | c) PHBV | d) PVC |
|--------------|-------------|---------|--------|

Integer Type Questions

11. How many of the following are biodegradable polymers, Nylon-6, Nylon-6,6, Nylon –2– Nylon – 6, starch, PHBV, polyglycolic acid, polylactic acid, polyacrylonitrile.

EXERCISE-V

(Commercial importance of polymers)

LEVEL-I (MAIN)

Straight Objective Type Questions

- The raw materials used in Nylon - 6 is

1) Adipic acid	2) Phthalic acid
3) Ethylene glycol	4) Caprolactam
- Nylon threads are made of

1) Polyethylene polymer	2) Polyvinyl polymer
3) Polyester polymer	4) Polyamide polymer
- Polymers used in unbreakable glass is

1) PMMA	2) Poly vinyl cyanide
3) PVC	4) PVP
- The polymer used in the manufacture of electrical goods such as switches, plugs etc is

1) Polythene	2) Bakelite
3) Neoprene	4) PHBV

LEVEL-II (ADVANCED)

Straight Objective Type Questions

- Which of the following is a polymer containing nitrogen
a) Terylene b) Polythene c) PVC d) Nylon
 - Which of the following monomers gives the polymer neoprene on polymerisation?
a) $\text{CH}_2 = \text{CHCl}$ b) $\text{Cl}_2\text{C} = \text{CCl}_2$ c) $\text{CH}_2 = \underset{\text{Cl}}{\text{C}} - \text{CH} = \text{CH}_2$ d) $\text{CF}_2 = \text{CF}_2$

3. Monomer of $\left(\begin{array}{c} \text{CH}_3 \\ | \\ -\text{C}-\text{CH}_2- \\ | \\ \text{CH}_3 \end{array} \right)_n$ is
- 2-methyl propene
 - Styrene
 - Propylene
 - Ethene
4. Polymer used in bullet proof is or plexi glass is
- Polystyrene
 - Poly acrylonitrile
 - Poly ethyl acrylate
 - Polymethyl methacrylate
5. The catalyst used for the polymerisation of olefins is
- Ziegler Natta catalyst
 - Wilkinson's catalyst
 - Pd - catalyst
 - Zeise's salt catalyst
6. Which of the following polymer is an example of fibre
- Silk
 - Dacron
 - Nylon 66
 - All of these
7. Which of the following is not correct regarding terylene
- Step growth polymer
 - Synthetic fibre
 - Condensation polymer
 - Thermosetting plastic

More than One correct answer Type Questions

8. Example of addition polymer is
- buna-S
 - PVC
 - nylon-6
 - neoprene
9. Which of the following set(s) contains only addition polymers?
- Polyethylene, polypropylene, terylene
 - Polyethylene, PVC, acrolin
 - Buna-S, nylon, polybutadiene
 - Neoprene, orlon, teflon
10. Teflon, polystyrene and neoprene are all
- copolymers
 - condensation polymers
 - homopolymers
 - addition polymers
11. Dacron is an example of
- Polamide
 - Polypropylene
 - Polyurethane
 - Polyester
12. Which one of the following is/are not a thermosetting polymer
- Nylon - 6
 - Nylon- 6,6
 - Bakelite
 - SBR
13. Polymer obtained by condensation polymerization is
- Polyethene
 - Bakelite
 - PVC
 - Phenol-formaldehyde resin
14. Melamine plastic crockery is a copolymer of
- HCHO
 - Ethylene
 - Melamine
 - Malonic acid

Linked Comprehension Type Questions***Passage***

The polymer which can conduct electricity is called conducting polymers. The conducting polymers may be conductive element filled polymers or conjugated π - electrons conducting polymer or it can also be doped conducting polymer or bledded conducting polymers. Conducting polymers find great importance in electronics, micro electronics and biomedical fields.

15. Which of the following is a conducting polymer
 a) Poly caprolactam b) Polyacrylic acid c) Polyacetylene d) Poly ethylene
16. Which polymer is used in batteries
 a) PVC b) Polypyrrole c) Polymethylacrylate d) None
17. Presence of conjugated π - electrons in a polymer
 a) Increases its conductivity b) Decreases its conductivity
 c) May increase or decrease its conductivity d) None

Matrix Matching Type Questions

18. **Column-I**
- A) PAN
 - B) PMMA
 - C) PVC
 - D) PTFE
- Column-II**
- p) Orlon
 - q) Plexiglass
 - r) Thermoplastics
 - s) Teflon

19. **Column-I**
- A) Terylene
 - B) Bakelite
 - C) neoprene
 - D) Polystyrene
- Column-II**
- p) Elastomer
 - q) fibre
 - r) thermo setting
 - s) addition polymer
 - t) condensation polymer

20. **Column-I**
- A) PVC
 - B) Teflon
 - C) nylon-6
 - D) PET
- Column-II**
- p) adhesives
 - q) cooking ware
 - r) textiles
 - s) ropes
 - t) homo polymer

Integer Type Questions

21. The ratio between homopolymers and Co-polymers of the following compounds will be PVC, polystyrene, Nylon-6, PCTFE, PTFE, Dynel, Vynylon, Saran, Chloroprene, Polyisoprene, PMMA, HDPE.

KEY SHEET (LECTURE SHEET)**EXERCISE - I**

- | | | | | | | | | |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|
| LEVEL-I | 1) 4 | 2) 2 | 3) 4 | 4) 4 | 5) 1 | 6) 2 | 7) 4 | 8) 4 |
| | 9) 4 | 10) 1 | 11) 3 | 12) 3 | 13) 2 | 14) 2 | 15) 1 | 16) 2 |
| | 17) 2 | | | | | | | |

- | | | | | | | | | |
|-----------------|--------|--------|------------------------|--------|---------|-------|--------------------------------|-------|
| LEVEL-II | 1) d | 2) d | 3) a | 4) b | 5) abc | 6) ad | 7) abcd | |
| | 8) abc | 9) acd | 10) ac | 11) ab | 12) abc | 13) d | 14) d | 15) b |
| | 16) a | 17) d | 18) A-p; B-s; C-q; D-r | | | | 19) A-pst; B-prt; C-qrt; D-qst | |
| | 20) 2 | 21) 2 | 22) 6 | 23) 3 | 24) 6 | | | |

EXERCISE - II

LEVEL-I

- 1) 2 2) 3 3) 4 4) 4 5) 3 6) 1 7) 4 8) 3
9) 1 10) 3 11) 4 12) 3

LEVEL-II

- 1) a 2) b 3) b 4) c 5) ac 6) ad 7) abcd 8) abd
9) abd 10) b 11) c 12) a 13) A-st; B-pr; C-pq; D-s 14) 5

EXERCISE - III

LEVEL - I

- 1) 2 2) 1 3) 2 4) 2 5) 4 6) 3 7) 1

LEVEL-II

- 1) b 2) a 3) ab 4) ac 5) abcd 6) b
7) A-q; B-p; C-r; D-s 8) 3 9) 7 10) 5

EXERCISE - IV

LEVEL 1

- 1) 2 2) 2 3) 4 4) 2 5) 2 6) 3 7) 3 8) 2
9) 2

LEVEL-II

- 1) c 2) c 3) c 4) a 5) d 6) d 7) c 8) d
9) a 10) c 11) 5

EXERCISE - V

LEVEL - I

- 1) 4 2) 4 3) 1 4) 2 5) 4 6) 2 7) 3 8) 2
9) 2 10) 2 11) 3 12) 3 13) 1 14) 1

LEVEL-II

- 1) d 2) c 3) a 4) d 5) a 6) d 7) d 8) abd
9) bd 10) cd 11) cd 12) abd 13) bd 14) ac 15) c 16) b
17) a 18) A-p; B-q; C-r; D-s 19) A-qt; B-rt; C-ps; D-s
20) A-pt; B-qt; C-rt; D-s 21) 3

PRACTICE SHEET

EXERCISE-I

(Classification & Polymerisation process)

LEVEL-I (MAIN)

Straight Objective Type Questions

- $$\text{Phenol} \xrightarrow{\text{Raney nickel}} \text{Benzene} \xrightarrow{\text{CrO}_3/\text{H}_2\text{SO}_4} \text{Benzaldehyde} \xrightarrow{\text{H}_2\text{NOH}} \text{Benzyl alcohol} \xrightarrow{\text{H}_2\text{SO}_4 \text{ and heat}} \text{Benzyl sulfide} \xrightarrow{\text{H}_2\text{O, heat}} \text{Benzyl alcohol}$$

Polymer. The polymer is:

- 1) Dacron 2) Nylon-6 3) Nylon-6, 6 4) None of them

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. What are the monomers in Kevlar ?
a) terephthalic acid and P-phenylenediamine
c) phthalic acid & m-diamino benzene
b) phthalic acid & p-phenylene diamine
d) terephthalic acid & m-diamino benzene
 2. What are the monomers in Nomex ?
a) terephthalic acid and P-phenylenediamine
c) phthalic acid & m-diamino benzene
b) phthalic acid & p-phenylene diamine
d) terephthalic acid & m-diamino benzene
 3. Polystyrene is a
a) addition polymer
c) both a and b
b) thermoplastic polymer
d) none

4. Caprolactum polymerises to give
 a) Nylon-6 b) Buna-s c) Glyptal d) Teflon
5. Plexiglass is a commercial name of
 a) glyptal b) poly acrylnitrile
 c) polymethyl methacrylate d) polyethyl crylate
6. Which of the following statement is not true?
 a) natural rubber has the trans-configuration at every double bond
 b) Buna-s is a copolymer of butadiene and styrene
 c) Natural rubber is a, 1, 4 polymer of isoprene
 d) In vulcanization the formation of sulphur bridges b/w different chains make rubber harder and stronger
7. Di-n-butyl phthalate is a
 a) plasticizer b) antibiotic
 c) natural rubber d) bio-degradable polymer

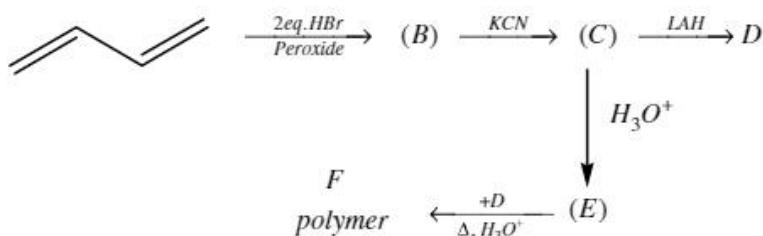
More than One correct answer Type Questions

8. Example of addition polymer is
 a) buna-S b) PVC c) nylon-6 d) neoprene
9. Chain initiation and chain propagation steps are involved in
 a) Cationic polymerization b) Anionic polymerization
 c) Free radical polymerization d) Condensation polymerization
10. Cationic polymerisation is initiated by
 a) BF_3 b) NaNH_2 c) BuLi d) SnCl_4
11. Which of the following set(s) contains only addition polymers?
 a) Polyethylene, polypropylene, terylene b) Polyethylene, PVC, acrolin
 c) Buna-S, nylon, polybutadine d) Neoprene, orlon, teflon
12. Which of the following is chain growth polymer
 a) Polypropylene b) Neoprene c) Nylon-6,6 d) Nylon-6
13. Polyethylene is
 a) Random copolymer b) Homopolymer
 c) Alternate copolymer d) Chain growth polymer
14. Teflon, polystyrene and neoprene are all
 a) copolymers b) condensation polymers
 c) homopolymers d) addition polymers
15. Which of the following is/are not a chain-growth polymer?
 a) Orlon b) Terylene c) Nylon-6 d) Glyptal
16. Which of the following is/are not a step-growth polymer?
 a) Orlon b) Terylene c) Teflon d) Styrene
17. Glyptal polymer is obtained from phthalic acid by treating it with
 a) Malonic acid b) Glycerol c) Maleic acid d) Ethylene glycol
18. Melamine plastic crockery is a copolymer of:
 a) HCHO b) Ethylene c) Melamine d) Malonic acid

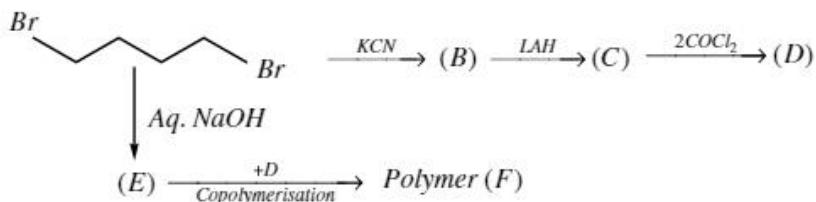
19. Which are true for elastomers ?
- They possess elasticity
 - These possess weakest intermolecular forces of attraction between polymer chains
 - These possess strongest inter molecular forces of attraction between polymer chains
 - Buna rubber is an example of elastomer
20. Which of the following statements about addition polymerisation are correct?
- Monomers containing C = C bond can undergo this polymerisation.
 - Polymer molecules many contain C = C bond
 - Addition polymers are formed by chain reactions
 - Molecular weight of addition polymer molecule is integral multiples of molecular weight of its monomers
21. Which of the following statements about condensation polymers are correct?
- Condensation polymer molecule does not contain same number of atoms as the number of atoms present in all monomers
 - Monomers of condensation polymers have polyfunctional groups
 - Majority of condensation polymers are co-polymers
 - Molecular weight of condensation polymer molecule is integral multiples of molecular weight of its monomers
22. Chain-growth polymerization may proceed by the following mechanism
- | | |
|--------------------------------|----------------------------|
| a) Free radical polymerization | b) Cationic polymerization |
| c) Anionic polymerization | d) None of the above |

Linked Comprehension Type Questions

Passage -I:



23. Compound (D) is
- $\text{H}_2\text{N}(\text{CH}_2)_4\text{NH}_2$
 - $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$
 - $\text{OHC}(\text{CH}_2)_4\text{CHO}$
 - $\text{OHC}(\text{CH}_2)_6\text{NH}_2$
24. Compound (E) is
- $\text{OHC}(\text{CH}_2)_4\text{CHO}$
 - $\text{OHC}(\text{CH}_2)_4\text{COOH}$
 - $\text{OHC}(\text{CH}_2)_6\text{COOH}$
 - $\text{HOOC}(-\text{CH}_2-)_4\text{COOH}$
25. Polymer (F) is
- Nylon – 6
 - Dacron
 - Nylon –6, 6
 - Nylon – 6, 10

Passage - II:

26. The compound (D) is

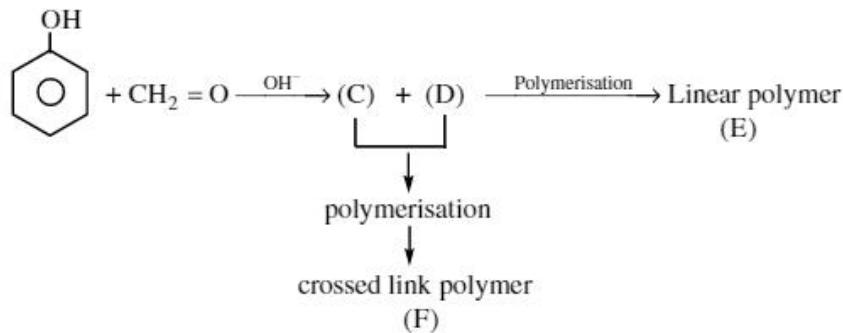
- a) $\text{O} = \text{C} = \text{N}(\text{CH}_2)_6\text{N} = \text{C} = \text{O}$
 b) $\overset{(-)}{\text{C}} \equiv \overset{(+)}{\text{N}} - (\text{CH}_2)_6 \overset{(+)}{\text{N}} \equiv \overset{(-)}{\text{C}}$
 c) $\text{O} = \text{C} = \text{N}(\text{CH}_2)_4\text{N} = \text{C} = \text{O}$
 d) $\overset{(-)}{\text{C}} \equiv \overset{(+)}{\text{N}} - (\text{CH}_2)_6 - \text{N} = \text{C} = \text{O}$

27. Compound (E) is

- a) b) $\text{Me} - \equiv - \text{Me}$ c) $\text{HO} \text{---} \text{CH}_2 \text{---} \text{CH}_2 \text{---} \text{CH}_2 \text{---} \text{HO}$ d) $\text{Br} \text{---} \text{CH}_2 \text{---} \text{CH}=\text{CH}_2$

28. The polymer (F) is

- a) Polyurethane b) Perlon – U c) Both a & b d) Nylon – 6

Passage - III:

29. The compounds (C) and (D) are

- a) b) c) d)

30. The linear polymer (E) is

- a) Resol b) Novolac c) Both a and b d) Decron

31. The cross - linked polymer (F) is

- a) Resol b) Novolac c) Bakelite d) Decorn

Matrix Matching Type Questions**32. Column-I****Compound**

- A) Benzoquinone
 B) CCl_4 and CBr_4
 C) Benzoyl peroxide
 D) t-butyl peroxide

Column-II**Characteristic property**

- p) Free radical initiator
 q) Free radical inhibitor
 r) Chain transfer agents
 s) Biopolymerer

33. Match the following correctly**Column-I****(Polymer)**

- A) Kevlar
 B) Nomex
 C) Lexan
 D) Nylon-6

- | | | | |
|----|-----|-----|----|
| A | B | C | D |
| a) | iv | iii | ii |
| c) | iii | i | ii |
| | | | iv |

Column-II**(Monomers)**

- i) Phthalic acid and m-diamino benzene
 ii) terephthalic acid and p-phenylene diamine
 iii) diethyl carbonate and bisphenol-A
 iv) Caprolactum

- | | | | |
|----|----|----|-----|
| A | B | C | D |
| b) | ii | i | iii |
| d) | iv | ii | i |
| | | | iii |

34. Column-I

- A) HDPE
 B) Polypropene
 C) PVC
 D) Dacron

Column-II

- p) Cationic addition polymerisation
 q) Condensation polymerisation
 r) Free radical addition polymerisation
 s) Anionic addition polymersation

35. Match the following correctly**Column-I****(Polymer)**

- A) PGA
 B) PLA
 C) PCL
 D) Nylon-2-Nylon-6

- | | | | |
|----|-----|-----|----|
| A | B | C | D |
| a) | iv | iii | ii |
| c) | iii | i | ii |
| | | | iv |

Column-II**(Monomers)**

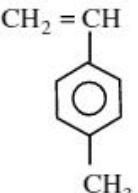
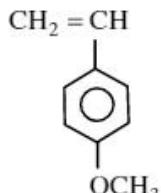
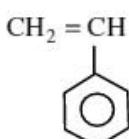
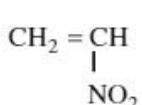
- i) Lactic acid
 ii) β -Hydroxy Hexanoic acid
 iii) Glycolic acid
 iv) Glycine and Amino Caproic acid

- | | | | |
|----|-----|---|-----|
| A | B | C | D |
| b) | ii | i | iii |
| d) | iii | i | ii |
| | | | iv |

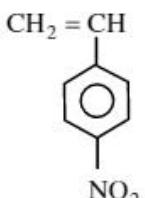
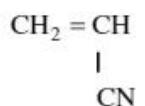
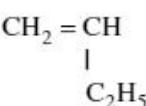
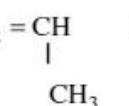
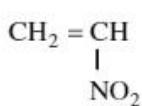
Integer Type Questions

36. The number of alternating Co-polymers in the following are, Nylon-6, Nylon -6, 6, PET, Neoprene, Buna-S, polyisoprene, PTFE, PVC, Bakelite.
37. The number of types of Co-polymers depend on the nature of distribution of two different monomers are ____ .

38. The ratio between homopolymers and Co-polymers of the following compounds will be PVC, polystyrene, Nylon-6, PCTFE, PTFE, Dynel, Vynylon, Saran, Chloroprene, Polyisoprene, PMMA, HDPE.
39. What are the oxidation states Al and Ti in the Zeigler -Natta catalyst?
40. How many of them are more reactive than $\text{CH}_2 = \text{CH}_2$ in the cationic polymerization?



41. How many of them are more reactive than $\text{CH}_2 = \text{CH}_2$ in the anionic polymerization



EXERCISE-II

(Natural Rubber & Synthetic Rubber)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. One would come across the terms isotactic, syndiotactic and atactic in connection with the chemistry of
 1) Polymers 2) Dyes 3) Crystals 4) Textiles
2. The commercial name of polymethyl methacrylate is
 1) Lucite 2) Plexiglass 3) Perspex 4) all of the above
3. The turbidity of a polymer solution measures
 1) light absorbed by the solution
 2) light transmitted by a solution
 3) light scattered by the solution
 4) none of the above
4. The mono unit of silicon, a water repellent, acid resistant and heat resistant, polymer is
 1) Si 2) SiO_2 3) R_2SiO 4) None of these
5. Synthetic human hair wigs are made from a copolymer of vinyl chloride and acrylonitrile, which is called
 1) PVC 2) polyacrylonitrile 3) cellulose 4) Dynel
6. Which of the following polymers can be used for lubrication and as an insulator.
 1) SBR 2) PAn 3) PTFE 4) PVC

7. Vulcanised rubber resists
- wear and tear due to friction
 - cryogenic temperature
 - high temperature
 - action of acids

LEVEL-II (ADVANCED)***More than One correct answer Type Questions***

- Vulcanised rubber resists
 - wear and tear due to friction
 - cryogenic temperature
 - high temperature
 - action of acids
- Which of the following polymer contain 1, 3 buta diene as one of the monomers?
 - ABS plastic
 - SBR
 - Saran
 - Nitrile rubber

Matrix Matching Type Questions

- | | | | | | |
|----------------------------------|----------------------|------------------------------|-----|----|-----|
| 3. Column-I | Column-II | | | | |
| A) DOP | p) Natural | | | | |
| B) O – cresyl phosphate | q) Plasticiser | | | | |
| C) Bakelite | r) Synthetic polymer | | | | |
| D) Cellulose | s) Thermosetting | | | | |
| 4. Match the following correctly | | | | | |
| Column-I | | | | | |
| (Catalyst) | | | | | |
| A) V_2O_5 | | | | | |
| B) Ziegler-Natta | | | | | |
| C) Peroxide | | | | | |
| D) Finely divided Fe | | | | | |
| A | B | C | D | | |
| a) iv | i | ii | iii | | |
| c) iii | i | ii | iv | | |
| | | A | B | C | D |
| | | b) iv | iii | ii | i |
| | | d) iv | ii | i | iii |
| | | i) High density polyethylene | | | |
| | | ii) Polyacrylonitrile | | | |
| | | iii) NH_3 | | | |
| | | iv) H_2SO_4 | | | |

Integer Type Questions

- What are the oxidation states Al and Ti in the Zeigler –Natta catalyst?
- The ratio of ' π ' bond between monomer units of Buna–N is $0.3x$. What is x ?

EXERCISE-III***(Molecular weight of polymers)*****LEVEL-I (MAIN)*****Straight Objective Type Questions***

- A sample of a polymer contains 200 molecules of molecular mass 10^3 each, 300 molecules of molecular mass 10^4 each and 500 molecules each having 10^5 as a molecular mass. \bar{M}_n is
 - 94553
 - 53200
 - 25,200
 - 26,000

LEVEL-II (ADVANCED)

More than One correct answer Type Questions

1. Which of the following is correct ?
 - a) $\overline{M_w}$ of a polymer is greater than $\overline{M_n}$
 - b) $\overline{M_n}$ of a polymer is greater than $\overline{M_w}$
 - c) For synthetic polymers PDI is greater than 1
 - d) During vulcanization rubber becomes cross linked with zinc oxide
2. Average molecular weight of a polymer can be determined by
 - a) Colligative property osmotic pressure
 - b) End group analysis
 - c) Viscosity measurements
 - d) Scattering of light
3. The most suitable method for determination of the molecular mass of polymer is/are
 - a) Osmotic pressure
 - b) End group analysis
 - c) Elevation in boiling point
 - d) Depression in freezing point

Matrix Matching Type Questions

- | | |
|--|---|
| 4. Column-I
Molecular mass of
Polymer and PDI | Column-II
Method of determination of
molecular mass of polymer |
| A) Number avg molecular mass ($\overline{M_n}$) | p) Light scattering and ultracentrifuge methods |
| B) Weight avg molecular mass ($\overline{M_w}$) | q) osmotic pressure method |
| C) PDI of natural polymer | r) $PDI = 1$ |
| D) PDI of synthetic polymer | s) $PDI > 1$ |

Integer Type Questions

5. A polymer has weight average molecular weight is 40% more than is number average molecular weight. Its PDI is equal to $0.7x$. What is x ?

EXERCISE-IV

(Bio degradable polymers)

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Elastomers among the following are
 - a) Buna-N
 - b) Buna-S
 - c) Neoprene
 - d) All
2. Which of the following sets contain only addition homopolymer
 - a) polyethene, naturalrubber, cellulose
 - b) Starch, nylon, polyester
 - c) Teflon, Bakelite, Orlon
 - d) Neoprene, PVC, Polyethene

More than One correct answer Type Questions

3. Which of the following is a biodegradable polymer
a) PHBV b) Polyglycolic acid c) PMMA d) Nylon -2-Nylon-6
4. Which of the following is/are not natural polymer ?
a) Terylene b) Orlon c) Starch d) Dacron
5. PCL polymer is a
a) copolymer polymer b) Homo polymer
c) condensation polymer d) addition polymer

Matrix Matching Type Questions

6. Match the following correctly

Column-I (Polymer)				Column-II (Monomers)			
A) PGA				i) Lactic acid			
B) PLA				ii) β -Hydroxy Hexanoic acid			
C) PCL				iii) Glycolic acid			
D) Nylon-2-Nylon-6				iv) Glycine and Amino Caproic acid			
A B C D				A B C D			
a) iv iii ii i				b) ii i iii iv			
c) iii i ii iv				d) iii i ii iv			

Integer Type Questions

7. How many of them are bio-degradable Ester linkage polymers PHB, PHBV, PGA, Nylon-2, 6, PCL
8. How many of the following are biodegradable co-polymers ? Nylon-2, Nylon-6, PHBV, PGA, PLA, melamine
9. How many of the following are biodegradable homopolymers ? PCL, PHBV, Nylon-6, 6, PHB, Teflon, Bakelite
10. In the following polymer of monomer having how many –OH and –COOH groups? PHB, PLA, PCL

EXERCISE-V*(Commercial importance of polymers)***LEVEL-I (MAIN)***Straight Objective Type Questions*

1. Caprolactum is used to prepare which of the following polymer
1) Nylon-6,6 2) Malamine 3) Nylon-6 4) PMMA
2. Melmac is a polymer of melamine and
1) Glycerol 2) Formaldehyde 3) Cyclohexane 4) Caprolactum
3. Buna-S is obtained by the Co-polymerisation of
1) Chloroprene 2) Styrene 3) Acrylonitrile 4) Adipic acid

4. Which of the following is a linear polymer
 1) Nylon 2) Bakelite 3) Alkyd resin
 4) Melamine-formaldehyde polymer
5. Among the following branched chain polymer is
 1) PVC 2) Polyester 3) Low density polymer 4) Nylon -6,6

LEVEL-II (ADVANCED)***Straight Objective Type Questions***

1. The turbidity of a polymer solution measures
 a) light absorbed by the solution b) light transmitted by a solution
 c) light scattered by the solution d) none of the above
2. Drink and baby feeding bottles are generally made of
 a) poly-urea b) polyurethane c) polyester d) polyamide
3. Which of the following is used to make paints and lacquers?
 a) Polystyrene b) Polyvinyl chloride c) Glyptal d) Nylon
4. Which of the following used for preparation of bullet proof windows and safty (or) crash helmets
 a) Kevlar b) Nomex c) Lexan d) None
5. Plexiglass is a commercial name of
 a) glyptal b) poly acrylnitrile
 c) polymethyl methacrylate d) polyethyl crylate

KEY SHEET (PRACTICE SHEET)**EXERCISE - I**

LEVEL-I	1) 2	2) 3	3) 1	4) 4	5) 3	6) 3	7) 3	8) 4
	9) 1	10) 1						

LEVEL-II	1) a	2) c	3) c	4) a	5) c	6) a	7) a	8) abd
	9) bc	10) ad	11) bd	12) ab	13) bd	14) cd	15) bcd	16) acd
	17) d	18) ac	19) abd	20) abcd	21) abc	22) abc	23) b	24) d
	25) c	26) a	27) c	28) c	29) b	30) c	31) c	
	32) A-q; B-r; C-p; D-p		33) b	34) A-r; B-p; C-s; D-q				
	35) c	36) 4		37) 4	38) 3	39) 3,4	40) 3	41) 3

EXERCISE - II

LEVEL-I	1) 1	2) 4	3) 3	4) 3	5) 4	6) 3	7) 1
LEVEL-II	1) a	2) a	3) A-q; B-q; C-rs; D-p		4) a	5) 3,4	
	6) 5						

EXERCISE - III

LEVEL-I	1) 2
LEVEL-II	1) ac 2) abcd 3) ab 4) A-q; B-p; C-r; D-s 5) 2

EXERCISE - IV

LEVEL-II

- 1) d 2) d 3) bd 4) abd 5) bc 6) c 7) 4 8) 2
 9) 3 10) 1

EXERCISE - V

LEVEL-I

- 1) 1 2) 2 3) 2 4) 1 5) 3

LEVEL-II

- 1) c 2) c 3) c 4) c 5) c

ADDITIONAL PRACTICE EXERCISE

LEVEL-I (MAIN)

Straight Objective Type Questions

- Which of the following is incorrect
 - Polyethylene contains double bonds
 - The monomer used to make teflon is C_2F_4
 - Condensation polymers are also known as step growth polymers.
 - A denatured protein could have the same primary structure as the active protein
- Inorganic polymer among the following is
 - Rayon
 - Starch
 - Silicone rubber
 - Natural rubber
- In which one of the following type of polymerization generally no initiator is required
 - Cationic polymerization
 - Anionic polymerization
 - Free radical polymerization
 - Condensation polymerization
- Initiators that can be used in cationic polymerization is/are
 - KNH_2
 - H_2SO_4
 - BF_3 with little amount of H_2O
 - t - butyl peroxide

The correct answer is

- All are correct
- only a
- only b and c
- only a and d

LEVEL-II

LECTURE SHEET (ADVANCED)

Straight Objective Type Questions

- Glyptal polymer is obtained from phthalic acid by treating it with
 - Malonic acid
 - Glycerol
 - Maleic acid
 - Ethylene glycol
- Which of the following sets contain only addition polymers
 - Polyethene, terylene, PVC
 - Teflon, PVC, PAN
 - Buna-S, PVC, Bakelite
 - Buna – N, PVC, Bakelite
- IUPAC name of chloroprene is
 - 1 – chloro – 1, 3 – butadiene
 - 2 – chloro – 1, 3 – butadiene
 - 1 – chloro – butadiene
 - 2 – chloro – 1, 2 – butadiene

4. Which of the following used to coagulate the rubber latex ?
 - a) HCOOH
 - b) H₂O
 - c) CH₃COOH
 - d) C₆H₆
5. A polymer commonly used for making non-stick cookware is
 - a) SBR
 - b) Teflon
 - c) PVC
 - d) Poly ethyl acrylate
6. Bakelite is obtained from phenol by reacting with
 - a) CH₃CHO
 - b) CH₃COCH₃
 - c) HCHO
 - d) (CH₂OH)₂

More than One correct answer Type Questions

7. Which of the following statements about terylene are correct
 - a) It is poly ester
 - b) It is obtained by the reaction between ethylene glycol and terephthalic acid
 - c) It is a condensation polymer
 - d) It is a natural polymer
8. Polymers can be classified on the basis of
 - a) Origin
 - b) Structure
 - c) Mechanism
 - d) Synthesis
9. Which one of the following is branch-chain polymer
 - a) Glycogen
 - b) Terylene
 - c) Cellulose
 - d) Silicones
10. Chain initiation and chain propagation steps are involved in
 - a) Cationic polymerization
 - b) Anionic polymerization
 - c) Free radical polymerization
 - d) Condensation polymerization
11. Polyethylene is
 - a) Random copolymer
 - b) Homopolymer
 - c) Alternate copolymer
 - d) Chain growth polymer

Linked Comprehension Type Questions

Passage

The combination of several monomers under suitable experimental condition to form a giant, three dimensional polymer is known as polymerisation. Natural polymers are classified on the basis of their chemical composition. Synthetic polymers are classified on the basis of the physical properties, into elastomers, plastics and fibres

12. Identify the incorrect statement regarding thermosetting polymers
 - a) They soften on heating
 - b) They are formed by condensation reaction
 - c) They have cross-linked structure
 - d) They are hard rigid are brittle
13. Which pair corresponds to fibre polymer
 - a) Polythene, PMMA
 - b) Polythene, Nylon 66
 - c) Urea- formaldehyde, PMMA
 - d) Polyester, PAN
14. Saran is
 - a) An addition homopolymer
 - b) A co-polymer of vinyl chloride and vinylidene chloride
 - c) A condensation homopolymer
 - d) A condensation co-polymer

Matrix Matching Type Questions

- | 15. Column-I | Column-II |
|---------------------|----------------------------|
| A) Styrene | p) Step - growth polymer |
| B) Dacron | q) Chain- growth copolymer |
| C) Nylon-6, 6 | r) Amide linkages |
| D) Proteins | s) Ester linkages |

Integer Type Questions

16. Co-polymers in the following are bakelite, melamine, buna-S, Nylon-6,6, PMMA, teflon, HDPE, Terylene, Polysiloxane, Polyvinyl Pyrrolidene.

17. The number of chain growth polymers among polypropylene, neoprene, Nylon-6,6; PAN; bakelite, terylene.

18. Polymers containing –CONH– linkage among; nylon, bakelite, urea formaldehyde resin, buna-S, neoprene, natural rubber, proteins.

19. How many of the following are condensation polymers ?
Terylene, Teflon, nylon, cellulose, starch, proteins, bakelite, melamine, PVC, PAN

20. How many of the following are homopolymers ?
Polystyrene, Dacron, nylon-66, Bakelite, PVC, PAN, Teflon, Rayon

PRACTICE SHEET (ADVANCED)

Straight Objective Type Questions

- Heating rubber to high temperature in the absence of air or O₂ gives
 - CO₂
 - CH₄
 - CH₂ = C - CH = CH₂
 |
 CH₃
 - CH₂ = C - C = CH₂
 | |
 CH₃ Cl
 - Rubber latex is
 - Emulsion of polyhydrocarbon droplets in an aqueous solution
 - Milk white suspension of crude rubber in CCl₄
 - True solution of crude rubber in water
 - True solution of crude rubber in alcohol
 - A non-elastic, hard material known as ebonite is formed when crude rubber is heated with
 - 5% of sulphur
 - 20 % of sulphur
 - 30 % of sulphur
 - 40 - 45% of sulphur
 - For a class of proteins the correct relation among the following is
 - $\overline{M}_w > \overline{M}_n$
 - $\overline{M}_n > \overline{M}_w$
 - $\overline{M}_n = \overline{M}_w$
 - $\overline{M}_n = 2\overline{M}_w$

More than One correct answer Type Questions

7. Which of the following is/are not a fibre ?
 a) Bakelite b) Polyethylene c) Nylon-6 d) Natural rubber

Integer Type Questions

8. How many of the following are co polymers ?
 Polystyrene, Polyester, Bakelite, Buna – N-Rubber, Buna – S-Rubber, glyptal, Teflon, Terylene, polythene
9. Total number of ' π ' – bonds present in styrene is
10. How many of the following are synthetic polymers ?
 Cellulose, cellulose nitrate, rayon, nylon, teflon, P.V.C., polyacrylonitrile, terylene

KEY SHEET (ADDITIONAL PRACTICE EXERCISE)**LEVEL-I (MAIN)**

- 1) 1 2) 3 3) 4 4) 3

LEVEL-II**LECTURE SHEET (ADVANCED)**

- 1) d 2) b 3) b 4) ac 5) b 6) c 7) bc 8) bc 9) cd 10) abc
 11) bd 12) a 13) d 14) b 15) A-q; B-ps; C-pr; D-pr 16) 6 17) 3 18) 3
 19) 7 20) 4

PRACTICE SHEET (ADVANCED)

- 1) c 2) a 3) d 4) c 5) ab 6) bcd 7) abd 8) 6 9) 4 10) 5

Numerical Exercise

1. In the monomer of polymer acrilan how many π – bonds are present
2. Ozonolysis experimental on natural rubber suggested that the isoprene units are joined head-to-tail by x,y-links where x and y are numbers. What is value of x+y?
3. In the monomer of polymer Neoprene. how many σ – bonds are present
4. Nylon – x – nylon – y is an alternating polyamide and a biodegradable polymer. If x, y are numbers. What is value of x + y?
5. How many fluorine atoms are present in monomer of polymer fluon?
6. $(CH_3CH_2)_xAl+Ticly$ is Ziegler – Natta catalyst. If x and y are numbers what is value of x + y.

KEY SHEET (Numerical Exercise)

- 1) 3 2) 5 3) 9 4) 8 5) 4 6) 7

