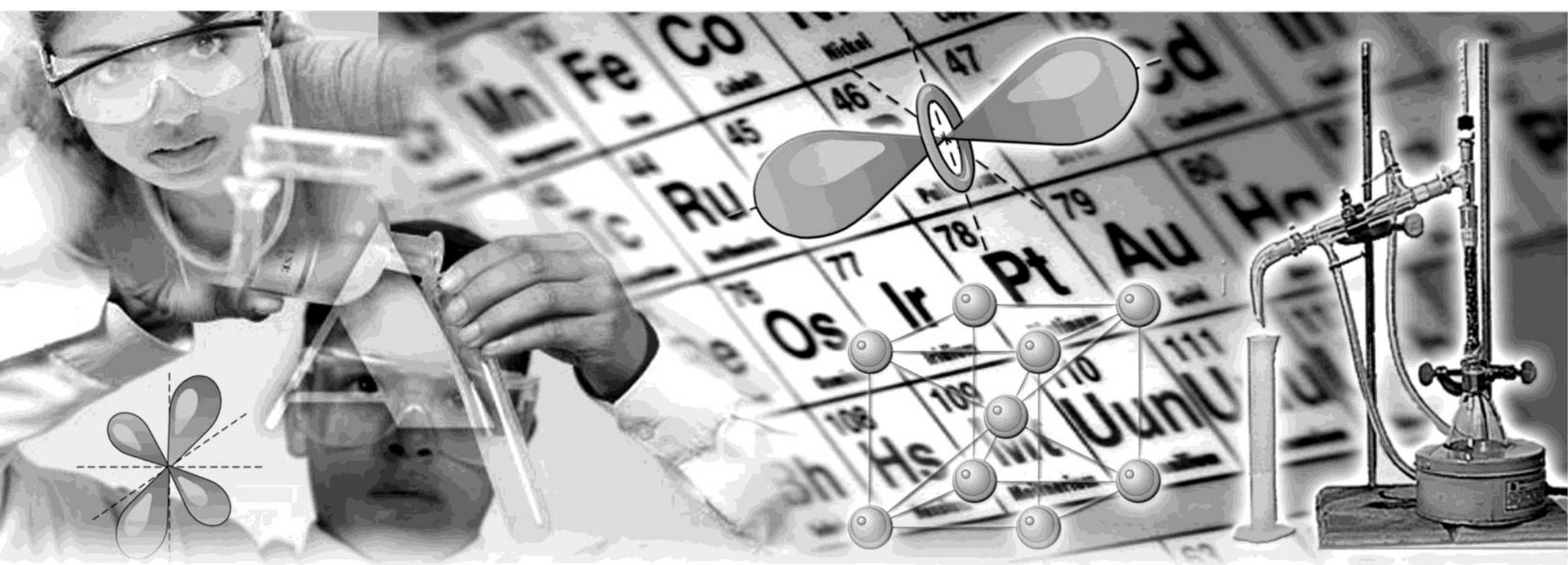


Chapter

30

Polymer

Polymers are compound of very high molecular masses formed by the combination of a large number of simple molecules.

The simple molecules which combine to give polymers are called monomers. The process by which the simple molecule (i.e. monomers) are converted into polymers is called polymerisation.

Example : Polyethylene

❑ All polymers are macromolecule but all macromolecules are not polymers because polymer consist repeating unit of monomer e.g., chlorophyll is a macromolecule but not a polymer.

Classification of polymers

(1) **Classification based on source of availability :** They are classified as

(i) Natural polymers (ii) Synthetic polymers
(iii) Semi-synthetic polymers

(i) ***Natural polymers*** **:** The polymers obtained from nature (plants and animals) are called natural polymers. These polymers are very essential for life. They are as under.

(a) *Starch* **:** It is polymer of glucose and it is food reserve of plant.

(b) *Cellulose* **:** It is also a polymer of glucose. It is a chief structural material of the plant both starch and cellulose are made by plants from glucose produced during photosynthesis.

(c) *Proteins* **:** These are polymers of α-amino acids, they have generally 20 to 1000 α amino acid joined together in a highly organized arrangement. These are building blocks of animal body and constitute an essential part of our food.

(d) *Nucleic acids* : These are polymers of various nucleotides. For example RNA and DNA are common nucleotides.

❑ It may be noted that polymers such as polysaccharides (starch, cellulose), proteins and nucleic acids etc. which control various life processes in plants and animals are also called ***biopolymers***.

(ii) ***Synthetic polymers*** **:** The polymers which are prepared in the laboratories are called synthetic polymers. These are also called man made polymers. For example polyethene, PVC nylon, teflon, bakelite terylene, synthetic rubber etc.

(iii) ***Semisynthetic polymers*** **:** These polymers are mostly derived from naturally occurring polymers by chemical modifications. For example cellulose is naturally occurring polymers, cellulose on acetylation with acetic anhydride in the presence of sulphuric acid forms cellulose diacetate polymers. It is used in making thread and materials like films glasses etc. Vulcanized rubber is also an example of semisynthetic polymers used in making tyres etc. gun cotton which is cellulose nitrate used in making explosive.

❑ ***Semi-synthetic polymers :*** Rayon and other cellulose derivatives like cellulose nitrate, cellulose acetate etc., are semi-synthetic polymers. These are thermoplastic polymers. Viscose rayon in the form of a thin transparent film is known as cellophane. Cellophane is softened with glycerol. Unlike plastic sheets it absorbs water.

❑ ***Rayon :*** Rayon is a man made material which consists of purified cellulose in the form of long fibres. Cellulose is treated with cold $NaOH$ solution to purify it and then treated with CS_2 to form a viscose solution.

This is why rayon is sometimes called viscose rayon. This solution is allowed to pass through fine pores in metal cylinder, into a dilute solution of H_2SO_4. This results in the formation of long fibres. Rayon fibre is chemically identical to cotton but has a shine like silk. As such rayon is also known as ***artificial silk***. Rayon is used on a large scale for making textiles, tyre-chord, carpets and surgical dressings. Unlike fully synthetic polymers, it absorbs moisture and is bio-degradable.

(2) **Classification based upon structure :** On the basis of structure of polymers these can be classified as

(i) Linear polymers (ii) Branched chain polymers (iii) Cross linked polymers

(i) ***Linear polymers*** **:** These are polymers in which monomeric units are linked together to form linear chain. These linear polymers are well packed and have high magnitude of intermolecular forces of attraction and therefore have high densities, high tensil (pulling) strength and high melting points. Some common example of linear polymers are high density polyethylene nylon, polyester, PVC, PAN etc.

(ii) ***Branched chain polymers*** **:** These are polymers in which the monomers are joined to form long chains with side chains or branches of different lengths. These branched chain polymers are irregularly packed and therefore, they have low tensile strength, low density, boiling point and melting points than linear polymers. Some common examples are low density polythene, glycogen, starch etc. (Amylopectin).

(iii) ***Cross linked polymers*** **:** These are polymers in which monomers unit are crosslinked together to form a three dimensional network polymers. These polymers are hard, rigid and brittle because of network structure *e.g.*, Bakelite, malamine formaldehyde resin etc.

(3) **Classification based upon molecular forces :** Depending upon the intermolecular forces, the polymers have been classified into four type.

(i) Elastomers (ii) Fibres

(iii) Thermoplastics (iv) Thermosetting polymers

(i) ***Elastomers*** **:** The polymers that have elastic character like rubber (a material that can return to its original shape after stretching is said to be elastic) are called elastomers. In elastomers the polymers chains are held together by weak intermolecular forces. Because of the presence of weak forces, the polymers can be easily stretched by applying small stress and regains their original shape when the stress is removed. The most important example of elastomers is natural rubber.

(ii) ***Fibres*** **:** These are the polymers which have strong intermolecular forces between the chain. These forces are either hydrogen bonds or dipole-dipole interaction. Because of strong forces, the chains are closely packed giving them high tensil strength and less elasticity. Therefore, these polymers have sharp melting points. These polymers are long, thin and thread like and can be woven in fabric. Therefore, these are used for making fibres.

Example : Nylon 66, dacron, silk etc.

(iii) ***Thermoplastics*** **:** These are the polymers which can be easily softened repeatedly when heated and hardened when cooled with little change in their properties. The intermolecular forces in these polymers are intermediate between those of elastomers and fibres. There is no cross linking between the chain. The softening occurs as the polymer chain move more and more freely because of absence of cross link. When heated, they melt and form a fluid which can be moulded into any desired shapes and then cooled to get the desired product.

Example : Polythene, polystyrene, PVC, teflon etc.

(iv) ***Thermosetting polymers*** **:** These are the polymers which undergo permanent change on heating. They become hard and infusible on heating. They are generally prepared from low molecular mass semifluid substances. When heated they get highly cross linked to form hard infusible and insoluble products. The cross links hold the molecule in place so that heating does not allow them to move freely. Therefore a thermosetting plastic is cross linked and is permanently rigid.

Example : Bakelite, melamine formaldehyde resin etc.

❑ Plasticizers do lower the softening point (so called melting point) of a polymer. A plasticizer cannot convert a thermosetting polymer into thermoplastic one. In fact plasticizers can convert a hard and brittle plastic into soft and easily pliable. Plasticizers reduce the interparticle forces between polymer molecules. ***Plasticizers*** are generally high-boiling esters or high-boiling haloalkanes. They are added to plastics to make them soft and rubber-like. For example, polyvinyl chloride as such is hard, stiff and glass-like, but the addition of plasticizers like dioctylphthalate (DOP) or dibutylphthalate (DBP) can make it soft and rubber like. Similarly, chlorinated paraffin wax (CPW) is used as a plasticizer in polythene. On long exposure to air and sunlight, these plasticizers evaporate and the plastic articles become hard and brittle.

Table : 30.1 Difference between thermoplastic and thermosetting polymers

Thermoplastic polymers	Thermosetting polymers
(1) These soften and melt on heating.	These do not soften on heating but rather become hard in case prolonged heating is done these start burning.
(2) These can be remoulded recast and	These can not be remoulded or reshaped.

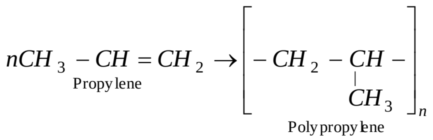
reshaped.	
(3) These are less brittle and soluble in some organic solvents.	These are more brittle and insoluble in organic solvents.
(4) These are formed by addition polymerisation.	These are formed by condensation polymerisation.
(5) These have usually linear structures. Ex. Polyethylene, PVC, teflon.	These have three dimensional cross linked structures. Ex. Bakelite, urea, formaldehyde, resin.

(4) **Classification based upon mode of synthesis :** They are of two types on the basis of their synthesis.

(i) Addition polymers (ii) Condensation polymers

(i) ***Addition polymers* :** A polymer formed by direct addition of repeated monomers without the elimination of by product molecule is called addition polymers. For example,

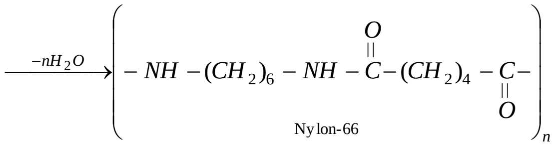
$$\underset{\text{Ethene}}{nCH_2=CH_2}\rightarrow\underset{\text{Polyethene}}{(-CH_2-CH_2-)_n}$$



$$\underset{\text{Propylene}}{nCH_3-CH=CH_2}\rightarrow\underset{\text{Polypropylene}}{\left[-CH_2-\underset{\underset{CH_3}{|}}{CH}-\right]_n}$$

(ii) ***Condensation polymers* :** A polymer formed by the condensation of two or more than two monomers with the elimination of simple molecule like water, ammonia, *HCl*, alcohol etc. is called condensation polymers. For example,

$$\underset{\text{Hexamethylenediamine}}{nH_2N-(CH_2)_6-NH_2}+\underset{\text{Adipic acid}}{nHOOC-(CH_2)_4-COOH}$$



$$\xrightarrow{-nH_2O}\underset{\text{Nylon-66}}{\left(-NH-(CH_2)_6-NH-\overset{\overset{O}{||}}{C}-(CH_2)_4-\underset{\underset{O}{||}}{C}-\right)_n}$$

Table : 30.2 Difference between addition and condensation polymers

Addition polymers	Condensation polymers
Formed by addition reaction.	Formed by condensation process with elimination of small molecules like H_2O.
Molecular mass is a whole number multiple of the monomer.	Molecular mass is not whole number multiple of the monomer units.
Generally involve one monomer unit.	Generally involve more than one monomer unit.
Monomers are unsaturated molecules.	Monomer units must have two active functional groups.
They are generally chain growth polymers.	They are generally step growth polymers.

(5) **Classification based upon the nature of monomer :** On the basis of nature of monomer. Polymer are of two types

(i) Homopolymers (ii) Copolymers

(i) ***Homopolymers* :** A polymer formed from one type of monomers is called **homopolymer**. For example, polythene is a homopolymer of monomer ethene.

$$\underset{\text{Ethene}}{nH_2C=CH_2}\xrightarrow{\text{Polymerisation}}\underset{\text{Polythene}}{(-CH_2-CH_2-)_n}\ \text{Homopolymer}$$

(ii) ***Copolymers* :** A polymer formed from two or more different monomers is called **copolymer** or **mixed polymer**. For example, nylon-66 is a polymer of two types of monomers : hexamethylenediamine and adipic acid.

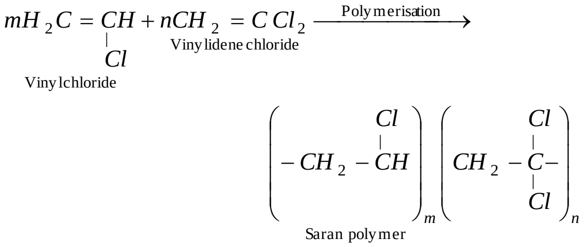
$$\underbrace{\underset{\text{Hexamethylenediamine}}{nH_2N-(CH_2)_6-NH_2}+\underset{\text{Adipic acid}}{nHOOC-(CH_2)_4-COOH}}_{\text{monome}}$$

$$\Big\downarrow \text{Polymerisat}$$

$(-NH-(CH_2)_6-NH-CO-(CH_2)_4-CO-)_n$ $+nH_2O$

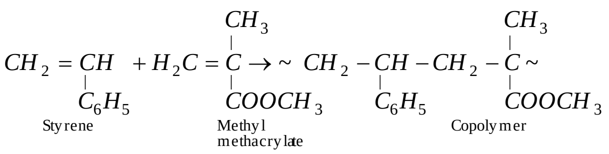
Copolymer are commercially more important.

For example copolymerisation of vinyl chloride with vinylidene chloride (1, 1 dichloroethane) in a 1 : 4 ratio forms a copolymer known as saran.



$$\underset{\text{Vinylchloride}}{mH_2C=\underset{\underset{Cl}{|}}{CH}}+\underset{\text{Vinylidene chloride}}{nCH_2=CCl_2}\xrightarrow{\text{Polymerisation}}\underset{\text{Saran polymer}}{\left(-CH_2-\overset{\overset{Cl}{|}}{CH}\right)_m\left(CH_2-\overset{\overset{Cl}{|}}{\underset{\underset{Cl}{|}}{C}}-\right)_n}$$

Copolymerisation of monomer mixtures often leads to the formation of polymers which have quite different properties than those of either corresponding homopolymer. For example, a mixture of styrene and methyl methacrylate can form a copolymer.



$$\underset{\text{Styrene}}{CH_2=\underset{\underset{C_6H_5}{|}}{CH}}+\underset{\text{Methyl methacrylate}}{H_2C=\overset{\overset{CH_3}{|}}{\underset{\underset{COOCH_3}{|}}{C}}}\rightarrow\underset{\text{Copolymer}}{\sim CH_2-\underset{\underset{C_6H_5}{|}}{CH}-CH_2-\overset{\overset{CH_3}{|}}{\underset{\underset{COOCH_3}{|}}{C}}\sim}$$

The composition of the copolymer depends on the proportion of the monomers and their reactivity. It may be noted that some monomers do not polymerise at all but copolymerize. For example, maleic anhydride does not polymerise as such. However, it copolymerises with styrene in a highly symmetrical manner to form styrene maleic anhydride copolymer.

It may be noted that many types of copolymers can be obtained depending upon the distribution of monomer units in the chain. Two monomers can combine in either regular fashion (although this is rare) or random fashion. For example, if monomer *A* is copolymerised with monomer *B*, the resultant product may have a random distribution of the two units throughout the chain or it might have alternating distribution.

$(-A-B-A-B-A-B-A-B-)$ Alternating copolymer

$(-A-A-A-B-A-B-B-A-B-)$ Random copolymer

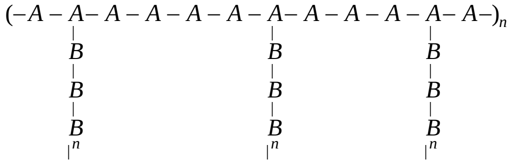
The exact distribution of monomer units depends on the initial proportion of the two-reactant monomers and their reactivities. Most copolymers have varying distributions. Two other types of copolymers that can be prepared under certain conditions are called block copolymers and graft copolymers.

(a) *Block copolymers* are those in which different blocks of identical monomer units alternate with each other as

$$(-A-A-A-A-B-B-B-B-A-A-A-A-B-B-B-B-)_n$$

These are prepared by initiating the polymerisation of one monomer as if growing a homopolymer and then adding an excess of second monomer to the active reaction mixture.

(b) *Graft polymers* are those in which homopolymer branches of one monomer units are grafted on the homopolymer chains of another monomer units as :



$$(-A-\underset{\underset{\underset{\underset{|_n}{B}}{|}}{\underset{B}{|}}}{\underset{B}{A}}-A-A-A-A-\underset{B\text{–}B\text{–}B_n}{A}-A-A-A-A-\underset{B\text{–}B\text{–}B_n}{A}-A-)_n$$

These are prepared by radiation of γ-rays on a completed homopolymer chain in the presence of the second monomer. The high energy radiation knocks hydrogen atoms of the homopolymer chain at random points resulting radical sites for initiation of the added monomer. By careful control of the polymerisation reaction, we can produce copolymers of desired properties by combination of different monomers in various ratios and geometric arrangements.

General methods and mechanism of polymerisation

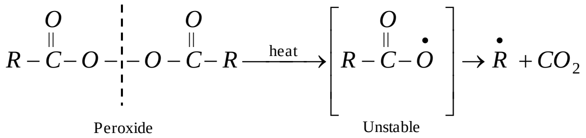
(1) **Chain growth or addition polymerisation :** It involve a series of reaction each of which consumes a reactive particle and produces another similar one. The reactive particle may be free radicals or ion (cation or anion) to which monomers get added by a chain reaction. The polymers thus formed are known as chain growth polymers. Chain growth polymerisation is an important reaction of alkenes and conjugated dienes or indeed of all kinds of compounds that contain carbon-carbon double bond polythene, polypropylene, polybutadiene, teflon PVC, polystyrene are some of chain growth polymers. It is based on three mechanism

(i) Free radical mechanism (ii) Cation mechanism (iii) Anion mechanism

Each mechanism of polymerisation reaction involves an initiator of their corresponding nature. The addition polymerisation reaction is very rapid and is also characterized by three steps *i.e.* chain initiation, chain propogation and chain termination step.

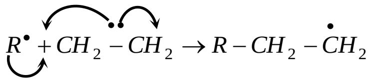
(i) ***Free-radical mechanism*** **:** Free-radical polymerisation is initiated by organic peroxide or other reagents which decompose to give free radicals. Following steps are involved.

(a) *Chain initiation* **:** Organic peroxides undergo homolytic fission to form free radicals.



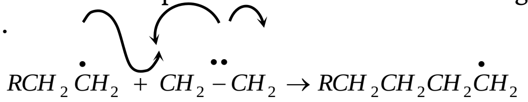
$$\underset{\text{Peroxide}}{R-\overset{\overset{O}{\|}}{C}-O-\vdots-O-\overset{\overset{O}{\|}}{C}-R} \xrightarrow{\text{heat}} \underset{\text{Unstable}}{\left[R-\overset{\overset{O}{\|}}{C}-\dot{O}\right]} \rightarrow \dot{R}+CO_2$$

(b) *Chain propagation* **:** Free radical adds to an alkene molecule to form a new free radical.



$$R^{\bullet}+CH_2\,\ddot{}\,-CH_2 \rightarrow R-CH_2-\dot{C}H_2$$

The free radical formed attacks another alkene molecule and the process continues in building a long chain.



$$RCH_2\dot{C}H_2 + CH_2\,\ddot{}\,-CH_2 \rightarrow RCH_2CH_2CH_2\dot{C}H_2$$

(c) *Chain termination* **:** The chain reaction comes to halt when two free radical chains combine.

$$2R(CH_2CH_2)_nCH_2\dot{C}H_2 \rightarrow R(CH_2CH_2)_nCH_2CH_2$$
$$:CH_2CH_2(CH_2CH_2)_nR$$

❑ *Benzoyl or t-Butyl peroxide are common initiators, used.*

Free radical polymerisation can also be initiated by a mixture of ferrous sulphate and hydrogen peroxide $(FeSO_4+H_2O_2)$.

(ii) **Cationic mechanism :** Cationic polymerisation is initiated by use of acids such as H_2SO_4, HF or BF_3 in H_2O. The following steps are involved :

(a) *Chain initiation* **:** The acid furnishes proton.

$$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$$

$$HF \rightleftharpoons H^+ + F^-$$

$$BF_3 + H_2O \rightleftharpoons H^+ + BF_3(OH)^-$$

The proton adds to the carbon of the double bond of the alkene to form a carbonium ion.

$$H^+ + CH_2=CH_2 \rightarrow CH_3\overset{+}{C}H_2$$

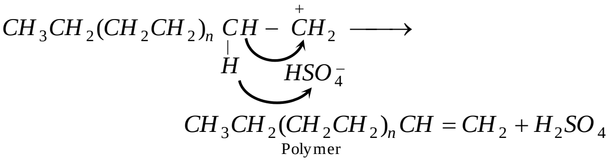
(b) *Chain propagation* **:** The carbonium ion combines with another molecule of alkene to form a new carbonium ion and the process continues to form a long chain.

$$CH_3\overset{+}{C}H_2 + CH_2=CH_2 \rightarrow CH_3CH_2CH_2\overset{+}{C}H_2$$

$$CH_3CH_2CH_2\overset{+}{C}H_2 + nCH_2 = CH_2$$

$$\rightarrow CH_3CH_2(CH_2CH_2)_nCH_2\overset{+}{C}H_2$$

(c) *Chain termination* **:** The chain may be halted by combination with negative ion or loss of a proton.



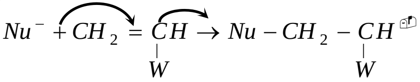
$$CH_3CH_2(CH_2CH_2)_n\underset{\underset{H}{|}}{CH}-\overset{+}{C}H_2 \xrightarrow{\quad} \;\; HSO_4^-$$

$$\underset{\text{Polymer}}{CH_3CH_2(CH_2CH_2)_nCH=CH_2} + H_2SO_4$$

(iii) ***Anionic polymerisation*** **:** This type of polymerisation is initiated by anion (Bases nucleophiles) it proceeds through the formation of carbanion. The initiation may be brought about by $K^+\overline{N}H_2$ of $L^+N\overline{H}_2$.

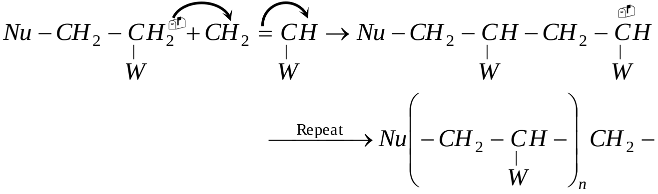
The following steps are involved

(a) *Chain initiation* **:**



$$Nu^- + CH_2=\underset{\underset{W}{|}}{CH} \rightarrow Nu-CH_2-\underset{\underset{W}{|}}{CH^{\ominus}}$$

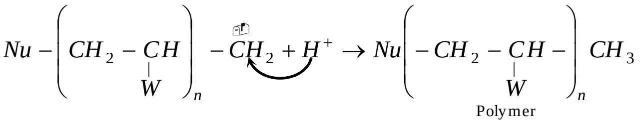
(b) *Chain propagation* **:**



$$Nu-CH_2-\underset{\underset{W}{|}}{CH_2^{\ominus}}+CH_2=\underset{\underset{W}{|}}{CH} \rightarrow Nu-CH_2-\underset{\underset{W}{|}}{CH}-CH_2-\underset{\underset{W}{|}}{CH^{\ominus}}$$

$$\xrightarrow{\text{Repeat}} Nu\left(-CH_2-\underset{\underset{W}{|}}{CH}-\right)_n CH_2-$$

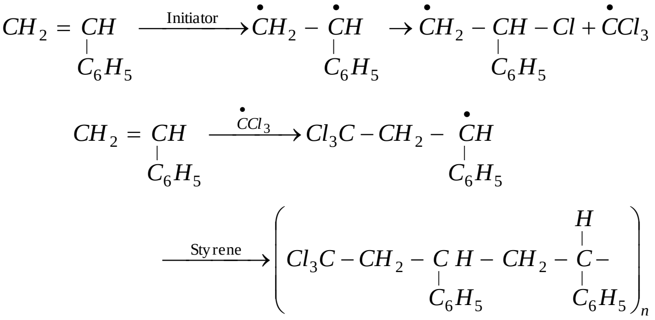
(c) *Termination* :



$$Nu-\left(CH_2-\underset{\underset{W}{|}}{CH}\right)_n-\overset{\ominus}{C}H_2+H^+ \rightarrow \underset{\text{Polymer}}{Nu\left(-CH_2-\underset{\underset{W}{|}}{CH}-\right)_n CH_3}$$

Chain transfer agents : In Vinylic polymerisation various other molecules react with main growing chain to interrupt the further growth of the original chain. This leads to lowering of average molecular mass of the polymer such reagents are called chain transfer agents. The common example CCl_4, CBr_4 etc.

For example in the presence of CCl_4 styrene polymerizes to form a polymer of lower average molecular mass which also contains some chlorine.



$$CH_2=\underset{\underset{C_6H_5}{|}}{CH} \xrightarrow{\text{Initiator}} \dot{C}H_2-\underset{\underset{C_6H_5}{|}}{\dot{C}H} \rightarrow \dot{C}H_2-\underset{\underset{C_6H_5}{|}}{CH}-Cl+\dot{C}Cl_3$$

$$CH_2=\underset{\underset{C_6H_5}{|}}{CH} \xrightarrow{\dot{C}Cl_3} Cl_3C-CH_2-\underset{\underset{C_6H_5}{|}}{\dot{C}H}$$

$$\xrightarrow{\text{Styrene}} \left(Cl_3C-CH_2-\underset{\underset{C_6H_5}{|}}{C}H-CH_2-\underset{\underset{C_6H_5}{|}}{\overset{\overset{H}{|}}{C}}-\right)_n$$

Chain transfer agents determinate chain reaction and inhibit further polymerisation and are also called inhibitors.

(2) **Step growth or condensation polymerisation :** In this type of polymerisation monomers generally contain two functional groups, *i.e.*, difunctional monomers. In this process no initiator is needed and each step is the same type of chemical reaction. Since in this polymerisation reaction the polymer is formed in a stepwise manner. It is called step growth polymer and the process is called step growth polymerisation. The process for two monomer *A* and *B* may be expressed as.

$$\underset{\text{Monomers}}{A+B} \xrightarrow{\text{Condense}} \underset{\text{Dimer}}{A-B}$$

$$A-B+A \xrightarrow{\text{Condense}} \underset{\text{Trimer}}{A-B-A}$$

$$A-B-A+B \longrightarrow A-B-A-B$$

Alternatively, step growth can proceed as

$$A+B \rightarrow A-B$$

$$A-B+A-B \rightarrow A-B-A-B \text{ or } (A-B)_2$$

$$A-B-A-B+A-B-A-B \xrightarrow[\text{Polymer}]{} (A-B)_n$$

Some common examples of step growth polymers are

Polymers	Monomers
Nylon-66	Hexamethylenediamine and adipic acid
Bakelite	Phenol and formaldehyde
Dacron (polyester)	Terephthalic acid and ethylene glycol

Rubber

It is a polymer which is capable of returning to its original length, shape or size after being stretched or deformed. It is the example of elastomer. Rubber are of two types.

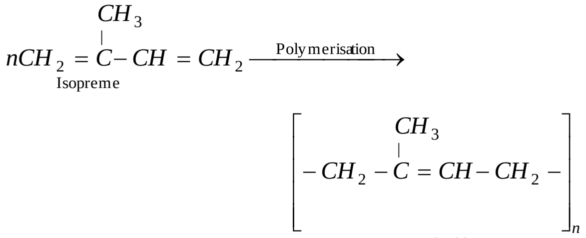
(1) Natural rubber (2) Synthetic rubber

(1) **Natural rubber :** It is obtained as latex from rubber trees. The latex is coagulated with acetic acid or formic acid. The coagulated mass is then squeezed.

The raw natural rubber is a soft gummy and sticky mass. It is insoluble in water, dil. Acids and alkalies but soluble in benzene, chloroform, ether, petrol and carbon disulphide. It absorb a large amount of water. It has low elasticity and tensile strength.

Destructive distillation of natural rubber gives mainly isoprene (2-methyl butadiene).

Thus isoprene is a monomer of natural rubber the no. of isoprene unit are 11,000 to 20,000 which linked together in a chain.



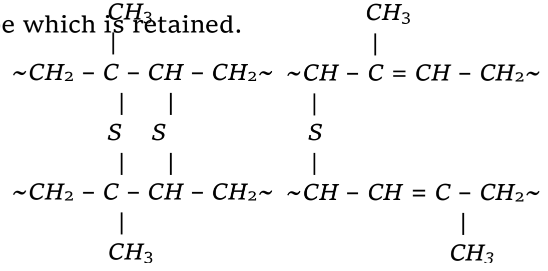
$$\underset{\text{Isopreme}}{nCH_2 = \overset{\overset{\large CH_3}{|}}{C} - CH = CH_2} \xrightarrow{\text{Polymerisation}} \left[- CH_2 - \overset{\overset{\large CH_3}{|}}{C} = CH - CH_2 - \right]_n$$

Natural rubber

(2) **Synthetic rubber :** The synthetic rubber is obtained by polymerising certain organic compounds which may have properties similar to rubber and some desirable properties. Most of these are derived from butadiene derivatives and contain carbon-carbon double bonds. The synthetic rubbers are either homopolymers of 1, 3 butadiene or copolymer in which one of the monomers is 1, 3 butadiene or its derivative so that the polymer has the availability of double bonds for its vulcanization. Some important examples are Neoprene, styrene, butadiene rubber (SBR) thiokol, silicones, polyurethane, rubber etc.

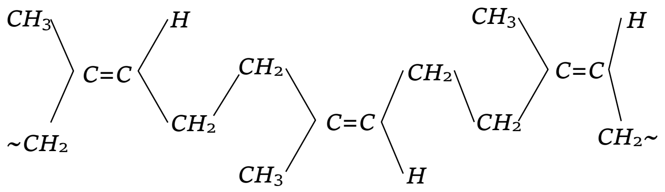
Vulcanization of rubber : The process of heating natural rubber with sulphur to improve its properties is called vulcanization. Vulcanization was introduced by Charles Goodyear.

Although natural rubber is thermoplastic substance in which there are no cross link between the polymer chain and it on vulcanization set into a given shape which is retained.



The vulcanization process performed originally was slow. Now a days, some additives such as zinc oxide etc. are used to accelerate the rate of vulcanization. During vulcanization, sulphur cross links are formed (figure) the double bonds in the rubber molecule acts as reactive sites. The allylic $-CH_2$, alpha to double bond is also very reactive. During vulcanization, sulphur forms cross links at these reactive sites. As a result, rubber gets stiffened and intermolecular movement of rubber springs is prevented resulting in physical character of rubber. The extent of stiffness of vulcanized rubber depend upon the amount of sulphur added. For example about 5% sulphur is used for making tyre rubber while 30% of the sulphur is used for making battery case rubber.

In a polymer, the chains are normally tangled up with each other. When the rubber is stretched, the chains straighten out to some extent. The chains cannot slip past each other because of the polysulphide bridges. Thus, rubber can be stretched only to a limited extent. When the tension is removed, the chains try to coil up again and the rubber resumes its original shape.



Natural rubber
All *cis*

The comparison of the main properties of natural rubber and vulcanized rubber are given below in the table,

Table : 30.3

Natural rubber	Vulcanized rubber
(1) Natural rubber is soft and sticky	Vulcanized rubber is hard and non-sticky.
(2) It has low tensile strength.	It has high tensile strength.
(3) It has low elasticity.	It has high elasticity.
(4) It can be used over a narrow range of temperature (from 10° to 60°C).	It can be used over a wide range of temperature (–40° to 100°C).
(5) It has low wear and tear resistance.	It has high wear and tear resistance.
(6) It is soluble in solvents like ether, carbon, tetrachloride, petrol, etc.	It is insoluble in all the common solvents.

Some important polymer and their uses

Table : 30.4 Rubber

Rubber	Monomers	Formula	Applications

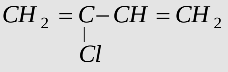
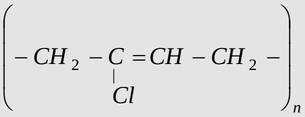
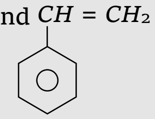
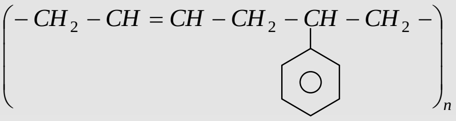
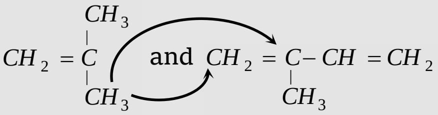
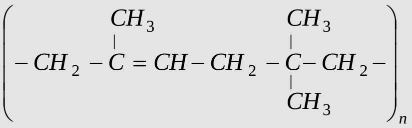
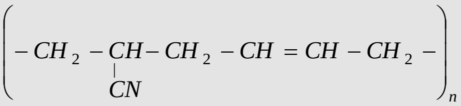
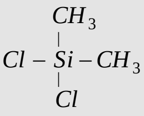
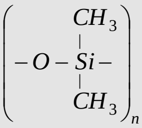
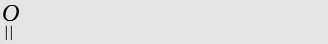
(i) Neoprene rubber	 $CH_2=\underset{Cl}{\underset{\vert}{C}}-CH=CH_2$ Chloroprene	 $\left(-CH_2-\underset{Cl}{\underset{\vert}{C}}=CH-CH_2-\right)_n$	Making automobile, refrigerator parts and electric wire.
(ii) Styrene Butadiene Rubber (SBR) or Buna-*S*	$CH_2=CH-CH=CH_2$ Butadiene (75%) and  Styrene		Making of tyre and other mechanical rubber goods.
(iii) Butyl rubber	 $CH_2=\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{C}}}}$ and $CH_2=\underset{CH_3}{\underset{\vert}{C}}-CH=CH_2$ Isobutylene (98 %) Isoprene (2-3 %)	 $\left(-CH_2-\overset{CH_3}{\overset{\vert}{C}}=CH-CH_2-\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{C}}}}-CH_2-\right)_n$	Making of toys, tyre, tube etc.
(iv) Nitrile rubber or Buna *N* or GRA	$CH_2=CH-CH=CH_2$ and Butadiene (75%) $CH_2=CH-CN$ Acrylonitrile (25%)	 $\left(-CH_2-\underset{CN}{\underset{\vert}{CH}}-CH_2-CH=CH-CH_2-\right)_n$	Used for make of fuel tank.
(v) Polysulphide rubber (Thiokol)	$Cl-CH_2-CH_2-Cl$ Ethylene dichloride and Na_2S_4 Sodium tetrasulphide	$(-CH_2-CH_2-S-S-S-S-)_n$	Used in the manufacture of hoses and tank lining, engine gasket and rocket fuel.
(vi) Silicone rubber	 $Cl-\overset{CH_3}{\overset{\vert}{\underset{Cl}{\underset{\vert}{Si}}}}-CH_3$ Chlorosilanes	 $\left(-O-\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{Si}}}}-\right)_n$	Silicon rubber
(vii) Polyurethane rubber	$HOCH_2-CH_2OH$ Ethylene glycol and  $\overset{O}{\overset{\vert\vert}{C}}=N-CH=CH-N=C=O$ Ethylene di-isocyanate		In the manufacture of fibre. Paints and heat insulator.

Table : 30.5 Plastics and resin

Name of polymer	Abbreviat-ion	Starting materials (monomers)	Nature of polymer	Properties	Applications
(i) Polyolefines (a) Polyethylene or polyethene	LDPE (Low density polyethene)	$CH_2=CH_2$	*Low density* homopolymer (branched) chain growth.	Transparent, moderate tensile strength, high toughness.	Packing material carry bags, insulation for electrical wires and cables.
	HDPE (high density polyethene)	$CH_2=CH_2$	*High density* homopolymer (linear) chain growth.	Transluscent, chemically inert, greater tensile strength, toughness.	Manufacture of buckets, tubs, house ware, pipes, bottles and toys.
(b) Polypropylene or polypropene	PP	$CH_3CH=CH_2$	Homopolymer, linear, chain growth.	Harder and stronger than polyethene.	Packing of textiles and foods, liners for bags, heat shrinkage wraps, carpet fibres,

					ropes, automobile mouldings, stronger pipes and bottles.
(c) Polystyrene or Styron or styrofoam		$C_6H_5CH = CH_2$	Homopolymer, linear, chain growth	Transparent	Plastic toys, house hold wares, radio and television bodies, refrigerator linings.
(ii) Polyhaloolefines (a) Polyvinyl chloride	PVC	$\underset{\text{Vinylchloride}}{CH_2 = CH - Cl}$	Homopolymer chains growth	Thermoplastic	(i) Plasticised with high boiling esters PVC used in rain coats, hand bags, shower curtains, fabrics, shoe soles, vinyl flooring (ii) Good electrical insulator (iii) Hose pipes.
(b) Polytetrafluoroethylene or Teflon	PTFE	$F_2C = CF_2$	Homopolymer, high melting point	Flexible and inert to solvents boiling acids even aqua regia. Stable upto 598 K.	(i) For nonstick utensiles coating (ii) Making gaskets, pump packings valves, seals, non lubricated bearings.
(c) Polymonochlorotrifluroroethylene	PCTFE	$ClFC = CF_2$	Homopolymer	Less resistant to heat and chemicals due to presence of chlorine atoms.	Similar to those of teflon.
(iii) Formaldehyde resins (a) Phenol formaldehyde resin or Bakelite		Phenol and formaldehyde	Copolymer, step growth	Thermosetting polymer, hard and brittle	(i) With low degree polymerisation as bindings glue for wood varnishes, lacquers. (ii) With high degree polymerisation for combs, for mica table tops,

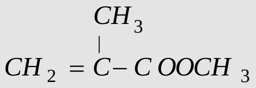
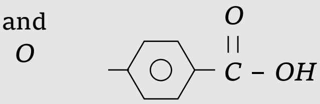
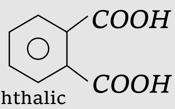
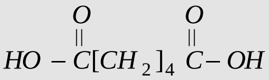
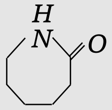
					fountain pen barrels electrical goods (switches and plugs).
(b) Melamine formaldehyde resin		Melamine and formaldehyde	Copolymer, step growth	Thermosetting polymer, hard but not so breakable.	Non-breakable crockery.
(iv) Polyacrylates (a) Polymethacrylate (lucite, acrylite and plexiglass and perspex)	PMMA	 $CH_2 = \overset{CH_3}{\overset{\vert}{C}} - COOCH_3$	Copolymer	Hard transparent, excellent light transmission, optical clarity better than glass takes up colours.	Lenses light covers lights, shades signboards transparent domes skylight aircraft window, dentures and plastic jewellery.
(b) Polyethylacrylate		$CH_2 = CH - COOC_2H_5$	Copolymer	Tough, rubber like product	

Table : 30.6 Fibre

Name of polymer	Abbreviation	Starting materials	Nature of polymer	Properties	Applications
(i) Polysters (a) Terylene or Dacron or mylar	PET (Polyethylene terephthalate)	$\underset{\text{Ethylene glycol or Ethane -1, 2-diol}}{HO - CH_2 - CH_2 - OH}$ and  Terephthalic	Copolymer, step growth linear condensation polymer	Fibre crease resistant, low moisture absorption, not damaged by pests like moths etc.	For wash and wear fabrics, tyre cords seat belts and sails.
(b) Glyptal or alkyd resin		$\underset{\text{Ethylene glycol}}{HO - CH_2 - CH_2 - OH}$ and  Phthalic	Copolymer, linear step growth condensation polymer	Thermoplastic, dissolves in suitable solvents and solutions on evaporation leaves a tough but not flexible film.	Paints and lacquers.
(ii) Polyamides (a) Nylon-66		 $HO - \overset{\overset{O}{\vert\vert}}{C}[CH_2]_4\overset{\overset{O}{\vert\vert}}{C} - OH$ Adipicacid and $\underset{\text{Hexamethyl lenediamin e}}{H_2N - [CH_2]_6 - NH_2}$	Copolymer, linear, step growth condensation polymer	Thermoplastic high tensile strength abrasion resistant.	Textile fabrics, bristles for brushes etc.
(b) Nylon-610		$\underset{\text{Hexamethyl lene diamine}}{H_2N - [CH_2]_6 - NH_2}$ and $\underset{\text{Sebacic acid}}{HOOC\,[CH_2]_8\,COOH}$	Copolymer, linear, step growth	Thermoplastic, high tensile strength, abrasion	(i) Textile fabrics, carpets, bristles for

				resistant	brushes etc. (ii) Substitute of metals in bearings. (iii) Gears elastic hosiery.
(c) Nylon-6 or Perlon		 Caprolactum or $H_2N-[CH_2]_5-COOH$ ∈-Aminocaproic acid	Homopolymer, linear	Thermoplastic high tensile strength abrasion resistant.	Mountaineering ropes, tyre cords, fabrics.
(iii) Polyacrylonitrile or orlon or acrilon	PAN	$CH_2=CH-CN$	Copolymer	Hard, horney and high melting materials.	Orlon, arcrilon used for making clothes, carpets blankets and preparation of other polymers.

❑ *Copolymer of acrylonitrile (40%) and vinyl chloride (60%) is called dynel it is used in hair wigs.*

❑ *Artificial silk is the term given to fibres derived from cellulose. The most important process for the production of artificial silk is viscose process. The difference between natural and artificial silk is natural silk contain nitrogen while artificial silk may not have nitrogen. Natural silk on burning gives a smell of burning hair and shrinks into a ball of cinder while artificial silk gives a thread of ash.*

Biodegradable polymers

These are the polymers which are degraded by micro-organisms within a suitable period so that biodegradable polymers and their degraded products do not cause any serious affects on the environment.

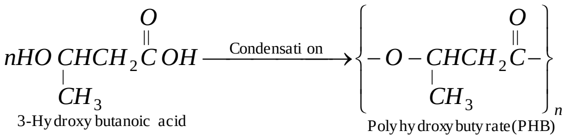
In biological systems, biopolymers degrade mainly by enzymatic hydrolysis and to some extent by oxidation. Therefore, in view of the disposal problems of polymer waste and for developing polymers for other safe uses in human systems, attempts have been made to develop biodegradable synthetic polymers. These synthetic polymers mostly have functional groups which are normally present in biopolymers and lipids.

Among these aliphatic polyesters are one important class of biodegradable polymers which are commercially potential biomaterials. The common examples of biodegradable polymers are polyhydroxy butyrate (PHB), polyhydroxy butyrate –*co*-β-hydroxy valerate (PHBV), polyglycolic acid (PGA), polylactic acid (PLA), poly (∈-caprolactone) (PCL), etc.

Uses : Biodegradable polymers are used mainly for medical goods such as surgical sutures, tissue in growth materials or for controlled drug release devices, plasma substitutes etc. The decomposition reactions usually involve hydrolysis (either enzymatically induced or by non-enzymatic mechanisms) to non-toxic small molecules which can be metabolized by or excreted from the body. These are also finding use in agriculture materials (such as films, seed coatings), fast food wrappers, personal hygiene products, etc.

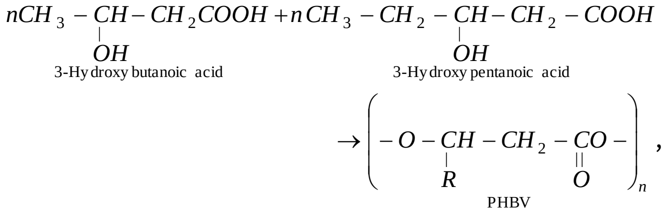
(i) ***Polyhydroxy butyrate (PHB)***

Polyhydroxy butyrate (PHB) is obtained from hydroxy butyric acid (3-hydroxy butanoic acid)



$$\underset{\text{3-Hydroxy butanoic acid}}{nHO\underset{\overset{|}{CH_3}}{CH}CH_2\overset{\overset{O}{||}}{C}OH} \xrightarrow{\text{Condensation}} \underset{\text{Polyhydroxybutyrate (PHB)}}{\left\{-O-\underset{\overset{|}{CH_3}}{CH}CH_2\overset{\overset{O}{||}}{C}-\right\}_n}$$

(ii) ***Poly-Hydroxybutyrate-co-β-Hydroxy valerate (PHBV)*** : It is copolymer of 3-hydroxy butanoic acid and 3-hydroxy pentanoic acid, in which the monomer units are joined by ester linkages.



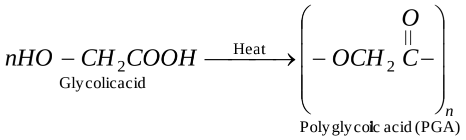
$$\underset{\text{3-Hydroxy butanoic acid}}{nCH_3-\underset{OH}{\underset{|}{CH}}-CH_2COOH}+\underset{\text{3-Hydroxy pentanoic acid}}{nCH_3-CH_2-\underset{OH}{\underset{|}{CH}}-CH_2-COOH}$$

$$\rightarrow \underset{\text{PHBV}}{\left(-O-\underset{R}{\underset{|}{CH}}-CH_2-\underset{O}{\underset{||}{CO}}-\right)_n},$$

$R=CH_3,\ C_2H_5$

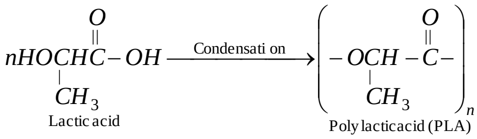
The properties of PHBV vary according to the ratio of both the acids. 3-Hydroxy butanoic acid provides stiffness while 3-Hydroxypentanoic acid gives flexibility to the copolymer.

(iii) ***Polyglycolic acid* (PGA) :** Polyglycolic acid (PGA) is obtained by the chain polymerisation of cyclic dimer of glycolic acid, $HO-CH_2-COOH$.



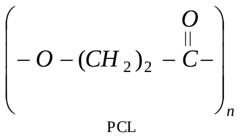
$$\underset{\text{Glycolicacid}}{nHO-CH_2COOH}\xrightarrow{\text{Heat}}\underset{\text{Polyglycolc acid (PGA)}}{\left(-OCH_2\overset{O}{\overset{||}{C}}-\right)_n}$$

(iv) ***Polylactic acid* (*PLA*) :** Polylactic acid (PLA) is obtained by polymerisation of the cyclic dimer of lactic acid $(HO-CH(CH_3)COOH)$ or by microbiological synthesis of lactic acid followed by the polycondensation and removal of water by evaporation.



$$\underset{\text{Lactic acid}}{nHO\underset{CH_3}{\underset{|}{C}}H\overset{O}{\overset{||}{C}}-OH}\xrightarrow{\text{Condensation}}\underset{\text{Poly lacticacid (PLA)}}{\left(-O\underset{CH_3}{\underset{|}{C}}H-\overset{O}{\overset{||}{C}}-\right)_n}$$

(v) ***Poly (∊-caprolactone) (PCL)* :** It is obtained by chain polymerisation of the lactone of 6-hydroxy hexanoic acid.



$$\underset{\text{PCL}}{\left(-O-(CH_2)_2-\overset{O}{\overset{||}{C}}-\right)_n}$$

Uses : PGA and PLA (90 : 10) is used to make absorbable structure to close an internal of external wound and has replaced cat gut these are completely degraded and absorbed by the body within 15 days to one month of the surgery.

Polyhydroxybutyrate (PHB) and (PHBV) have been used for making films for packaging and into moulded items.

Molecular masses of polymers

A polymer sample contains chain of varying lengths and therefore its molecular mass is always expressed as an average on the other hand natural polymer such as proteins contain chain of identical length and therefore they have definite molecular mass.

The molecular mass of a polymer can be expressed in two ways.

(1) Number average molecular mass $(\overline{M}_N)$

(2) Weight average molecular mass $(\overline{M}_W)$.

(1) **Number average molecular mass $(\overline{M}_N)$:** If N_1, N_2, N_3 ..... are the number of molecules with molecular masses M_1, M_2, M_3 ...... respectively, then the number average molecular mass is

$$\overline{M}_N=\frac{N_1M_1+N_2M_2+N_3M_3+...}{N_1+N_2+N_3...}$$

This may be expressed as : $\overline{M}_N=\dfrac{\sum N_iM_i}{\sum N_i}$

Where N_i is the number of molecules of the *i*th type with molecular mass M_i.

(2) **Weight average molecular mass $(\overline{M}_W)$:** If m_1, m_2, m_3 .... are the masses of species with molecular masses M_1, M_2, M_3 ..... respectively, then the weight average molecular mass is

$$\overline{M}_W=\frac{m_1M_1+m_2M_2+m_3M_3....}{m_1+m_2+m_3+...}\text{ or }=\frac{\sum m_iM_i}{\sum m_i}$$

But $m_i=N_iM_i$, so that $\overline{M}_W=\dfrac{\sum N_iM_i^2}{\sum N_iM_i}$

where N_i is the number of molecules of mass M_i.

❑ ***Polydispersity index* :** *The ratio of weight average molecular mass to the number average molecular mass is called* ***polydispersity index, PDI.***

$$PDI=\frac{\overline{M}_W}{\overline{M}_n}$$

This gives an idea about the homogeneity of a polymer.

(i) The polymers whose molecules have nearly same molecular masses are called ***monodisperse polymers****. For these molecules,* $\overline{M}_W=\overline{M}_N$ *and therefore, PDI is one.*

(ii) The polymers whose molecules have wide range of molecular masses are called ***polydisperse polymers.*** *For these polymers,* $\overline{M}_W>\overline{M}_N$ *and therefore, their PDI is greater than one.*

Thus, it may be concluded that in general, ***natural polymers are more homogeneous than synthetic polymers.***

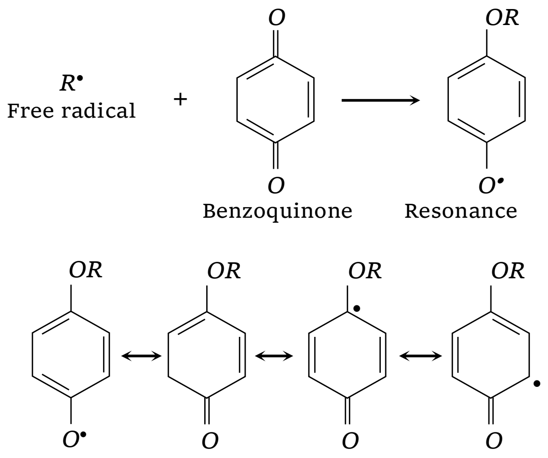
For natural polymers, PDI is usually unity and therefore, natural polymers are monodisperse.

For synthetic polymers, the PDI is greater than one and therefore $\overline{M}_W$ *is always greater than* $\overline{M}_N$. $\overline{M}_N$ *is always determined by employing methods which depend upon the number of molecules present in the polymer sample. For example, colligative property such as osmotic pressure is used. On the other hand, weight average molecular mass is measured by using the methods such as light scattering and ultracentrifugation, sedimentation, etc. which depend upon the mass of individual molecules.*

(3) Polymer in increasing order of their intermolecular forces are polythene < Buna *S* < Nylon-66.

(4) We always use purest monomer in free radical polymerisation reaction because the impurities can act as chain transfer agent and may combine with the free radical to slow down the reaction or even stop the reaction.

(5) Benzoquinone inhibit the free radical polymerisation of vinyl derivative because it combine with free radical intermediate to form a non reactive radical which is highly stabilized by resonance because of the lack of reactivity of the new radical formed, it inhibit the further progress of the chain reaction. Therefore the reaction stops.



(6) A thin film of polyester is known as Mylar film.

(7) PET plastic commonly used for soft drink bottles, transparent jars and bottles for use in kitchen are made up of polyethylene terephthalate.

(8) Glyptal resins or Alkyd resins obtained from ethylene glycol and phthalic acid are thermoplastic. However, resins obtained from glycerol and phthalic acid are thermosetting polymers, due to the formation of cross-links by the third –*OH* group present in glycerol.

(9) Thermosetting plastics are also called heat setting plastics whereas thermoplastics are called cold setting plastics.

(10) Latex is a colloidal dispersion of rubber in water. It is not a colloidal solution of isoprene in water or any other solvent.

(11) Polymerisation of isoprene by free radical mechanism (in the presence of *Na* and heat) gives a product which is different from natural rubber (Natural rubber is a polymer of isoprene). The synthetic product so obtained is a mixture of *cis* and *trans* configurations **and resembled** *Gutta percha*. Gutta percha is a naturally occurring polymer in plants. It is all *trans*-stereoisomer and is non-elastic.

(12) Terylene is a British name of *Dacron*.

(13) Co-polymer of vinyl chloride 90% and vinyl acetate 10% is called *VINYON*.

(14) Co-polymer of acrylonitrile 40% and vinyl chloride 60% is called *DYNEL*.

(15) Co-polymer of vinyl chloride and vinyledene chloride is called *SARAN*.

(16) Plasticizers cannot convert a thermosetting polymer into thermoplastic one. It converts a hard and brittle plastic into soft and easily pliable one at room temperature.

(17) Free radical polymerisation of isoprene do not give Gutta percha (Gutta percha is a natural polymer). The synthetic product so obtained resembles Gutta percha.

(18) Co-ordination polymerisation of isoprene gives a product similar to natural rubber.

(19) Latex is not a colloidal dispersion of isoprene in water.

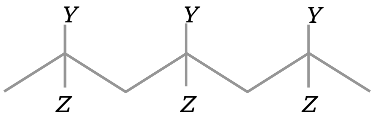
Advance level information

(1) Thermocol is polystyrene foamed with vapour of pentane.

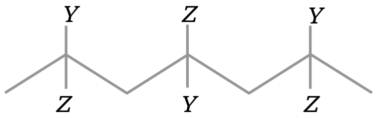
(2) Cups used for hot drinks are made up of polystyrene. It does not become soft like other plastics at temperatures near boiling point of water.

(3) A major development of co-ordination polymerisation is *stereochemical control*. For example Propene could polymerise to any of the three different arrangements.

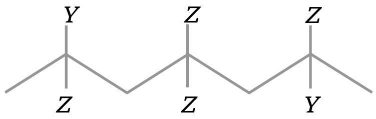
(i) ***Isotactic (Same order)*** **:** When groups are arranged on one side of the chain. All *y* group *i.e.* on one side and all *Z* groups on the opposite side of the chain.



(ii) ***Syndiotactic (Alternating order)*** **:** The Y and Z groups lie alternately on each side of the chain.



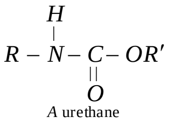
(iii) ***Atactic (Random order)*** **:** The Y and Z groups are arranged in a random fashion.



(4) Addition polymers, generally, have only carbon atoms in their main chain. On the other hand, condensation polymers, generally, have atoms other than carbon atoms, in their main chain.

(5) **Polyurethanes :** Polyurethanes are polymers obtained by the polymerisation of a urethane.

It is used for heat and sound insulation in the form of polyurethane foam. Mattresses, cushions and pillows made out of polyurethane foam are washable and long lasting.



$$R - \overset{\overset{\large H}{|}}{N} - \underset{\underset{\large O}{||}}{C} - OR'$$

A urethane

(6) **Epoxy resins :** These are obtained by copolymerisation of epichlorohydrin and bisphenol-A. These resins have good adhesive strength. These are used for making adhesives (Araldite, M-seal etc.) for making glass reinforced plastic (fibre glass), for lamination, to impart crease resistance and shrinkage control to cotton, rayon and for making anti-skid surface for highways.

(7) **Polycarbonates :** These are obtained by copolymerisation of diphenyl carbonate and bisphenol-A. It has very high optical transparency, high impact strength over wide range of temperature. It is used for making bullet-proof glass, baby-feed bottles, fridge containers, mixi jars etc.

(8) Thermoplastics are also called cold setting polymers. They are moulded when hot but set into the required shape only on cooling. Thermosetting polymers are also called heat setting polymers. Such polymers are supplied in the partially polymerised form.

(9) On long exposure to air and sun-light thermoplastics becomes brittle. It is due to the evaporation of plasticizer with time. The faint smell associated with various thermoplastics is due to slow evaporation of this plasticizer.

(10) High density polyethene is a linear polymer. Carry bags made out of it are not so soft and make a crackling sound when crushed in hands. You can easily tear them in one direction, but not at right angle to it. Plastic twine is made out of such a polymer. They have very high tensile strength in one direction (along the polymer chain) and a low tensile strength at right angle to it. Such carry bags are used to carry clothes, note-books etc. Carry bags made of low density polyethene are soft, make no noise when crushed with hands, have same tensile strength in all directions. Such carry bags are used to carry heavy objects (vegetables, fruits etc.)

(11) **Kevlar** is a nylon-polymer and is obtained by condensation copolymerization of terephthalic acid with 1, 4-diaminobenzene (*p*-phenylenediamine). The fibres of this polymer are so strong that they are used to make bullet-proof vests.

(12) **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 helmits.

(13) **Nomex** is a polyamide made from *m*-phthalic 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.

(14) **Ebonite** is high sulphur (20-30 %S) rubber and is obtained by vulcanization of natural rubber.

(15) **Rayon** was originally called artificial silk but now the name rayon is given to all fibres obtained by chemical treatment of cellulose. Thus, artificial silk is polysaccharide, *i.e.*, cellulose derivative.

Tips & Tricks

- Nucleic acids and proteins though macromolecules are also regarded as polymers
- Diphenylamine is added as an antioxidant to rubber to protect it from degradation on exposure to air.
- Plasticizers are non volatile liquid such as di-*n*-butylphthalate, tricresyl phosphates which are added to a polymer such as PVC to make it soft and readily workable on heating.
- Low density polythene is a branched polymer and is prepared by free radical polymerization while high density polythene is a linear polymer and is prepared by coordination polymerization.
- Coordination polymerization was developed by Zeigler and natta.
- Neoprene is a synthetic rubber. It is superior to natural rubber in its stability to aerial oxidation and

resistance to oils, gasoline and solvents.

✍ Super glue is a polymer of methyl α-cyanoacrylate.

✍ Polyurethanes are obtained by condensation of toluene diisocyanate with ethylene glycol. During polymerization, low boiling liquid such as Freon-11 are added to the reaction mixture. The heat of polymerization vaporizes the volatile liquid producing bubble which convert the viscous polymer to a frothy mass of polyurethane foam.

✍ Ebonite is high sulphur (20-30%S) rubber and is obtained by vulcanization of natural rubber.

Ordinary Thinking

Objective Questions

Classification of Polymer

1. Which one among the following is a thermosetting plastic **[MP PMT 1993, 95; AIIMS 1999]**

(a) PVC (b) PVA
(c) Bakelite (d) Perspex

2. The basis on the mode of their formation, the polymers can be classified **[MP PET 1999]**

(a) As addition polymers only
(b) As condensation polymers only
(c) As copolymers
(d) Both as addition and condensation polymers

3. Thermoplastics are

(a) Linear polymers (b) Highly cross-linked
(c) Both (a) and (b) (d) Crystalline

4. '*Cis*-1, 4-polyisoprene' is

(a) Thermoplastic (b) Thermosetting plastic
(c) Elastic (rubber) (d) Resin

5. 'Shellac' secreted by lac insects is

(a) Natural plastic (b) Natural resin
(c) Natural elastic (d) Any of these

6. Which of the following is not a polymer

(a) Gun cotton
(b) Perspex
(c) Shellac (*eg*. lac shellac)
(d) Wax (*eg*. bees wax)

7. Which of the following is not a polymer

(a) Wool (b) Cotton
(c) Leather (d) Fat

8. Melmoware are

(a) Thermosetting (b) Thermoplastic
(c) Both (a) and (b) (d) None of these

9. Among the following a natural polymer is **[MP PET 1993; BCECE 2005]**

(a) Cellulose (b) PVC
(c) Teflon (d) Polyethylene

10. Which of the following is thermoplastic

(a) Nylon (b) Polyethylene
(c) Terylene (d) All of these

11. Which of the following is an example of condensation polymer

(a) Nylon
(b) Bakelite
(c) Urea-formaldehyde resin
(d) All of these

12. Which of the following is a natural polymer

(a) Polyester (b) Glyptal
(c) Starch (d) Nylon-6

13. Which is a naturally occuring polymer **[BHU 1980]**

(a) Polythene (b) PVC
(c) Acetic acid (d) Protein

14. Which of the following is a branched polymer

(a) Low density polymer (b) Polyester
(c) High density polymer (d) Nylon

15. Which is the monomer of polypeptide

(a) Propene (b) Butadiene
(c) Adipic acid (d) Amino acid

16. Which of the following is an addition polymer

(a) Glucose (b) Polyethylene
(c) Ethylene (d) Terylene

17. Which one of the following is a linear polymer**[KCET 1998**

(a) Amylopectin (b) Glycogen
(c) Starch (d) Amylose

18. Which of the following polymer is an example of fibre **[AIIMS 2000; Pb. CET 2001]**

(a) Silk (b) Dacron
(c) Nylon-66 (d) All of these

19. Natural rubber is which type of polymer**[DCE 2002]**

(a) Condensation polymer (b) Addition polymer
(c) Co-ordination polymer (d) None of these

20. Polyethylene is **[DCE 2003]**

(a) Random copolymer (b) Homo polymer
(c) Alternate copolymer (d) Crosslinked copolymer

21. Which of the following is a biodegradable polymer **[AIIMS 2004]**

(a) Cellulose (b) Polythene
(c) Polyvinyl chloride (d) Nylon-6

22. Which of the following is an example of condensation polymers **[MP PMT 1995; BHU 2000; UPSEAT 2004]**

(a) Polythene (b) PVC
(c) Orlon (d) Terylene

23. Nylon is not a **[KCET 2004]**

(a) Condensation polymer (b) Polyamide
(c) Copolymer (d) Homopolymer

24. Which of the following is not an example of additional polymer **[KCET 2001; CBSE 2001]**

(a) Terylene (b) Polypropylene
(c) Polyethylene (d) Polystyrene

25. Polythene is
(a) Thermoplastic (b) Thermosetting
(c) Both (a) and (b) (d) None of these

26. Bakelites are
(a) Rubber (b) Rayon
(c) Resins (d) Plasticisers

27. Which of the following is a step-growth polymer
(a) Polyisoprene (b) Polythene
(c) Nylon (d) Polyacrylonitrile

28. An example of chain growth polymer is **[Pb. PMT 1999]**
(a) Nylon-66 (b) Bakelite
(c) Terylene (d) Teflon

29. Which of the following is synthetic rubber **[NCERT 1978]**
(a) Buna-S (b) Neoprene
(c) Both (a) and (b) (d) None of these

30. Which of the following is a linear polymer
(a) Nylons
(b) Bakelite
(c) Low density polythene
(d) Melamine-formaldehyde polymer

31. Which of the following is not an example of natural polymer
[BHU 1987]
(a) Wool (b) Silk
(c) Leather (d) Nylon

32. Which of the following is a chain growth polymer
(a) Nylon-6 (b) Dacron
(c) Glyptal (d) Polypropylene

33. Natural rubber is a **[MP PMT 1994]**
(a) Polyester (b) Polyamide
(c) Polyisoprene (d) Polysaccharide

34. Which of the following is not a synthetic polymer
[MP PET 1999]
(a) Polyethylene (b) *PVC*
(c) Nylon (d) Cellophane

35. Nylon-66 is a **[RPET 1999; MP PMT 1993]**
(a) Natural polymer (b) Condensation polymer
(c) Addition polymer (d) Substitution polymer

36. A condensation polymer among the following polymers is
[KCET 2002]
(a) PVC (b) Teflon
(c) Decron (d) Polystyrene

37. Which of the following is not a natural polymer
[AFMC 2003]
(a) Cellulose (b) Protein
(c) PVC (d) Nucleic acid

38. Which of the following is not correct regarding terylene
[Kerala PMT 2004]
(a) Step-growth polymer
(b) Synthetic fibre
(c) Condensation polymer
(d) It is also called decron
(e) Thermosetting plastic

39. Which is not a polymer **[DPMT 2005]**
(a) Sucrose (b) Enzyme
(c) Starch (d) Teflon

General Methods of Preparation and Mechanism of Polymerisation

1. Which of the following is a syndiotactic polymer in $-[-CH_2-C(YZ)-]_n-$
(a) All *Y* groups lie on one side of the chain and all Z groups on the other side
(b) The *Y* and *Z* groups lie alternately on each side of the chain
(c) The *Y* and *Z* groups are arranged in a random fashion
(d) *Y* and *Z* groups are same

2. Polymers of the type *Z – Mn – Y,* i.e. those which contain a foreign molecule in addition to the recurring unit are known as
(a) Semisynthetic polymers (b) Atactic polymers
(c) Telomers (d) Plasticiser

3. In the natural rubber 'Caoutchouc', the isoprene units are joined by
(a) Head-to-head (b) Tail-to-tail
(c) Head-to-tail (d) All of these

4. The degree of crystallinity of which of the following is highest
(a) Atactic polyvinylchloride
(b) Isotactic polyvinylchloride
(c) Syndiotactic polyvinylchloride
(d) All of these

5. Monomers are converted to polymer by **[DCE 2002]**
(a) Hydrolysis of monomers
(b) Condensation reaction between monomers
(c) Protonation of monomers
(d) None of these

6. Polymer formation from monomers starts by **[AIEEE 2002]**
(a) Condensation reaction between monomers
(b) Coordinate reaction between monomers

(c) Conversion of monomer to monomer ions by protons

(d) Hydrolysis of monomers

7. When condensation product of hexamethylenediamine and adipic acid is heated to $553\,K(80^{o}C)$ in an atmosphere of nitrogen for about 4-5 hours, the product obtained is **[DCE 2002; MHCET 2004]**

(a) Solid polymer of nylon 66

(b) Liquid polymer of nylon 66

(c) Gaseous polymer of nylon 66

(d) Liquid polymer of nylon 6

8. Polymerization of glycol with dicarboxylic acids is

(a) Addition polymerisation

(b) Condensation polymerisation

(c) Telomerisation

(d) Any of these

9. The 'mercerised cellulose' is chemically prepared by

(a) Acetylation

(b) Mercuriation

(c) Halogenation

(d) Hydrolysis

10. The plastics if are hard, become soft and readily workable by addition of certain compounds called

(a) Catalysts

(b) Telomers

(c) Plasticisers

(d) Vulcaniser

11. The alkyd resins are condensation polymers obtained from dibasic acids and

(a) Phenol

(b) Glycol

(c) Glycerol

(d) Formaldehyde

12. Celluloid is

(a) A thermoplastic material obtained from caprolactam and urea

(b) A thermoplastic material obtained from cellulose nitrate and camphor

(c) A thermosetting material obtained from urea and formaldehyde

(d) A thermosetting material obtained from glycerol and phthalic anhydride

13. The product of addition polymerisation reaction is **[KCET 1993]**

(a) PVC

(b) Nylon

(c) Terylene

(d) Polyamide

14. Example of condensation polymer is **[RPMT 1999]**

(a) Formaldehyde → meta-formaldehyde

(b) Acetaldehyde → para-aldehyde

(c) Acetone → mesityl oxide

(d) Ethene → polyethene

15. Complete hydrolysis of cellulose gives **[AIEEE 2003]**

(a) D-fructose

(b) D-ribose

(c) D-glucose

(d) L-glucose

16. Which of the following can be polymerised to polythene

(a) Ethylene

(b) Ethylene chlorohydrin

(c) Ethyl acetate

(d) Ethylmethyl ketone

17. Polypropylene can be obtained by polymerisation of

(a) $CH \equiv CH$

(b) $CH_2 = CH_2$

(c) $CH_3 - CH = CH_2$

(d) $CH_3 - C \equiv CH$

18. When heated with zinc chloride, lactides forms a linear polymer which may be

(a) Polystyrene

(b) Polyamide

(c) Polyester

(d) Polythene

19. Which of the following has been used in the manufacture of non-inflammable photographic films

(a) Cellulose nitrate

(b) Cellulose acetate

(c) Cellulose xanthate

(d) Cellulose perchlorate

20. The phenol-formaldehyde resins are formed by polymerisation of phenol and formaldehyde by

(a) Addition polymerisation

(b) Condensation polymerisation

(c) Both (a) and (b)

(d) None of these

21. PVC is obtained by polymerization of

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

(b) $CH_2 = CH - Cl$

(c) $CH_3 - Cl$

(d) $CH_3 - CHCl_2$

22. The monomers used in the production of nylon-66 are **[CBSE 1999; RPET 2000; KCET 2000; Kurukshetra CEE 2002]**

(a) Hexamethylene diamine and ethylene glycol

(b) Adipic acid and ethylene glycol

(c) Adipic acid and hexamethylene diamine

(d) Dimethyl terephthalate and ethylene glycol

23. A raw material used in making nylon is **[NCERT 1980; MP PET 2004]**

(a) Adipic acid

(b) Butadiene

(c) Ethylene

(d) Methyl methacrylate

24. Nylon is formed when a dicarboxylic acid is treated with a

(a) Dihydric alcohol (b) Polyhydric alcohol

(c) Diamine (d) Diester

25. Vinyl chloride can be converted into PVC. In this reaction, the catalyst used is

(a) Peroxides (b) Cuprous chloride

(c) Anhydrous zinc chloride (d) Anhydrous $AlCl_3$

26. Terylene is **[BHU 2000]**

(a) An addition polymer with a benzene ring in every repeating unit

(b) A condensation polymer with a benzene ring in every repeating unit

(c) An addition polymer with two carbon atoms in every repeating unit

(d) A condensation polymer with two nitrogen atoms in every repeating unit

27. **Teflon** is a polymer of the monomer **or** Teflon is obtained by the polymerisation of

[CPMT 1986, 91; MP PET/PMT 1998; AIIMS 2002]

(a) Monofluoroethene (b) Difluoroethene

(c) Trifluoroethene (d) Tetrafluoroethene

28. The catalyst used in the manufacture of polyethene by Ziegler method is **[KCET 1993, 99]**

(a) Titanium tetrachloride and triphenyl aluminium

(b) Titanium tetrachloride and trimethyl aluminium

(c) Titanium dioxide

(d) Titanium isopropoxide

29. Acetate rayon is prepared from**[Kurukshetra CEE 1998]**

(a) Acetic acid (b) Glycerol

(c) Starch (d) Cellulose

30. The compound required for the formation of a thermosetting polymer with methanol is

[CBSE 1992, 95; MNR 1993; JIPMER 1999; BHU 2000; AFMC 2000; MP PET 2003; RPMT 2002]

(a) Benzene (b) Phenyl amine

(c) Benzaldehyde (d) Phenol

31. Which polymer is formed by chloroethene **[RPET 1999]**

(a) Teflon (b) Polyethene

(c) PVC (d) Nylon

32. The starting material for the preparation of styrene is

[MP PMT 2001]

(a) Ethane (b) Ethene

(c) Ethyne (d) Vinyl chloride

33. The catalyst used for the polymerisation of olefins is

[Kerala (Engg.) 2002]

(a) Ziegler Natta catalyst

(b) Wilkinson's catalyst

(c) Pd-catalyst

(d) Zeise's salt catalyst

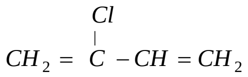
34. Rayon yarns are obtained from **[MP PET 2001]**

(a) Polymethylene (b) Polyesters

(c) Cellulose (d) Styrene

35. Which one of the following monomers gives the polymer neoprene on polymerization **[CBSE PMT 2003]**

(a) $CF_2 = CF_2$ (b) $CH_2 = CHCl$

(c) $CCl_2 = CCl_2$ (d) 
$CH_2 = \overset{\overset{\large Cl}{|}}{C} - CH = CH_2$

36. Terylene is the polymer of

[AFMC 1993; Manipal MEE 1995; KCET 1998; 2001]

(a) Ethylene glycol and terephthalic acid

(b) Melamine and formaldehyde

(c) Vinyl chloride and formaldehyde

(d) Hexamethylene diamine and adipic acid

37. The compound used in the manufacture of terylene is

[MP PET 1996]

(a) Ethylene (b) Vinyl chloride

(c) Ethylene glycol (d) Adipic acid

38. PVC is prepared by the polymerisation of**[Pb. CET 2002]**

(a) Ethylene (b) 1-chloropropene

(c) Propene (d) 1-chloroethene

39. Condensation product of caprolactum is**[BCECE 2005]**

(a) Nylon-6 (b) Nylon-66

(c) Nylon-60 (d) Nylon-6,10

Composition, Properties and Uses of Polymer

1. Discovery of 'nylon' is associated with

(a) Newyork and London(b) Newyork and Longuet

(c) Nyholm and London (d) None of these

2. Which of the following is resistant to boiling aqua-regia

(a) Polythene (b) Perspex

(c) Teflon (d) Bakelite

3. Nylon polymers are

(a) Acidic (b) Basic

(c) Amphoteric (d) Neutral

4. Nylon yarns are usually

(a) Highly inflammable

(b) Non-inflammable

(c) Both (a) and (b) types are known

(d) Uncertain inflammability

5. Which of the following is a synthetic polymer

(a) Rubber (b) Perspex

(c) Protein (d) Cellulose

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

[Kerala CET 2005]

(a) < 1 (b) > 1

(c) 1 (d) 0

(e) – 1

7. In the process of forming 'mercerised cellulose' the swelling of cellulose is caused by

(a) Water (b) Na_2CO_3

(c) $Aq.\ NaOH$ (d) $Aq.\ HCl$

8. 'Rayon' is

(a) Natural silk (b) Artificial silk

(c) Natural plastic or rubber (d) Synthetic plastic

9. As the molecular weight increases the tensile strength of polymers

(a) Increases (b) Decreases

(c) Remains unchanged (d) Uncertain

10. Triethyl aluminium titanium chloride used in plastic industry is a

(a) Vulcaniser (b) Plasticiser

(c) Ziegler-Natta catalyst (d) Telomer

11. Glyptals are chiefly employed in

(a) Toy making (b) Surface coating

(c) Photofilm making (d) Electrical insulators

12. The sterile gauze (or cotton) used in medicine is obtained by oxidising cellulose with

(a) Nitrogen (b) $KMnO_4$

(c) Nitrogen dioxide (d) Potassium chlorate

13. Ethylene-propylene rubber (EPR) is

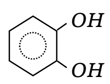
(a) Unsaturated, stereoregular

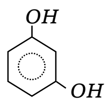
(b) Saturated, stereoregular

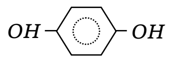
(c) Atactic, unsaturated

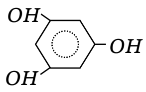
(d) Syndiotactic, unsaturated

14. The monomeric units of terylene are glycol and which of the following

(a) 

(b) 

(c) 

(d) 

15. Neoprene, a synthetic rubber contains which of the following element besides C and H

(a) N (b) O

(c) Cl (d) F

16. Acrylic resins are

(a) Colourless and transparent

(b) Dark brown and thermosetting

(c) Dark brown and thermoplastic

(d) White like milk

17. Which of the following has a higher glass-transition temperature

(a) Polyethylene (b) Polypropylene

(c) Polyvinylchloride (d) Polystyrene

18. A polymer with the high chemical stability has $M.P.\ 327^{o}C$ and the density of complete crystalline sample is $2.3\ g/cm^3$. It can be

(a) PVC (b) Teflon

(c) Melamine (d) Bakelite

19. The process of vulcanisation makes rubber

(a) Soluble in water (b) Elastic

(c) Hard (d) Soft

20. Terylene is a **[AFMC 1989; MP PET 1994; RPET 1999; Kerala (med.) 2002; MP PMT 2004]**

(a) Polyamide (b) Polyester

(c) Polyethylene (d) Polypropylene

21. $F_2C = CF_2$ is the monomer of **[CBSE PMT 2000]**

(a) Nylon-6 (b) Buna-S

(c) Glyptal (d) Teflon

22. Molecular mass of a polymer is

(a) Small (b) Very small

(c) Negligible (d) Large

23. Which of the following has cross-links

(a) Vulcanised rubber

(b) Nylon

(c) Phenol-formaldehyde resins

(d) Both (a) and (c) are correct

24. Orlon is a polymer of

[NCERT 1984; BHU 1995; AFMC 1997; DCE 2001]

(a) Styrene (b) Tetrafluoro ethylene

(c) Vinyl chloride (d) Acrylonitrile

25. Caprolactam is the monomer of **[DCE 2000]**

(a) Nylon-6 (b) Glyptal

(c) P.T.F.E. (d) Melamine

26. Which of the following intermolecular forces are present in 'nylon – 66' **[JIPMER 1997]**

(a) Vander Waals (b) Hydrogen bonding

(c) Dipole-dipole interaction (d) None of these

27. *Neoprene* is a polymer of **[AFMC 1993; NCERT 1980, 84, 86; CBSE 1991; DCE 2001]**

(a) Propene (b) Vinyl chloride
(c) Chloroprene (d) Butadiene

28. Polyvinyl chloride is

(a) An isomer of vinyl chloride
(b) An addition product of vinyl chloride
(c) An allotrope polymer of vinyl chloride
(d) A polymer of hydrated vinyl chloride

29. Which of the following polymers are hard

(a) Linear (b) Cross-linked
(c) Branched chain (d) Thermoplastic

30. Which of the following has the largest molecular mass

(a) Monomer (b) Dimer
(c) Polymer (d) Oligomer

31. Heating of rubber with sulphur is known as **[CBSE PMT 1989]**

(a) Galvanisation (b) Vulcanisation
(c) Bessemerisation (d) Sulphonation

32. $CH_2 = CH_2$ is a **[MP PMT 1986; CBSE PMT 1991]**

(a) Monomer (b) Polymer
(c) Isomer (d) Equimer

33. Which of the following fibres are made of polyamides **[CPMT 1982; NCERT 1981; MNR 1992; DCE 1999; UPSEAT 2001, 02]**

(a) Dacron (b) Orlon
(c) Nylon (d) Rayon

34. Which is not a polymer **[CPMT 1994]**

(a) Ice (b) Starch
(c) Protein (d) Cellulose

35. Acrylonitrile forms **[BHU 1995]**

(a) Terylene (b) Orlon
(c) PVC (d) Bakelite

36. Synthetic fibres like nylon-66 are very strong because

(a) They have high molecular weights and high melting points
(b) They have a high degree of cross-linking by strong $C-C$ bond
(c) They have linear molecules consisting of very long chains
(d) They have linear molecules interlinked with forces like hydrogen bonding

37. Natural rubber contains several thousand units of X linked together in the polymer chain. X is **[NCERT 1980, 84; BHU 1983; CBSE PMT 1991; MP PMT 2001]**

(a) Neoprene (b) Isoprene
(c) Chloroprene (d) Styrene

38. Natural rubber is basically a polymer of **or** The monomer of natural polymer rubber is **[MP PMT 1993, 95, 98, 99, 2000, 01; RPET 2000; MP PMT/PET 1998; MP PET 1994, 95, 98, 2001; BHU 1999; 2001; CBSE PMT 1999]**

(a) Neoprene (b) Isoprene
(c) Chloroprene (d) Butadiene

39. What is not true about polymers **[MP PET 1999]**

(a) Polymers do not carry any charge
(b) Polymers have high viscosity
(c) Polymers scatter light
(d) Polymers have low molecular weight

40. The synthetic polymer which resembles natural rubber is **[Bihar MEE 1996; DCE 2004]**

(a) Neoprene (b) Chloroprene
(c) Glyptal (d) Nylon

41. Which one is a polymer compound **[CPMT 1997; Bihar MEE 1997]**

(a) SO_2 (b) CO_2
(c) CH_4 (d) PVC

42. Which one of the following in used to make 'non-stick' cookware **[CBSE PMT 1997; AIIMS 1998]**

(a) PVC
(b) Polystyrene
(c) Polyethylene terephthalate
(d) Polytetrafluoroethylene

43. The polymer used for making contact lenses for eyes is **[AMU 1999]**

(a) Polymethylmethacrylate (b) Polyethelene
(c) Polyethylacrylate (d) Nylon-6

44. Which polymer is used for making magnetic recording tapes **[AMU 1999]**

(a) Dacron (b) Acrilan
(c) Glyptal (d) Bakelite

45. Characteristic property of Teflon is **[RPET 2000]**

(a) 2000 poise viscosity
(b) High surface tension
(c) Non-inflammable and resistant to heat
(d) Highly reactive

46. Which of the following is not a polymer **[MP PET 2001]**

(a) Silk (b) DNA
(c) DDT (d) Starch

47. Nylone 66 is **[RPMT 2002; MH CET 2003; AFMC 1998]**

(a) Polyamide (b) Polyester

(c) Polystyrene (d) Polyvinyl

48. Isoprene is a valuable substance for making **[MP PET 2002; UPSEAT 2004]**

(a) Propene (b) Liquid fuel

(c) Synthetic rubber (d) Petrol

49. Terylene is used for making **[AFMC 2002]**

(a) Silks (b) Fabrics

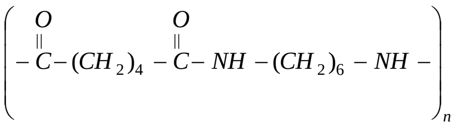
(c) Seat belts (d) All of these

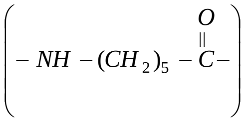
50. Nylon threads are made of **[MP PMT 2001, 03; AIEEE 2003]**

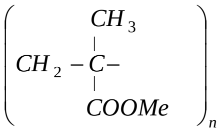
(a) Polyvinyl polymer (b) Polyester polymer

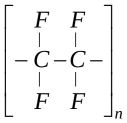
(c) Polyamide polymer (d) Polyethylene polymer

51. Nylon – 66 is **[RPMT 2003]**

(a)

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

(b)

$\left(-NH-(CH_2)_5-\overset{O}{\overset{\|}{C}}-\right)$

(c)

$\left(CH_2-\underset{COOMe}{\overset{CH_3}{C}}-\right)_n$

(d)

$\left[-\underset{F}{\overset{F}{C}}-\underset{F}{\overset{F}{C}}-\right]_n$

52. Which of the following is currently used as a tyre cord **[Kerala (Med.) 2003]**

(a) Terelene (b) Polyethylene

(c) Polypropylene (d) Nylon - 6

53. PVC is polymer of **[CPMT 2003]**

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

(c) $CH_2=CH-CH_2Cl$ (d) $CH_3-CH=CH-Cl$

54. Teflon is a polymer of **[Kerala PMT 2004]**

(a) Tetrafluoro ethane

(b) Tetrafluro propene

(c) Difluorodichloro ethane

(d) Difluoro ethene

(e) Trifluoro ethene

55. Which of the following is used in vulcanization of rubber **[MH CET 2004]**

(a) SF_6 (b) CF_4

(c) Cl_2F_2 (d) C_2F_2

56. PVC is used for .... **[Orissa JEE 2002]**

(a) Manufacture of cosmetics

(b) Manufacture of tyres

(c) Manufacture of nonstick pans

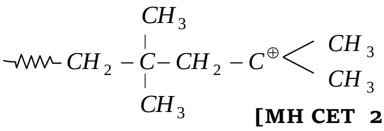
(d) Manufacture of plastic pipes

57. Polythene is a resin obtained by polymerisation of **or** The monomer unit in polythene is **[CPMT 1983; JIPMER 1997; MP PMT 2002]**

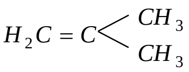
(a) Butadiene (b) Ethylene

(c) Isoprene (d) Propylene

58. The monomer of the polymer


$\sim\!\sim CH_2-\underset{CH_3}{\overset{CH_3}{C}}-CH_2-C^{\oplus}<^{CH_3}_{CH_3}$

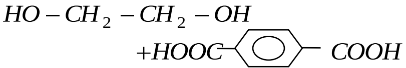
is **[MH CET 2004; CBSE PMT 2005]**

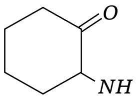
(a)

$H_2C=C<^{CH_3}_{CH_3}$

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

(c) $CH_3CH=CHCH_3$ (d) $CH_3CH=CH_2$

59. The monomer of Nylon-6 is/are **[DPMT 2004]**

(a)

$HO-CH_2-CH_2-OH$ $+HOOC-C_6H_4-COOH$

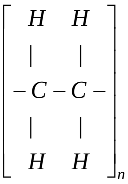
(b)


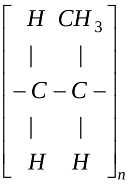
$+H_2O$

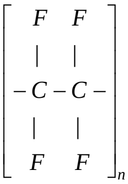
(c) $F_2C=CF_2$

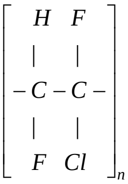
(d) $H_2C=CH_2$

60. Which of the following is **teflon** **[MP PMT 2000, 03]**

(a)

$\left[-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\right]_n$

(b)

$\left[-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{CH_3}{C}}-\right]_n$

(c)

$\left[-\underset{F}{\overset{F}{C}}-\underset{F}{\overset{F}{C}}-\right]_n$

(d)

$\left[-\underset{F}{\overset{H}{C}}-\underset{Cl}{\overset{F}{C}}-\right]_n$

61. Thermosetting plastics are

(a) Soluble in water (b) Soluble in alcohol

(c) Soluble in benzene (d) Insoluble

62. Cellulose is

(a) $(C_6H_{10}O_5)_n$ (b) $(C_3H_3N_3)_n$

(c) $(C_3H_6N_6)_n$ (d) $(C_{12}H_{22}O_{11})_n$

63. The molecular weight of cellulose varies between

(a) 1000 to 20000 (b) 20000 to 500000

(c) 100 to 200 (d) 1000000 to 5000000

64. The value of *n* in the formula $(C_5H_{10}O_5)_n$ for inulin is about

(a) 30 (b) 300

(c) 3000 (d) 300000

65. 'Starch' consists of two fractions; one is $\alpha-\text{amylose}$ and the other is

(a) Amylopectin (b) Glycogen

(c) Pecticamide (d) Alginic acid

66. The process of heat-softening, moulding and cooling to rigidness' can be repeated for which plastics

(a) Thermoplastics (b) Thermosetting plastics

(c) Both (a) and (b) (d) None of the above

67. In the trinitrocellulose each glucose unit contains how many $-OH$ groups

(a) 2 (b) 3

(c) 4 (d) 5

68. Shellac contains mainly

(a) Cellulose

(b) Polyhydroxy organic acids

(c) Polyamides

(d) Polyesters

69. In elastomer, intermolecular forces are **[AIIMS 2000; BHU 2004]**

(a) Nil (b) Weak

(c) Strong (d) Very strong

70. Cellulose is a polymer of **[CBSE PMT 2002]**

(a) Fructose (b) Ribose

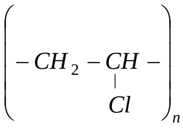
(c) Glucose (d) Sucrose

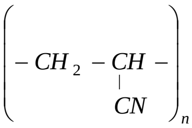
71. Which of the following polymer has ester linkage **[BVP 2004]**

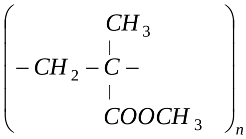
(a) Nylon-66 (b) PVC

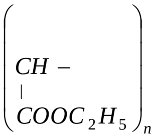
(c) Terylene (d) SBR

72. Acrilan is a hard, horny and a high melting material. Which of the following represents its structure **[CBSE PMT 2003]**

(a) 
$\left(-CH_2-\underset{Cl}{CH}-\right)_n$

(b) 
$\left(-CH_2-\underset{CN}{CH}-\right)_n$

(c) 
$\left(-CH_2-\overset{CH_3}{\underset{COOCH_3}{C}}-\right)_n$

(d) 
$\left(\underset{COOC_2H_5}{CH}-\right)_n$

73. Which of the following has amide links

(a) Protein (b) Nylon

(c) Peptide (d) All of these

74. Which of the following is a polyamide **[AIEEE 2005]**

(a) Teflon (b) Nylon –66

(c) Terylene (d) Bakelite

75. Which of the following is fully fluorinated polymer **[AIEEE 2005]**

(a) Neoprene (b) Teflon

(c) Thiokol (d) PVC

76. Three dimensional molecules with cross links are formed in the case of a **[KCET 2005]**

(a) Thermoplastic (b) Thermosetting plastic (c) Both (d) None

Critical Thinking

Objective Questions

1. Trans-form of polyisoprene is

(a) Guttapercha (b) Hydrochloride rubber

(c) Buna-N (d) Synthetic rubber

2. Wash and wear clothes are manufactured using

(a) Nylon fibres (b) Cotton mixed with nylon

(c) Terylene fibres (d) Wool fibres

3. In the manufacture of polythene by the Ziegler process using ethylene, the temperature for proper polymerisation required is

(a) Below 10^oC (b) 10^o to 50^oC

(c) 50^o to 80^oC (d) 80^o to 140^oC

4. High density polyethylene (HDPE) can be prepared from ethylene by

(a) Ziegler-Natta process

(b) Heating with peroxides

(c) Condensing in sealed tubes

(d) Condensing with styrenes

5. Perlon is **[AFMC 2001]**

(a) Rubber (b) Nylon-6

(c) Terelene (d) Oxlon

6. Styrene at room temparature is

(a) Solid (b) Liquid

(c) Gas (d) Colloidal solution

7. Which one of the following can be used as monomer in a polymerisation reaction **[MP PMT 1993]**

(a) CH_3CH_2Cl (b) CH_3CH_2OH

(c) C_6H_6 (d) C_3H_6

8. The Zieglar-Natta catalysts are

(a) Stereospecific

(b) Non-metallic complexes

(c) Gaseous catalysts

(d) Universal in all polymerisation reactions

9. Melamine is

(a) Gas (b) Yellow liquid

(c) White crystalline solid (d) Colloidal solution

10. Glyptal is a

(a) Viscose rayon (b) Nylon

(c) Polystyrene (d) Alkyd resin

11. Which of the following is not polyamide **[AFMC 2000; CBSE PMT 2001; KCET 2001]**

(a) Nylon-66 (b) Protein

(c) Glyptal (d) Nylon-6

12. Which of the following statement is correct regarding the drawbacks of raw rubber **[AIIMS 2001]**

(a) It is plastic in nature

(b) It has little durability

(c) It has large water-absorption capacity

(d) All of these

13. Which of the following is a chain growth polymer **[CBSE PMT 2004]**

(a) Polystyrene (b) Protein

(c) Starch (d) Nucleic acid

14. '*Celanese silk*' is

(a) Cellulose trinitrate (b) Cellulose acetate

(c) Cellophane (d) Pyroxylin

15. Ebonite is **[CBSE PMT 2000]**

(a) Polropene (b) Natural rubber

(c) Synthetic rubber (d) Highly vulcanized rubber

16. Polymer used in bullet proof glass is **[MP PET 2004]**

(a) Lexane (b) PMMA

(c) Nomex (d) Kevlar

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : The time of vulcanisation and temperature is increased by adding accelerators.
Reason : By vulcanising, a material of high tensile strength can be obtained.

2. Assertion : Hydrogenation is the process of converting an oil into a fat, called vegetable ghee.
Reason : Hydrogenation as carried out in presence of a catalyst usually finely divided nickel.

3. Assertion : In vulcanisation of rubber, sulphur cross links are introduced.
Reason : Vulcanisation is a free radical initiated chain reaction.

4. Assertion : Bakelite is a thermosetting polymer.
Reason : Bakelite can be melted again and again without any change.

5. Assertion : Teflon has high thermal stability and chemical inertness.
Reason : Teflon is a thermoplastic.

Answers

Classification of Polymer

1	c	2	d	3	a	4	c	5	b
6	d	7	d	8	a	9	a	10	d
11	d	12	c	13	d	14	a	15	d
16	b	17	d	18	d	19	b	20	b
21	a	22	d	23	d	24	a	25	a
26	c	27	c	28	d	29	c	30	a
31	d	32	d	33	c	34	d	35	b
36	c	37	c	38	e	39	a		

General methods of preparation and mechanism of polymerisation

1	b	2	c	3	c	4	c	5	b
6	a	7	b	8	b	9	d	10	c
11	b	12	b	13	a	14	c	15	c
16	a	17	c	18	a	19	b	20	b
21	b	22	c	23	a	24	c	25	a
26	b	27	d	28	b	29	d	30	d
31	c	32	c	33	a	34	c	35	d
36	a	37	c	38	d	39	a		

Composition, Properties and Uses of Polymer

1	a	2	c	3	c	4	c	5	b
6	b	7	c	8	b	9	a	10	c
11	b	12	c	13	b	14	c	15	c
16	a	17	d	18	b	19	c	20	b
21	d	22	d	23	d	24	d	25	a
26	b	27	c	28	b	29	b	30	c
31	b	32	a	33	c	34	a	35	b
36	d	37	b	38	b	39	d	40	a
41	d	42	d	43	a	44	d	45	c
46	c	47	a	48	c	49	d	50	c
51	a	52	d	53	b	54	a	55	a
56	d	57	b	58	a	59	b	60	c
61	d	62	a	63	b	64	a	65	a
66	a	67	b	68	b	69	b	70	c
71	c	72	b	73	d	74	b	75	b
76	b								

Critical Thinking Questions

1	a	2	c	3	c	4	a	5	b
6	b	7	d	8	a	9	c	10	d
11	c	12	d	13	a	14	b	15	d
16	b								

Assertion and Reason

1	e	2	b	3	b	4	c	5	b

Answers and Solutions

Classification of Polymer

1. (c) Bakelite is thermosetting polymer. It becomes infusible on heating and can not be remoulded

4. (c) Natural rubber is the only addition polymer of nature and is known as $Cis-1,4-$ polyisoprene.

6. (d) Wax is a molecular solid.

9. (a) It is present in the cell wall of plant.

12. (c) Starch is a natural polymer and other are synthetic.

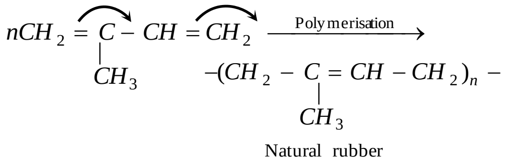
13. (d) Protein is a natural polymer of $\alpha-$amino acids.

17. (d) Amylose is a linear polymer of $\alpha-D-$Glucose

$$\underset{(C_1-C_4\ \alpha-\text{linkage})}{(-\text{Glucose}-\text{Glucose}-\text{Glucose}-)_n}$$

18. (d) Silk is protein fibre. Dacron is polyester fibre and Nylon-66 is polyamide fibre.

19. (b) Natural rubber is addition polymer of isoprene (2-methyl-1, 3-butadiene)



$$nCH_2=\underset{CH_3}{\underset{|}{C}}-CH=CH_2 \xrightarrow{\text{Polymerisation}} -(CH_2-\underset{CH_3}{\underset{|}{C}}=CH-CH_2)_n-$$

20. (b) Polyethylene is a homopolymer

$$nCH_2=CH_2 \rightarrow (-CH_2-CH_2)_n$$

21. (a) Cellulose is the natural fibre which are biodegradable polymer rest are synthetic polymer which are not biodegradable.

23. (d) Nylon is the copolymer of Hexamethylene diamine and adipic acid. It is not a homo-polymer because homopolymer formed by two same monomer unit.

25. (a) Thermoplastic are those which becomes soft on heating and can be remoulded again.

26. (c) Resins are amorphous organic solids or semisolids which usually have a typical lustre and are often transparent or translucent.

27. (c) Step growth polymerization involves condensation reaction between two difunctional monomer to produce dimer which in turn, produce, tetramer and so on with the loss of simple molecules like H_2O, NH_3, HCl etc.

29. (c) Buna-*S* and Neoprene both are synthetic rubber.

31. (d) Nylon is a synthetic polymer.

35. (b) Nylon-66 is manufactured by the condensation polymerization of adipic acid and hexamethylenediamine with the lose of H_2O as steam.

36. (c) The polymer formed by the condensation polymerisation is known as condensation polymer. Decron (Terylene) is a condensation polymer. It is formed by the condensation polymerisation of terephthalic acid and ethylene glycol.

37. (c) PVC is a synthetic polymer made by vinylchloride.

38. (e) Terylene is fibre not a thermosetting plastic because on heating they melt and do not show plastic property while rest option are true regarding to Terylen

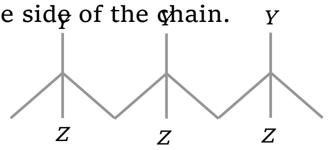
39. (a) Sucrose is a disaccharides which upon acid or enzymatic hydrolysis gives only two molecules of monosaccharides.

Sucrose $\xrightarrow{H^+ \text{or invertaase}}$ D(+)-glucose+(D)(–)-fructose

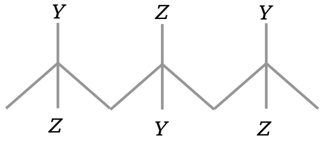
General methods of preparation and mechanism of Polymerisation

1. (b) There are 3 stereo chemical arrangements are possible

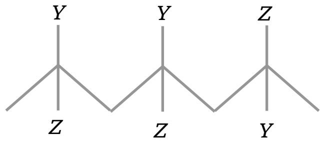
(i) Isotactic (Same order):- Here groups are arranged on one side of the chain. All *Y* groups lie on one side and all *Z* groups on the opposite side of the chain.



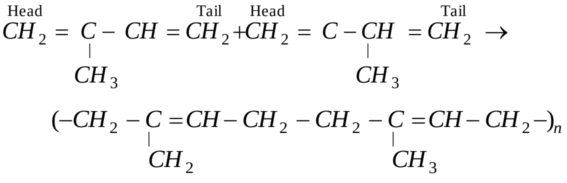
(ii) Syndiotactic (Alternating order) - The *Y* and *Z* groups lie alternately on each side of the chain.



(iii) Atactic (Random order) - The *Y* and *Z* groups are arranged in *a* random fashion.



3. (c)

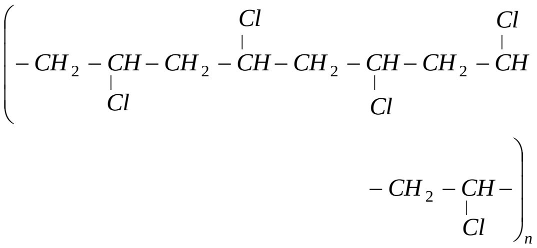


$$\overset{\text{Head}}{CH_2} = \underset{\substack{|\\ CH_3}}{C} - CH = \overset{\text{Tail}}{CH_2} + \overset{\text{Head}}{CH_2} = C - \underset{\substack{|\\ CH_3}}{CH} = \overset{\text{Tail}}{CH_2} \rightarrow$$

$$(-CH_2 - \underset{\substack{|\\ CH_2}}{C} = CH - CH_2 - CH_2 - \underset{\substack{|\\ CH_3}}{C} = CH - CH_2 -)_n$$

From steric effects, the polymer formed has head to tail configuration.

4. (c) Syndiotactic polyvinylchloride

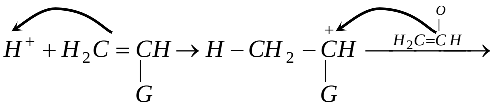


$$\left(-CH_2 - \underset{\substack{|\\ Cl}}{CH} - CH_2 - \overset{\substack{Cl\\ |}}{CH} - CH_2 - \underset{\substack{|\\ Cl}}{CH} - CH_2 - \overset{\substack{Cl\\ |}}{CH} \right.$$

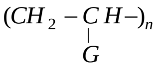
$$\left. - CH_2 - \underset{\substack{|\\ Cl}}{CH} - \right)_n$$

In this arrangement the chlorine atoms are alternately arranged. The polymer is stereoregular and has high crystallinity.

5. (b)



$$H^+ + H_2C = \underset{\substack{|\\ G}}{CH} \rightarrow H - CH_2 - \underset{\substack{|\\ G}}{\overset{+}{C}H} \xrightarrow{H_2C=\overset{\substack{O\\ |}}{C}H}$$



Repeat $\Rightarrow (CH_2 - \underset{\substack{|\\ G}}{C}H -)_n$

Polym

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.

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

$$nHOOC-(CH_2)_4-COOH \xrightarrow[-nH_2O]{\text{Polymerisation}}$$

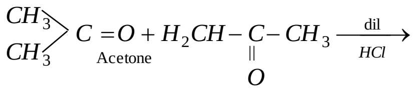
$$\underset{\text{Nylon}}{[-HN-(CH_2)_6-NHCO-(CH_2)_4-CO-]_n}$$

8. (b) Condensation Polymerization because loss of water molecule takes place.

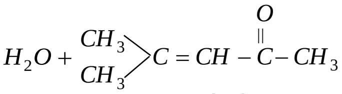
10. (c) *e.g.*- PVC is extremely stiff and hard but the addition of *di-n* butyl phthalate Plasticizers makes it soft and rubber like.

14. (c) Polymers formed by condensation process with eliminaiton of small molecule like H_2O, CO_2 etc. are known as condensation polymers.

eg.



$$\underset{\text{Acetone}}{\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!> C = O} + H_2CH - \underset{\substack{\|\\ O}}{C} - CH_3 \xrightarrow[HCl]{\text{dil}}$$



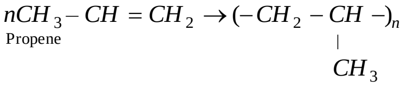
$$H_2O + \begin{matrix} CH_3 \\ CH_3 \end{matrix} > C = CH - \overset{\overset{\displaystyle O}{\|}}{C} - CH_3$$

Mesityloxide

15. (c) *D*-glucose is the monomer of cellulose.

16. (a) $\underset{\text{Ethylene}}{nCH_2 = CH_2} \rightarrow \underset{\text{Polythene}}{(-CH_2 - CH_2 -)_n}$

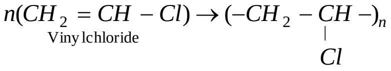
17. (c)



$$\underset{\text{Propene}}{nCH_3 - CH = CH_2} \rightarrow (-CH_2 - \underset{\underset{\displaystyle CH_3}{|}}{CH} -)_n$$

Polypropylene

21. (b)



$$\underset{\text{Vinylchloride}}{n(CH_2 = CH - Cl)} \rightarrow (-CH_2 - \underset{\underset{\displaystyle Cl}{|}}{CH} -)_n$$

(PVC)

22. (c) Adipic acid $(HOOC - (CH_2)_4 - COOH)$ and Hexamethylene diamine $(NH_2 - (CH_2)_6 - NH_2)$

27. (d) Tetrafluoroethene $(CF_2 = CF_2)$.

29. (d) Rayon fibre is chemically identical to cotton but has a shine like silk, rayon is also called a regenerated fibre because during its preparation. Cellulose is regenerated by dissolving it in $NaOH$ and CS_2.

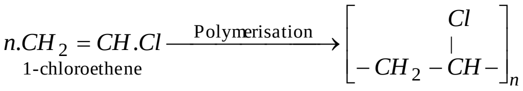
30. (d) When phenol react with $HCHO$ form bakelite which is a thermosetting polymer.

31. (c) Generally chloroethene (vinyl chloride) formed PVC polyvinyle chloride.

33. (a) $Al(C_2H_5)_3 + TiCl_4$ is Ziegler Natta catalyst.

37. (c) Terylene is a polymer of ethylene glycol and terephthalic acid.

38. (d) PVC is polyvinyl chloride, a polymer of vinyl chloride.



$$\underset{\text{1-chloroethene}}{n.CH_2 = CH.Cl} \xrightarrow{\text{Polymerisation}} \left[- CH_2 - \overset{\overset{\displaystyle Cl}{|}}{CH} - \right]_n$$

PVC

Composition, properties and uses of Polymers

1. (a) Nylon was simultaneously discovered in New york and London.

2. (c) Teflon is flexible, inert to solvents and to boiling with acids even to aqua - regia and is stable upto $598\ K$.

4. (c) Both highly inflammable and Non-inflammable

5. (b) Perspex is a synthesized polymer.

6. (b) Average number molecular weight $\overline{M_n} = 30{,}000$

Average mass molecular weight $\overline{M_w} = 40{,}000$

Polydispersity index (PDI)

$$= \frac{\overline{M_w}}{\overline{M_n}} = \frac{40{,}000}{30{,}000} = 1.33$$

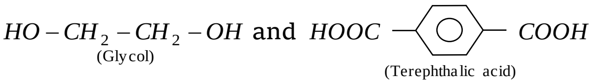
7. (c) Cellulose forms a transluscent mass on treatment with conc. $NaOH$ which imparts a silky lustre to cotton. This process is mercerisation and the cotton so produced is known as mercerised cotton.

8. (b) 'Rayon' is man-made fibre which consists of purified cellulose in the form of long threads. Rayon resembles silk in appearance. Hence called as artificial silk.

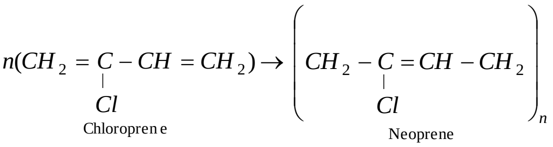
$$\underset{\text{(from woodpulp)}}{\text{Cellulose}} \xrightarrow[CS_2]{NaOH} \underset{\text{(Syrup like liquid)}}{\text{Viscose}} \xrightarrow[\substack{\text{Spinneret} \\ \text{into dil. } H_2SO_4}]{\text{Pass through}} \underset{\text{(Fine silken thread)}}{\text{Rayon}}$$

10. (c) Ziegler-Natta catalyst $(C_2H_5)_3Al + TiCl_4$

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



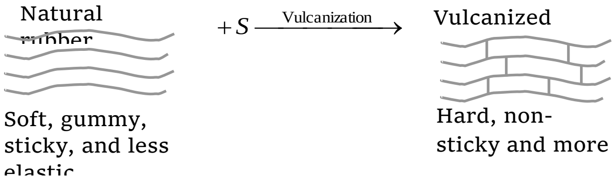
15. (c)



$$\underset{\text{Chloroprene}}{n(CH_2 = \underset{\underset{\displaystyle Cl}{|}}{C} - CH = CH_2)} \rightarrow \left(CH_2 - \underset{\underset{\displaystyle Cl}{|}}{C} = CH - CH_2 \right)_n$$

Neoprene

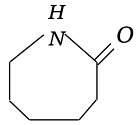
19. (c)



22. (d) Polymer always consists of hundreds to thousands of repeating structural units. Hence they have very high molecular mass.

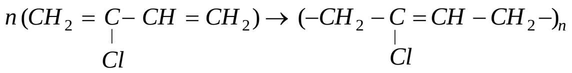
24. (d) Acrylonitrile is a hard, horny and high melting material. It is used in the manufacture of oron and Acrilan fibres which are used for making clothes, carpets and blankets.

25. (a)



Caprolactam

27. (c)

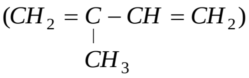


$$\underset{\text{Chloroprene}}{n(CH_2 = \underset{\underset{\displaystyle Cl}{|}}{C} - CH = CH_2)} \rightarrow \underset{\text{Neoprene}}{(-CH_2 - \underset{\underset{\displaystyle Cl}{|}}{C} = CH - CH_2 -)_n}$$

34. (a) Ice is a molecular solid.

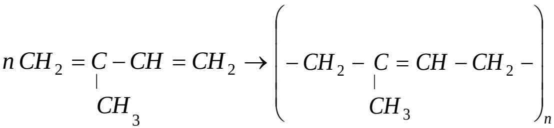
36. (d) They have linear molecules interlinked with forces like hydrogen bonding.

37. (b) Isoprene



$$(CH_2 = \underset{\underset{\displaystyle CH_3}{|}}{C} - CH = CH_2)$$

38. (b)

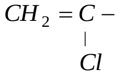


$$nCH_2 = \underset{\underset{\displaystyle CH_3}{|}}{C} - CH = CH_2 \rightarrow \left(- CH_2 - \underset{\underset{\displaystyle CH_3}{|}}{C} = CH - CH_2 - \right)_n$$

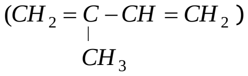
Natural rubber

39. (d) Polymers have high molecular weight.

40. (a) In Neoprene monomer unit is


$CH_2=\underset{\underset{Cl}{|}}{C}-CH=CH_2$ (chloroprene)

while Isoprene $(CH_2=\underset{\underset{CH_3}{|}}{C}-CH=CH_2)$ is the monomer of natural rubber.



42. (d) Teflon has great chemical inertness and high thermal stability, hence used for making non-stick utensils. For this purpose, a thin layer of teflon is coated on the inner side of the vessel.

43. (a) Also known as PMMA. It is a transparent, excellent light transmitter and its optical clarity better than glass so it is used in the preparation of lenses for eyes.

45. (c) Teflon is non-inflammable and resistant to heat so it is used in coating, particularly in non-sticking frying pans.

46. (c) DDT is an organic compound used as insectiside not is a polymer.

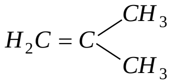
47. (a) All the nylons are polyamides.

48. (c) Rubber is a polymer of isoprene. Its chemical formula is $(C_5H_8)_n$.

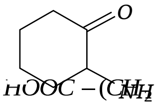
54. (a) $\underset{\text{Tetrafluoro ethane}}{nCF_2=CF_2} \longrightarrow \underset{\text{Teflon}}{[-CF_2-CF_2-]_n}$

55. (a) SF_6 is used in the vulcanisation of rubber. Sulphur is heated with polymer to introduce cross-linking and thus, form tough polymer.

58. (a)

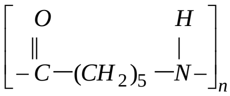


59. (b) The monomer used in the preparation of Nylon-6 is caprolactam.



$$+H_2O \rightarrow HOOC-(CH_2)_5-NH_2+HNO$$

$$\rightarrow HOOC-(CH_2)_5-HN-CO-(CH_2)_5-NH_2$$



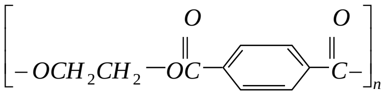
$$\left[-\overset{\overset{O}{\|}}{C}-(CH_2)_5-\overset{\overset{H}{|}}{N}-\right]_n$$

Nylon-6

64. (a) 30-Inulin $(C_5H_{10}O_5)_{30}$ is found in the “Roots of Dahaliya”.

69. (b) Polymer chain in elastomer are held together by weak intermolecular forces eg. Vulacanised rubber.

71. (c) Terylene has ester linkage. It is the polymer of ethylene glycol with terephthalic acid. It is used in textile industry.



Dacron or terylene

74. (b) Nylons are polyamide fibres.

76. (b) Thermosetting plastics have three dimensional cross-linked structure. Such polymers are prepared in two steps. The first step is the foramtion of long chain molecules which are capable of further reaction with each other. the second step is the application of heat which cause a reaction to occur between the chains, thus producing a complex cross-linked polymer.

Critical Thinking Questions

1. (a) Guttapercha rubber is very hard horny material consisting of trans 1, 4 - polyisoprene polymer

2. (c) The fibre of terylene is highly crease - resistant, durable and has low moisture content. It is also not damaged by pests like moths and mildew. It is therefore used for the manufacture of wash and wear fabrics. It is also blended with cotton (Terycot) and wool (Terywool) to increase their resistance to wear and tear.

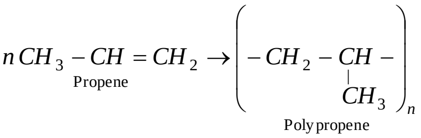
3. (c) The reaction carried out at temp. 50°-80°*C*.

4. (a) *HDPE* is prepared by co-ordination polymerization which occurs through the intermediate formation of co-ordination complexes. For example, ethylene first forms a co-ordination complex with the transition metal titanium by donating its π -electrons. The π complex thus formed then reacts stepwise with a large number of ethylene molecules ultimately leading to the formation of a polymer. The polythene so obtained has high density $(0.97\,g/cm^3)$ and higher *m.pt.* (403*K*) as compare to *LDPE* (density- 0.92 g/cm^3 and *m.pt.* 384*K*)

5. (b) Perlon is Nylon-6. It is prepared from a single monomer having a potential amino group of one end and a potential carbonyl group of other end.

6. (b) Styrene at room temperature is liquid.

7. (d)



$$\underset{\text{Propene}}{n\,CH_3-CH=CH_2} \rightarrow \underset{\text{Poly propene}}{\left(-CH_2-\underset{\underset{CH_3}{|}}{CH}-\right)_n}$$

8. (a) Zieglar Natta catalyst is a mixture of $TiCl_4$ and $(C_2H_5)_3Al$ used in the synthesis of stereoregular polymers.

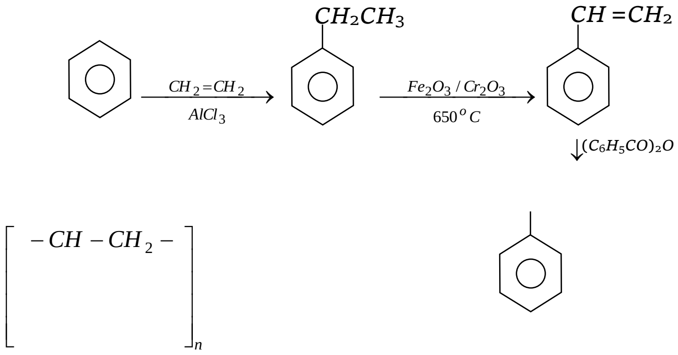
9. (c) Melamine is the phenol-urea resin which are white crystalline solid.

10. (d) Glyptal is a polymer of phthallic acid and Glycol.

11. (c) Glyptal is an alkyd resin of ethylene glycol $(HO-CH_2-CH_2-OH)$.

12. (d) The raw rubber is plastic in nature. It becomes soft at high temperature. It has little durability and it has large water absorption capacity.

13. (a) Chain growth polymers involve a series of reaction each of which consume a reactive particles & produces another similar one. The reactive particles may be free radicals or ions (cation or anion) to which monomers get added by a chain reaction. It is an important reaction of alkenes & conjugated dienes or indeed of all kinds of compounds that contains $C-C$ double bond



14. (b) Cellulose acetate known as celanese silk.

15. (d) Ebonite is a hard and highly (20-30%) vulcanized rubber.

16. (b) PMMA is used in bullet proof glass.

Assertion & Reason

1. (e) The time of vulcanisation is reduced by adding accelerators and activators.

2. (b) Hydrogenation or hardening of oil is a process in which various unsaturated radicals of fatty glycerides are converted into more highly or completely saturated glycerides by the addition of hydrogen in the presence of a catalyst, usually finely divided nickel.

3. (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.

4. (c) Bakelite can be heated only once.

5. (b) Due to the presence of strong $C-F$ bonds, teflon has high thermal stability and chemical inertness.

Polymer

SET Self Evaluation Test - 30

1. Nylon-6 is made from **[MP PMT 2002; BHU 2002]**

(a) Butadiene (b) Chloroprene

(c) Adipic acid (d) Caprolactum

2. A polymer containing nitrogen is **[UPSEAT 2004; MP PET 2003]**

(a) Bakelite (b) Dacron

(c) Rubber (d) Nylon-66

3. Cellulose acetate is a **[JIPMER 2002]**

(a) Natural polymer

(b) Semisynthetic polymer

(c) Synthetic polymer

(d) Plasticiser

4. Ethylene-propylene rubber can be

(a) Vulcanized by sulphur

(b) Vulcanized by peroxides

(c) Both (a) and (b)

(d) Non-vulcanizable

5. Buna-S is a polymer of **[CPMT 1987; JIPMER 1999]**

(a) Butadiene and styrene

(b) Butadiene

(c) Styrene

(d) Butadiene and chloroprene

6. Nylon is generic name for all synthetic fibre forming

(a) Polyesters (b) Polymeric amides

(c) Polystyrene (d) Polyethylene

7. Polymerisation in which two or more chemically different monomers take part is called **[MP PMT 1991, 93]**

(a) Addition polymerisation

(b) Copolymerisation

(c) Chain polymerisation

(d) Homopolymerisation

8. Whether small molecules liberate in addition polymerisation

(a) Yes (b) No

(c) Sometimes (d) Only H_2O

9. Orlon has a unit **[AFMC 2004]**

(a) Vinyl cyanide (b) Acrolein

(c) Glycol (d) Isoprene

10. The common acid used in the manufacture of rayon and plastics is **[Kerala (Engg.) 2002]**

(a) Methanoic acid (b) Ethanoic acid

(c) Propanoic acid (d) Butanoic acid

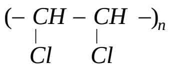
11. Buna-s rubber is which of the following of 1-3-butadiene and styrene **[Pb. PMT 2000]**

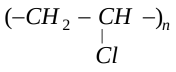
(a) Polymers (b) Copolymer

(c) Addition polymer (d) Condensation

12. Which one of the following polymers will not catch fire **[MP PET 1994]**

(a) $(-CF_2-CF_2-)_n$ (b) $(-CH_2-CH_2-)_n$

(c) 
$(-\underset{Cl}{\underset{|}{CH}}-\underset{Cl}{\underset{|}{CH}}-)_n$

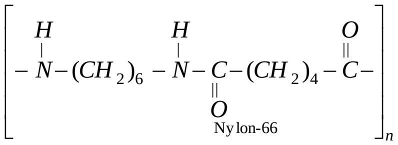
(d) 
$(-CH_2-\underset{Cl}{\underset{|}{CH}}-)_n$

Answers and Solutions

(SET -30)

1. (d) Caprolactun is the monomer of nylon –6.

2. (d) Nylon-66- It is a polymer containing alitrogen

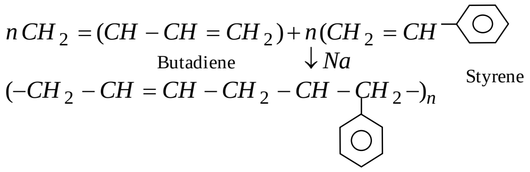


$$\left[-\overset{H}{\overset{|}{N}}-(CH_2)_6-\overset{H}{\overset{|}{N}}-\underset{O}{\underset{||}{C}}-(CH_2)_4-\overset{O}{\overset{||}{C}}-\right]_n$$

Nylon-66

3. (b) Because cellulose is a natural polymer.

4. (b) It is vulcanized by peroxide because it requires the more electronegative element to form cross - link structure.

5. (a) 

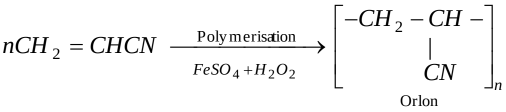
It is also called SBR (styrene butadiene rubber).

6. (b) Nylon is a polyamide fibre representing the polyamide linkage.

7. (b) *e.g.* Adipic acid + Hexamethylene diamine → Nylon - 6 6

8. (b) In addition polymerization simple addition of monomer unit takes place without any loss of small molecules.

9. (a) Orlon is prepared by polymerization of vinyl cyanide in presence of ferrous sulphate & hydrogen peroxide



$$nCH_2=CHCN\xrightarrow[FeSO_4+H_2O_2]{\text{Polymerisation}}\left[-CH_2-\underset{CN}{\underset{|}{CH}}-\right]_n$$

Orlon

10. (b) Ethanoic acid is used in the manufacture of regin and plastics.

11. (b) Buna-*S* is a coplymer of 1, 3- butadiene and styrene.

12. (a) Teflon $(-CF_2-CF_2-)_n$ is stable upto 598 *K*.

***