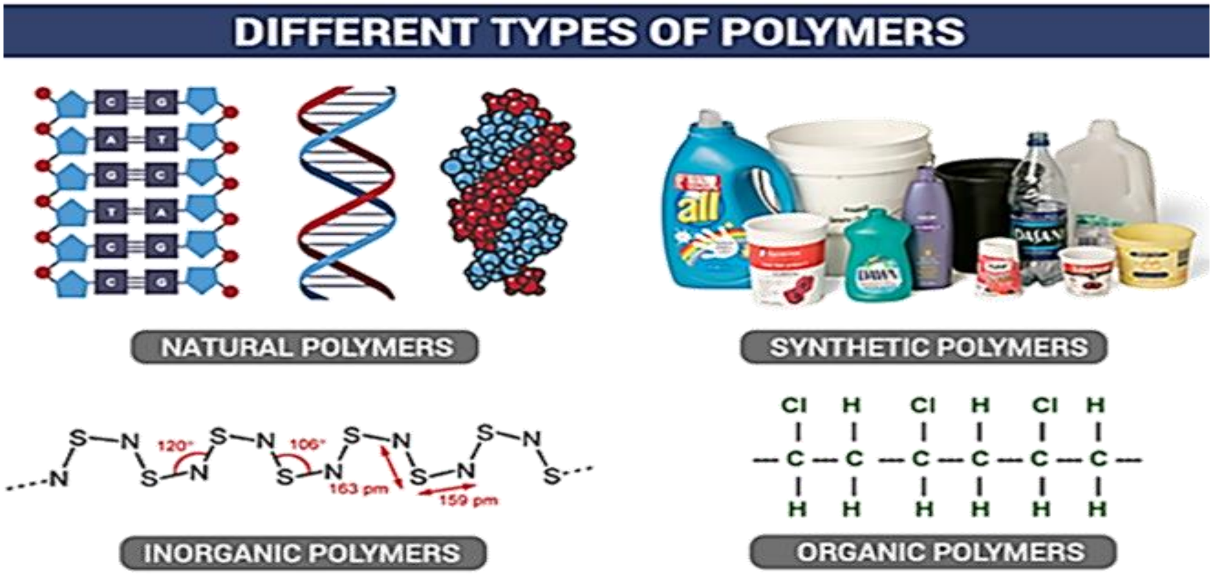
POLYMERS

CHAPTER – 15

POLYMERS



Introduction - Polymers can be found all around us. From the strand of our DNA, which is a naturally occurring biopolymer, to polypropylene which is used throughout the world as plastic.

Polymers may be naturally found in plants and animals (natural polymers) or may be man-made (synthetic polymers). Different polymers have a number of unique physical and chemical properties, due to which they find usage in everyday life.

Poly means – more than one
Mer - part

Polymers: The word ‘polymer’ is derived from two Greek words: poly means many and mer means unit or part. The term polymer is defined as the large molecules whose molecular size varies from 10^3 -10^7 u). These are also called macromolecules, which are formed by assembling repeating building blocks or units in large quantities.

Monomers: Repetitive structural units derived from other simple and functional molecules known as monomers.

The process of forming polymers from different monomers is called polymerization. Example - Conversion of ethylene to polyethylene.

Classification of polymers on the basis of source:
Natural Polymers – It is obtained from plants
Proteins, cellulose, starch, other resins and rubber are examples of polymers found in plants.

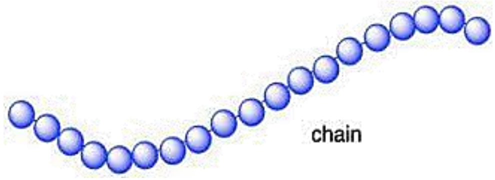
Semi-synthetic polymers – the polymers which are formed by the chemical modification of natural polymers
Extracts from cellulose such as cellulose acetate (rayon) and cellulose nitrate etc. are examples of this category.

Synthetic polymers – the polymers which are synthesised in laboratory.
Plastic (polythene), nylon (6, 6) and synthetic rubber (Buna-S) are examples of man-made polymers.

Classification based on the structure of polymers:
Linear polymer – A type of polymer in which linear polymeric chain are present which are well-packed to each other due to which it has maximum density, melting point and tensile strength.
A linear polymer is a long continuous chain of carbon-carbon bonds and two remaining valence bonds attached primarily to hydrogen or other small part of hydrocarbon.

Example

PVC, HDP etc.



Note

All fibers are linear polymers. Examples – are cellulose, silk, nylon, terylene etc.
Linear polymers may be condensation as well as addition polymers. Examples are cellulose, polypeptide, nucleic acid, nylon, terylene etc.

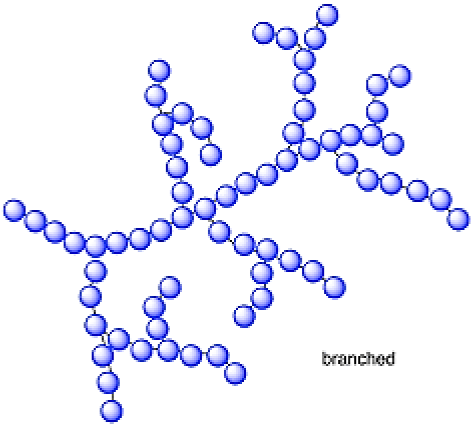
Branched chain polymers – The polymers made up of main chain(linear chain) with smaller chains as branches of main chain are called branched chain polymers. They have lower melting points, densities and tensile strength as compared to linear polymers.

Example

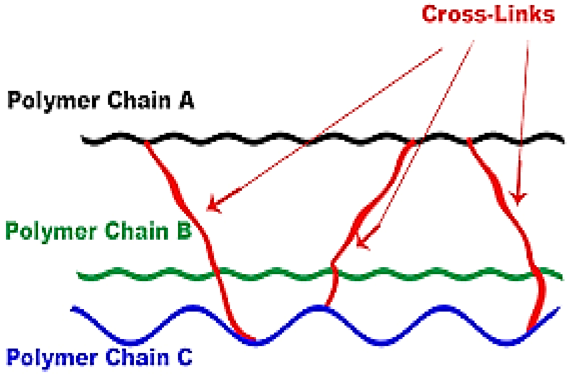
Polypropylene, LDP

OR

Branched polymers are defined as secondary polymer chains attached to the primary backbone, resulting in a variety of star-shaped polymer structures, H-shaped, pom-pom, and comb-shaped polymers. A common example of branched polymers is low-density polyethylene (LDPE). It has a wide range of applications ranging from plastic bags, fabrics, containers, to holes in various packaging materials. -There is a reduction in packing efficiency in branch chains as a result of which they show low density.



Cross-linked or network polymers – it is such type of polymer which is generally formed by the bifunctional or trifunctional monomer. In this polymer linear polymeric chain are held together by the strong covalent bond. Example – melamine, Bakelite.



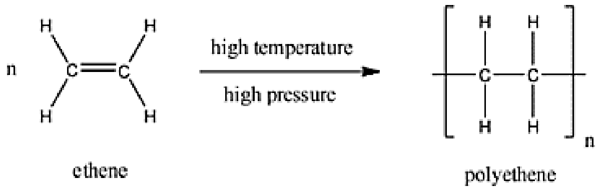
Classification based on polymerization mode:
Addition Polymer –It is formed by the repeated addition of same or different monomer. These polymers are usually made up of molecules with a carbon-carbon double bond which means that additional polymers are prepared from alkenes. Additional polymers include polystyrene, polyethylene, polyacrylates, and methacrylates.

It is further divided into two parts:
Homopolymer – it is formed by the repeated addition of same monomer..

Example

polythene.

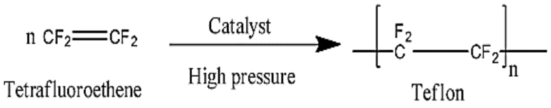
Polythene - Polythenes are linear or long chain molecules with few branches. These are able to repeatedly soften in heat and to harden in cooling and thus are thermoplastic polymers.



Types of polythene

Low density polythene
High density polythene

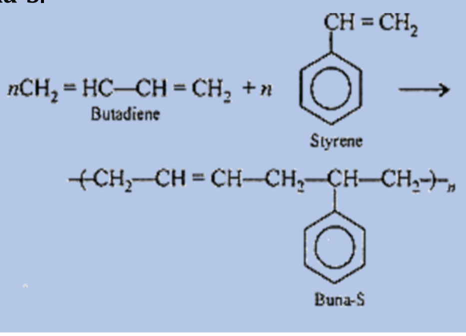
Teflon - Teflon is produced by burning tetrafluoroethene by free radical or persulphate catalyst at high pressure. It is chemically inactive and resists attack by corrosive reagents.



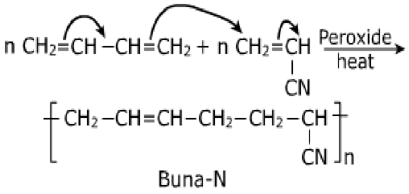
Heteropolymer or copolymer – It is formed by the repeated addition of different monomers.

Example

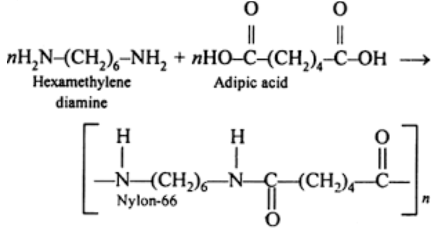
Buna-S.



Buna-N



Condensation polymer –it is formed by the condensation polymerisation reaction of bi-functional or tri-functional monomer. In this polymer, small molecule like alcohol, water, hydrochloric acid, etc., is removed. In this type, monomers usually have two or three different functional groups.
Example – Nylon – 6,6.



(i) They are formed due to condensation reactions.
(ii) Condensation polymerisation is also known as step growth polymerisation.
(iii) For condensation polymerisation, monomers should have at least two functional groups. Both functional groups may be same or different.
(iv) Monomers having only two functional group always give linear polymer.
(v) Condensation polymers do not contain all atoms initially present in the monomers.
Some atoms are lost in the form of small molecules.
(vi) Monomer having three functional groups always gives cross-linked polymer.

Example

Urea-formaldehyde resin, phenol-formaldehyde resin.

Typically, PVC is a condensing polymer with a pressure of 100 atmospheres at 200^{0}C. Polyethylene consists of condensation polymers formed by a combination of monomer and dissolution of simple molecules such as H_2O or CH_3OH.

Classification based on the molecular forces:

Elastomers - Elastomers are polymers that have viscosity and elasticity and therefore are known as viscoelasticity. The molecules of elastomers are held together by weak intermolecular forces and generally exhibit low Young's modulus and high yield strength or high failure strain. They inherit the unique property of regaining their original shape and size after being significantly stretched. IUPAC defines the term "elastomer" as "Polymer that reflects rubber-like elasticity."

Example

Natural rubber: These are used in the automotive industry and in the manufacture of medical tubes, balloons, adhesives.
Polyurethanes: These are used in the textile industry for manufacturing elastic clothing like lycra.
Polybutadiene: These are used for providing wear resistance in wheels of vehicles.

Fibres - It is such type of polymer in which polymeric chain are held together by the strong H-bond. It has crystalline nature.
Example: Polyamides (nylon 6, 6), polyester (terylene), etc.

Thermoplastics – It is a such type of polymers which possesses intermediate force of elastomers and fibres.
Examples include poly vinyl chloride, polythene, polystyrene.
It became soft on heating and hard on cooling.

Thermosetting plastics – It is such type of polymer in which heavily branched molecule are present. Thermosetting

polymer is a permanent setting polymer as it hardens and set during the molding process and cannot soften again. They are held together by covalent bond.
Examples of Thermosetting polymers are Bakelite, Urea-formaldehyde resins etc.

Two broad types of polymerization reactions

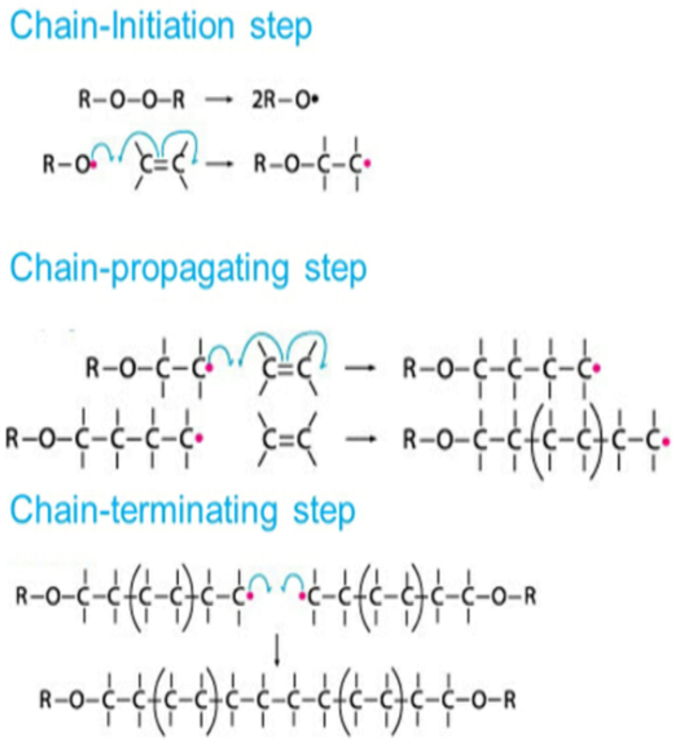
1. **Addition or Chain growth polymerization** – It takes place in unsaturated monomer.
   Like $CH_2=CH_2$
   $CF_2=CF_2$
   $CH_2=CH\text{-}CN$
   $CH_2=CH\text{-}C_6H_5$
   It takes place by the free radical mechanism.
   Free radical mechanism takes place in the presence of per oxide.
   It takes three steps to complete.
   It can be understood with the help of following examples.

Example

Ethene → Polythene

Mechanism:

Step-I formation of free radical
Step-II free radical attacks on substrate molecule.
Step-III free radical combines with free radical to form neutral molecules.



Classification of polythene:

LDP (Low Density polythene) – It is formed by the polymerisation of ethane at high pressure and high temperature (1000-2000 atm, 350-370k) in the presence of peroxide.

Some important points about LDP

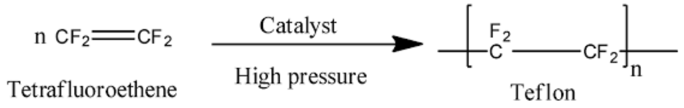
- It is flexible in nature
- It is poor conductor of electricity
- It is chemically inert
- It is used in making flexible pipe, toys and insulation of electric wire.

HDP (High density polythene) – by the polymeristaion of ethane in hydrocarbon solvent in the presence of Ziegler-Natta catalyst at 333 – 343k temperature and 6-7 atm pressure, HDP is formed.
The micture of triethyl aluminium and titanium tetrachloride is known as Ziegler-Natta catalyst.

Some important points about HDP

- It is hard and tough
- It is chemically inert
- It is poor conductor of electricity
- It is used in making pipe, bucket, bottle etc.

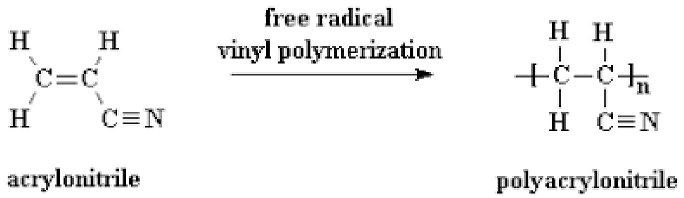
Teflon – by the polymerisation of tetrafluoroethene at high pressure in the presence of free radical catalyst, Teflon if formed.



- It is chemically inert
- It is corrosive resistant
- It is used in making non-stick utensils

Polyacrylonitrile –

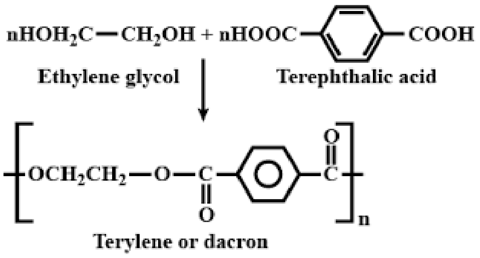
- The addition polymerisation of acrylonitrile in presence of a peroxide catalyst leads to the formation of polyacrylonitrile.
- Polyacrylonitrile is used as a substitute for wool in making commercial fibres as Orlon or acrilan.



- It is substituted of wool
- It is used in making synthetic fibre in the name of orlon.

2. **Condensation or Step growth polymerization** –
   - This type of polymerisation involves a repetitive condensation reaction between two bi-functional monomers.
   - These poly condensation reactions results in the loss of some simple molecules as water, alcohol, etc., and lead to the formation of high molecular mass condensation polymers.
   - In these reactions, the product of each step is again a bi-functional species and the sequence of condensation goes on.

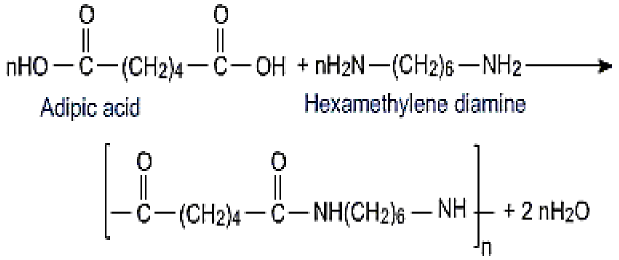
- Since, each step produces a distinct functionalised species and is independent of each other; this process is also called as step growth polymerisation.
- The formation of Terylene or Dacron by the interaction of ethylene glycol and terephthalic acid is an example of this type of polymerisation.



Another important Condensation polymerization

Nylon 6,6 - Prepared by condensation polymerization of hexamethylenediamine and adipic acid under high pressure and high temperature.

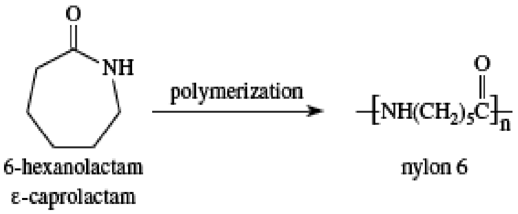
It is used to make sheets, bristles and brushes in the textile industry.



$$nHO-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH + nH_2N-(CH_2)_6-NH_2 \longrightarrow \left[-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-NH(CH_2)_6-NH-\right]_n + 2nH_2O$$

Nylon 6 - It is obtained by heating the caprolactum with water at high temperatures.

It is used for the construction of tires, fabrics and ropes.



Polyamides:-

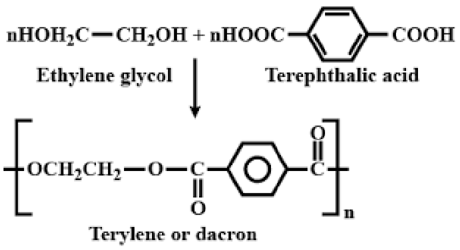
These polymers possessing amide linkages are important examples of synthetic fibres and are termed as nylons. The general method of preparation consists of the condensation polymerisation of diamines with dicarboxylic acids and also of amino acids and their lactams.

Polyesters: - These are the poly condensation products of dicarboxylic acids and diols.

Dacron or Terylene is the best known example of polyesters.

It is manufactured by heating a mixture of ethylene glycol and terephthalic acid at 420 to 460 K in the presence of Zinc acetate antimony trioxide catalyst.

Dacron fibre (Terylene) is crease resistant and is used in blending with cotton and wool fibres and also as glass reinforcing materials in safety helmets, etc.



- It is synthetic fibre
- It is used in textile industries
- It is used in blending of cotton or wool.

Phenol – formaldehyde polymer (Bakelite and related polymers):-

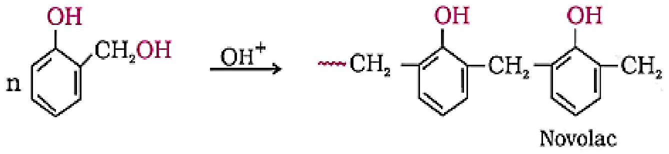
Phenol - formaldehyde polymers are the oldest synthetic polymers.

These are obtained by the condensation reaction of phenol with formaldehyde in the presence of either an acid or a base catalyst.

The reaction starts with the initial formation of o-and/or p-hydroxymethylphenol derivatives, which further react with phenol to form compounds having rings joined to each other through $-CH_2$

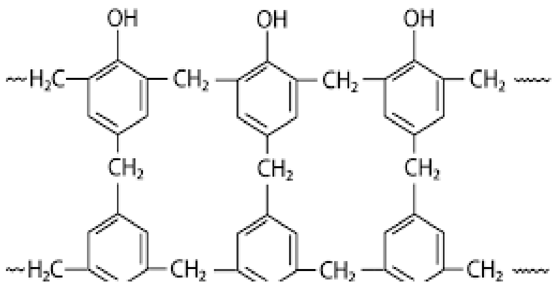
The initial product could be a linear product – Novolac used in paints.

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



Navolac are cross-linked to each other to form infeasible solid mass. It is known as Bakelite.

Structure of Bakelite

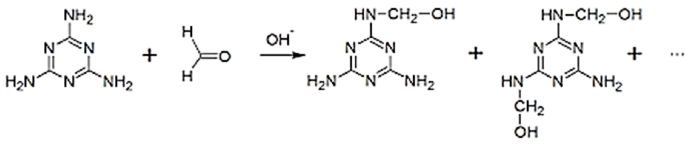


It is used in making dustbin, comb, bucket, electrical switch etc.

Melamine- formaldehyde Polymer:-

Melamine formaldehyde polymer is formed by the condensation polymerisation of melamine and formaldehyde.

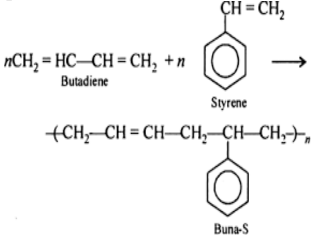
It is used in the manufacture of unbreakable crockery.



Melamine polymer is used for the preparation of unbreakable crockery.

Copolymerization - Co Polymerization

- Copolymerisation is a polymerisation reaction in which a mixture of more than one monomeric species is allowed to polymerise and form a copolymer.
- The copolymer can be made not only by chain growth polymerisation but by step growth polymerisation also.
- It contains multiple units of each monomer used in the same polymeric chain.
- For example:-a mixture of 1, 3 – butadiene and styrene can form a copolymer.
- Copolymers have properties quite different from homopolymers.
- For example: - butadiene - styrene copolymer is quite tough and is a good substitute for natural rubber.
- It is used for the manufacture of auto tyres, floor tiles, footwear components, cable insulation, etc.



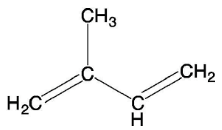
Rubber

Rubber is a natural substance obtained by collecting the latex of a certain tree. Rubber trees are found in abundance in Brazil. Later, these trees were planted in other countries too. Latex is colloidal dispersion of rubber in water. This latex is obtained from the bark of rubber tree and is found in India, Sri Lanka, Indonesia, Malaysia and South America.

Natural Rubber - Natural rubber may be considered as a linear polymer of isoprene (2-methyl-1, 3-butadiene) and is also called as cis - 1, 4 -polyisoprene.

The cis-polyisoprene molecule consists of various chains held together by weak van der Waals interactions and has a coiled structure.

Thus, it can be stretched like a spring and exhibits elastic properties.

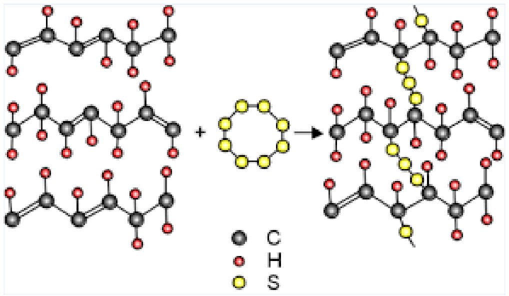


Properties of rubber:

- It has elastic nature
- It is soft above 335 K temperature and hard below 283 K temperature.
- It has maximum water absorption capacity.
- It is soluble in non-polar solvent.

Vulcanization of rubber –

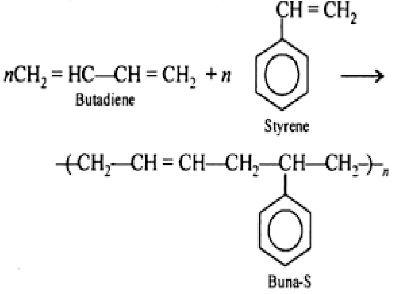
- Natural rubber becomes soft at high temperature (>335 K) and brittle at low temperatures (<283 K) and shows high water absorption capacity.
- It is soluble in non-polar solvents and is non-resistant to attack by oxidising agents. To improve upon these physical properties, a process of vulcanisation is carried out. This process consists of heating a mixture of raw rubber with sulphur and an appropriate additive at a temperature range 373 K to 415K.
- On vulcanisation, sulphur forms cross links at the reactive sites of double bonds and thus the rubber gets stiffened.
- In the manufacture of tyre rubber, 5% of sulphur is used as a crosslinking agent.



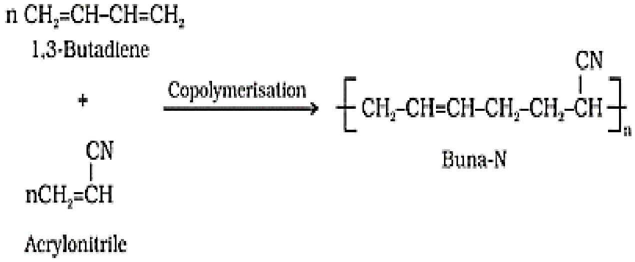
2 Synthetic rubber –

Synthetic rubber is any vulcanisable rubber like polymer, which is capable of getting stretched to twice its length.
However, it returns to its original shape and size as soon as the external stretching force is released.
Thus, synthetic rubbers are either homopolymers of 1, 3 - butadiene derivatives or copolymers of 1, 3 - butadiene or its derivatives with another unsaturated monomer.

Buna-S
(1, 3-Butadiene styrene co-polymer)

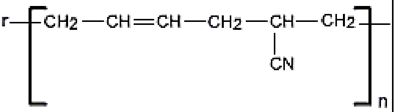


Buna N
(1, 3-Butadiene acrylonitrile copolymer)



$$\underset{\text{1,3-Butadiene}}{n\,CH_2{=}CH{-}CH{=}CH_2} + \underset{\text{Acrylonitrile}}{nCH_2{=}\overset{CN}{CH}} \xrightarrow{\text{Copolymerisation}} \underset{\text{Buna-N}}{\left[CH_2{-}CH{=}CH{-}CH_2{-}CH_2{-}\overset{CN}{CH}\right]_n}$$

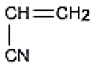
Polymer : Nitrile rubber (Buna - N)



$$\left[CH_2-CH=CH-CH_2-\underset{\displaystyle CN}{\underset{|}{CH}}-CH_2 \right]_n$$

Monomer : a) $CH_2=CH-C=CH_2$

b)



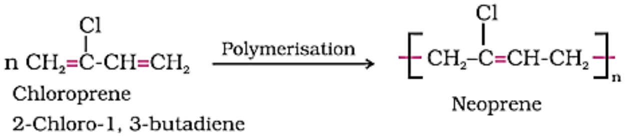
$$\underset{\displaystyle CN}{\underset{|}{CH}}=CH_2$$

Uses : In making oil seels, manufacure of tank linings

- It is resistant to the action of petrol fabricating oil and organic solvent.
- It is used in making oil seals, tank lining etc.

Neoprene:-

- Neoprene or poly chloroprene is formed by the free radical polymerisation of chloroprene.
- It has superior resistance to vegetable and mineral oils.
- It is used for manufacturing conveyor belts, gaskets and hoses.



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

Biodegradable polymers -

A large number of polymers are quite resistant to the environmental degradation processes and are thus responsible for the accumulation of polymeric solid waste materials.

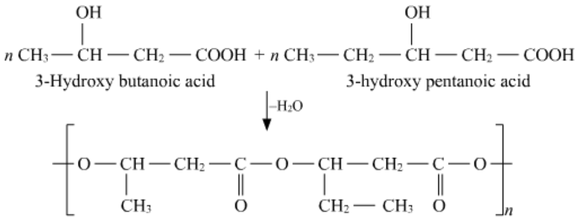
Aliphatic polyesters are one of the important classes of biodegradable polymers.

Some important examples are given below:

Poly β-hydroxybutyrate – co-β-hydroxy valerate (PHBV)

It is obtained by the copolymerisation of 3-hydroxybutanoic acid and 3 - Hydroxypentanoic acid.

PHBV is used in speciality packaging, orthopaedic devices and in controlled release of drugs. PHBV undergoes bacterial degradation in the environment.

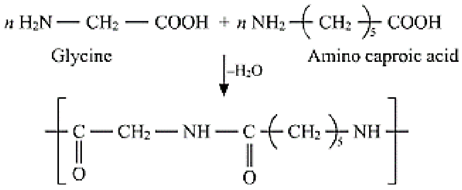


$$n\ CH_3-\overset{\displaystyle OH}{\overset{|}{CH}}-CH_2-COOH + n\ CH_3-CH_2-\overset{\displaystyle OH}{\overset{|}{CH}}-CH_2-COOH \xrightarrow{-H_2O} \left[O-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-\underset{\displaystyle O}{\underset{\|}{C}}-O-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-CH_2-\underset{\displaystyle O}{\underset{\|}{C}}-O \right]_n$$

PHBV

Nylon-2 Nylon-6

It is formed by the polymerisation of glycine and amino caproic acid

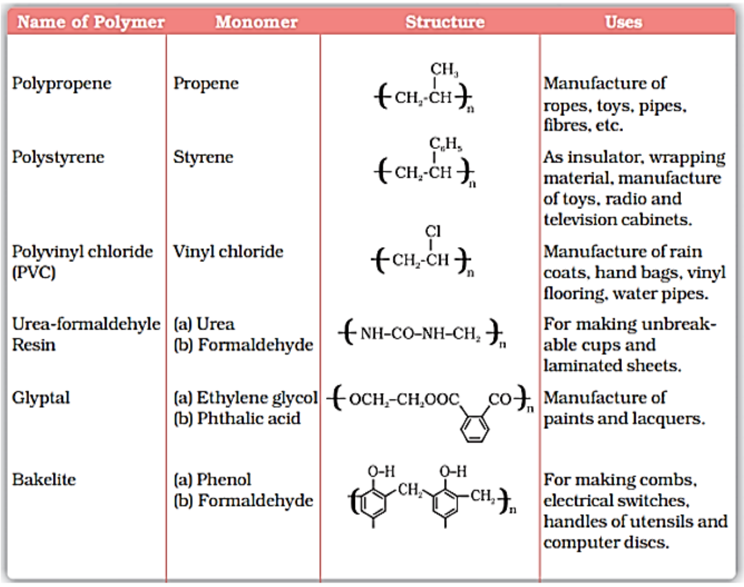


$$n\ H_2N-CH_2-COOH + n\ NH_2 \left(CH_2 \right)_5 COOH \xrightarrow{-H_2O} \left[\underset{\displaystyle O}{\underset{\|}{C}}-CH_2-NH-\underset{\displaystyle O}{\underset{\|}{C}}\left(CH_2 \right)_5 NH \right]$$

Nylon-2-nylon-6

It is used for stiching during surgery.

Some Other Commercially Important Polymers



Name of Polymer	Monomer	Structure	Uses
Polypropene	Propene	$\left(CH_2-\overset{\displaystyle CH_3}{\overset{|}{CH}} \right)_n$	Manufacture of ropes, toys, pipes, fibres, etc.
Polystyrene	Styrene	$\left(CH_2-\overset{\displaystyle C_6H_5}{\overset{|}{CH}} \right)_n$	As insulator, wrapping material, manufacture of toys, radio and television cabinets.
Polyvinyl chloride (PVC)	Vinyl chloride	$\left(CH_2-\overset{\displaystyle Cl}{\overset{|}{CH}} \right)_n$	Manufacture of rain coats, hand bags, vinyl flooring, water pipes.
Urea-formaldehyde Resin	(a) Urea (b) Formaldehyde	$\left(NH-CO-NH-CH_2 \right)_n$	For making unbreakable cups and laminated sheets.
Glyptal	(a) Ethylene glycol (b) Phthalic acid	$\left(OCH_2-CH_2OOC \quad CO \right)_n$	Manufacture of paints and lacquers.
Bakelite	(a) Phenol (b) Formaldehyde	O-H CH$_2$ O-H CH$_2$ $)_n$	For making combs, electrical switches, handles of utensils and computer discs.

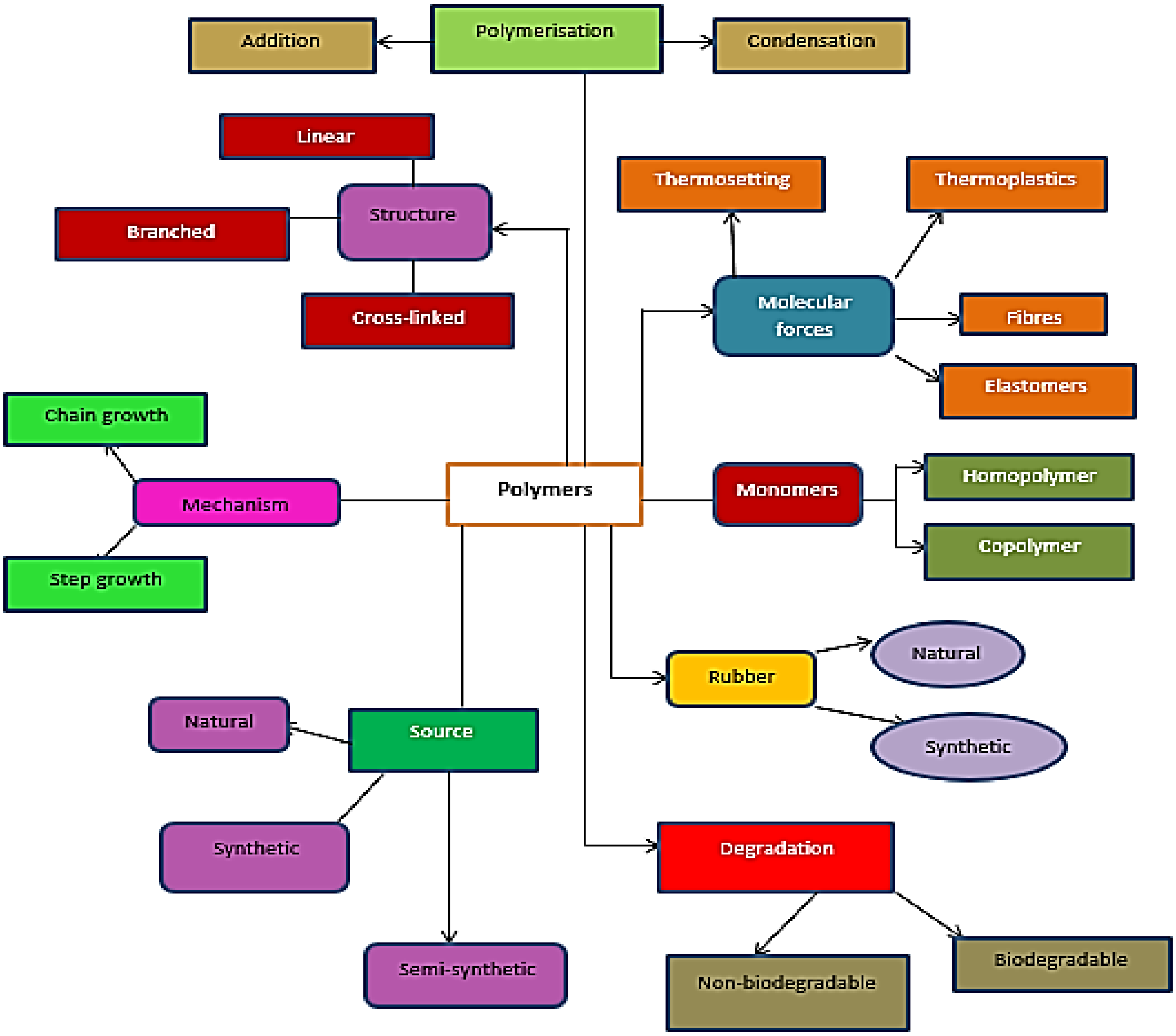
SUMMARY

Polymers are defined as high molecular mass macromolecules, which consist of repeating structural units derived from the corresponding monomers. These polymers may be of natural or synthetic origin and are classified in a number of ways.

In the presence of an organic peroxide initiator, the alkenes and their derivatives undergo addition polymerisation or chain growth polymerisation through a free radical mechanism. Polythene, teflon, orlon, etc. are formed by addition polymerisation of an appropriate alkene or its derivative. Condensation polymerisation reactions are shown by the interaction of bi – or poly functional monomers containing – NH_2 , – OH and – COOH groups. This type of polymerisation proceeds through the elimination of certain simple molecules as H_2O, CH_3OH, etc. Formaldehyde reacts with phenol and melamine to form the corresponding condensation polymer products. The condensation polymerisation progresses through step by step and is also called as step growth polymerisation. Nylon, bakelite and dacron are some of the important examples of condensation polymers. However, a mixture of two unsaturated monomers exhibits copolymerisation and forms a co-polymer containing multiple units of each monomer. Natural rubber is a cis 1, 4-polyisoprene and can be made more tough by the processof vulcanisation with sulphur. Synthetic rubbers are usually obtained by copolymerisation of alkene and 1, 3 butadiene derivatives.

In view of the potential environmental hazards of synthetic polymeric wastes, certain biodegradable polymers such as PHBV and Nylon-2- Nylon-6 are developed as alternatives

MIND MAP



QUESTIONS FOR PRACTICE

Q1 Which of the following is a polymer containing nitrogen?
(a) Polyvinyl chloride
(b) Bakelite
(c) Nylon
(d) Terylene

Q2 Teflon, styron and neoprene are all
(a) Copolymers
(b) Condensation polymers
(c) Homopolymers
(d) Monomers

Q3 The repeating unit present in Nylon 6 is
(a) — [$NH(CH_2)_6NHCO(CH_2)_4CO$] —
(b) — [$CO(CH_2)_5NH$] —
(c) — [$CO\ (CH_2)_6NH$] —
(d) — [$CO\ (CH_2)_4NH$] —

Q4 Which one of the following is not a condensation polymer?
(a) Melamine
(b) Glyptal
(c) Dacron
(d) Neoprene

Q5 On the basis of mode of formation, polymers can be classified?
(a) as addition polymers only
(b) as condensation polymers only
(c) as copolymers
(d) both as addition and condensation polymers

Q6 Which of the following polymers do not involve cross linkages?
(a) Melmac
(b) Bakelite
(c) Polythene
(d) Vulcanised rubber

Q7 Which one of the following is not an example of chain growth polymer?
(a) Neoprene
(b) Buna-S
(c) PMMA
(d) Glyptal

Q8 —[$NH(CH_2)_6NHCO(CH_2)_4CO$—]n is a
(a) addition polymer
(b) thermosetting polymer
(c) homopolymer
(d) copolymer

Q9 PVC is a
(a) thermoplastic polymer
(b) compound polymer
(c) thermosetting polymer
(d) simple polymer

Q10 The synthetic polymer which resembles natural rubber is
(a) neoprene
(b) chloroprene
(c) glyptal
(d) nylon

Q11 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) neither (a) nor (b)

Q12 Which of the following statements is false?
(a) Artificial silk is derived from cellulose.
(b) Nylon-66 is an example of elastomer.
(c) The repeat unit in natural rubber is isoprene.
(d) Both starch and cellulose are polymers of glucose.

Q13 The monomer(s) used in the preparation of orlon, a substitute for wool is/are
(a) caprolactam
(b) tetrafluoroethene
(c) styrene and 1, 3-butadiene
(d) acrylonitrile

Q14 Polymer obtained by condensation polymerization is
(a) Polythene
(b) Teflon
(c) Bakelite
(d) Nitrile rubber

Q15 Polyvinyl alcohol can be prepared by
(a) polymerization of vinyl alcohol
(b) alkaline hydrolysis of polyvinyl acetate
(c) polymerization of acetylene
(d) reaction of acetylene with H_2SO_4 in presence of $HgSO_4$

Q16 Which of the following is not a biopolymer?
(a) Proteins
(b) Rubber
(c) Cellulose
(d) RNA

Q17 Bakelite is
(a) addition polymer
(b) elastomer
(c) thermoplastic
(d) thermosetting.

Q18 Buna-S is
(a) Homo polymer
(b) Condensation polymer
(c) Copolymer
(d) none of these.

Q19 The S in Buna-S refers to
(a) sodium
(b) sulphur
(c) styrene
(d) just a trade name.

Q20 The repeating units of PTFE is
(a) $Cl_2CH—CH_3$
(b) $F_2C = CF_2$
(c) $F_3C—CF_3$
(d) $FCIC = CF_2$.

Q21 The inter-particle forces between linear chains in Nylon-66 are
(a) H-bonds
(b) covalent bonds
(c) ionic bonds
(d) unpredictable.

Q22 Nylon-66 is a polyamide of
(a) vinyl chloride and formaldehyde
(b) adipic acid and methyl amine
(c) adipic acid and hexamethylene diamine
(d) formaldehyde and malamine.

Q23 Which of the following is a condensation polymer?
(a) Polystyrene
(b) Neoprene
(c) PAN
(d) Polyethylene terephthalate)

Q24 Which of the following polymer is a copolymer?
(a) Pqlyprene
(b) Nylon-66
(c) PVC
(d) Teflon

Q25 Caprolactum is the starting material for
(a) Nylon-6 (b) Terylene
(c) Nylon-6, 10 (d) Nylon

Q26 Synthetic polymer prepared by using ethylene glycol and terephthalic acid is known as:
(a) Teflon (b) Terylene
(c) Nylon (d) PVC

Q27 Bakelite is obtained from phenol by reacting with
(a) Ethanal (b) Methanal
(c) Vinyl chloride (d) Ethyleneglycol.

Q28 Which of the following is a natural fibre?
(a) Starch (b) Cellulose
(c) Rubber (d) Nylon-6.

Q29 Which of the following is used in paints.
(a) Nylon (b) Terylene
(c) Glyptal (d) Chlroprene.

Q30 Which is not a polymer?
(a) Sucrose (b) Enzyme
(c) Starch (d) Teflon.

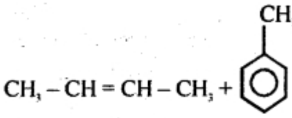
Q31 Which of the following is a fully flourinated polymer?
(a) Teflon (b) Neoprene
(c) Thiokol (d) PVC

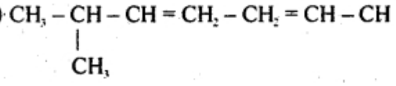
Q32 Orion has a unit of
(a) Vinyl Cyanide (b) acrolein
(c) glycol (d) isoprene

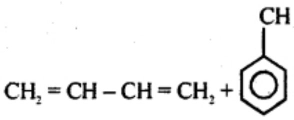
Q33 Which of the following is a biodegradable polymer?
(a) Cellulose (b) Polyethene
(c) Polyvinyl chloride (d) Nylon-6.

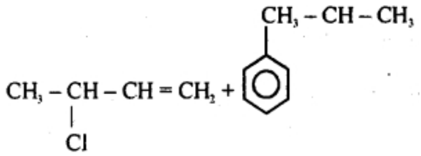
Q34 Arrange the following polymers is an increasing order of intenqolecular forces: fibre, plastic, elastomer
(a) Elastomer < Fibre < Plastic
(b) Elastomer < Plastic < Fibre
(c) Plastic < Elastomer < Fibre
(d) Fibre < Elastomer < Plastic

Q35 The correct structure of monomers of buna-S is

(a)


(b)

$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH=CH_2-CH_2=CH-CH$

(c)


(d)


Q36 Identify the type of polymer
(i) -A-A-A-A-A-A-
(ii) -A-B-B-A-A-A-B-A-
(a) (i) Homopolymer, (ii) Copolymer
(b) (i) Natural polymer, (ii) Synthetic polymer
(c) (i) Linear polymer, (ii) Branched polymer
(d) (i) Fibre, (ii) Elastomer

Q37 Which of the following are thermoplastic polymers?
(a) Polythene, urea-formaldehyde, polyvinyls
(b) Bakelite, polythene, polystyrene
(c) Polythene, polystyrene, polyvinyls
(d) Urea-formaldehyde, polystyrene, Bakelite

Q38 Glycogen, a naturally occuring polymer stored in animals is a
(a) monosaccharide (b) disaccharide
(c) trisaccharide (d) polysaccharide

Q39 Terylerte is a condensation polymer of ethylene glycol and
(a) benzoic acid (b) phthalic acid
(c) terephthalic acid (d) salicylic acid

Q40 Heating rubber with sulphur is known as
(a) galvanisation (b) bessemerisation
(c) vulcanisation (d) sulphonation

Q41 Which of the following is a naturally occurning polymer?
(a) Nylon and starch (b) Starch and cellulose
(c) Teflon and nylon (d) Neoprene and PVC

Q42 Which of the following is an example of addition polymer?
(a) Teflon (b) Nylon-6
(c) Bakelite (d) Nylon-66

Q43 Which of the following has amide linkage?
(a) Nylon-66 (b) Bakelite
(c) Teflon (d) Terylene

Q44 Which of the following is thermoplastic ?
(a) terylene (b) nylon
(c) polyethylene (d) all of these

Q45 The process of vuleanisation is at ion of rubber makes it
(a) souble in water (b) hard
(c) soft (d) less elastic

Q46 Which of the following statements is not true about low density polythene?
(a) Tough
(b) Hard
(c) Poor conductor of electricity
(d) Highly branched structure

Q47 Isoprene polymerises to
(a) starch (b) synthetuc rubber
(c) natural rubber (d) PVC

Q48 The constituents of Nylon-66 are
(a) Benzoic acid and ethylamine
(b) Phthalic acid and hexamethylene diamine
(c) Phenol and adipic acid
(d) Adipic acid and hexamethylene diamine

49 Which of the following is not a semisynthetic polymer?
(a) cis-polyisoprene (b) Cellulose nitrate
((c) Cellulose acetate (d) Vulcanised rubber

50 For the formation of fibre,
(a) monomers must contain tetrahedral geometry
(b) monomers have high tensile strength
(C) monomers must have complex structure
(d) monomers must contain linear geometry

ASSERTION AND REASONING

Q1. Assertion: Most of the Synthetic polymers are not biodegradable.
Reason: Polymerisation process induces toxic character in organic molecules
(a) Assertion and reason both are correct statement but reason does not explain assertion.
(b) Assertion and reason both are correct statements and reason explains the assertion.
(c) Both assertion and reason are wrong statement.
(d) Assertion is correct statement and reason is wrong statement.
(e) Assertion is wrong statement and reason is correct statement.

Q2. Assertion: Olefinic monomers undergo addition polymerisation.
Reason: Polymerisation of vinylchloride is initiated by peroxides/ persulphates.
(a) Assertion and reason both are correct statement but reason does not explain assertion.
(b) Assertion and reason both are correct statements and reason explains the assertion.
(c) Both assertion and reason are wrong statement.
(d) Assertion is correct statement and reason is wrong statement.
(e) Assertion is wrong statement and reason is correct statement.

Q3. Assertion: Network polymers are thermosetting.
Reason: Network polymers have high molecular mass.
(a) Assertion and reason both are correct statement but reason does not explain assertion.
(b) Assertion and reason both are correct statements and reason explains the assertion.
(c) Both assertion and reason are wrong statement.
(d) Assertion is correct statement and reason is wrong statement.
(e) Assertion is wrong statement and reason is correct statement.

Q4. Assertion: Polytetrafluoroethene is used in making non-stick cookwares.
Reason: Fluorine has highest electronegativity.
(a) Assertion and reason both are correct statement but reason does not explain assertion.
(b) Assertion and reason both are correct statements and reason explains the assertion.
(c) Both assertion and reason are wrong statement.
(d) Assertion is correct statement and reason is wrong statement.
(e) Assertion is wrong statement and reason is correct statement.

TRUE/FALSE

Q1. Synthetic fibre is polymer, while plastic is not a polymer.
(a) True (b) False

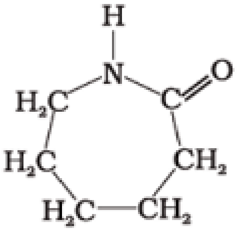
Q2. Polymers are small molecules made by stringing together several monomers.
(a) True (b) False

Q3. Blended fabrics contain only synthetic fibres.
(a) True (b) False

Q4. Dusters made of nylon or other synthetic materials are good for use in the kitchen.
(a) True (b) False

HOMEWORK

Q1. Which of the following polymer can be formed by using the following monomer unit?



(a) Nylon 6, 6 (b) Nylon 2–nylon 6
(c) Melamine polymer (d) Nylon-6

Q2. Which of the following polymers, need atleast one diene monomer for their preparation?
(a) Dacron (b) Buna-S
(c) Neoprene (d) Novolac

Q3. Which of the following are characteristics of thermosetting polymers?
(a) Heavily branched cross linked polymers.
(b) Linear slightly branched long chain molecules.
(c) Become infusible on moulding so cannot be reused.
(d) Soften on heating and harden on cooling, can be reused.

Q4. Which of the following phenols are able to form Novolac?
(a) 2,4,6-(Trihydroxymethyl)phenol
(b) m-Hydroxybenzyl alcohol
(c) o-Hydroxybenzyl alcohol and p-hydroxybenzyl alcohol
(d) 2,4-(Dihydroxymethyl)phenol

Q5. The polymer of type [-AAAABBBAAAABBB-]$_n$, where A and B are two different monomers, is called a ______ copolymer.
(a) Random (b) Alternating
(c) Block (d) Graft

Q6. Which of the following is the monomer of natural rubber?
(a) Butadiene (b) Neoprene
(c) Isoprene (d) Chloroprene

Q7. Vulcanization is carried out with which element?
(a) Sulphur (b) Phosphorous
(c) Oxygen (d) Chlorine

Q8. X on polymerisation gives neoprene. Identify X.
(a) 2-Methyl-1,3-butadiene
(b) 1-Chloro-1,3-butadiene
(c) 2-Chloro-1,3-butadiene
(d) 1-Methyl-1,3-butadiene

Q9. Molecular mass of polymers are expressed as a/an
(a) average (b) median
(c) mode (d) percentage

Q10. The polydispersity index of natural polymers is
(a) >1.2 (b) 0
(c) <0.8 (d) 1

Q11. Calculate the number average molecular mass of a polymer having four different monomers A, B, C and D present in equal number. The molecular masses of the monomers are 10000, 15000, 30000 and 50000 respectively.
(a) 35475 (b) 10050
(c) 17350 (d) 26250

Q12. Which of the following is a non-biodegradable polymer?
(a) PHBV (b) PHB
(c) PGA (d) LDPE

Q13. Identify the biodegradable polymer from the following.
(a) Polylactic acid
(b) Polyvinyl chloride
(c) Polypropylene
(d) Polystyrene

Q14. What are the monomers of PHBV?
(a) 2-Hydroxybutanoic acid, 2-hydroxypentanoic acid
(b) 2-Hydroxybutanoic acid, 3-hydroxypentanoic acid
(c) 3-Hydroxybutanoic acid, 2-hydroxypentanoic acid
(d) 3-Hydroxybutanoic acid, 3-hydroxypentanoic acid

Q15. Which of the following is not a trade name of PMMA polymer?
(a) Perspex (b) Acrylite
(c) Lucite (d) Vectran

Q16. Which of the following is used in the manufacture of building materials?
(a) Bakelite
(b) Urea-formaldehyde resin
(c) Kevlar (d) Glyptal

Q17. Which of the following is used in the making of unbreakable cups?
(a) Bakelite (b) Urea formaldehyde
(c) Novolac (d) Polystyrene

Q18. What is the order of a self-catalyzed polyesterification reaction?
(a) 2 (b) 3
(c) 1 (d) 4

Q19. Which of the following is true about polymer systems in polycondensation?
(a) have higher viscosity than small non-polymeric molecules
(b) insoluble beyond a critical molecular weight
(c) all of the mentioned
(d) none of the mentioned

Q20. Which order kinetics does a strong acid catalyzed polyesterification reaction follow?
(a) 1 (b) 2
(c) 3 (d) 4

Q21. What is true about an end functional group, having a terminal reactive centre, of a polymer molecule?
(a) cannot be determined
(b) has a greater mobility than the polymer molecule as a whole
(c) has a lower mobility than the polymer molecule as a whole
(d) same as polymer molecule

Q22. How does the reaction rate vary with increasing extent of reaction beyond 94% conversion in self catalyzed reaction?
(a) none of the mentioned (b) decreases
(c) increases (d) remains same

Q23. The average functionality of a polyfunctional system is 2.4. What will be the average degree of polymerization for 80% completion of reaction?
(a) 2.97 (b) 20.55
(c) 27.67 (d) 50.3

Q24. Which tree gives out the latex to obtain natural rubber?
(a) eucalyptus
(b) hevea brasiliensis
(c) anogeissus
(d) astragalus

Q25. Which substance is added to the dilute latex to prevent darkening of latex?

(a) potassium sulfate (b) sodium bisulfite
(c) potassium sulfite (d) sodium sulfate

Q26. Which component has the maximum composition in the Hevea rubber latex?

(a) sugars (b) rubber hydrocarbon
(c) water (d) proteins

Q27. Consider the following statements about hydrocarbons of natural rubber and gutta percha.

I. They have same elementary formula.
II. They have same molecular weight.
III. Rubber hydrocarbon has low specific gravity than gutta percha.

Which of the following statements are true?

(a) I only (b) I, III
(c) I, II, III (d) II, III

Q28. What are the sequential processes through which rubber latex undergo to give natural rubber?

(a) tapping-preservation-coagulation
(b) preservation-tapping-coagulation
(c) tapping-coagulation-preservation
(d) coagulation-tapping-preservation

Q29. How much would the unsaturation of cyclized rubber reduce to its original when it forms polycyclic structure?

(a) 57-60% (b) 20-30%
(c) 40% (d) 70%

Q30. What kind of product is obtained on chlorination of natural rubber?

(a) elastomer (b) thermoplastic
(c) resinous (d) none of the mentioned

ASSERTION AND REASONING

Q1. **Assertion:** Teflon has high thermal stability and chemical inertness.

Reason: Teflon is a thermoplastic.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

Q2. **Assertion:** Bakelite is a thermosetting polymer.

Reason: Bakelite can be melted again and again without any change.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

Q3. **Assertion (A):** Low density polythene is used in the insulation of electricity carrying wires.

Reason (R): Low density polythene is chemically inert and tough.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

Q4. **Assertion (A):** Zeigler-Natta catalyst is a mixture of triethylaluminium and titanium tetrachloride.

Reason (R): Zeigler-Natta catalyst is used to make low density polythene.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

Q5. **Assertion (A):** 5% of sulphur is added to natural rubber for manufacturing tyre tubes.

Reason (R): It acts as a cross linking agent and thus makes the rubber stiffer.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

TRUE/FALSE

Q1. Polyester fibres are obtained from petroleum products.

(a) True (b) False

Q2. Terylene, a synthetic fibre, can be used instead of wool.

(a) True (b) False

Q3. Rayon, which is obtained from cellulose, is a natural fibre.

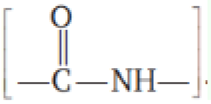
(a) True (b) False

Q4. Proteins are natural polymers.

(a) True (b) False

SOLUTIONS

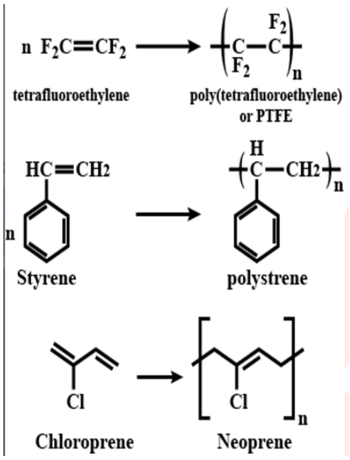
S1. (c) Nylon is a polymer which contains nitrogen.
Nylon has amide linkages



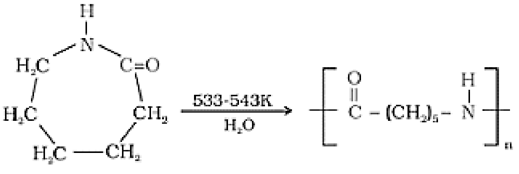
$$\left[-\overset{\overset{\displaystyle O}{\|}}{C}-NH-\right]$$

Nylon is used in making bristles for brushes, in the manufacture of cords, sheets, ropes etc.

S2. (c) Teflon (PTFA), Styron (Polystyrene) and Neoprene are all homopolymers formed by single monomers tetrafluoroethylene, styrene and chloroprene.



S3. (b) The repeating unit (i.e., monomer) in nylon-6 is - amino caproyic acid



S4. (d) Neoprene is not a condensation polymer. It is an addition polymer.
Neoprene is made from monomer chloroprene (2-chlorobuta-1,3-diene).
Dacron, Melamine and Glyptal are condensation polymers.
Dacron (also known as terylene) is a polyester made by condensation polymerisation of ethylene glycol and dimethyl terephthalate
Glyptal is a copolymer of ethylene glycol and phthalic acid.
Melamine (or formaldehyde melamine polymer) is obtained from condensation polymerisation of melamine with formaldehyde.

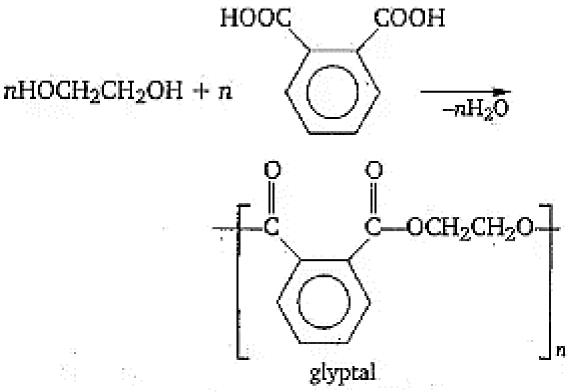
S5. (d) On the basis of the mode of their formation, the polymers can be classified as addition polymers and condensation polymers.
Addition polymers are formed by chain growth polymerization and condensation polymers are formed by the combination of two monomers by the elimination of a small molecule like water or methyl alcohol.

S6. (c) Cross-linked polymers are usually formed from bifunctional and trifunctional monomers and contain strong covalent bonds between various linear polymer chains.
For example, bakelite, melamine, vulcanized rubber.
Polythene is a linear polymer of monomer ethene.

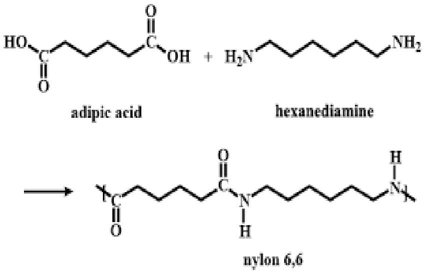
$$nCH_2 = CH_2 \rightarrow n[-CH_2 - CH_2-] \rightarrow [-CH_2 - CH_2-]_n$$

Ethene Repeating unit Polythene polymer

S7. (d) Glyptal is a condensation or step growth polymer of ethylene glycol and phthalic acid.



S8. (d) The given structure in the question is a nylon 6,6 polymer. It is a copolymer because it is made up of two types of monomer, adipic acid, and hexamethylenediamine.



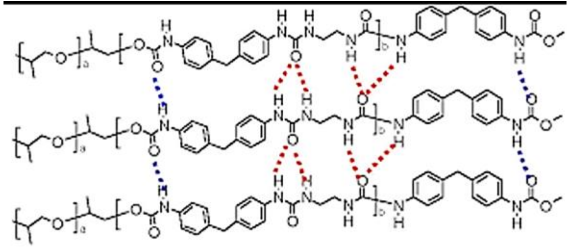
S9. (a) Polyvinyl Chloride is a "thermoplastic". Polyvinyl Chloride (PVC or Vinyl) is a high strength thermoplastic material widely used in applications, such as pipes, medical devices, wire and cable insulation and the list is endless. It is the world's third-most widely produced synthetic plastic polymer.

S10. (a) The synthetic polymer neoprene (polymer of chloroprene) resembles natural rubber because chemically it has a close resemblance to natural rubber which is a polymer of isoprene.

S11. (a) A thermoplastic, or thermosoftening plastic, is a plastic polymer material that becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling.

Thermosetting plastics can't be remoulded or reused.

S12. (b) Elastomers are the long chain polymers with elasticity and a cross-linkage in structure. Nylon-66 are not elastomers they are condensation polymers formed by adipic acid and hexamethylenediamine. Vulcanised rubber is an example of elastomers.



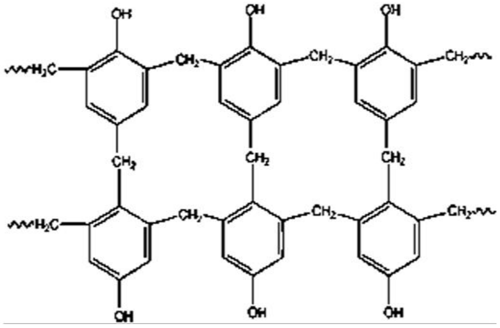
S13. (d)

S14. (c) Bakelite (as shown in the figure) is formed by condensation reaction of phenol with formaldehyde.

Polythene is an addition polymer formed by addition of ethene monomer.

Teflon is an addition polymer formed by carbon tetraflouride.

Polyvinyl chloride (PVC) is formed by addition of vinyl chloride molecules. It is an addition polymer.

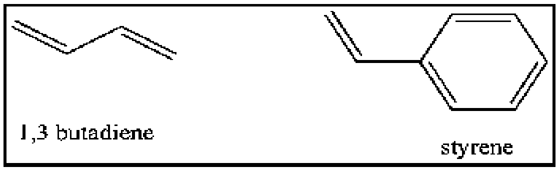


S15. (b) Polyvinyl alcohol can be prepared by alkaline hydrolysis of polyvinyl acetate.

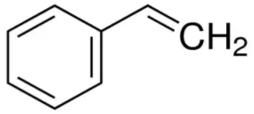
S16. (b) Rubber is a natural polymer but not a natural biopolymer. While starch protein and nucleic acid are the Biopolymer.

S17. (d) Bakelite is an example of a thermosetting polymer and also a type of phenol-formaldehyde polymers. These are obtained by the condensation reaction of phenol with formaldehyde in the presence of either an acid or a base catalyst. The reaction starts with the initial formation of o− and/or p−hydroxymethyl phenols derivatives, which further react with phenol to form compounds having rings joined to each other through $-CH_2$ groups.

S18. (c) Buna-S Rubber: It is a random co-polymer formed by the emulsion polymerisation of a mixture of 1,3 butadiene and styrene in the presence of peroxide catalyst at 5 degree Celsius and therefore the product is called as cold rubber.

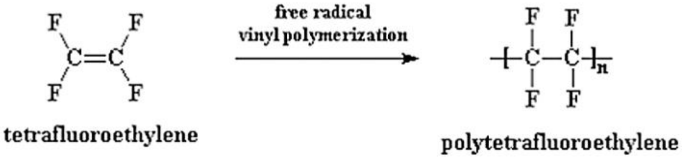


S19. (c) The S in buna-S refers to styrene, it is ethenylbenzene as shown in the above image. Buna-S and buna-N both are the types of synthetic rubbers.

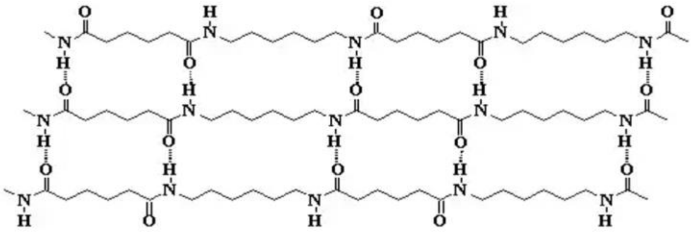


S20. (b) The repeating unit of PTFE is F2C=CF2.

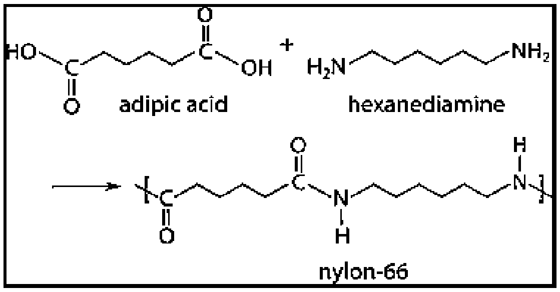
The above image explains the formation of PTFE by process of polymerisation.



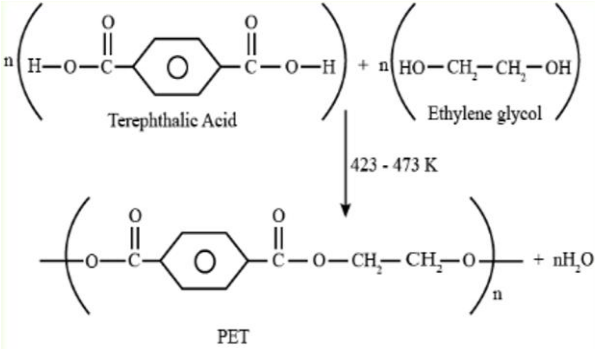
S21. (a) The nitrogen-bonded hydrogens of one nylon chain form strong hydrogen bonds with the carbonyl oxygens of another nylon chain. These hydrogen bonds make crystals of nylon very strong because they hold the nylon chains together very tightly. These strong crystals make strong fibers.



S22. (c) Nylon-6,6 is synthesised by polycondensation of adipic acid and hexamethylenediamine (hexanediamine).



S23. (d) Polyethylene terephthalate (PET) is a condensation polymer.



Polystyrene is an addition polymer of styrene.

Neoprene is formed by the free radical polymerisation of chloroprene. It is an addition polymer.

PAN is prepared by free radical addition polymerisation.

S24. (b) A polymer derived from more than one species of monomer is a co-polymer e.g. Nylon - 6,6.

All others are formed by following single monomers:

Polytetrafluoroethylene - tetrafluoroethylene,

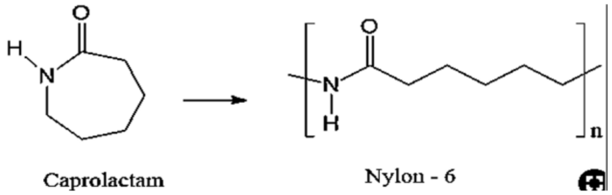
Polyvinyl chloride - vinyl chloride,

Polyethylene - ethylene and

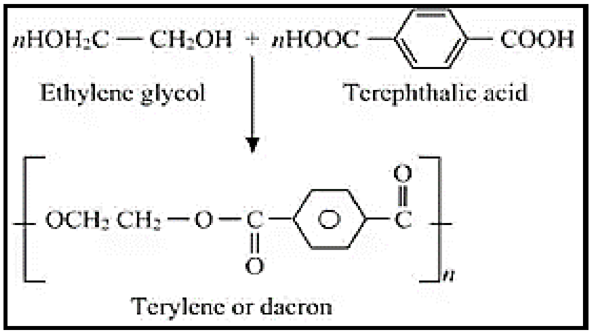
Natural rubber or polyisoprene - isoprene (2-methyl-1,3-butadiene).

S25. (a) Caprolactam is used for the manufacture of Nylon - 6.

Caprolactam is heated at 533 K in an inert atmosphere to form Nylon - 6.



S26. (b) Ethylene glycol on reaction with terephthalic acid forms the polymer terylene (also known as Dacron or terylene) which is used as synthetic fibre.



S27. (b) Bakelite is a thermosetting phenol formaldehyde resin, formed from elimination reaction of phenol with formaldehyde.

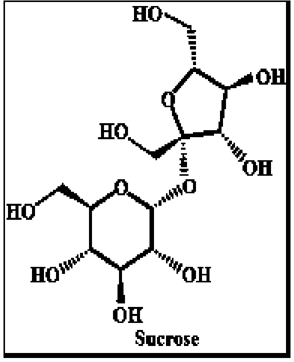
S28. (b) Cellulose is a natural fibre. Starch and rubber are also natural polymers but these do not produce fibres.

S29. (c) Glyptal is a polyester modified by the addition of fatty acids and other components. They are derived from polyols and a dicarboxylic acid or carboxylic acid anhydride.

Alkyds (like Glyptal) are used in paints and in moulds for casting.

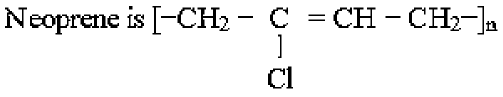
They are the dominant resin or binder in most commercial oil-based coatings.

S30. (a) Sucrose is not a polymer. It is a disaccharide. It contains only 2 sugar units.



S31. (a) Teflon is fully fluorinated polymer. Its monomer is tetrafluoro ethylene, $F_2C{=}CF_2$.

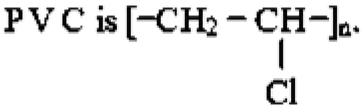
Neoprene is made from monomer chloroprene (2-chlorobuta-1,3-diene).



$$\text{Neoprene is } [-CH_2-\underset{\substack{|\\ Cl}}{C}=CH-CH_2-]_n$$

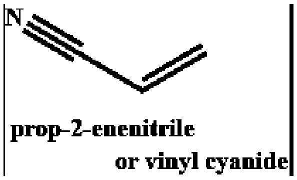
Thiokol is an organic polysulfide polymer.

PVC is polyvinyl chloride. Its monomer is vinyl chloride.



$$\text{PVC is } [-CH_2-\underset{\substack{|\\ Cl}}{CH}-]_n.$$

S32. (a) Orlon has a unit of vinyl cyanide also called prop-2-ene-nitrile.



S33. (a) Cellulose is a biodegradable polymer. Different enzymes secreted by bacteria digest it. Synthetic polymers like polyvinyl chloride, nylon-6, polyester, polyethene etc.) are not acted upon by bacteria and hence, are nonbiodegradable.

S34. (b) The strength of polymers is as:

Elastomers < Thermoplastic < Fibre

Fibers have the strongest bonds in the structure.

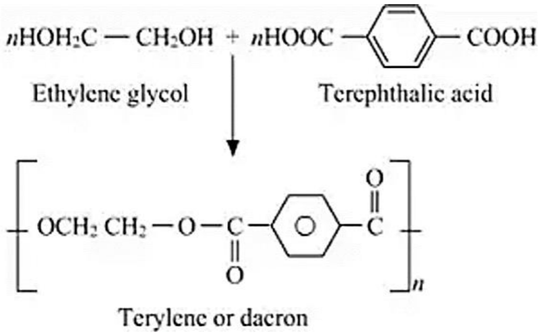
S35. (c)

S36. (a)

S37. (c) Polythene, polystyrene, polyvinyls are the thermoplastic polymers, Characteristics of thermoplastic polymers- These are linear and slightly branched long chain molecules, These are capable of repeatedly softening on heating and hardening on cooling, These possess intermolecular forces of attraction intermediate between elastomers and fibers.

S38. (d) Glycogen is a polysaccharide made up of almost 2000–200000 units of α–D glucose, it is a branched structure, there are two types of bonds present in glycogen as the α 1-4 glycosidic and α 1-6 glycosidic bond.
Glycogen stores in cells of liver and muscles and gives the red colour with iodine also it is named as animal starch.

S39. (c) Above reaction explains the polymerization reaction of Terylene



S40. (c) The formation of vulcanised rubber-
To improve these physical properties, water repellent
Less water absorption
Resist for oxidising agents
Strength
a process of vulcanisation is carried out. This process consists of heating a mixture of raw rubber with sulphur and an appropriate additive at a temperature range between 373 K to 415 K. On vulcanisation, sulphur forms cross links at the reactive sites of double bonds and thus the rubber gets stiffened.

S41. (b) Starch, cellulose and proteins are purely polymeric or naturally occurring polymers composed in large parts of polymeric components. Nylon and PVC are synthetic polymers.

S42. (a) Neoprene and Teflon are formed by addition polymerization while terylene and nylon-6,6 are formed by condensation polymerization.

S43. (a) Polyamides have the amide linkage.
Example- Nylon 6-6, Nylon 6
Nylon 6, 6 is used in making sheets, bristles for brushes and in the textile industry.

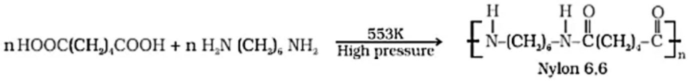
S44. (d) A thermoplastic is a polymer that becomes pliable or moldable above a specific temperature and returns to a solid state upon cooling.
Nylon is a thermoplastic silky material that can be melt-processed into fibers, films, or shapes.
Polyethylene is a lightweight, durable thermoplastic with a variable crystalline structure.
Polyethylene terephthalate or Terylene is the most common thermoplastic polymer resin of the polyester family and is used in fibers for clothing, containers for liquids, and foods.
All the given compounds are thermoplastic polymers.

S45. (b) Vulcanization is a chemical process in which the rubber is heated with sulphur at 373K to 415K. The process involves the formation of cross-links between long rubber molecules so as to achieve improved elasticity, resilience, tensile strength, viscosity, hardness and weather resistance.

S46. (b) : Low density polythene: It is obtained by the polymerisation of ethane under high pressure of 1000 to 2000 atmosphere at a temperature of 350 K to 570 K in the presence of traces of dioxygen or a peroxide initiator (catalyst). They are flexible in nature.

S47. (c) Natural rubber is an addition polymer that is obtained as a milky white fluid known as the latex from a tropical rubber tree. Natural rubber is from the monomer isoprene (2-methyl-1,3-butadiene). Since isoprene has two double bonds, it still retains one of them after the polymerization reaction. Natural rubber has the cis configuration for the methyl groups.

S48. (d) Nylon 6,6 is obtained by condensation polymerisation of adipic acid and hexamethylenediamine,
Nylon 6, 6 is used in making sheets, bristles for brushes and in the textile industry.



$$n\,HOOC(CH_2)_4COOH + n\,H_2N\,(CH_2)_6\,NH_2 \xrightarrow[\text{High pressure}]{553K} \left[\overset{H}{\overset{|}{N}}-(CH_2)_6-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}(CH_2)_4-\overset{O}{\overset{\|}{C}} \right]_n$$

Nylon 6.6

S49. (a) cis-polyisoprene is not a semisynthetic polymer whereas other are semisynthetic polymers.

S50. (d) All polymers cannot form fibres. The key requirement of a fibre forming polymer is that the molecule must be linear. This permits their side by side alignment.

ASSERTION AND REASONING

S1. (d) Most of the synthetic polymers are not biodegradable. Because a large number of polymers are quite resistant to the environmental degradation processes and are thus responsible for the accumulation of polymeric solid waste materials.

S2. (a) In addition, polymerisation, the molecules of the same monomer of different monomers add together on a large scale to form a polymer. The monomers used are unsaturated compounds, e.g., alkenes, alkadienes and their derivatives. This mode of polymerisation leading to an increase in chain length or chain growth can take place through the formation of either free radicals or ionic species.

S3. (a) Thermosetting polymers: These polymers are cross linked or heavily branched molecules, which on heating undergo extensive cross linking in moulds and again become infusible.

S4. (a) Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at high pressures. It is chemically inert and resistant to attack by corrosive reagents. It is used in making oil seals and gaskets and also used for non-stick surface coated utensils.

TRUE/FALSE

S1. (b) Synthetic fibre is polymer, while plastic is not a polymer.

S2. (b) Polymers are large molecules made by stringing together several monomers (small molecules).

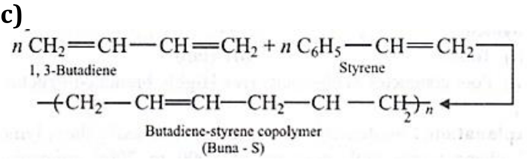
S3. (b) Blended fabrics contain both synthetic and natural fibres. They are produced by the combination of synthetic fibres and natural fibres.

S4. (b) Dusters made of cotton (natural fibre) are good for use in kitchen. They absorb water and do not catch fire easily. Even if they catch fire, they do not stick to the body of the person who is holding it.

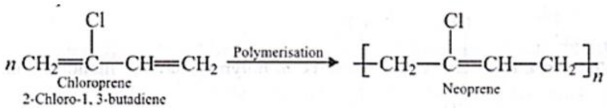
HOMEWORK

S1. **(d)** Nylon-6: It is obtained by heating caprolactum with water at a high temperature.

S2. **(b), (c)**



Neoprene or polychloroprene is formed by the free radical polymerisation of chloroprene.



S3. **(a), (c)** Thermosetting polymers: These polymers are cross linked or heavily branched molecules, which on heating undergo extensive cross linking in moulds and again become infusible. These cannot be reused.

S4. **(c)** Novolac is a linear chain phenol-formaldehyde polymer. The ortho and para hydroxy derivatives of benzyl alcohol, initially formed by the reaction of phenol with HCHO, further react with phenol to form compounds having benzene rings joined together by -CH_2– links (Novolac).

S5. **(c)** Bock copolymers are those in which blocks of each type of monomer alternate with each other. In this case, the block AAAA and block BBB are alternatively repeated after each other.

S6. **(c)** Isoprene (or 2-methyl-1,3-butadiene) repeats itself in a linear chain to form natural rubber. This is also called as cis-1,4-polyisoprene, in which the monomers are linked by weak van der Waals forces, thus making it elastic in nature.

S7. **(a)** Vulcanization is a process of improving the physical properties of natural rubber by introducing sulphur cross-links at the reactive sites of double bonds. This is done by heating the rubber with sulphur and an additive.

S8. **(c)** Neoprene or polyisoprene is a synthetic rubber obtained from the addition polymerisation of chloroprene (2-chloro-1,3-butadiene) through free radical mechanism. It has a better stability towards oxidation than natural rubber.

S9. **(a)** The length of polymer and their molecular mass depends on the number of monomers available for reaction. As a result, the chain lengths of polymers are varying and are expressed as an average.

S10. **(d)** Natural polymers generally have chains of identical lengths and have definite molecular masses (Mw=Mn). This makes them more homogeneous and monodisperse, with a PDI of approximately 1.

S11. **(d)** Since the 4 monomers are present in equal amount, there is 25% of each monomer in the polymer. The number average molecular mass is,

⇒ Mn = (25×10000 + 25×15000 + 25×30000 + 25×50000)/(25+25+25+25)

⇒ Mn = (250000+375000+750000+1250000)/100

⇒ Mn = 2625000/100

⇒ Mn = 26250.

S12. **(d)** Low density polyethylene is a plastic that cannot be decomposed by the abiotic sources and microorganisms and have a harmful effect on the environment.

S13. **(a)** Polylactic acid (PLA) is one of the most common bioplastics which can be easily broken down by soil microorganisms and does not cause any negative effects on the environment. It is a polyester made from lactic acid and lactide.

S14. **(d)** PHBV is short for poly β-hydroxybutyrate-co-β-hydroxy valerate. This shows that is a copolymer of β-hydroxybutyrate (3-hydroxybutanoic acid) and β-hydroxy valerate (3-hydroxypentanoic acid). PHBV is biodegradable as it can be decomposed by bacteria.

S15. **(d)** PMMA is a polymer of methyl methacrylate. It is used in the manufacturing of lenses, dentures, aircrafts windows, etc. It is known by the commercial names plexiglass, lucite, acrylite, perspex and crylux. Vectran is an aromatic polyester.

S16. **(d)** Glyptal is a copolymer of ethylene glycol and phthalic acid. It is an important component in the manufacturing of paints, lacquers and building materials.

S17. **(b)** Urea formaldehyde is a thermosetting resin polymer produced by the condensation of urea and methanal. It is used in making unbreakable cups and laminated sheets.

S18. **(b)** For each step of reaction between a –COOH group and –OH group, a second functional group –COOH acts as a catalyst in the reaction. Therefore, the reaction follows the third order kinetics.

S19. **(c)** The medium viscosity in polymer systems is much higher than the systems of small non-polymeric molecules. Besides, there tend to become insoluble after a certain range of chain length or molecular weight.

S20. (b) This reaction is achieved by addition of a strong acid catalyst, which is not utilized in the reaction as in self catalyzed reaction. So, the reaction clearly, follows second order kinetics.

S21. (b) The functional group at a free end has a good degree of mobility to collide and faster reaction to take place.

S22. (b) The reaction rate decreases with increasing extent of reaction beyond 94%. The factors responsible are loss of reactants, difficulty in removal of byproduct molecule due to high viscosity and other side reactions.

S23. (c) Using the formula,
p = (2/f)[1-(1/Xn)] and putting the values of f=2.4 and p=0.8, we get the value of Xn as 27.67.

S24. (b) Hevea tree produces a milk-white latex that contains the natural rubber hydrocarbon present in the form of fine emulsion in an aqueous serum which is then later processed to give natural rubber.

S25. (b) A little amount of sodium bisulfite is added to the dilute latex before tapping to prevent darkening or discoloration of the latex which may otherwise develop as a consequence of an enzymatic reaction in the latex involving its phenolic constituents producing the dark coloured pigment melanin.

S26. (c) Hevea latex consist of 55-65 % of water, 30-40% of rubber hydrocarbon while proteins and sugars are present in little amount.

S27. (b) The hydrocarbons of natural rubber and gutta percha are the same in elementary formula and in their products of ozonolysis. Gutta percha has a lower molecular weight than natural rubber and so natural rubber is less dense than gutta percha.

S28. (a) The rubber latex from hevea tree firstly undergoes tapping, then it is preserved using a preservative like sodium pentachlorophenate followed by coagulation using acetic acid o formic acid.

S29. (b) Cyclization reaction of rubber leading to the formation of bi- or even polycyclic structures result in the reduction in unsaturation to 20-30% of the original rubber, while the formation of monocyclic structure lead to the drop in unsaturation by 57% of original.

S30. (c) The chlorinated rubber formed by chlorination of natural rubber is resinous in character while natural rubber is elastomeric in nature.

ASSERTION AND REASONING

S1. (b) Teflon is classified as a thermoplastic because it is capable of repeatedly softening on heating (it will only melt and soften under extreme temperatures) and hardening on cooling.
Teflon's thermal stability and chemical inertness are due to its high C–C bond energy.
So, both Assertion and Reason are correct but Reason is not the correct explanation for Assertion.

S2. (c) Bakelite is a thermosetting polymer which are cross linked or heavily branched molecules, which on heating undergo extensive cross-linking in moulds and again become infusible. This can not be reused means it can't regain their original shape after melting.

S3. (b)

S4. (c) Ziegler Natta catalyst is a mixture of triethylaluminium and titanium tetrachloride i.e. $Al(C_2H_5)_3 + TiCl_4$. It is used for polymerization of alkenes to produce polymers.

S5. (a)

TRUE/FALSE

S1. (a)

S2. (b) Acrylic is a synthetic fibre that can be used instead of wool.

S3. (b) Rayon, which is obtained from cellulose, is a synthetic fibre. Rayon is prepared chemically from wood pulp (cellulose).

S4. (a) There are two types of polymers: synthetic and natural. Synthetic polymers are derived from petroleum oil, and made by scientists and engineers. Examples of synthetic polymers include nylon, polyethylene, polyester, Teflon, and epoxy. Natural polymers occur in nature and can be extracted. They are often water-based. Examples of naturally occurring polymers are silk, natural rubber, wool, DNA, cellulose and proteins