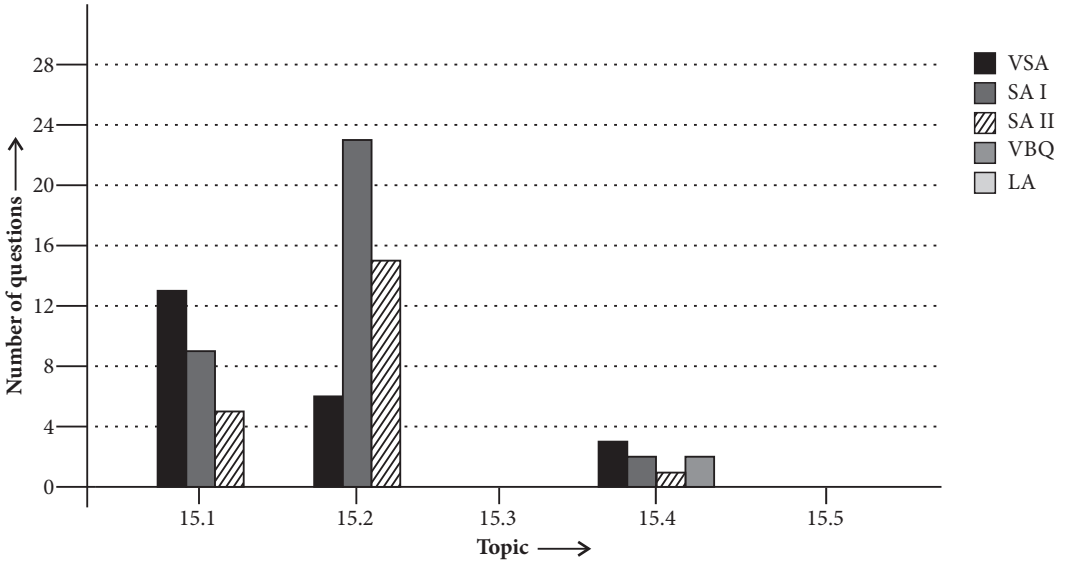
# 15 Polymers



## Topicwise Analysis of Last 10 Years' CBSE Board Questions



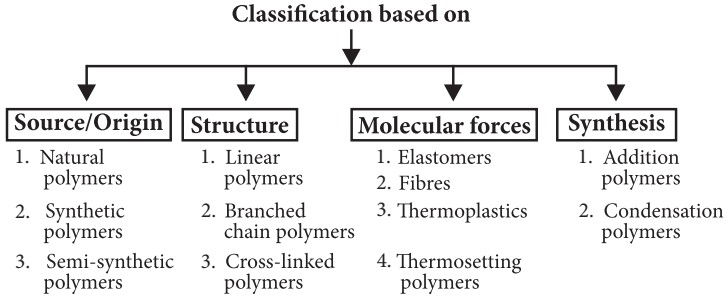

- Maximum total weightage is of *Types of Polymerisation.*
- Maximum VSA type questions were asked from *Classification of Polymers.*
- Maximum SA I and SA II type questions were asked from *Types of Polymerisation.*

## QUICK RECAP

- **Polymers :** They are macro-sized, high molecular mass compounds, formed by the combination of a large number of simple molecules or repeating units.
- **Monomers :** These simple molecules or repeating units which combine to give polymers are called *monomers*.
- The process of joining together of a large number of the monomers is termed as *polymerization*.
- A polymer formed from one type of monomers is called *homopolymer*, *e.g.*, polyethene, PVC, polyacrylonitrile, etc.

- A polymer formed from two or more different monomers is called *copolymer e.g.,* Nylon-6,6, polyester, bakelite, etc.
- The number of times a monomer unit is repeated in a polymer, is called its *degree of polymerization*.

- **Classification of polymers :**

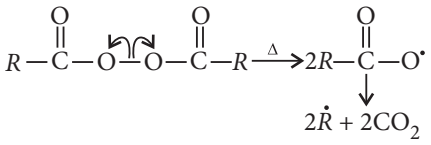


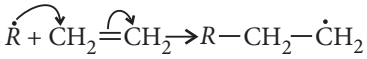

- **Natural polymers :** These are substances of natural origin and are mainly found in plants and animals, *e.g.*, starch, cellulose, proteins, etc.
- **Synthetic polymers :** These polymers are prepared in the laboratories, they are also called *man-made polymers*, *e.g.*, teflon, terylene, synthetic rubber, etc.
- **Semi-synthetic polymers :** They are mostly derived from naturally occurring polymers by chemical modifications, *e.g.*, vulcanised rubber, cellulose nitrate, etc.
- **Linear polymers :** In these polymers monomers are linked together to form linear chains, *e.g.*, polyethene, polyester, nylon, etc.
- **Branched chain polymers :** In these polymers the monomers are joined to form long chains or branches of different lengths, *e.g.*, glycogen, starch, etc.
- **Cross-linked polymers :** In these polymers the monomer units are cross-linked together to form a three-dimensional network polymers, *e.g.*, bakelite, melamine, etc.
- **Elastomers :** These are the polymers having very weak intermolecular forces between the polymer chains. The weak forces permit the polymer to be stretched. Elastomers, thus, possess elastic character, *e.g.*, vulcanised rubber.
- **Fibres :** These are the polymers which have strong intermolecular forces between the chains. These are either hydrogen bonds or dipole-dipole interactions, *e.g.*, Nylon-6,6.
- **Thermoplastics :** These are the polymers in which the intermolecular forces of attraction are intermediate between those of elastomers and fibres. These polymers do not have any cross-links between the chains, they can be easily mouled on heating, *i.e.*, thermoplastics soften on heating and become hard on cooling, *e.g.*, polythene, polystyrene, PVC, etc.
- **Thermosetting polymers :** They have extensive cross-links formed between polymer chains on heating. They undergo a permanent change on heating, *e.g.*, bakelite, melamine, etc.
- **Addition polymerization :** A polymer formed by direct addition of repeated monomers without the elimination of by-product molecules is called *addition polymer* and the phenomenon is known as *addition polymerization*, *e.g.*, polythene.
- **Condensation polymerization :** A polymer formed by the condensation of two or more than two monomers with the elimination of simple molecules like water, ammonia, alcohol, etc. is called *condensation polymer* and the phenomenon is known as *condensation polymerization*, *e.g.*, Terylene.

- **Types of polymerisation reactions :**

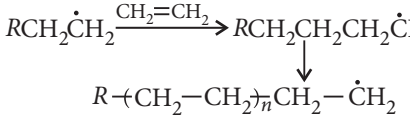
- **Addition or chain growth polymerisation :** Depending upon the reactive particles formed, it is of three types :
  - **Free radical polymerisation :** It takes place in three steps :

- **Chain initiating step :** This step requires initiators which are free radicals produced on heating *e.g.*, benzoyl peroxide, acetyl peroxide, dioxygen, etc.



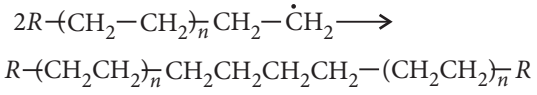


- **Chain propagating step :** The free radical thus formed adds to the double bond of the monomer to form larger free readical.

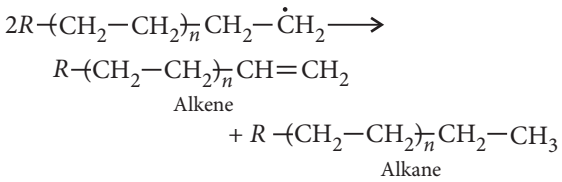


- **Chain terminating step :** The growing free radical chain consumes free radicals either by combination or by disproportionation to get polymer.

- **Combination :**



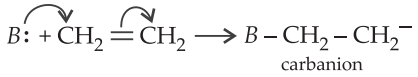
- **Disproporation :**



– **Cationic addition polymerisation :** Initiated by the use of strong Lewis acids such as HF, $AlCl_3$, $H_2SO_4$, etc.

*e.g.*, polyvinyl ether, polyisobutylene, polystyrene, etc.

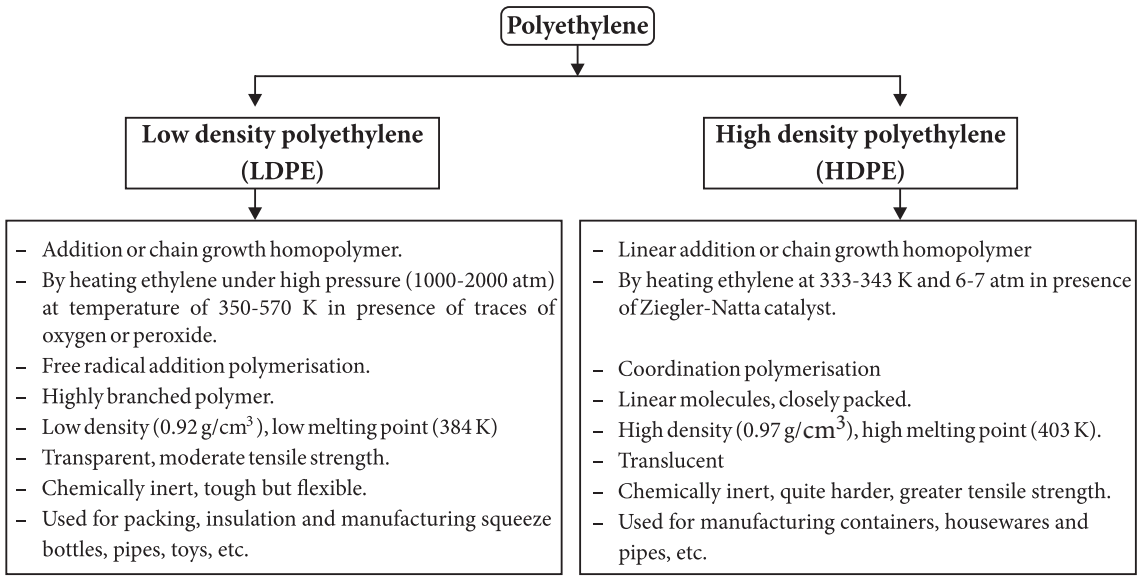
– **Anionic addition polymerisation :** Initiated by strong bases such as $NaNH_2$, $C_4H_9Li$ and Grignard reagent, etc.



*e.g.* polyacrylonitrile, polyvinyl chloride and polymethyl methacrylate, etc.

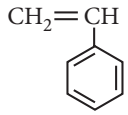
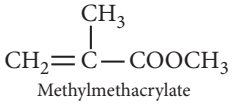
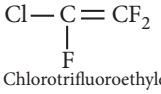
▶ **Condensation or step growth polymerisation :** In this type of polymerisation reactions monomers are bifunctional and form bond with the loss of simple molecule of water, alcohol, ammonia, etc.

**Differences between LDPE and HDPE :**

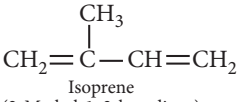
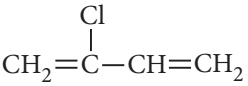
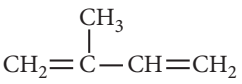


## Preparation of some important addition homopolymers :

**Polyolefins**

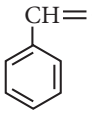
| Polymer | Structure of monomers |
|---|---|
| Polythene | $CH_2=CH_2$ Ethylene |
| Polypropylene | $CH_3-CH=CH_2$ Propylene |
| Polytetrafluoroethene (Teflon) (PTFE) | $CF_2=CF_2$ Tetrafluoroethene |
| Polyacrylonitrile (Orlon) (PAN) | $CH_2=CHCN$ Acrylonitrile (Vinyl cyanide) |
| Polyvinyl chloride (PVC) | $CH_2=CHCl$ Chloroethene (Vinyl chloride) |
| Polystyrene (Styron) |  |
| Polymethylmethacrylate (PMMA) |  Methylmethacrylate |
| Polymonochlorotrifluoroethylene (PCTFE) |  Chlorotrifluoroethylene |

**Polydienes**

| Polymer | Structure of monomers |
|---|---|
| Natural rubber (cis-1, 4-polyisoprene) |  Isoprene (2-Methyl-1, 3-butadiene) |
| Neoprene (synthetic rubber) |  Chloroprene (2-chloro-1, 3-butadiene) |
| Gutta-percha (*trans*-polyisoprene) |  Isoprene (2-Methyl-1, 3-butadiene) |

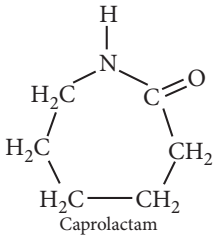
## Preparation of some important addition copolymers :

**Polydienes**

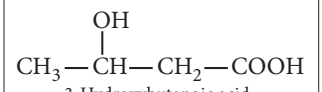
| Polymer | Structure of monomers |
|---|---|
| Buna-S (Styrene Butadiene Rubber) (SBR) | $CH_2=CH-CH=CH_2$ 1,3-Butadiene  Styrene |
| **Buna-N** (Nitrile rubber) | $CH_2=CH-CH=CH_2$ 1,3-Butadiene $CH_2=CH-CN$ Acrylonitrile |

## Preparation of some important condensation homopolymers :

**Polyamides**

| Polymer | Structure of monomers |
|---|---|
| **Nylon-6 (Perlon-L)** |  Caprolactam |

**Polyesters**

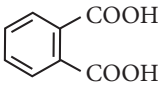
| Polymer | Structure of monomers |
|---|---|
| **Polyhydroxy** butyrate (PHB) |  3-Hydroxybutanoic acid |

## Preparation of some important condensation copolymers :

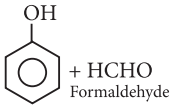
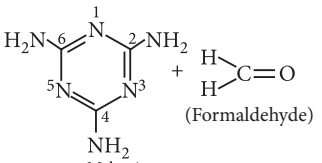
**Polyamides**

| Polymer | Structure of monomers |
|---|---|
| **Nylon-6, 6** | $HOOC-(CH_2)_4-COOH$ Adipicocid $H_2N-(CH_2)_6-NH_2$ Hexamethylenediamine |
| **Nylon-6, 10** | $HOOC-(CH_2)_8-COOH$ Sebacic acid $H_2N-(CH_2)_6-NH_2$ Hexamethylenediamine |
| **Nylon-2, 6** | $H_2N-CH_2-COOH$ Glycine $H_2N-(CH_2)_5-COOH$ 6-Aminohexanoic acid |

**Polyesters**

| Polymer | Structure of monomers |
|---|---|
| Terylene (Dacron) | $HOCH_2—CH_2OH$ Ethylene glycol (Ethane-1,2,-diol); HOOC–C$_6$H$_4$–COOH Terephthalic acid (Benzene-1, 4-dicarboxylic acid) |
| Glyptal (Alkyd resin) | $HOCH_2—CH_2OH$ Ethylene glycol;  Phthalic acid (Benzene-1, 2-dicarboxylic acid) |
| Poly β-hydroxy butyrate-co-β-hydroxy valerate (PHBV) | $CH_3—\underset{\displaystyle OH}{\underset{\vert}{CH}}—CH_2—COOH$ 3-Hydroxybutanoic acid; $CH_3—CH_2—\underset{\displaystyle OH}{\underset{\vert}{CH}}—CH_2—COOH$ 3-Hydroxypentanoic acid |
| Poly (glycolic acid) poly(lactic acid) (Dextron) | $HO—CH_2—COOH$ Glycolic acid; $HO—\underset{\displaystyle CH_3}{\underset{\vert}{CH}}—COOH$ Lactic acid |

**Formaldehyde resins**

| Polymer | Structure of monomers |
|---|---|
| Phenol-formaldehyde resin (Bakelite) |  + HCHO Formaldehyde; Phenol |
| Melamine-formaldehyde resin (Melmac) |  (Formaldehyde); Melamine (2, 4, 6-Triamino-1,3,5-triazine) |
| Urea-formaldehyde resin | $NH_2CONH_2 + HCHO$ Urea Formaldehyde |

**Polysulphide**

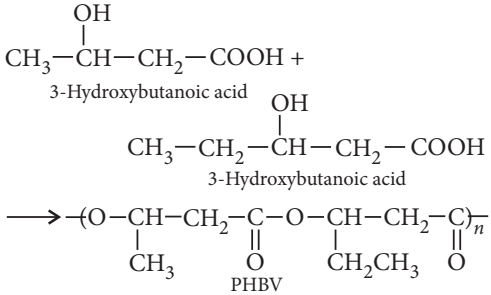
| Polymer | Structure of monomers |
|---|---|
| Thiokol $+CH_2CH_2—S—S—S—S+_n$ | $Cl—CH_2CH_2—Cl$ Ethylene dichloride; $Na_2S_4$ Sodium tetrasulphide |

**Differences between natural rubber and vulcanized rubber :**

| | 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 wide narrow range of temperature (from 10°C to 60°C). | It can be used over a wide range of temperature (– 40°C 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. |

**Biodegradable polymers :** Aliphatic polyesters are one of the most important class of biodegradable polymers. Some important examples are given below :

- **Poly β-hydroxybutyrate-co-β-hydroxy valerate (PHBV) :** PHBV is used in speciality packaging, orthopaedic devices and in controlled release of drugs. PHBV undergoes bacterial degradation in the environment.




- **Nylon 2-nylon 6 :** It is an alternating polyamide copolymer of glycine ($H_2NCH_2COOH$) and amino caproic acid [$H_2N(CH_2)_5COOH$] and is biodegradable.

$$nH_2N—CH_2—COOH + nH_2N—(CH_2)_5—COOH \xrightarrow{\Delta} +NH—CH_2—C(=O)—NH—(CH_2)_5—C(=O)+_n$$

Nylon 2-nylon 6

# Previous Years' CBSE Board Questions

## 15.1 Classification of Polymers

### VSA (1 mark)

**1.** Arrange the following polymers in the increasing order of their intermolecular forces : Polystyrene, Terylene, Buna-S. *(1/3, Delhi 2016)*

**2.** Arrange the following polymers in the increasing order of their intermolecular forces : Terylene, Polythene, Neoprene. *(1/3, AI 2016)*

**3.** Write the name and structure of the monomers of the following polymer :

Buna-S *(1/3, Delhi 2015C, 2013, 2010, 2008)*

**4.** Which of the following is a natural polymer?
Buna-S, Proteins, PVC *(AI 2014)*

**5.** Based on molecular forces what type of polymer is neoprene? *(AI 2014)*

**6.** Which of the following is a fibre?
Nylon, Neoprene, PVC *(AI 2014)*

**7.** Define the term, 'homopolymerisation' giving an example. *(Delhi 2012)*

**8.** Explain the following term giving a suitable example :
Elastomers *(1/3, AI 2012)*

**9.** Write a distinguishing feature between homopolymer and copolymer. *(Delhi 2010C)*

**10.** Define the term 'polymerisation'. *(AI 2008)*

### SA I (2 marks)

**11.** Define thermoplastic and thermosetting polymers. Give one example of each. *(2/3, AI 2013, 2008)*

**12.** How are thermosetting polymers different from thermoplastic polymers? *(2/3, Delhi 2013C, 2012C)*

**13.** Distinguish between homopolymers and copolymers. Give one example of each. *(AI 2013, 2008)*

**14.** Explain the following terms giving a suitable example for each:
(i) Condensation polymers
(ii) Addition polymers *(AI 2012)*

**15.** Differentiate between molecular structures and behaviours of thermoplastic and thermosetting polymers. Give one example of each type. *(AI 2009)*

**16.** What is the difference between elastomers and fibres? Give one example of each. *(2/3, AI 2008C)*

### SA II (3 marks)

**17.** Differentiate between thermoplastic and thermosetting polymers. Give one example of each. *(AI 2012)*

**18.** What are addition polymers? How are the two types of addition polymers different from each other? Give one example of each type. *(Forign 2011)*

**19.** Find the main difference between them
(i) Thermoplastic polymers
(ii) Thermosetting polymers *(Delhi 2010)*

**20.** Differentiate between condensation and addition polymerisations. Give one example each of the resulting polymers. *(AI 2009)*

**21.** (a) Distinguish between homopolymers and copolymers. Give one example of each.
(b) Is $-(CH_2-CH(C_6H_5)-)_n$ a homopolymer or a copolymer? Why? *(Delhi 2008C)*

## 15.2 Types of Polymerisation

### VSA (1 mark)

**22.** Is $-(CH_2-\underset{\displaystyle Cl}{\underset{|}{CH}}-)_n$ a homopolymer or a copolymer? *(AI 2013)*

**23.** Name the polymer which is used for making non-stick cooking utensils. *(1/3, Delhi 2013C)*

**24.** What does the part '6,6' mean in the name nylon-6, 6? *(Delhi 2009)*

**25.** What does '6,6' indicate in the name nylon-6,6? *(AI 2009)*

**26.** What is the primary structural feature necessary for a molecule to make it useful in a condensation polymerisation reaction? *(AI 2009)*

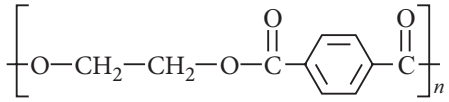
**27.** What is the difference between the two notations : nylon – 6 and nylon – 6,6 ? *(AI 2008C)*

## SA I (2 marks)

**28.** (i) What is the role of *t*-butyl peroxide in the polymerisation of ethene?
(ii) Identify the monomers in the following polymer :

*(2/3, Delhi 2016)*

**29.** (i) What is the role of sulphur in the vulcanisation of rubber?
(ii) Identify the monomers in the following polymer :



*(2/3, AI 2016)*

**30.** Write the names and structures of the monomers of the following polymers :
(i) Nylon 6, 6 (ii) Neoprene
*(2/3, Delhi 2015, 2013)*

**31.** Write the names and structures of the monomers of the following polymers :
(i) Neoprene (ii) Teflon
*(2/3, Delhi 2015C)*

**32.** Explain the term 'copolymerisation' and give two examples of copolymerization. *(2/3, AI 2015C)*

**33.** Write the name of monomers used for getting the following polymers :
(i) Bakelite (ii) Neoprene
*(AI 2014)*

**34.** Write the name of monomers used for getting the following polymers :
(i) Terylene (ii) Nylon-6,6
*(AI 2014)*

**35.** Write the name of monomers used for getting the following polymers :
(i) Teflon (ii) Buna-N *(AI 2014)*

**36.** Give names of the monomers of the following polymers :
(i) Neoprene (ii) Polystyrene
(iii) Polypropene *(Delhi 2014C)*

**37.** Write the names and structures of monomers used for getting the following polymers :
(i) Buna-S (ii) Nylon-6,6
*(AI 2014C)*

**38.** Draw the structure of the monomer for each of the following polymers.
(i) Nylon-6 (ii) Polypropene
*(Delhi 2012)*

**39.** Write down the structure of monomer and one use of the polymer polystyrene.
*(2/3, Delhi 2012C)*

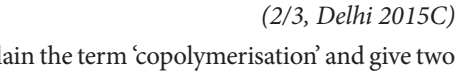
**40.** Mention two important uses of each of the following :
(i) Bakelite (ii) Nylon 6
*(2/3, Delhi 2011)*

**41.** Write the name and structure of the monomer of each of the following polymers :
(i) Neoprene (ii) Buna-S (iii) Teflon
*(2/3, Delhi 2010)*

**42.** Draw the molecular structures of the monomers of
(i) PVC (ii) Teflon *(AI 2010)*

**43.** Draw the structures of the monomers of the following polymers :
(i) Bakelite (ii) Nylon-6 *(AI 2010)*

**44.** Write the names of monomers of the following polymers.



*(Delhi 2009)*

**45.** Write the names and structures of the monomers of the following polymers :
(i) Neoprene (ii) Nylon-6
*(2/3, Delhi 2008)*

**46.** What is step growth polymserisation? Explain the steps involved in this process. *(AI 2008C)*

**47.** Write the structures of monomers used in the preparation of
(a) Teflon (b) PMMA
*(AI 2007)*

**48.** Draw the structures of the monomer of each of the following polymers.
(i) Polyvinylchloride (PVC)
(ii) Nylon-6. *(Delhi 2007)*

## SA II (3 marks)

**49.** Write the mechanism of free radical polymerisation. *(Delhi 2016)*

**50.** Write the names and structures of the monomers of the following polymers :
(i) Buna-S (ii) Glyptal
(iii) Polyvinyl chloride *(AI 2015)*

**51.** Write the names and structures of the monomers of the following polymers :
(i) Terylene (ii) Bakelite
(iii) Buna-S *(Foreign 2015)*

**52.** Write the name of the monomers of the following polymers :
(i) Polythene (ii) Polyvinyl chloride
(iii) Bakelite *(Delhi 2014C)*

**53.** Write the names and structures of the monomers of the following polymers :
(i) Bakelite (ii) Nylon-6
(iii) Polythene *(Delhi 2013)*

**54.** (a) Differentiate between copolymerisation and homopolymerisation. Give one example of each.
(b) What is the role of Benzoyl peroxide in preparation of polythene? *(Delhi 2013C)*

**55.** Write the monomers of the following polymers and classify them as addition or condensation polymers :
Teflon, Bakelite and Natural rubber *(AI 2013C)*

**56.** Explain the term co-polymerization and give two examples of copolymers and the reactions for their preparations. *(AI 2012C)*

**57.** Draw the structure of the monomers of the following polymers :
(i) Polythene (ii) PVC
(iii) Teflon *(AI 2011)*

**58.** Mention two important uses for each of the following polymers :
(i) Bakelite (ii) Nylon 6,6
(iii) PVC *(Forign 2011)*

**59.** Distinguish between addition polymers and condensation polymers. Classify the following into addition and condensation polymers :
(i) Polythene (ii) PTFE
(iii) Polybutadiene (iv) Bakelite*(AI 2011C)*

**60.** Give one example each of
(i) addition polymers,
(ii) condensation polymers,
(iii) copolymers. *(Delhi 2010)*

**61.** Write the (i) structure and (ii) one use of each of the following polymers :
(a) PVC
(b) Urea-formaldehyde resin
(c) Bakelite *(AI 2010C)*

**62.** Write the monomers which are used for the synthesis of the following polymers :
(i) Terylene (ii) Polythene
(iii) Bakelite
Indicate the type of polymerisation for each which forms the polymer. *(AI 2009C)*

**63.** Write chemical equations to form the following :
(i) Nylon-6 (b) Nylon-6,6
(iii) Polythene *(AI 2009C)*

## 15.4 Biodegradable Polymers

### VSA (1 mark)

**64.** Write the names and structures of the monomer of the following polymer :
PHBV *(1/3, Delhi 2015)*

**65.** What are biodegradable polymers? Give one example. *(1/3, AI 2013C)*

**66.** What are biodegradable polymers? *(Delhi 2011)*

### SA I (2 marks)

**67.** What is a biodegradable polymer? Give an example of a biodegradable aliphatic polyester. *(2/3, AI 2013)*

**68.** What are biodegrable and non-biodegradable polymers? Give one example of each class. *(Delhi 2008)*

### SA II (3 marks)

**69.** What are biodegradable polymers? Give an example of such a polymer and mention its uses. *(Delhi 2009C)*

### VBQ (3 marks)

**70.** After the ban on plastic bags, students of one school decided to make the people aware of the harmful effects of plastic bags on environment and Yamuna River. To make the awareness more impactful, they organized rally by joining hands with other schools and distributed paper

bags to vegetable vendors, shopkeepers and departmental stores. All students pledged not to use polythene bags in future to save Yamuna River. After reading the above passage, answer the following questions:

(i) What values are shown by the students?
(ii) What are biodegradable polymers? Give one example.
(iii) Is polythene a condensation or an addition polymer?

*(Delhi 2014)*

**71.** After the ban on plastic bags, students on one school decided to create awareness among the people about the harmful effects of plastic bags on the environment and the Yamuna river. To make it more impactful, they organised a rally by joining hands with other schools and distributed paper bags to vegetable vendors, shopkeepers and departmental stores. All students pledged not to use polythene bags in future to save the Yamuna river.

After reading the above passage, answer the following questions :

(i) What values are shown by the students?
(ii) What are biodegradable polymers? Give one example.
(iii) Is polythene a homopolymer or copolymer?

*(Foreign 2014)*

## Detailed Solutions

**1.** The intermolecular forces are least in case of elastomers like Buna-S while strongest in case of fibres like terylene and in case of thermoplastics like polystrene the intermolecular forces are intermediate in between elastomers and fibres.

Thus, the increasing order of their intermolecular forces is Terylene > Polystyrene > Buna-S

**2.** Neoprene < Polythene < Terylene.

**3.** Buna-S :

$\underset{\text{1,3–Butadiene}}{CH_2=CH-CH=CH_2}$ and $\underset{\text{Styrene}}{C_6H_5CH=CH_2}$

**4.** Proteins are natural polymers.

**5.** Elastomer.

**6.** Nylon is a fibre.

**7.** A polymer made by polymerisation of a single monomer is known as homopolymer and the process is known as homopolymerisation For *e.g.*, Polythene made by polymerisation of ethene molecules.

$$\underset{\text{Ethene}}{nCH_2=CH_2} \longrightarrow \underset{\text{Polythene}}{+CH_2-CH_2+_n}$$

**8.** Elastomers are the polymers in which polymer chains are held by weakest intermolecular forces.

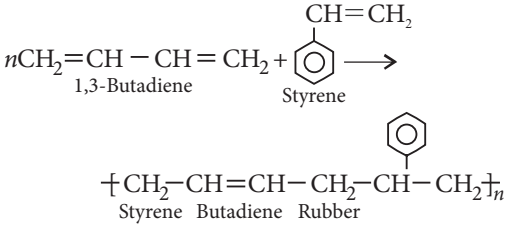
*e.g.* Buna-S, Buna-N.

**9. Homopolymer :** A polymer made by polymerisation of a single monomer is known as homopolymer and the reaction is called homopolymerisation.

*e.g.* Polythene made by ethene molecules.

$$\underset{\text{Ethene}}{nCH_2=CH_2} \rightarrow \underset{\text{Polythene (homopolymer)}}{+CH_2-CH_2+_n}$$

**Copolymer :** A polymer made by polymerisation of two or more different monomers is called copolymer and the reaction is called copolymerisation. When styrene and butadiene are polymerised together, a polymer called styrene-butadiene rubber is formed



$$+\underset{\text{Styrene}}{CH_2-CH=CH-CH_2-}\underset{\text{Butadiene}}{CH-CH_2+_n}$$

Rubber

**10.** The process of formation of macromolecules/ polymers from their respective monomeric units, is called polymerisation.

**11. Thermoplastics :** Thermoplastics are linear or slightly branched polymers which can be repeatedly softened on heating and hardened on cooling and hence can be used again and again without any change in chemical composition and mechanical strength.

Example : Polythene and polystyrene.

**Thermosetting Polymers:** Thermosetting polymers on heating in a mould get hardened and set and cannot be softned again. This hardening on heating is due to cross-linking between different polymer chains to give a three-dimensional network solid.

Example : Bakelite.

**12.** *Refer to answer 11.*

**13.** *Refer to answer 9.*

**14. Addition polymers :** The polymers formed by the addition reaction of a large number of unsaturated monomers are called addition polymers.

For example : Polythene, polystyrene.

**Condensation polymers :** The polymers formed by the condensation of two or more bifunctional monomers are called condensation polymers.

For example : Nylon 6,6, Bakelite.

**15.** *Refer to answer 11.*

**16.** (i) In elastomers polymer chains are held together by weakest intermolecular forces.

These have elastic properties. e.g. Buna-N, Buna-S.

(ii) In fibres polymer chains are held together by strong intermolecular forces like hydrogen bonding.

These have high tensile strength.

*e.g.,* Terylene, Nylon 6,6, etc.

**17.** *Refer to answer 11.*

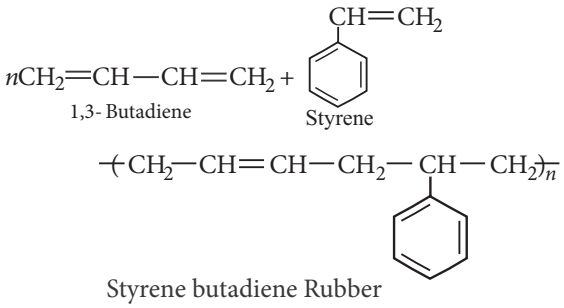
**18.** Polymers which are formed by the repeated addition reaction of unsaturated monomer molecules are called the addition polymers.

The two types of addition polymers are :

(i) **Homopolymers :** The addition polymers formed by the polymerisation of a single compound are called homopolymers. *e.g.*, polyethene.

$$n CH_2=CH_2 \longrightarrow \underset{\text{Polyethene}}{+CH_2-CH_2+_n}$$
Ethene

(ii) **Copolymers :** The polymers made by addition polymerisation from two different compounds are known as copolymers. *e.g.*, Buna-S.




**19.** *Refer to answer 11.*

**20.** *Refer to answer 14.*

**21.** (a) *Refer to answer 9.*

(b) It is a homopolymer because it is formed by the repetition of single compound *i.e.*, monomer unit $C_6H_5CH = CH_2$.

**22.** Homopolymer

**23.** Teflon $+CF_2-CF_2+_n$

**24.** In nylon 6, 6, designation '6, 6' mean that both the monomers hexamethylene diamine and adipic acid contain six carbon atoms each.

**25.** *Refer to answer 24.*

**26.** Monomers should possess more than one functional group.

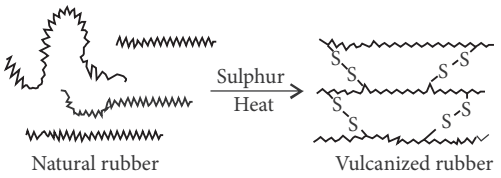
**27.** Nylon 6 is obtained from the monomer caprolactam which contains 6 carbon atoms. Nylon 6,6 is a condensation polymer of hexamethylene diamine and adipic acid. Both the monomers have 6 carbon atoms each.

**28.** (i) Polymerisation of ethene requires an initiator to start the polymerisation with free radical mechanism. Thus, peroxide like *t*-butyl peroxide decomposes to give free radical that initiates the reaction.

(ii) Hexamethylene diamine and adipic acid.

**29.** Vulcanisation is a process of heating natural rubber with sulphur and an appropriate additive to modify its properties.

It gives greater elasticity and ductility. Sulphur forms cross linked network which gives mechanical strength to the rubber.




(ii) Terephthalic acid and ethylene glycol.

**30.** (i) Nylon 6,6 : $\underset{\text{Adipic acid}}{HOOC+CH_2+_4-COOH}$ and

$\underset{\text{Hexamethylene diamine}}{H_2N+CH_2+_6NH_2}$

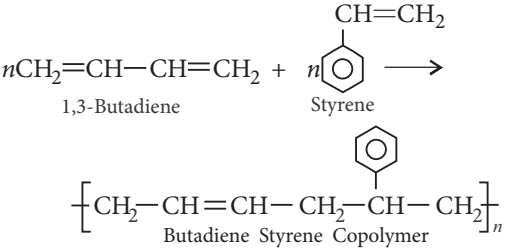
(ii) Neoprene : $CH_2=\underset{\text{Chloroprene}}{\overset{Cl}{\overset{|}{C}}-CH=CH_2}$

**31.** (i) *Refer to answer 30(ii).*

(ii) Teflon : $\underset{\text{Tetrafluroethylene}}{CF_2=CF_2}$

**32. Copolymerization :** When the polymers are synthesised by polymerization of two or more than two different monomers then this process is called as copolymerization. example,

(i) Styrene butadiene rubber (SBR) :




(ii) Buna–N :

$n CH_2=CH-CH=CH_2 + n CH_2=CHCN \longrightarrow$

1,3-Butadiene, Acrylonitrile

$$+CH_2-CH=CH-CH_2-CH_2-\overset{CN}{\overset{|}{C}}H+_n$$
Buna - N

**33.** (i) Bakelite : Formaldehyde (HCHO) and Phenol ($C_6H_5OH$)

(ii) *Refer to answer 30(ii).*

**34.** (i) *Refer to answer 29(ii).*

(ii) *Refer to answer 30(i).*

**35.** (i) *Refer to answer 31(ii).*

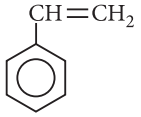
(ii) Buna–N : $\underset{\text{1,3–Butadiene}}{CH_2=CH-CH=CH_2}$ and

$\underset{\text{Acrylonitrile}}{CH_2=CHCN}$

**36.**

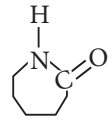
| Name of polymer | Monomer |
|---|---|
| Neoprene | Chloroprene |
| Polystyrene | Styrene |
| Polypropene | Propene |

**37.** (i)Buna–S :

$CH_2=CH-CH=CH_2$ and 

1,3-Butadiene Styrene

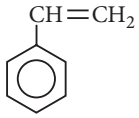
(ii) *Refer to answer 30(i).*

**38.** (i) Nylon–6 : 

Caprolactam

(ii) Polypropene : $CH_3-CH=CH_2$

Propene

**39.** Polystyrene : 

Styrene

Used to make transparent drinking cups.

**40.** (i) Bakellite is used for making combs, electrical switches, handles of various utensils and phonograph records.

(ii) Nylon–6 is used for making tyre cords, ropes and fabrics.

**41.** (i) *Refer to answer 30(ii).*

(ii) *Refer to answer 37(i).*

(iii) *Refer to answer 31(ii).*

**42.** (i) Structure of monomer PVC : $CH_2=CHCl$ Vinyl chloride

(ii) *Refer to answer 31(ii).*

**43.** (i) *Refer to answer 33(i).*

(ii) *Refer to answer 38(i).*

**44.** (i) Caprolactam

(ii) Tetrafluoroethene

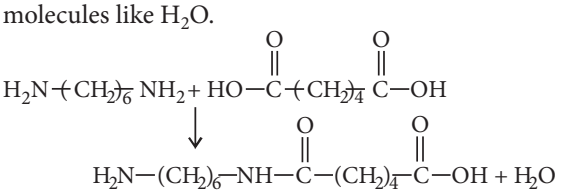
**45.** (i) *Refer to answer 30(ii).*

(ii) *Refer to answer 38(i).*

**46.** Step growth polymerisation involves a repetitive condensation reaction between two bi-functional monomers. Each step produces a distinct functionalised species and in independent of each other.

All condensation polymerisation are step growth polymerisation.

Step : It involves condensation reaction of bifunctional molecules with elimination of smaller molecules like $H_2O$.



**47.** (i) *Refer to answer 31(ii).*

(ii) PMMA : $CH_2=\underset{\displaystyle CH_3}{\overset{|}{C}}-COOCH_3$

Methyl methacrylate

**48.** (i) *Refer to answer 42(i).*

(ii) *Refer to answer 38(i).*

**49.** Chain initiation :

$\dot{R} + CH_2=CH_2 \longrightarrow R-CH_2-\dot{C}H_2$

Chain propagation :

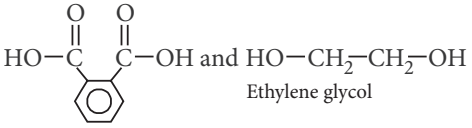
$R-CH_2-\dot{C}H_2 + CH_2=CH_2 \longrightarrow R-CH_2-CH_2-CH_2-\dot{C}H_2$

Chain termination :

$R-CH_2-CH_2-CH_2-\dot{C}H_2 + \dot{R} \longrightarrow R-(CH_2)_4-R$

**50.** (i) *Refer to answer 37(i).*

(ii) Glyptal :

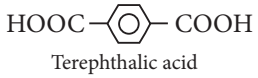


Phthalic acid Ethylene glycol

(iii) *Refer to answer 42(i).*

**51.** (i) $HOH_2C-CH_2OH$ and

Ethylene glycol



Terephthalic acid

(ii) *Refer to answer 33(i).*

(iii) *Refer to answer 37(i).*

**52.** (i) Monomer of polythene is ethene.

(ii) Monomer of PVC is vinyl chloride.

(iii) Monomers of Bakelite are formaldehyde and Phenol.

**53.** (i) *Refer to answer 33(i).*

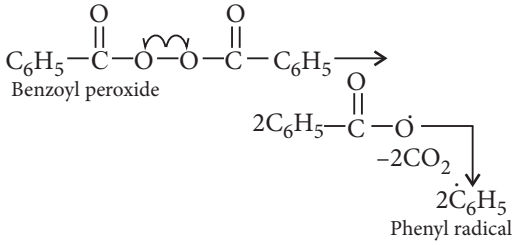
(ii) *Refer to answer 38(i).*

(iii) Polythene : $CH_2=CH_2$

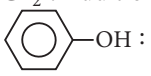
Ethene

**54.** (a) *Refer to answer 9.*

(b) In the preparation of polythene from ethene, benzoyl peroxide acts as an initiator or free radical generator.




**55.** Teflon : $CF_2 = CF_2$ : Addition Polymer

Bakelite : HCHO +  : Condensation Polymer

Natural Rubber : $CH_2=\underset{\underset{CH_3}{|}}{C}-CH=CH_2$ : Addition Polymer.

**56.** *Refer to answer 32.*

**57.** (i) *Refer to answer 53(iii).*
(ii) *Refer to answer 42(i).*
(iii) *Refer to answer 31(ii).*

**58.** (i) Bakelite – (1) In electrical switches
(2) In making handles of various utensils.
(ii) Nylon 6,6 – (1) In Fabrics
(2) In tyre cords
(iii) PVC – (1) In hand bags
(2) In water pipes

**59.** *Refer to answer 14.*
(i) Polythene – addition polymer
(ii) PTFE – addition polymer
(iii) Polybutadiene – addition polymer
(iv) Bakelite – condensation polymer

**60.** (i) Addition polymers : Polythene, rubber.
(ii) Condensation polymers : Terylene, Nylon 6,6.
(iii) Copolymers : SBR, Buna-N.

**61.** (i) PVC

Structure $-\!\left(CH_2-\underset{\underset{Cl}{|}}{CH}\right)_n-$

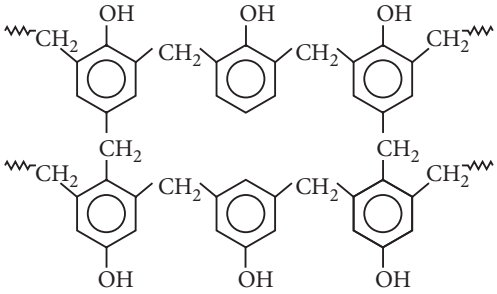
Use in making pipes and raincoats.

(ii) Urea-formaldehyde resin

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

Used in making unbreakable crockery.

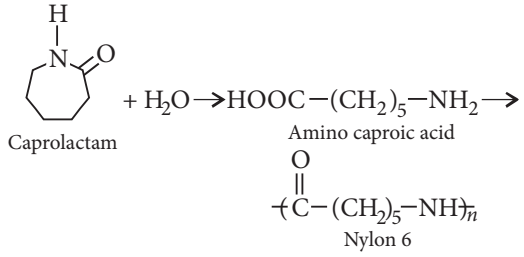
(iii) Bakelite



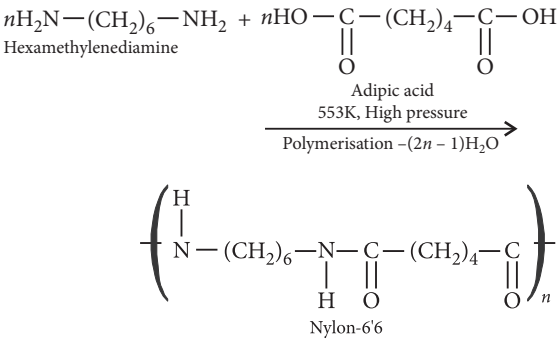
Used in making electrical switches and handles of utensils.

**62.** (i) *Refer to answer 29(ii).* It is a condensation polymer.
(ii) *Refer to answer 52(i).* It is an addition polymer.
(iii) *Refer to answer 33(i).* It is a condensation polymer.

**63.** (i) Nylon–6 : It is formed by self condensation of caprolactam in the presence of water.




(ii) Nylon–6'6

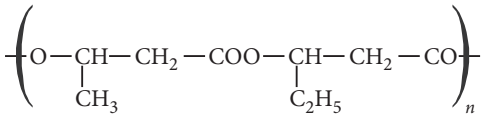



(iii) Polythene

$$n CH_2=CH_2 \xrightarrow[200°C]{O_2} -\!(CH_2-CH_2)_n-$$

**64.** PHBV – Poly – β – hydroxybutyrate – co – β – hydroxyvalerate

Structure :



**65. Biodegradable Polymers :** The natural polymer, which disintegrates by itself or by micro-ogranisms within certain period of time is called biodegradable polymer, *e.g.*, PHBV (poly–β–hydroxybutyrate–co–β–hydroxyvalerate), Nylon 2–nylon 6.

**66.** *Refer to answer 65.*

**67.** *Refer to answer 65.*

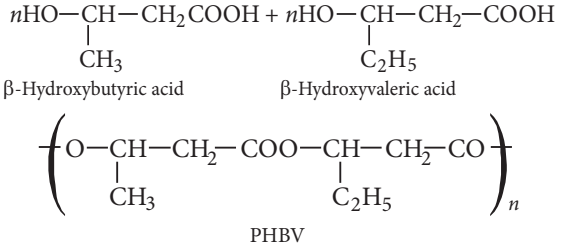
**68.**

| Biodegradable polymer | Non-biodegradable polymer |
|---|---|
| The natural polymer, which disintegrates by itself or by micro-ogranisms within certain period of time is called *biodegradable polymer*, *e.g.*, PHBV (poly–β–hydroxybutyrate–co–β–hydroxyvalerate), Nylon 2–nylon 6. | They generally consist of long chains of carbon and hydrogen atoms. The interatomic bonding of these molecules is very strong, which makes it very difficult for microbes to break the bonds and digest them. Thus a long period of time is required to decompose them. For *e.g.*, Polythene, PTFE etc. |

**69.** *Refer to answer 65.*

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

It is a co-polymer of β-hydroxybutyric acid and β-hydroxy valeric acid.




Butyric acid provides stiffness and valeric acid imparts flexibility to the polymer.

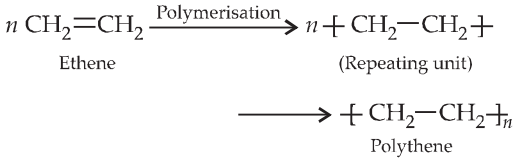
Uses : In packaging orthopaedic devices and control drug release.

A drug is put in capsules of PHBV, which is degraded in the body and drug is released. PHBV also undergoes bacterial degradation in the environment.

**70.** (i) Students show awareness and responsibility towards the environment.

(ii) *Refer to answer 65.*

(iii) Polythene is an addition polymer that is formed by addition of ethene molecules.




**71.** (i) *Refer to answer 70(i).*

(ii) *Refer to answer 65.*

(iii) Polythene is homopolymer because it is formed by the repeatition of single monomer unit *i.e.*, ethene, $CH_2 = CH_2$.