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**Polymers**  
**Multiple Choice Questions (Type-I)**

1. Which of the following polymers of glucose is stored by animals?

- (i) Cellulose
- (ii) Amylose
- (iii) Amylopectin
- (iv) Glycogen

Ans. (iv) Glycogen

**Explanation:** Glycogen is a polymer of glucose found in liver, brain and muscles of animals.

2. Which of the following is not a semisynthetic polymer?

- (i) *cis*-polyisoprene
- (ii) Cellulose nitrate
- (iii) Cellulose acetate
- (iv) Vulcanised rubber

Ans. (i) *cis*-polyisoprene

**Explanation:** *cis*-polyisoprene is not a semisynthetic polymer whereas other are semisynthetic polymers.

3. The commercial name of polyacrylonitrile is \_\_\_\_\_.

- (i) Dacron
- (ii) Orlon (acrilan)
- (iii) PVC
- (iv) Bakelite

Ans. (ii) Orlon (acrilan)

**Explanation:** Polyacrylonitrile is used as a substitute for wool in making commercial fibres as orlon or acrilan.

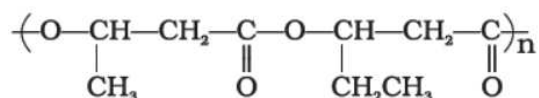
4. Which of the following polymer is biodegradable?

- (i)  $\left( \text{CH}_2 - \underset{\text{Cl}}{\text{C}} = \text{CH} - \text{CH}_2 \right)_n$
- (ii)  $\left( \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \overset{\text{CN}}{\text{CH}} \right)_n$
- (iii)  $\left( \text{O} - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_2 - \underset{\text{O}}{\text{C}} - \text{O} - \underset{\text{CH}_2\text{CH}_3}{\text{CH}} - \text{CH}_2 - \underset{\text{O}}{\text{C}} \right)_n$
- (iv)  $\left( \underset{\text{H}}{\text{N}} - (\text{CH}_2)_6 - \underset{\text{H}}{\text{N}} - \overset{\text{O}}{\text{C}} - (\text{CH}_2)_4 - \overset{\text{O}}{\text{C}} \right)_n$

Ans. (iii)

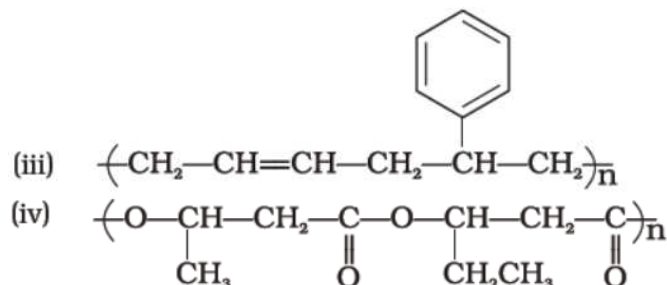
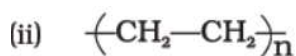
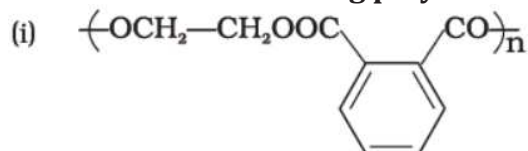
**Explanation:** Poly  $\beta$ -hydroxybutyrate-co- $\beta$ -hydroxy valerate (PHBV):

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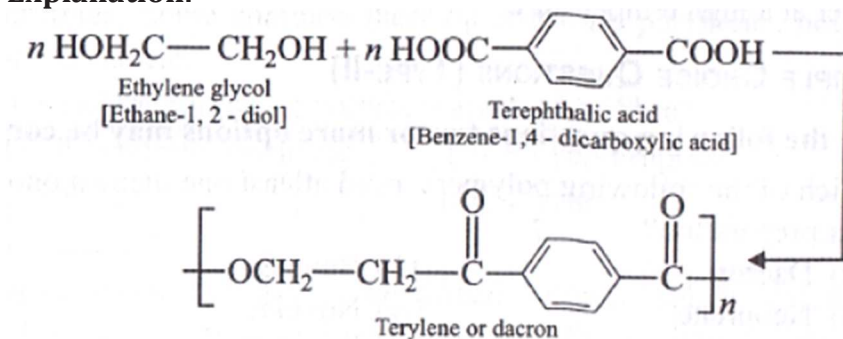
It is obtained by the copolymerization of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid. PHBV is used in speciality packaging orthopaedic devices and in controlled release of drugs. PHBV undergoes bacterial degradation in the environment.

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



Ans. (i)

Explanation:

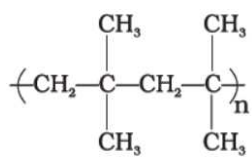


6. Which of the following statements is not true about low density polythene?

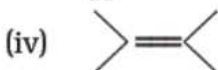
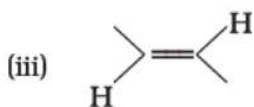
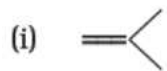
- (i) Tough
- (ii) Hard
- (iii) Poor conductor of electricity
- (iv) Highly branched structure

Ans. (ii)

**Explanation:** 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.

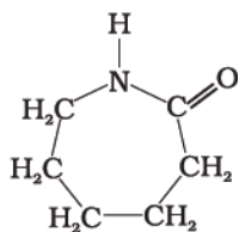


7. is a polymer having monomer units \_\_\_\_\_.



Ans. (i)

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



- (i) Nylon 6, 6
- (ii) Nylon 2-nylon 6
- (iii) Melamine polymer
- (iv) Nylon-6

Ans. (iv)

**Explanation: Nylon-6:** It is obtained by heating caprolactum with water at a high temperature.

**Polymers**  
**Multiple Choice Questions (Type-II)**

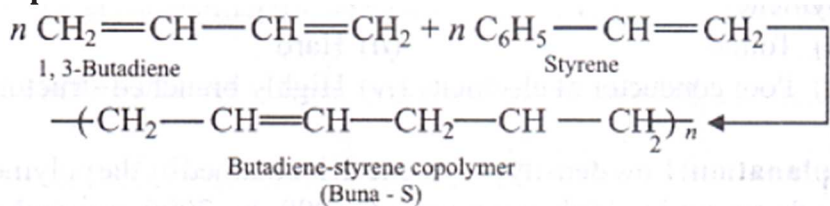
**Note:** In the following questions two or more options may be correct.

9. Which of the following polymers, need atleast one diene monomer for their preparation?

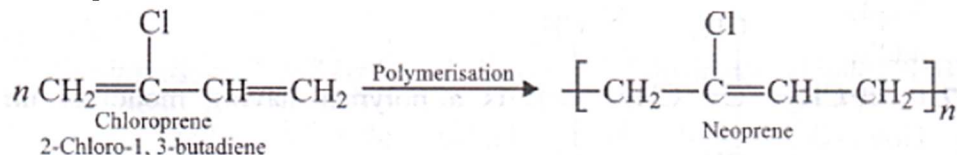
- (i) Dacron
- (ii) Buna-S
- (iii) Neoprene
- (iv) Novolac

**Ans. (ii) and (iii)**

**Explanation:**



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



10. Which of the following are characteristics of thermosetting polymers?

- (i) Heavily branched cross linked polymers.
- (ii) Linear slightly branched long chain molecules.
- (iii) Become infusible on moulding so cannot be reused.
- (iv) Soften on heating and harden on cooling, can be reused.

**Ans. (i) and (iii)**

**Explanation: 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.

11. Which of the following polymers are thermoplastic?

- (i) Teflon
- (ii) Natural rubber
- (iii) Neoprene
- (iv) Polystyrene

**Ans. (i) and (iv)**

**Explanation: Thermoplastic polymers:** These are the linear or slightly branched long chain molecules capable of repeatedly softening on heating and hardening on cooling. These polymers possess intermolecular forces of attraction intermediate between

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elastomers and fibres. Some common thermoplastics are polythene, polystyrene, polyvinyls, etc.

12. Which of the following polymers are used as fibre?

- (i) Polytetrafluoroethane
- (ii) Polychloroprene
- (iii) Nylon
- (iv) Terylene

Ans. (iii) and (iv)

**Explanation:** Fibres are the thread forming solids which possess high tensile strength and high modulus. These characteristics can be attributed to the strong intermolecular forces like hydrogen bonding. These strong forces also lead to close packing of chains and thus impart crystalline nature. The examples are polyamides (nylon 6,6), polyesters (terylene), etc.

13. Which of the following are addition polymers?

- (i) Nylon
- (ii) Melamine formaldehyde resin
- (iii) Orlon
- (iv) Polystyrene

Ans. (i) and (iv)

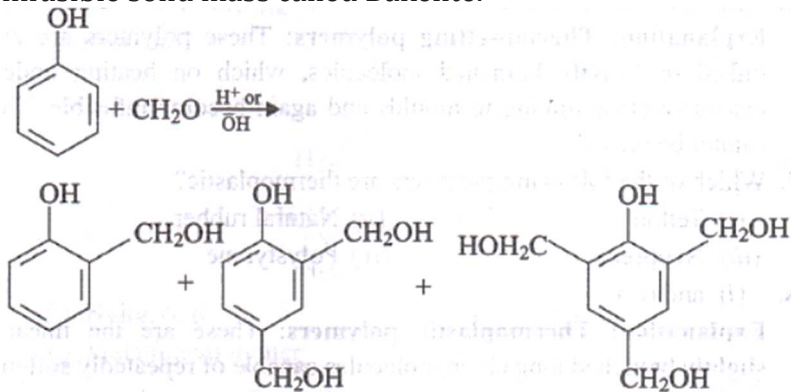
**Explanation:** The addition polymers are formed by the repeated addition of monomer molecules possessing double or triple bonds, e.g., the formation of polythene from ethene and polypropene from propene. However, the addition polymers formed by the polymerisation of a single monomeric species are known as homopolymers.

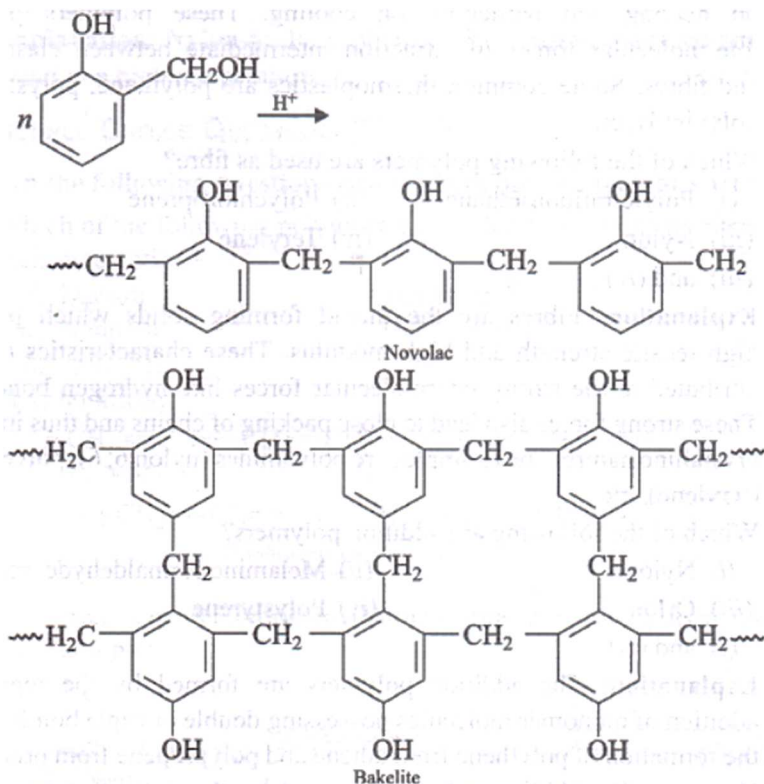
14. Which of the following polymers are condensation polymers?

- (i) Bakelite
- (ii) Teflon
- (iii) Butyl rubber
- (iv) Melamine formaldehyde resin

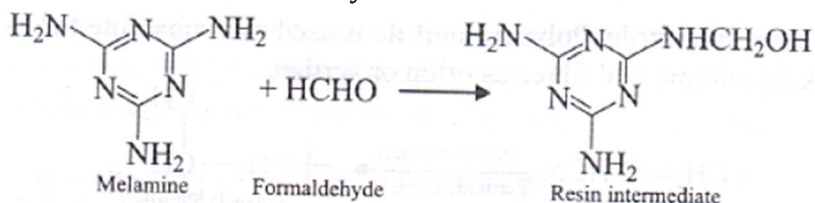
Ans. (i) and (iv)

**Explanation:** Novolac on heating with formaldehyde undergoes cross linking to form an infusible solid mass called Bakelite.





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



15. Which of the following monomers form biodegradable polymers?

- (i) 3-hydroxybutanoic acid + 3-hydroxypentanoic acid
- (ii) Glycine + amino caproic acid
- (iii) Ethylene glycol + phthalic acid
- (iv) Caprolactum

Ans. (i) and (ii)

**Explanation:** *Poly- $\beta$ -hydroxybutyrate co- $\beta$ -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.

*Nylon-2-nylon 6:* It is an alternating polyamide copolymer of glycine ( $\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$ ) and amino caproic acid [ $\text{H}_2\text{N}(\text{CH}_2)_5\text{COOH}$ ] and is biodegradable.

16. Which of the following are example of synthetic rubber?

- (i) Polychloroprene

- (ii) Polyacrylonitrile
- (iii) Buna-N
- (iv) *cis*-polyisoprene

**Ans. (i) and (iii)**

**Explanation:** Synthetic rubbers are either homopolymers of 1,3-butadiene derivatives or copolymers of 1,3-butadiene or its derivatives with another unsaturated monomer.

**17. Which of the following polymers can have strong intermolecular forces?**

- (i) Nylon
- (ii) Polystyrene
- (iii) Rubber
- (iv) Polyesters

**Ans. (i) and (iv)**

**Explanation:** *Polyamides:* These polymers possessing amide linkages are important examples of synthetic fibres and are termed as nylons.

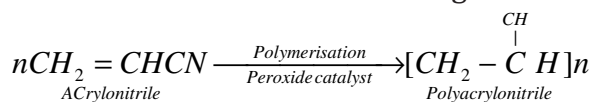
*Polyesters:* These are the polycondensation products of dicarboxylic acids and diols. Dacron or terylene is the best-known example of polyesters.

**18. Which of the following polymers have vinylic monomer units?**

- (i) Acrilan
- (ii) Polystyrene
- (iii) Nylon
- (iv) Teflon

**Ans. (i), (ii) and (iv)**

**Explanation:** *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.



Polystyrene has the monomer unit styrene. Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at high pressures.

**19. Vulcanisation makes rubber \_\_\_\_\_.**

- (i) more elastic
- (ii) soluble in inorganic solvent
- (iii) crystalline
- (iv) more stiff

**Ans. (i) and (iv)**

**Explanation:** To improve upon physical properties of natural rubber 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.

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**Polymers**  
**Matching Type**

**Note:** Match the items of Column I with the items in Column II.

**38. Match the polymer of column I with correct monomer of column II.**

Column I	Column II
(i) High density polythene	(a) Isoprene
(ii) Neoprene	(b) Tetrafluoroethene
(iii) Natural rubber	(c) Chloroprene
(iv) Teflon	(d) Acrylonitrile
(v) Acrilan	(e) Ethene

**Ans.** (i)- (e)  
(ii)- (c)  
(iii)- (a)  
(iv)- (b)  
(v)- (d)

**Explanation:**

Column I	Column II
(i) High density polythene	It is formed when addition poly-merisation of ethene takes place in a hydrocarbon solvent in the presence of a catalyst
(ii) Neoprene	Neoprene or polychloroprene is formed by the free radical polymerisation of chloroprene
(iii) Natural rubber	Natural rubber may be considered as a linear polymer of isoprene (2-methyl-1, 3-butadiene)
(iv) Teflon	Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at high pressures.
(v) Acrilan	The addition polymerisation of acrylonitrile in presence of a peroxide catalyst leads to the formation of polyacrylonitrile.

**39. Match the polymers given in Column I with their chemical names given in Column II.**

Column I	Column II
(i) Nylon 6	(a) Polyvinyl chloride
(ii) PVC	(b) Polyacrylonitrile
(iii) Acrilan	(c) Polycaprolactum
(iv) Natural rubber	(d) Low density polythene
(v) LDP	(e) <i>cis</i> -polyisoprene

**Ans.** (i)- (c)  
(ii)- (a)  
(iii)- (b)  
(iv)- (e)  
(v)- (d)

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**Explanation:**

Column I	Column II
(i) Nylon 6	It is obtained by heating caprolactum with water at a high temperature.
(ii) PVC	Polymer of vinyl chloride
(iii) Acrilan	The addition polymerisation of acrylonitrile in presence of a peroxide catalyst leads to the formation of polyacrylonitrile.
(iv) Natural rubber	Natural rubber may be considered as a linear polymer of isoprene (2-methyl-1, 3-butadiene) and is also called as <i>cis</i> -1, 4 polyisoprene.
(v) LDP	The low-density polythene (LDP) obtained through the free radical addition and H-atom abstraction has highly branched structure.

40. Match the polymers given in Column I with their commercial names given in Column II.

Column I	Column II
(i) Polyester of glycol and phthalic acid	(a) Novolac
(ii) Copolymer of 1, 3-butadiene and styrene	(b) Glyptal
(iii) Phenol and formaldehyde resin	(c) Buna- S
(iv) Polyester of glycol and terephthalic acid	(d) Buna- N
(v) Copolymer of 1,3-butadiene and acrylonitrile	(e) Dacron

- Ans. (i)- (b)  
(ii)- (c)  
(iii)- (a)  
(iv)- (e)  
(v)- (d)

41. Match the polymers given in Column I with their main applications given in Column II.

Column I	Column II
(i) Bakelite	(a) Unbreakable crockery
(ii) Low density polythene	(b) Non-stick cookwares
(iii) Melamine-formaldehyde resine	(c) Packaging material for shock absorbance
(iv) Nylon 6	(d) Electrical switches
(v) Polytetrafluoroethane	(e) Squeeze bottles
(vi) Polystyrene	(f) Tyre, cords

- Ans. (i)- (d)  
(ii)- (e)  
(iii)- (a)  
(iv)- (f)  
(v)- (b)  
(vi)- (c)

42. Match the polymers given in Column I with the preferred mode of polymerisation followed by their monomers.

Column I	Column II
(i) Nylon-6,6	(a) Free radical polymerisation
(ii) PVC	(b) Ziegler-Natta polymerisation or coordination polymerisation
(iii) HDP	(c) Anionic polymerisation
	(d) Condensation polymerisation

Ans. (i)- (d)  
(ii)- (a)  
(iii)- (b)

43. Match the polymers given in Column I with the type of linkage present in them given in Column II.

Column I	Column II
(i) Terylene	(a) Glycosidic linkage
(ii) Nylon	(b) Ester linkage
(iii) Cellulose	(c) Phosphodiester linkage
(iv) Protein	(d) Amide linkage
(v) RNA	

Ans. (i)- (b)  
(ii)- (d)  
(iii)- (a)  
(iv)- (d)  
(v)- (c)

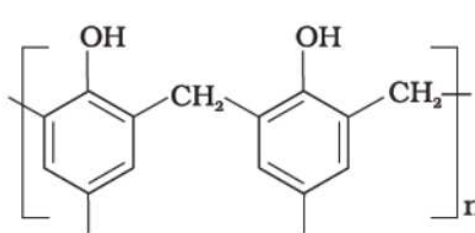
44. Match materials given in Column I with the polymers given in Column II.

Column I	Column II
(i) Natural rubber latex	(a) Nylon
(ii) Wood laminates	(b) Neoprene
(iii) Ropes and fibres	(c) Dacron
(iv) Polyester fabric	(d) Melamine formaldehyde resins.
(v) Synthetic rubber	(e) Urea-formaldehyde resins
(vi) Unbreakable crockery	(f) cis- polyisoprene

Ans. (i)- (f)  
(ii)- (e)  
(iii)- (a)  
(iv)- (c)  
(v)- (b)  
(vi)- (d)

45. Match the polymers given in Column I with their repeating units given in Column II.

Column I	Column II
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(i) Acrilan	(a) $\left(\text{CH}_2-\underset{\text{C}_6\text{H}_5}{\text{CH}}\right)_n$
(ii) Polystyrene	(b) $\left(\text{CH}_2-\underset{\text{Cl}}{\text{C}}=\text{CH}-\text{CH}_2\right)_n$
(iii) Neoprene	(c) $\left(\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}_2-\underset{\text{CN}}{\text{CH}}\right)_n$
(iv) Novolac	(d) $\left(\text{CH}_2-\underset{\text{CN}}{\text{CH}}\right)_n$
(v) Buna-N	(e) 
	(f) $\left(\text{CH}_2-\underset{\text{Cl}}{\text{CH}}\right)_n$

Ans. (i)- (d)  
(ii)- (a)  
(iii)- (b)  
(iv)- (e)  
(v)- (c)

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**Polymers**  
**Assertion and Reason Type**

**Note:** In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(i) Assertion and reason both are correct statement but reason does not explain assertion.

(ii) Assertion and reason both are correct statements and reason explains the assertion.

(iii) Both assertion and reason are wrong statement.

(iv) Assertion is correct statement and reason is wrong statement.

(v) Assertion is wrong statement and reason is correct statement.

**46. Assertion:** Rayon is a semi synthetic polymer and is taken as a better choice than cotton fabric.

**Reason:** Mechanical and aesthetic properties of cellulose can be improved by acetylation.

**Ans.** (ii)

**47. Assertion:** Most of the Synthetic polymers are not biodegradable.

**Reason:** Polymerisation process induces toxic character in organic molecules.

**Ans.** (iv)

**Explanation:** 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.

**48. Assertion:** Olefinic monomers undergo addition polymerisation.

**Reason:** Polymerisation of vinylchloride is initiated by peroxides/ persulphates.

**Ans.** (i)

**Explanation:** 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.

**49. Assertion:** Polyamides are best used as fibres because of high tensile strength.

**Reason:** Strong intermolecular forces (like hydrogen bonding within polyamides) lead to close packing of chains and increase the crystalline character, hence, provide high tensile strength to polymers.

**Ans.** (ii)

**50. Assertion:** For making rubber synthetically, isoprene molecules are polymerised.

**Reason:** Neoprene (a polymer of chloroprene) is a synthetic rubber.

**Ans.** (v)

**Explanation:** 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.

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**51. Assertion:** Network polymers are thermosetting.  
**Reason:** Network polymers have high molecular mass.

**Ans.** (i)

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

**52. Assertion:** Polytetrafluoroethene is used in making non-stick cookwares.

**Reason:** Fluorine has highest electronegativity.

**Ans.** (i)

**Explanation:** 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.

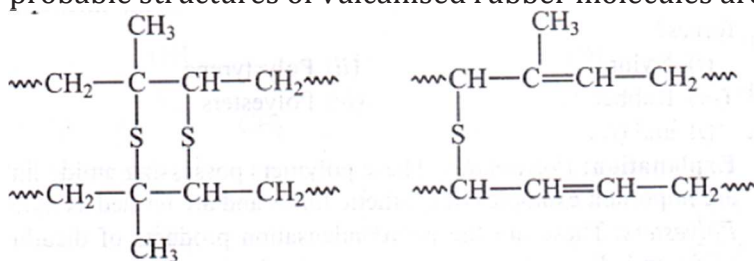
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**Polymers**  
**Short Answer Type**

20. A natural linear polymer of 2-methyl-1,3-butadiene becomes hard on treatment with sulphur between 373 to 415 K and —S—S— bonds are formed between chains. Write the structure of the product of this treatment?

Ans. In the manufacture of tyre rubber, 5% of sulphur is used as crosslinking agent. The probable structures of vulcanised rubber molecules are depicted below:



21. Identify the type of polymer.



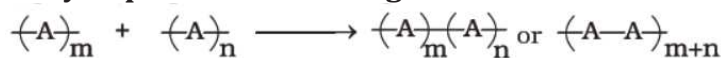
Ans. The addition polymers formed by the polymerisation of a single monomeric species are known as homopolymers,

22. Identify the type of polymer.



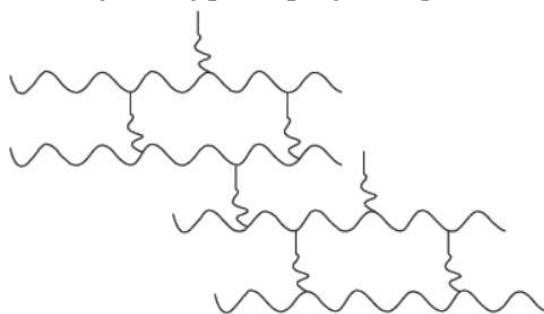
Ans. The polymers made by addition polymerisation from two different monomers are termed as copolymers, e.g., Buna-S, Buna-N, etc.

23. Out of chain growth polymerisation and step growth polymerisation, in which type will you place the following.



Ans. This is a type of chain growth polymerisation.

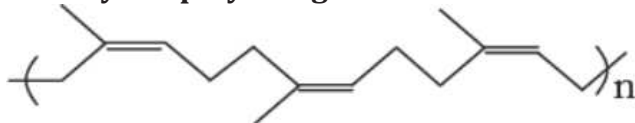
24. Identify the type of polymer given in the following figure.



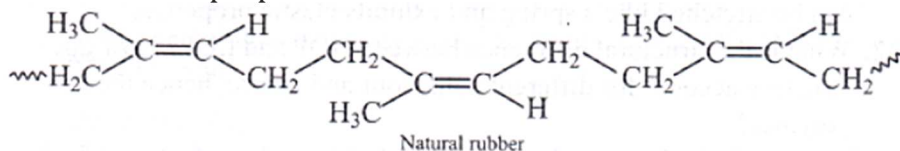
Ans. *Cross linked or Network polymers:* These are usually formed from bi-functional and tri-functional monomers and contain strong covalent bonds between various linear polymer chains, e.g. Bakelite, melamine, etc.

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25. Identify the polymer given below:



**Ans.** 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.



26. Why are rubbers called elastomers?

**Ans.** Rubber is a natural polymer and possesses elastic properties. It is also termed as elastomer and has a variety of uses. It is manufactured from rubber latex which is colloidal dispersion of rubber in water.

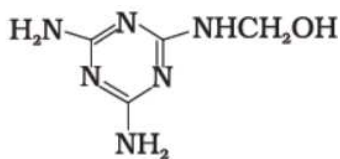
27. Can enzyme be called a polymer?

**Ans.** Enzymes are biocatalysts. They are basically proteins thus they are also considered as polymer.

28. Can nucleic acids, proteins and starch be considered as step growth polymers?

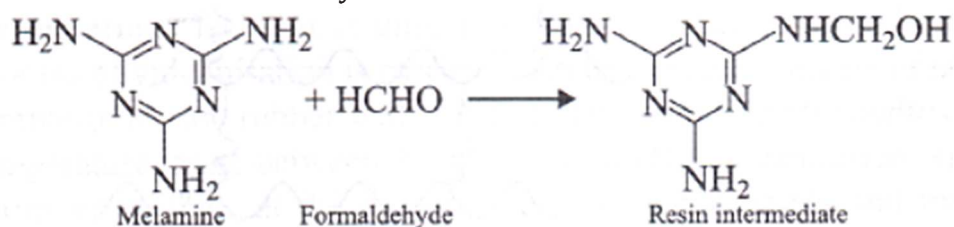
**Ans.** Yes, this type of polymerisation generally involves a repetitive condensation reaction between two bi-functional monomers. These polycondensation reactions may result in the loss of some simple molecules as water, alcohol, etc., and lead to the formation of high molecular mass condensation polymers.

29. How is the following resin intermediate prepared and which polymer is formed by this monomer unit?



(Resin intermediate)

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



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**30. To have practical applications why are cross links required in rubber?**

**Ans.** To improve upon physical properties of natural rubber, a process of vulcanisation is carried out. This process consists of heating a mixture of raw rubber with sulphur and an appropriate additive at temperature range between 373 K to 415 K. On vulcanization, sulphur forms cross links at the reactive sites of double bonds and thus the rubber gets stiffened.

**31. Why does *cis*-polyisoprene possess elastic property?**

**Ans.** 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.

**32. What is the structural difference between HDP and LDP? How does the structure account for different behaviour and nature, hence the use of a polymer?**

**Ans. Low density polythene:** It is obtained by the polymerisation of ethane under high pressure of 1000 to 2000 atmospheres at a temperature of 350 K to 570 K in the presence of traces of dioxygen or a peroxide initiator (catalyst). The low-density polythene (LDP) obtained through the free radical addition and H-atom abstraction has highly branched structure.

**High density polythene:** It is formed when addition polymerisation of ethane takes place in a hydrocarbon solvent in the presence of a catalyst such as triethylaluminium and titanium tetrachloride (Ziegler-Natta catalyst) at a temperature of 333 K to 343 K and under a pressure of 6-7 atmospheres. High density polythene (HDP) thus produced, consists of linear molecules and has a high density due to close packing. It is also chemically inert and more tougher and harder. It is used for manufacturing buckets, dustbins, bottles, pipes.

**33. What is the role of benzoyl peroxide in addition polymerisation of alkenes? Explain its mode of action with the help of an example.**

**Ans.** Role of benzoyl peroxide is to generate free radicals. A variety of alkenes or dienes and their derivatives are polymerised in the presence of a free radical generating initiator (catalyst) like benzoyl peroxide, acetyl peroxide, tert-butyl peroxide, etc. For example, the polymerisation of ethene to polythene consists of heating or exposing to light a mixture of ethane with a small amount of benzoyl peroxide initiator. The process starts with the addition of phenyl free radical formed by the peroxide to the ethane double bond thus generating a new and larger free radical. This step is called chain initiating step.

**34. Which factor imparts crystalline nature to a polymer like nylon?**

**Ans.** Polymers possessing amide linkages are important examples of synthetic fibres and are termed as nylons strong intermolecular forces like hydrogen bonding, lead to close packing of chains that imparts crystalline character.

**35. Name the polymers used in laminated sheets and give the name of monomeric units involved in its formation.**

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**Ans.** Urea formaldehyde resins. Monomer units are:  
Urea +formaldehyde

**36. Which type of biomolecules have some structural similarity with synthetic polyamides? What is this similarity?**

**Ans.** Proteins are also like polyamides. Proteins and polyamide both contains amide linkages.

**37. Why should the monomers used in addition polymerisation through free radical pathway be very pure?**

**Ans.** Pure monomers are required because even the traces of impurities may act like inhibitors which leads to the formation of polymers with shorter chain length.

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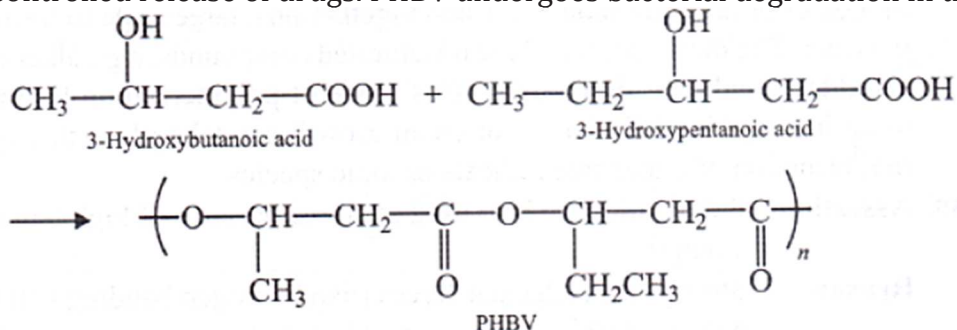
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**Polymers**  
**Long Answer Type**

53. **Synthetic polymers do not degrade in the environment for a long time. How can biodegradable synthetic polymers be made. Differentiate between biopolymers and biodegradable polymers and give examples of each type.**

Ans. 1. Poly- $\beta$ -hydroxybutyrate-co- $\beta$ -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.



2. Nylon 2-nylon 6: It is an alternating polyamide copolymer of glycine ( $\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$ ) and amino caproic acid [ $\text{H}_2\text{N}(\text{CH}_2)_5\text{COOH}$ ] and is biodegradable.

Biopolymers are the natural polymers found in plants and animals like protein, fat, cellulose etc. Biodegradable polymers are polymers that contain functional groups similar to the functional groups present in biopolymers. They are not resistant to the environmental degradation processes.

54. **Differentiate between rubbers and plastics on the basis of intermolecular forces.**

Ans. **Rubbers:** In rubber, the polymer chains are held together by the weakest intermolecular forces. These weak binding forces permit the polymer to be stretched. A few 'crosslinks' are introduced in between the chains, which help the polymer to retract to its original position after the force is released as in vulcanised rubber.

**Plastics:** These are the linear or slightly branched long chain molecules capable of repeatedly softening on heating and hardening on cooling. These polymers possess intermolecular forces of attraction intermediate between elastomers and fibres.

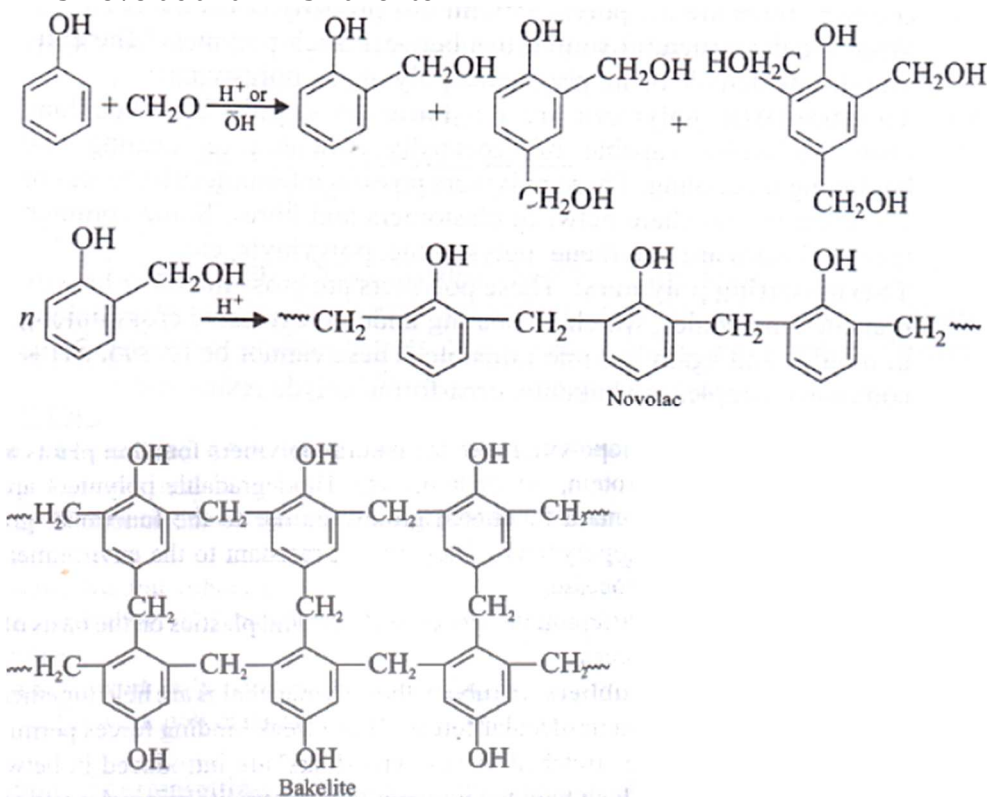
55. **Phenol and formaldehyde undergo condensation to give a polymer (A) which on heating with formaldehyde gives a thermosetting polymer (B). Name the polymers. Write the reactions involved in the formation of (A). What is the structural difference between two polymers?**

Ans. 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  $-\text{CH}_2$  groups. The initial product could be a linear product – Novolac.

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

'A' is Novolac and 'B' is Bakelite.



56. Low density polythene and high density polythene, both are polymers of ethene but there is marked difference in their properties. Explain.

Ans.

LDP	HDP
1. It is obtained the polymerisation of ethene under high pressure of 1000 to 2000 atmospheres at a temperature of 350 K to 570 K in the presence of traces of dioxygen or a peroxide initiator (catalyst).	1. It is formed when addition polymerisation of ethene takes place in a hydrocarbon solvent in the presence of a catalyst such as triethylaluminium and titanium tetrachloride (Ziegler Natta catalyst) at a temperature of 333 K to 343 K and under a pressure of 6-7 atmospheres.
2. (LDP) obtained through the free radical addition and H-atom abstraction has highly branched structure.	2. (HDP) consists of linear molecules and has a high density due to close packing.
3. Low density polythene is chemically inert and tough but flexible and a poor conductor of electricity.	3. It is also chemically inert and more tough and hard.

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57. Which of the following polymers soften on heating and harden on cooling? What are the polymers with this property collectively called? What are the structural similarities between such polymers? Bakelite, urea-formaldehyde resin, polythene, polyvinyls, polystyrene.

**Ans.** **Thermoplastic polymers** are the linear or slightly branched long chain molecules capable of repeatedly softening on heating and hardening on cooling. These polymers possess intermolecular forces of attraction intermediate between elastomers and fibres. Some common thermoplastics are polythene, polystyrene, polyvinyls, etc.

**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. Some common examples are Bakelite, urea-formaldehyde resins. etc.

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