

*aglasem.com*

# CLASS XII CHEMISTRY NOTES

POLYMERS

KEY NOTES AND IMPORTANT  
QUESTIONS WITH ANSWERS





## UNIT 15

## POLYMERS

1. **Polymer** : It is a very large molecule having molecular mass  $10^3$ - $10^7$  g mol<sup>-1</sup>. They are formed by joining together repeating structural units, called monomers.

2. **Classification of Polymers :**

(a) **Based on Source :**

- (i) **Natural** : Found in plants and animals, e.g., Proteins, cellulose, natural rubber, silk, wool.
- (ii) **Synthetic** : Man-made, e.g., Nylon, polyester, neoprene, bakelite, teflon, PVC, polystyrene.
- (iii) **Semisynthetic** : Natural but modified by man e.g. cellulose nitrate.

(b) **Based on Structure :**

- (i) **Linear polymers** : This consist of long and straight chain repeating units, e.g., Polythene (HDPE), PVC, nylon, polyester.
- (ii) **Branched polymers** : This contain linear chains having some branches, e.g., amylopectin, glycogen etc.
- (iii) **Cross-linked polymers** : Strong covalent bonds are present between various linear polymer chains, e.g., Bakelite, urea-formaldehyde polymer, melamine, formaldehyde polymer etc.

(c) **Based on mode of polymerization :**

- (i) **Addition polymers** : These are formed by the repeated addition of monomer molecules possessing multiple bonds, e.g., polythene, polypropene, polystyrene, PMMA (polymethyl methacrylate).
- (ii) **Condensation polymers** : These are formed by the repeated condensation reaction of different bifunctional or trifunctional monomers with the elimination of small molecules like water, HCl, NH<sub>3</sub>, alcohol, etc., e.g., Bakelite, nylon, polyester, urea-formaldehyde resin.

(d) **Based on molecular forces :**

- (i) **Elastomers** : Forces of interaction between polymer chains is weakest, e.g., natural rubber, neoprene, vulcanized rubber.



- (ii) **Fibers** : Strong hydrogen bonds are present between the polymer chains. They have high tensile strength, e.g., Nylon, polyester, silk, wool, orlon, rayon etc.
- (iii) **Thermoplastics** : They are linear/slightly branched chains molecules capable of repeated softening on heating and hardening on cooling, e.g., Polythene, PVC, polystyrene, polypropene.
- (iv) **Thermosetting plastics** : They are cross-linked or heavily branched molecules, which on heating undergo extensive cross-linkages and become infusible, e.g., Bakelite, urea-formaldehyde resin.
- (e) **Based on growth of polymerization** : Depending upon the mechanism of polymerization, polymers are classified as :
- (i) **Addition polymers or Chain growth polymers** : They follow mostly free radical mechanism.
- (ii) **Condensation polymers or Step growth polymers** : Because they are formed in gradual steps.

### Polymers and Their Monomers

| S. No. | Name of Polymer                          | Structure                                                                                                                                                         | Monomer                                                                                                                                                                      | Uses                                                                           |
|--------|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1.     | Polythene                                | $(-\text{CH}_2-\text{CH}_2-)_n$                                                                                                                                   | $\text{CH}_2=\text{CH}_2$                                                                                                                                                    | As insulator, anticorrosive, packing material, household and laboratory wares. |
| 2.     | Polystyrene                              | $\left( \begin{array}{c} \text{CH} - \text{CH}_2 \\   \\ \text{C}_6\text{H}_5 \end{array} \right)_n$<br>Poly Styrene                                              | $\begin{array}{c} \text{CH} = \text{CH}_2 \\   \\ \text{C}_6\text{H}_5 \end{array}$ Styrene                                                                                  | As insulator, wrapping material, manufacture of toys and household articles.   |
| 3.     | Polyvinylchloride (PVC)                  | $\begin{array}{c} \text{Cl} \\   \\ (-\text{CH}_2-\text{CH}-)_n \end{array}$                                                                                      | $\text{CH}_2 = \text{CHCl}$<br>Vinyl chloride                                                                                                                                | In manufacture of rain-coats, hand bags, vinyl flooring and leather clothes.   |
| 4.     | Polytetrafluoroethylene (PTFE) or Teflon | $(-\text{CF}_2-\text{CF}_2-)_n$                                                                                                                                   | $\text{CF}_2 = \text{CF}_2$<br>TFE                                                                                                                                           | As lubricant, insulator and making cooking wares.                              |
| 5.     | NOVOLAC                                  | $\left( \begin{array}{c} \text{OH} \quad \text{OH} \\   \quad   \\ \text{C}_6\text{H}_4 - \text{CH}_2 - \text{C}_6\text{H}_4 - \text{CH}_2 \end{array} \right)_n$ | (a) $\text{HCHO}$<br>(b) $\text{C}_6\text{H}_5\text{OH}$                                                                                                                     | In making bonding give varnishes, lacquers etc.                                |
| 6.     | Polyacrylonitrile (Orion) (Acrilan)      | $\begin{array}{c} \text{CN} \\   \\ (-\text{CH}_2-\text{CH}-)_n \end{array}$                                                                                      | $\text{CH}_2 = \text{CHCN}$<br>Acrylonitrile                                                                                                                                 | In making synthetic fibres and synthetic wool.                                 |
| 7.     | Styrene butadiene rubber (SBR or Buna-S) | $(-\text{CH}_2-\text{CH}(\text{C}_6\text{H}_5)-\text{CH}=\text{CH}-)_n$                                                                                           | (a) $\text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2$<br>$\begin{array}{c} \text{CH} = \text{CH}_2 \\   \\ \text{C}_6\text{H}_5 \end{array}$<br>(b) $\text{C}_6\text{H}_5$ | In making automobile tyres and footwear.                                       |



|     |                                                      |                                                                                                                                                                                      |                                                                                                                                      |                                                                     |
|-----|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 8.  | Nitrile rubber<br>(Buna-N)                           | $(-\text{CH}_2-\text{CH}(\text{CN})-\text{CH}_2-\text{CH}_2-)_n$                                                                                                                     | (a) $\text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2$<br>(b) $\text{CH} = \text{CH}_2$<br>$\text{CN}$                              | In making oil seals, manufacture of hoses and tank linings.         |
| 9.  | Neoprene                                             | $(-\text{CH}_2-\text{C}(\text{Cl})=\text{CH}-\text{CH}_2-)_n$                                                                                                                        | $\text{CH}_2 = \text{C}(\text{Cl}) - \text{CH} = \text{CH}_2$<br>Chloroprene                                                         | As insulator, making conveyor belts and printing rollers.           |
| 10. | Natural rubber<br>(NR)                               | $\left( \begin{array}{c} \text{CH}_2 \\ \text{CH}_3 \end{array} \text{C} = \text{C} \begin{array}{c} \text{CH}_2 \\ \text{H} \end{array} \right)_n$ is form                          | $\text{CH}_2 = \text{C}(\text{CH}_3) - \text{CH} = \text{CH}_2$<br>Isoprene                                                          | In making erasers, tyres, tubes, vulcanised rubber etc.             |
| 11. | Terylene (Dacron)                                    | $(-\text{O}-\text{CH}_2-\text{CH}_2-\text{O}-\text{C}(=\text{O})-\text{C}_6\text{H}_4-\text{C}(=\text{O})-)_n$                                                                       | (a) $\text{HOOC}-\text{C}_6\text{H}_4-\text{COOH}$<br>(b) $\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$                              | For making fibres, safety belts, tyre cords, tents etc.             |
| 12. | Polypropene = P<br>Propene                           | $(-\text{CH}_2-\text{CH}(\text{CH}_3)-)_n$                                                                                                                                           | Propen<br>$\text{CH}_3 - \text{CH} = \text{CH}_2$                                                                                    | Ropes, toys, pipes, fibre etc. strings.                             |
| 13. | Glyptal                                              | $(-\text{OCH}_2-\text{CH}_2\text{OOC}-\text{C}_6\text{H}_4-\text{COO}-)_n$                                                                                                           | $\text{HOOC}-\text{C}_6\text{H}_4-\text{COOH}$<br>$\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$                                      | As binding material in preparation of mixed plastics and plants.    |
| 14. | Nylon 6                                              | $(\text{NH}-[\text{CH}_2]_5-\text{C}(=\text{O})-)_n$                                                                                                                                 | <br>Caprolactum                                    | In making fibres, plastics, tyre cords and ropes.                   |
| 15. | Nylon 66                                             | $(\text{NH}-(\text{CH}_2)_4-\text{NH}-\text{C}(=\text{O})-(\text{CH}_2)_4-\text{C}(=\text{O})-)_n$                                                                                   | (a) $\text{HOOC}-(\text{CH}_2)_4-\text{COOH}$<br>(b) $\text{H}_2\text{N}-(\text{CH}_2)_6-\text{NH}_2$                                | In making brushes, synthetic fibres, parachutes, ropes and carpets. |
| 16. | Bakelite                                             | $\left( \begin{array}{c} \text{OH} \\ \text{CH}_2 \end{array} \text{C}_6\text{H}_4 \begin{array}{c} \text{OH} \\ \text{CH}_2 \end{array} \right)_n$                                  | (a) $\text{HCHO}$<br>(b) $\text{C}_6\text{H}_5\text{OH}$                                                                             | For making gears, protective coating and electrical fittings.       |
| 17. | Urea formaldehyde resin                              | $(-\text{NH}-\text{CO}-\text{NH}-\text{CH}_2-)_n$                                                                                                                                    | (a) $\text{HCHO}$<br>(b) $\text{NH}_2\text{CONH}_2$                                                                                  | For making unbreakable cups and laminated sheets.                   |
| 18. | Melamine formaldehyde resin                          | $\left( \begin{array}{c} \text{NH} \\ \text{N} \\ \text{NH} \end{array} \text{C}_6\text{H}_3 \begin{array}{c} \text{NH} \\ \text{N} \\ \text{NH} \end{array} \text{CH}_2- \right)_n$ | (a) <br>(b) $\text{HCHO}$                        | In making plastic crockery, unbreakable cups and plates.            |
| 19. | Poly-β-hydroxy butyrate-co-β-hydroxy valerate [PHBV] | $(-\text{O}-\text{CH}(\text{R})-\text{CH}_2-\text{C}(=\text{O})-)_n$<br>$\text{R} = \text{CH}_3\text{C}_2\text{H}_5$                                                                 | $\text{CH}_3-\text{CH}(\text{OH})-\text{CH}_2-\text{COOH}$<br>$\text{CH}_3-\text{CH}_2-\text{CH}(\text{OH})-\text{CH}_2-\text{COOH}$ | As packaging, orthopaedic devices and in controlled drug release.   |



### VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

**Q. 1. Define the term ‘homopolymerisation’ giving an example.**

**Ans.** The polymer formed by the polymerization of single/same monomeric species is known as homopolymerisation. E.g., Polythene/PVC/Polypropene.

**Q. 2. Give an example of elastomer.**

**Ans.** Natural rubber or Buna-S or Buna-N or Neoprene.

**Q. 3. Why is bakelite a thermosetting polymer ?**

**Ans.** Because bakelite have three dimensional network of covalent bonds with cross-linking between chains.

**Q. 4. Write the monomers of Buna-N.**

**Ans.**  $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2 + \text{H}_2\text{C}=\underset{\text{CN}}{\text{CH}}$   
1,3 Butadiene Acrylonitrile

**Q. 5. Is  $\text{[H}_2\text{C CH(C}_6\text{H}_5\text{)]}_n$  a homopolymer or copolymer ? Why ?**

**Ans.** Homopolymer, because it is formed by polymerization of one kind of monomer species.

**Q. 6. Write the structure and one use of urea formaldehyde resin.**

**Ans.**  $\{ \text{HNCONHCH}_2 \}_n$

It is used in unbreakable crockery.

Q. 7. Is  $\text{—}\text{H}_2\text{C—CH—}\text{—}$  a homopolymer or a copolymer ?  


**Ans.** Homopolymer.

**Q. 8. Which of the following is natural polymer ?**

## Buna-S, Proteins, PVC

**Ans.** Proteins.

**Q. 9. Based on molecular forces what type of polymer is neoprene ?**

**Ans.** Elastomer.

**Q. 10.** Which of the following is a fibre ?

### Nylon, Neoprene, PVC



**Ans.** Nylon

**Q. 11. Name a natural elastomer.**

**Ans.** Natural rubber.

**Q. 12. Write name of a synthetic polymer which is an ester.**

**Ans.** Terylene.

**Q. 13. Name of monomer of Nylon 6.**

**Ans.** Caprolactum

**Q. 14. Write the monomer units of bakelite.**

**Ans.** Phenol and formaldehyde.

**Q. 15. Define a copolymer.**

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

**Q. 16. Write one use of PVC.**

**Ans.** In manufacture of raincoats and vinyl flooring.

**Q. 17. Define polymer.**

**Ans.** Polymer is defined as very large molecules having molecular mass ( $10^3$ - $10^7$  u). These are also referred to as macromolecules.

**Q. 18. Give an example of thermoplastics.**

**Ans.** Thermoplastics are polythene, polystyrene, polyvinyls etc.

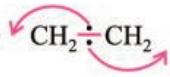
**Q. 19. To which class of polymers does Nylon-66 belong ?**

**Ans.** Polyamides.

**Q. 20. Name the type of monomers in terylene.**

**Ans.** Ethylene glycol and terephthalic acid.

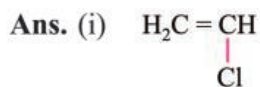
**Q. 21. How do you explain the functionality of a monomer ?**

**Ans.** Functionality means the number of bonding sites in a molecule. E.g., 

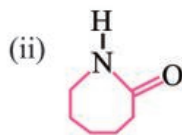
**Q. 22. Give chemical name of teflon.**

**Ans.** Polytetrafluoroethene.

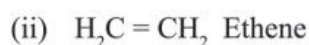


**SHORT ANSWER-I TYPE QUESTIONS (2 Marks)****Q. 1. Draw the structure of monomers of each of the polymers :****(i) PVC****(ii) Nylon-6**

Vinyl chloride



Caprolactum

**Q. 2. What is the repeating unit in the condensation polymer obtained by combining  $\text{HOOCCH}_2\text{CH}_2\text{COOH}$  (succinic acid) and  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$  (ethylene diamine) ?****Q. 3. Draw the structure of monomers of the following polymers :****(i) Teflon****(ii) Polythene****Q. 4. Name the two groups into which polymers are classified on the basis of magnitude of intermolecular forces.**

Ans. (i) Elastomers

(ii) Fibres

(iii) Thermoplastic polymers

(iv) Thermosetting polymers

**Q. 5. Mention two important uses of each of the following :****(i) Bakelite****(ii) Nylon-6**

Ans. (i) **Bakelite** : For making combs, electrical switches, handles of utensils, computer disc etc.

(ii) **Nylon-6** : For making tyre cords, fabrics, ropes etc.



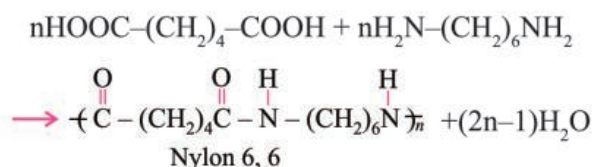
**Q. 6. Distinguish between homopolymers and copolymers with an example of each.**

**Ans. Homopolymers :** Polymers whose repeating structural units are derived from only one type of monomer units are called homopolymers. For example, Polythene.

**Copolymers :** Polymers whose repeating structural units are derived from two or more types of monomer units are called copolymers. For example, Nylon-6, 6.

**Q. 7. What is step growth polymerisation ? Explain with an example.**

**Ans.** Step growth polymerisation involves condensation between monomers having multifunctional groups. It is also known as condensation polymerisation. E.g.,



**Q. 8. What is the difference between elastomers and fibres ? Give one example of each.**

**Ans. Elastomers :** Polymers in which the intermolecular forces of attraction between the polymer chains are weakest are called elastomers. E.g., Natural rubber.

**Fibres :** Polymers in which intermolecular forces of attraction are the strongest are called fibres. E.g., Nylon-6, 6.

**Q. 9. Mention the important uses of each :**

- (i) Nylon-6, 6                      (ii) PVC

**Ans. (i) Uses of Nylon-6, 6 :**

- (a) It is used in making carpets, textile fibres etc.  
(b) It is used for making elastic hosiery.

**(ii) Uses of PVC :**

- (a) It is used for making raincoats, hand bags etc.  
(b) It is used in making water pipes.

**Q. 10. Arrange the following polymers in the order of increasing intermolecular forces :**

- (i) Nylon-6, Buna-S, Polythene  
(ii) Nylon-6, Neoprene, Polyvinyl chloride



**Ans. (i)** Buna-S < Polythene < Nylon-6

**(ii)** Neoprene < Polyvinyl chloride < Nylon-6

**Q. 11. Define thermoplastic and thermosetting polymers. Give one example of each.**

**Ans. Thermoplastics :** Polymers in which the intermolecular forces of attraction are in between those of elastomers and fibres are called thermoplastics. E.g., Nylon-6, PVC, etc.

**Thermosetting polymers :** These are semi-fluid substances with low molecular masses which when heated in a mould undergo a permanent change in chemical composition to give hard, infusible and insoluble mass. E.g., Bakelite.

**Q. 12. What is biodegradable polymer ? Give an example of a biodegradable polymer.**

**Ans.** Biodegradable polymers are those which are decomposed by micro organisms. E.g., PHBV (Poly-B-hydroxybutyrate – Co – B – hydroxyl valerate).

**Q. 13. How does vulcanization change the character of natural rubber ?**

**Ans.** It introduces sulphur bridge or cross-link between polymer chain.

**Q. 14. Name a polymer each for the following applications :**

**(i)** Insulation of electrical switches

**(ii)** Making laminated sheets

**Ans. (i)** Bakelite **(ii)** Urea formaldehyde resin

**Q. 15. How does the presence of double bonds in rubber influence their structure and reactivity ?**

**Ans.** Natural rubber is a cis-polyisoprene. These cis- double bonds do not allow to polymer unit to come close for effective interaction. Hence rubber shows elasticity.

### SHORT ANSWER-II TYPE QUESTIONS (3 Marks)

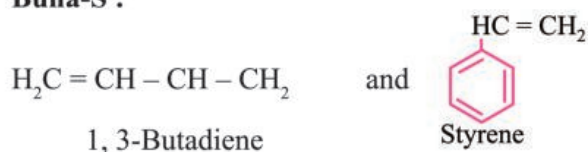
**Q. 1. Write the names and structure of the monomers of the following polymers :**

**(i) Buna-S**

**(ii) Neoprene**

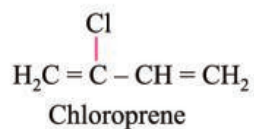
**(iii) Nylon-6**

**Ans. (i) Buna-S :**

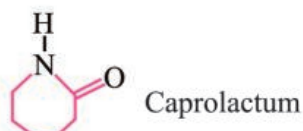




(ii) Neoprene :



(iii) Nylon-6 :



Q. 2. Write names and structure of monomers of following polymers :

(i) Bakelite

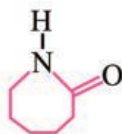
(ii) Nylon-6

(iii) Polythene

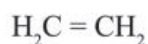
Ans. (i) Phenol and formaldehyde



(ii) Caprolactum



(iii) Ethene



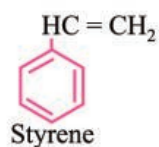
Q. 3. Write names and structure of monomers of following polymers :

(i) Polystyrene

(ii) Dacron

(iii) Teflon

Ans. (i) Styrene

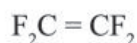


(ii) Ethylene glycol + Terephthalic acid





(iii) Tetrafluoroethene



**Q. 4. (i)** What is the role of t-butyl peroxide in the polymerisation of ethane ?

**(ii)** Identify the monomers in the following polymer :



**(iii)** Arrange the following polymers in the increasing order of their intermolecular forces :

**Polystyrene, Terylene, Buna-S**

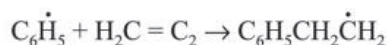
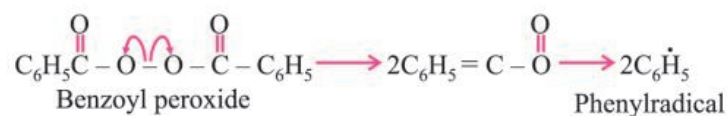
**Ans. (i)** Catalyst/initiator of free radical

**(ii)** Hexamethylenediamine and adipic acid

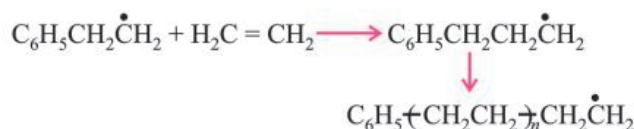
**(iii)** Buna-S < Polystyrene < Terylene

**Q. 5. Write the mechanism of free radical polymerisation of ethane.**

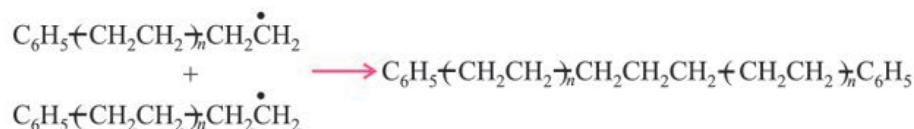
**Ans. (i)** Chain initiation step



**(ii)** Chain propagating step



**(iii)** Chain terminating step



**Q. 6. Write chemical equation for the synthesis of :**

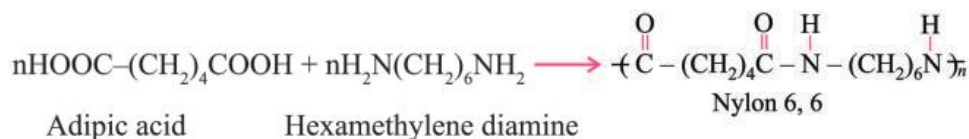
**(i)** Nylon-6, 6

**(ii)** Neoprene

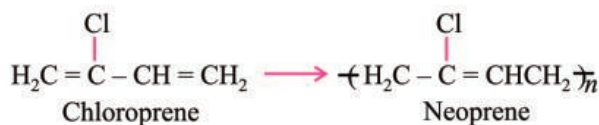
**(iii)** Terylene



Ans. (i) **Nylon-6, 6 :**

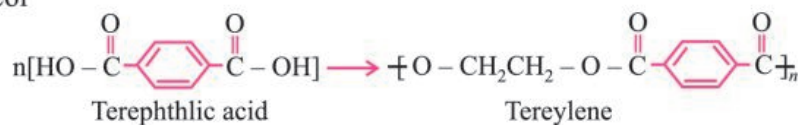


(ii) **Neoprene :**



(iii) **Terylene :**

$n\text{HO}-\text{CH}_2\text{CH}_2\text{OH} +$   
Ethylene glycol



**Q. 7. Write the monomers which are used for the synthesis of following polymers :**

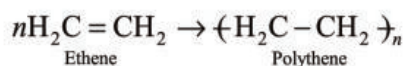
(i) **Terylene**    (ii) **Polythene**    (iii) **Bakelite**

**Indicate the type of polymerisation for each which forms polymers.**

| Ans.  | Monomers                            | Type of polymerisation |
|-------|-------------------------------------|------------------------|
| (i)   | Ethylene glycol + Terephthalic acid | Condensation           |
| (ii)  | Ethene                              | Addition               |
| (iii) | Phenol + Formaldehyde               | Condensation           |

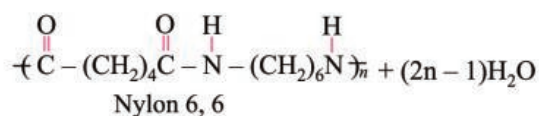
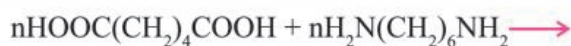
**Q. 8. How are polymers classified on the basis of mode of polymerisation ? Explain with examples.**

**Ans. Addition polymers :** Are formed by repeated addition of a large number of same or different monomers possessing double or triple bonds. E.g., Polythene.



**Condensation polymers :** Are formed by repeated condensation reaction between two bifunctional or trifunctional monomer units usually with the elimination of small molecules like water, alcohol, ammonia, etc. E.g., Nylon-6, 6.





**Q. 9.** A monomer of a polymer on ozonolysis gives two moles of  $\text{CH}_2\text{O}$  and one mol of  $\text{CH}_3\text{C}(=\text{O})\text{CHO}$ . Write the structure of monomer and polymer and each step of reaction.

**Ans.** Structure of monomer :



Structure of polymer :



**Q. 10.** Can a copolymer be formed in both addition and condensation polymerisation ? Explain with examples.

**Ans.** Yes. Buna-S, Buna-N : Addition polymer

Nylon-6, 6, terylene : Condensation

### LONG ANSWER TYPE QUESTIONS (5 Marks)

**Q. 1.** How are following polymers obtained ? Write the names and structures of monomers and structure of respective polymers :

(i) Dacron

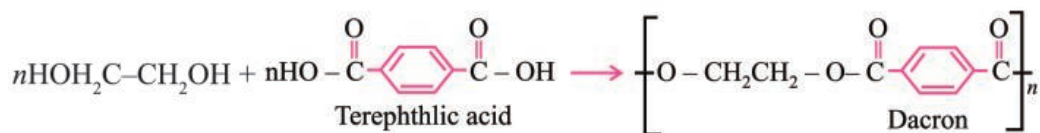
(ii) Nylon-6

(iii) Buna-N

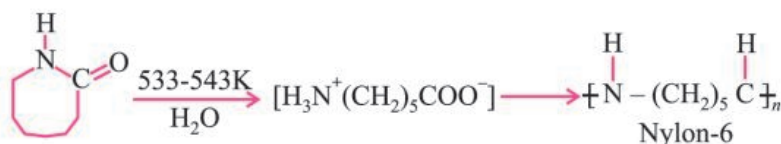
(iv) Glyptal

(v) PHBV

**Ans. (i) Dacron :** By condensation polymerisation.

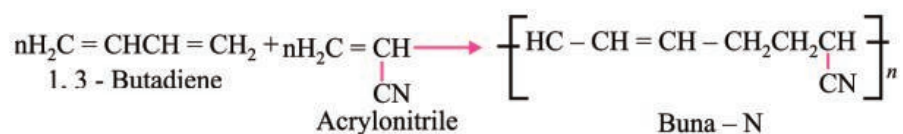


**(ii) Nylon-6 :** By condensation polymerisation.

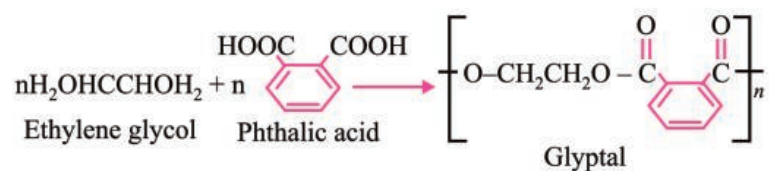




(iii) **Buna-N** : By addition polymerisation.



(iv) **Glyptal** : By condensation polymerisation.



(v) **PHBV** : By condensation polymerisation.

