POLYMERS

GIST

1. Polymer:

It is a very large molecule having molecular mass 10^3 - 10^7 g mol^{-1}. They are formed by joining together repeating structural units.

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, polyster, neoprene, Bakelite, Teflon, PVC, polystyrene.

(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 (polymethylmethacrylate)

(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_3, alcohol etc. e.g. Bakelite,nylon,polyster,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.polyster, 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, polystrene, 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.

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
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	(ii) Branched Polymers	This contain linear chains having some branches e.g. amylopectin, glycogen etc.
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(E) Based On Growth Of Polymerization	(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

POLYMER	MONOMER(Name & Structure)	USES
Addition or Chain Growth Polymer		
Polythene	Ethene $CH_2=CH_2$	Insulator, ,Packing material,
Teflon (Poly tetrfluoroethene)	Tetrfluoroethene $CF_2=CF_2$	Lubricant, Insulator and making non-stick cooking ware.
Poly acrylonitrile	Acrylonitrile $CH_2=CH-CN$	For syntheticfibres and synthetic wool.
Buna S	Buta-1,3-diene + Styrene $CH_2=CH-CH=CH_2$ $C_6H_5CH=CH_2$	Automobile tyres and Foot wears
Buna N	Buta-1,3-diene + Acrylonitrile $CH_2=CH-CH=CH_2$ $CH_2=CH-CN$	Oil seals, Tank lining
Natural Rubber	2-Methylbuta-1,3-diene (Isoprene)	Used for tyres after vulcanisation
Synthetic Rubber(Neoprene)	2-Chlorobuta-1,3-diene (Chloroprene)	Insulator, making conveyor belts and printing rollers
Polypropene	Propene $CH_3-CH=CH_2$	Ropes, toys,pipes and fibres
Polystyrene	Styrene $C_6H_5CH=CH_2$	Insulator, Wrapping material,toys, Radio and television cabinets.
Polyvinyl chloride (PVC)	Vinyl Chloride $CH_2=CH-Cl$	Rain coats, Hand bags, Vinyl flooring and water pipe.
Condensation or Step Growth Polymers		
Terylene(Dacron)	Ethane-1,2-diol + Benzene-1,4-dicarboxylic acid	Used for making fibres, safety belts, tents
Nylon 66	Hexamethylenediamine + Adipic acid $NH_2(CH_2)_6NH_2$ $HOOC(CH_2)_4COOH$	For making brushes,paratutes and ropes
Nylon 6	Caprolactum	Tyrescords,fabrics andropes
Bakelite	Phenol + Methanal	Combs,electricalswitches,handles of utensiles and computer discs
Melamine	Melamine + Methanal	Unbreakable crockery
PHBV **(biodegradable)**	3-Hydroxybutanoic acid + 3-Hydroxypentanoic acid	Specialty packaging, orthopedic devices, In controlled drug release
Nylon 2 – Nylon 6 **(biodegradable)**	Glycine + Amino caproic acid H_2N-CH_2-COOH $H_2N(CH_2)_5-COOH$	

Urea-formaldehyde resin	Urea + Formaldehyde	Unbreakable cups , laminated sheet
Glyptal	Ethane1,2-diol + Benzene-1,2-dicarboxylic acid	Binding material in preparation of mixed plastics and paints
**********		
Semi-synthetic poly	Cellulose Acetate (Rayon)	
Thermoplastic polymers	Linear or slightly branched / capable of repeatedly softening on heating and hardening on cooling. Example : Polythene, Polystyrene, Polyvinyls, etc.	
Thermosetting polymers	Cross linked or heavily branched molecules, / on heating undergo extensive cross linking in moulds and again become infusible. These cannot be reused. Examples : Bakelite, Urea-formaldelyde resins.	
Homo-polymer & Co-polymer	Homo-polymer →Polymer of a single monomeric species. Example : Polythene , PVC Co-polymer→ Polymer of more than one monomer .Example : Nylon66, Bakelite	
Initiators	Benzoyl Peroxide [$C_6H_5CO-O-O-CO-C_6H_5$] (in freeradical addition polymerization)	
Vulcanisation of Rubber.	Natural rubber is soft at high temp and brittle at low tempand absorbs water. To improve these physical properties, it is heated 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.	

VSA (1 marks)

1.Name a natural elastomer.

Ans . Natural rubber.

2. Write name of a synthetic polymer which is an ester.

Ans. Nylon 6 or Nylon 6,6.

3. Name of monomer of Nylon 6.

Ans. €-Aminocaproic acid

4. Write the monomer units of Bakelite.

Ans. Phenol and formaldehyde.

5. 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.

6. Write one use of PVC.

Ans: In manufacture of rain coats& vinyl flooring.

7. Define Polymer.

Ans: Polymer is defined as very large molecules having molecular mass (103-107u). These are also referred to as **macromolecules,**

8. Give an example of thermoplastics.

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

9. To which class of polymers does Nylon-66 belong?

Ans: ***Polyamides***

10. Name the type of monomers interylene?
Ans: Ethylene glycol and terephthalic acid.

SA-1 (2 marks)

1. Arrange the following polymers in increasing order of their intermolecular forces.

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

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

(ii)Neoprene < Polyvinyl chloride< Nylon

2.Classify the following as addition and condensation polymers:
Terylene, Bakelite,
Polyvinyl chloride, Polythene.

Ans. (i) addition polymers :Polyvinyl chloride, Polythene.

(ii) condensation polymers: Terylene , Bakelite.

3.What is a biodegradable polymer ? Give an example of a biodegradable aliphatic polyester.
Ans. Polymers which disintegrate by themselves over a period of time due to environmental degradation by bacteria,etc.are called biodegradable polymers. e.g. PHBV

4.How can you differentiate between addition and condensation polymerization

Ans. In addition polymerization the molecules of the same monomer or diferent monomers add together on a large scale to form a polymer. The monomers used are unsaturated compounds, *e.g.*, alkenes, alkadienes and their derivatives.

Condensation 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. *e.g. ,* Nylon 6,6.

5.What is meant by PTFE ?Give its popular name.

Ans.Polytetrafluoroethylene.it is called Teflon.

6.Write chemical name of (Ziegler-Natta catalyst).

Ans: Triethylaluminium and titanium tetrachloride

7.Write down the two differences between thermoplastic and thermosetting plastic and examples.
Ans:Thermoplastic 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 plastic 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-formaldelyde resins, etc.

8.DifferentiateNovolac and Bakelite on the basis of structure.

Ans: A linear product of ***Phenol - formaldehyde polymer*** is **Novolac,** used in paints.

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.

9. Distinguish between the terms homopolymer and copolymer and give an example of each.

Ans: the addition polymers formed by the polymerisation of a single monomeric species are known as **homopolymers**, *e.g.*, polythene.

The polymers made by addition polymerisation from two different monomers are termed as **copolymers**, *e.g.*, Buna-S, Buna-N, etc. 10. How will you differentiate between LDP and HDP?

Ans: ***Low density polythene*****:** It is obtained by 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 ofdioxygen or a peroxide initiator (catalyst).

Low density polythene is chemically inert and tough but flexible and a poor conductor of electricity.e.g., squeeze bottles, toys and flexible pipes.
High density polythene: It is formed when addition polymerisation of ethene takes place in a hydrocarbon solvent in the presence of a catalyst Ziegler-Natta catalyst at a temperature of 333 K to 343 K and under a pressure of 6-7 atmospheres. HDP consists of linear molecules and has a high density due to close packing. It is more tougher and harder. It is used for manufacturing buckets, dustbins, bottles, pipes, etc.

SA-II (3 marks)

1.Write the names of monomers of the following polymers:

(i) Nylon 6,6 (ii) Neoprene(iii) Buna –N

Ans. (i) hexamethylenediamine and adipic acid.

(ii) chloroprene.

(iii)1, 3 – butadiene and acrylonitrile.

3.How are polymers classified on the basis of structure?

Ans.On the basis of structure, the polymers are classified as below:

(i) Linear polymers such as polythene, polyvinyl chloride,HDP etc.

(ii) Branched chain polymers such as low density polythene,LDP,etc. (iii)Cross linked polymers such as bakelite, melamine, etc.

4. Write the monomers of the following polymers:

(i) Buna-N (ii) Teflon(iii) Neoprene.

Ans.(i) 1, 3 – butadiene and acrylonitrile (ii) ***tetrafluoroethene (iii)*** chloroprene.

6. Write use of each orion and Nylon-6.

Ans: use of orion is clothing as a substitute for wool& for Nylon-6. use of Nylon-6 is as fibrics

8. Explain elastomeric polymers & Fibres

Ans: These are rubber – like solids with elastic properties. In these elastomeric polymers, 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. The examples are buna-S, buna-N, neoprene, etc.

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.

9 . What is the function of sulphur in vulcanisation of rubber? Ans: Sulphur introduces sulphur bridges.So it is become more tensile strength,elasticity and resistance to abrasion etc.

10. Write **Commercially Importants of following Polymers**

(1) Polypropene (2)Polystyrene (3) Glyptal

Ans: (1) Manufacture of ropes, toys, pipes, fibres, etc.

(2)As insulator, wrapping material, manufacture of toys, radio and television cabinets.

(3) Manufacture of paints and lacquers.

HOTS QUESTIONS

VSA (1mark)

1.What is the main constituent of bubble gum?

Ans-Styrene - butadiene copolymer (SBR).

2.What is a plasticizer?

Ans; The substances which are added to increase the softness of hard polymers.

3.Draw the structures of the monomer of PAN.

Ans: CH_2=CH-CN

4.Give the name of polymer which is used for making non- stick utensils.

Ans: Teflon(CF_2=CF_2)

5.What is the % of sulphur using during in vulcanization of rubber ?

Ans: 3% to 5%

SA-I(2 marks)

1.Give the common and the IUPAC name of the monomer of natural rubber.

Ans: cis-Isoprene & 2-methyl-1,3-butadiene

2.Discuss the two main purpose of vulcanization of rubber.

Ans: (i)It makes the rubber hard.

(ii)It is more elastic.

(iii)It has more wear and tear resistance.

3.Explain the term ***Thermosetting polymers*** and give one example.

Ans: ***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-formaldelyde resins, etc.

4. Why should one always use purest monomer in free radical polymerisation?
Ans: Impurities of other substances if present,may inhibit or hinder the chain propagation.

5.How is dacron obtained from ethylene glycol and terephthalic acid?
Ans: It is the condensation product of ethylene glycol and terephthalic acid Carried out at 420 to 460K in the presence of catalyst mixture of zinc acetate and antimony trioxide.

SA-II(3 marks)

1.What does the following polymers stand for ?
(i)PVC (ii) DOP(iii) PAN

Ans: (1) Polyvinylchloride

(2)Dioctylphthalate

(3) Polyacrylonitrile

2. Why is Bakelite a thermosetting polymer?

Ans: It is a cross-linked polymer. On heating it sets permanently into a solid.Itcan not be remoulded by heating again.

3.A regular copolymer of ethylene and vinyl chloride contains alternate monomers of each type.What is the weight percent of ethylene in this copolymer?

Ans: the weight percent of ethylene in this copolymer

[28/(28+62.5)]*100

30.93%

Acid polymerisation

4.C_6H_{10}=NOH □ A □ B Give the products A& B.

A=€-Aminocaproic acid

B=nylon-6

5.(i) Give an example of a synthetic rubber.

(ii) Mention main advantage of synthetic rubber.

(iii)Arrange the polymers in the increasing order of tensile strength, Nylon-6, Buna-S,Polythene.

Ans: (i) synthetic rubber is Buna-S

(ii) It is used for making oil seals, tank linings.

(iii) Buna-S<Polythene< Nylon-6

Polymers

<u>Very Short Answer Type Questions</u> (1 marks)

Q.1 Classify the following as addition and condensation polymers. Terylene, Bakelite , polyvinyl chloride (PVC),polythene.

Sol. **Addition polymers**

Polyvinyl chloride and polythene

Condensation polymers

Treylene and Bakelite

Q2. Arrange the following in increasing order of their intermolecular forces.

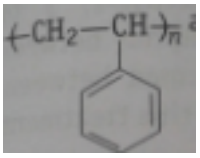
(i) Nylon-6,6, Buna-S , polythene

(ii) Nylon-6 , neoprene , polyvinyl chloride

Sol. Increasing order of the intermolecular forces of the polymers is as follows

(i)Buna-s **<** polythene **<**nylon-6,6

(ii)Neoprene < polyvinyl chloride < nylon-6

Q3. **Is a**  **homopolymer or a copolymer?**

Sol. It is a homopolymer because single type of monomer unit i.e., $C_6H_5CH—CH_2$ undergo polymerisation.

Q4. Define the term polymerisation.

Sol. The process in which small molecules constitute the repeating units in a polymer are called monomer units and are linked to each other by covalent bond and this process of formation of polymers from respective monomers is known as polymerisation.

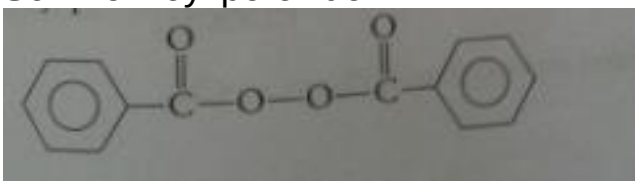
Q5. In which classes, the polymers are classified on the basis of molecular forces?

Sol.

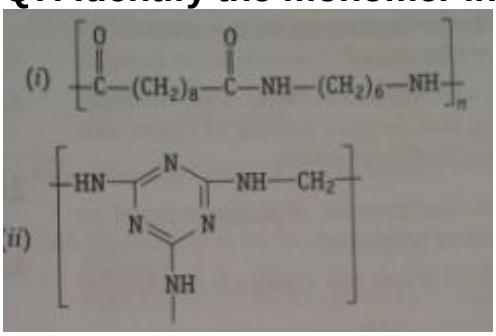
i. Elastomers
ii. Fibres
iii. Thermoplastics
iv. Thermosetting polymers.

Q6. Write the name and structure of one of the common initiators used in free radical addition polymerisation.

Sol. Benzoyl peroxide



Q7. Identify the monomer in the following polymeric structures

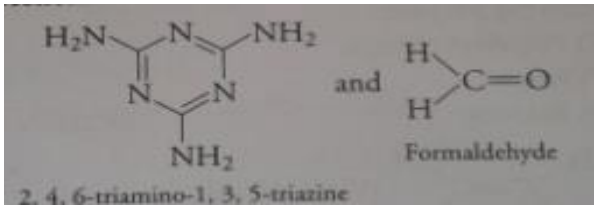


Sol. (i)Monomers are HOOC—$(CH_2)_8$—COOH and
Decanoic/Sebanic acid

H_2N—$(CH_2)_6$—NH_2

Hexamethylene diamine

(ii)Monomers



Q8. **In nylon-6,6, what does the designation6,6 mean?**
Sol. The amine and acid parts, of the monomers (adipic acid and hexamethylene diamine which condense to give the polymer, each of them contain 6 carbons.

Q9. Give an example of elastomers.
Sol. Buna-S, Buna-N, Rubber etc.

Q**10. Identify the type of polymer.**
--A—B—B—A—A—A—B—A—
Sol. Copolymer.

Q11. Identify the type of polymer
—A—A—A—A—A—
Sol. Homopolymer.

Q12.Give the classification of polymers based on structures of polymers?

Sol. On the basis of structure of polymers are classified as
(i)Linear polymers
(ii)Branched chain polymers
(iii)Cross-linked or Network polymer.

Q13. Which factor impacts crystalline nature to polymer like nylon?
Sol. Strong intermolecular forces like hydrogen bonding, lead to close packing of chains that impacts crystalline character.

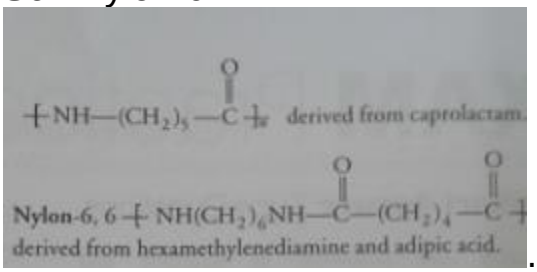
Q14.Which of the following are addition polymers : Terylene ;Teflon ;Neoprene?
Sol. Neoprene and Teflon are addition polymers.

Q15. Can enzyme be called a polymer?
Sol. Yes, they are biocatalysts which are proteins and therefore they are polymers.

Q16. Explain the difference between Buna-N and Buna-S.
Sol. Buna-N is a copolymer of 1,3-butadiene and acrylonitrile whereas Buna-S is a copolymer of 1,3butadiene and styrene.

Q17. What are the monomeric repeating units of nylon-6 and nylon-6,6?

Sol. Nylon-6



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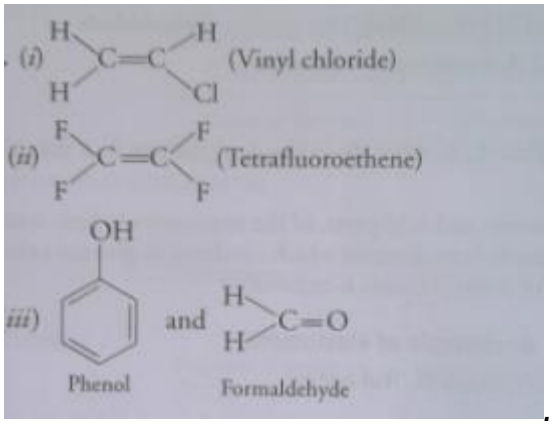
Q18. Write the monomers used for getting the following polymers
(i)Polyvinyl chloride
(ii)Teflon
(iii)Bakelite.

Sol.



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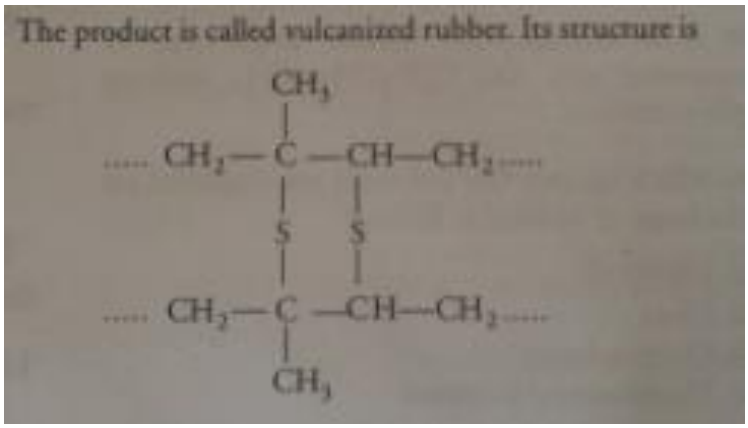
Q19. A natural linear polymer of 2-methyl-1, 3 butadiene becomes hard on treatment with sulphur between 373 to 414K and —S—S— bonds are formed between chains.
Write the structure of the product of this treatment?

Sol. 

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Q20. Which type of biomolecules have same structural similarity with synthetic polyamides? What is the similarity?
Sol. Protiens have structural similarity with polyamides because both have amide linkage.

Q21. What is the repeating unit in the condensation polymer obtained by combining $HO_2CCH_2CH_2CO_2H$(succinic acid) aand $H_2NCH_2CH_2NH_2$(ethylene diamine)?

Sol. $-[-NHCH_2CH_2NHCOCH_2CH_2CO---]_n--$.

Q**22. Draw the molecular structure of the monomers of**
(1)PVC (2) Teflon

Sol. (i) $CH_2=CHCl$
Vinyl chloride

(ii)$CF_2=CF_2$
Tetrafluroethene.

Q**23. Write the structures of monomers used in preparations of (i)Teflon (ii)PMMA**.

Sol. (i)$CF_2=CF_2$ tetrafluriethene $COOCH_3$
|
(ii)Methyl methacrylate, $CH_2=C—CH_3$.

Q24. Give one example of a condensation polymer.
Sol. Nylon-6,6 is an example of condensation polymer because it is the result of condensation reaction between adipic acid and hexamethlyendiamine.

Q25. Define plasticizers.
Sol. These organic compounds which added to plastics make them soft and workable are known as plasticizers e.g., tricresyl phosphate , di-n-octylphthalate.

Q**26. Name the main constituent of bubble gum?**
Sol. Styrene-butadiene copolymer.

Q**27.Write the monomers of the cellulose and polythene?**
Sol. Cellulose –β-D-glucose
Polythene --- Ethane.

Q28. Give an example of a polymer which is used to make cups for hot-drinks?
Sol. Urea-formaldehyde resin.

Q**29. Name the monomers of**
(i)Nylon 2-nylon-6 polymer
(ii)Teflon.
Sol. (i)Nylon 2-nylon-6 polymer is a polymer of
$H_2N—CH_2—COOH$ and $H_2N—(CH_2)_5COOH$.
Glycine Amino caproic acid.

Q30. **Name a synthetic polymer that contains amide.**
Sol. Nylon-6,6.

Short Answer Type Questions {2 Marks Questions}

Que.1:- (1) How does vulcanisation change the character of natural rubber?
(2) Why are the number, 6,6and6 put in the names of nylon-6,6 and nylon-6?
Sol.:- (1) Valcanisation of natural rubber makes it hard and even more elastic. It possess more wear and tear properties. It is used in automobile tyres.
(2) Nylon-6,6 and nylon-6 are the polymer of adipic acid, hexamitheylenediamini and caprolactam respectively. Each of them has 6 carbon atom. Therefore number 6,6 and 6 put in the names refer to the number of carbon atoms in the monomers involved.
Que.2:- Explain the term coplymerisation and give two examples.
Sol.:- Coplymerisation is the process in which two or more diffrent monomers polmerise together to form copolymer. e.g., Buna-S and Bina-N

Que.3:- What are the natural and synthetic polymers ? Give two example of each type.

Sol.:- **(1) Natural Polymers**. These are found in plants and animals. e.g., cellulose, starch(polymer of glucose),

Protein .

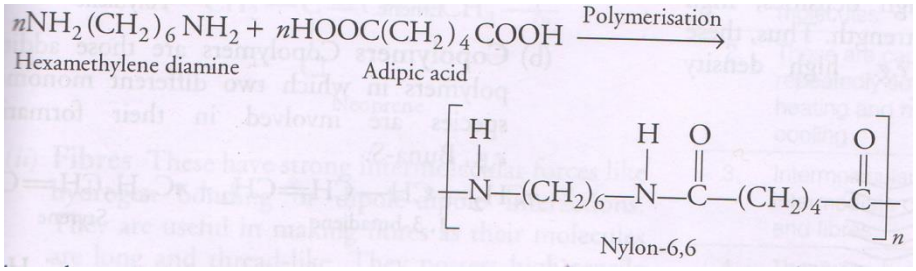
(2) Synthetic Polymers These are man-made polymers that are used in day to day life and in industries. e.g., Synthetic fibers, synthetic rubber

Que.4:- What are polymers?

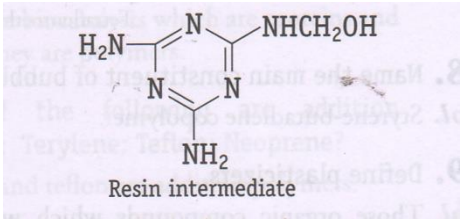
Sol.:- The word 'ploymer' is coined from two Greek words 'poly' means 'many' and 'mer' means 'unit/part'.

Ploymers can be defined as compound of high molecules formed by combination of large numbe of small molecules. The small molecules which constitute the reparing unit in polymer are called **monomer unit** and are linked to each other by covalebt bond and this process of formation of polymers from respective monomers is known as **polymerisation**.

e.g.-

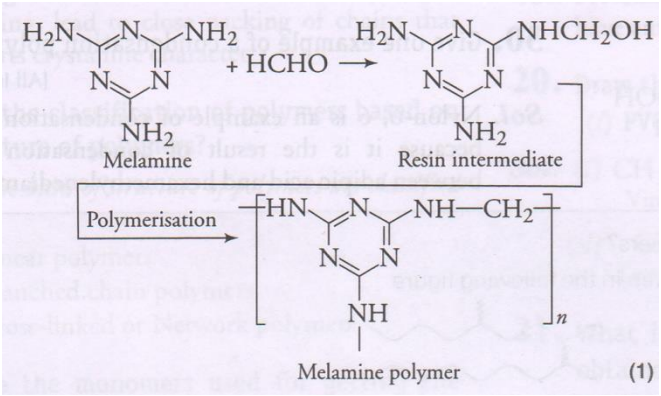


Que.5:- How is the following resin intermediate prepared and which polymer is formed by this monomer unit?



Sol.:-

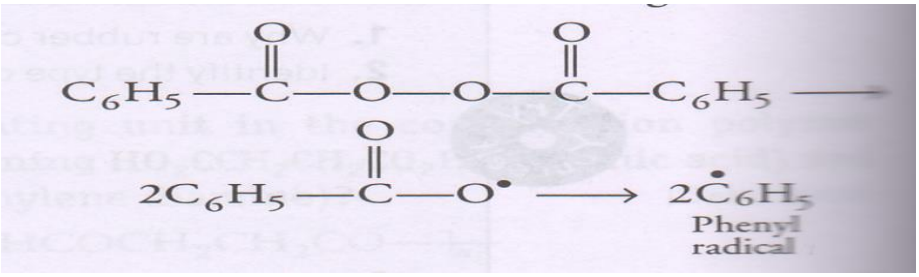
Melamine and formaldehyde are the staring material for this intermediate. Its polymerisation leads to the formation of melamine polymers.



Que.6:- (1) What is the role of benzoyl peroxide in polymerisation of ethene?

(2) What are LDP and HDP ? How are they prepared?

Sol.:- (1) Bezoyl peroxide acts as a initiator in the chain reaction. It dessociate to give radicals.



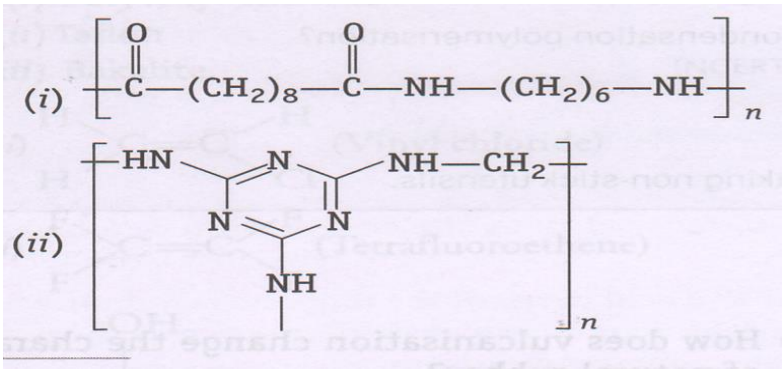
(2) **LDP** Low Density Polyethene.

Prepation By Polymerisation of ethene at 350-570 C Teampratur and 1000-2000 atm high pressure, in the branched presence of peroxide initator: it is a branched chain polymer.

HDP High Density Polyethene

Preparation Polymerisation of ethene at temprature of 333k to 343k And 6-7 atm prssure in the presence of Ziegler- Natt cataylst. HDp is a linear polymer.

Que.7:- Identify the monomer in the following polymeric sttructures.



Sol.:- (1) (a) Decanedioic acid

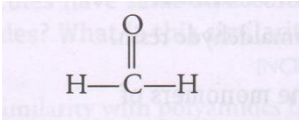
HOOC— $(CH_2)_8$— COOH

(b) Hexamethylenediamine

H_2N- (CH_2) - NH_2

(2) (a) 2,4,6- triamino- 1,3,5- triazine or melamine

(b) Formaldehyde or methanal (HCHO)



Short Answer Type Questions (3 marks)

Q1- Explain the terms polymer and monomer.

Ans- Polymers can be defined as compounds of high molecular mass (10^3-10^7 u) formed by combination of large number of small molecules. The small molecules which constitute the repeating units in a polymer are called monomer units and are linked to each other by covalent bond and this process of formation of polymers from respective monomers is known as polymerization. As polymers are single, giant molecules these are also called macromolecules.

Q2- Write the names and structures of the monomers of the following polymers

(i) Polystyrene

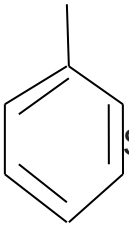
(ii) Teflon

Ans- (i) Polystyrene

Monomer Styrene (Vinyl benzene)

Structure

$CH{=}{=}CH_2$

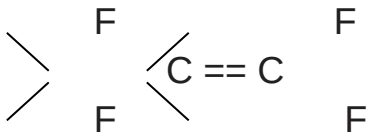


Styrene

(ii) Teflon

Monomer Tetrafluoroethene

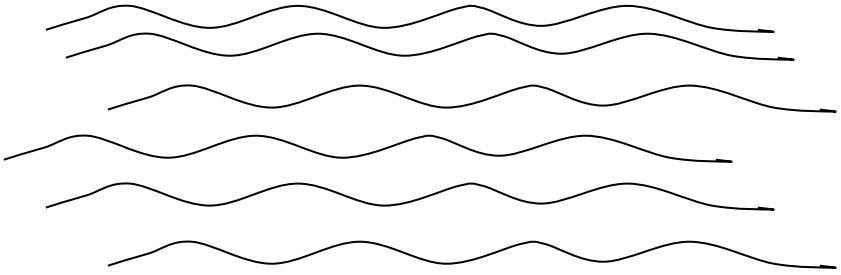
Structure



Q3- How are polymers classified on the basis of structure?

Ans- (i) Linear Polymers- These consist of long and straight chains. They have high densities, high melting points and high tensile strength. Thus, these are well packed structures e.g., high density polythene, polyvinyl chloride etc. These are represented as

(iii) Branched Chain Polymers- These contain linear chains having some branches. Due to their irregularly packed structure they have low tensile strength, low densities and lower melting point as compared to linear polymer e.g. low density polythene, glycogen etc. These are depicted as



Diag. BRANCHED CHAIN POLYMERS

(iii) 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. These are hard and rigid e.g. bakelite, melamine etc. These are depicted as

Diag. CROSS-LINKED POLYMERS

Q4-Distingush between the terms homopolymer and copolymer and give an example of each?

Ans- Homopolymers are those polymers whose repeating structural units are derived from only one type of monomer unit e.g. polythene, PVC, PAN, nylon-6, Teflon etc. Whereas copolymers are those polymers whose repeating structural units are derived from different types of monomer molecules e.g. Buna-S, nylon-6,6, melmac, polyester etc.

Q5- How do you explain the functionality of a monomer?

Ans- By functionality, we mean the number of bonding sites in a molecule. For instance, the functionality of ethane, propene, acrylonitrile is one because such molecules can react at one site while that of adipic acid, 1, 3-butadiene, hexamethylenediamine is two because they can bond at two positions with other molecules.

Q6- Draw the schematic representative of linear, branched chain and cross-linked polymers.

Ans- DIAG. DIAG.
DIAG.

Q7- Write the names and structures of the monomers of the following polymers

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

Ans- (i) Buna-S

$CH_2 == CH—CH == CH_2$; $C_6H_5—CH==CH2$

1, 3-butadiene Styrene

(ii) Buna-N

$CH_2==CH_2—CH==CH_2$; $CH_2==CH—CN$

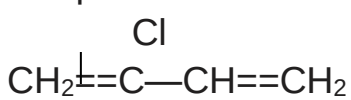
1, 3- butadiene Acrylonitrile

(iii) Dacron

$HO—CH_2—CH_2—OH$; $HOOC(C_6H_4)COOH$

Ethyl glycol Terephthalic acid

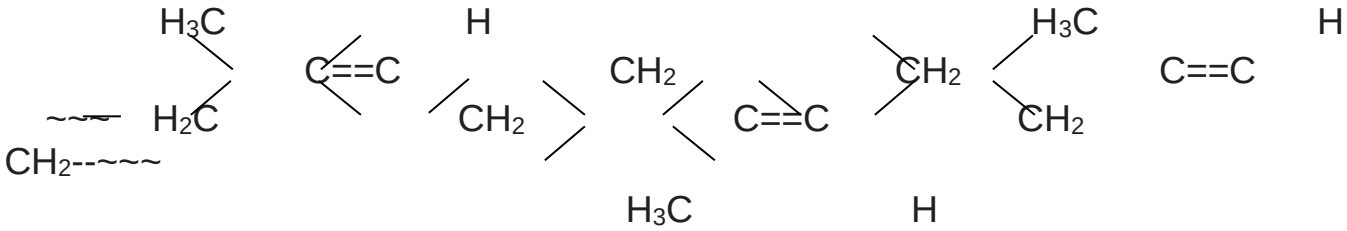
(iv) Neoprene



Chloroprene

Q8- How does the presence of double bonds in rubber molecules influence their structure and reactivity?

Ans- Natural rubber is cis-polyisoprene and it is obtained by 1, 4-polymerisation of isoprene units.



Natural rubber

The cis-configuration at double bonds does not allow the polymer chains to come closer for effective interactions and hence intermolecular forces are quite weak. As a result, natural rubber, cis-polyisoprene has a randomly coiled structure and hence shows elasticity.

Q9- Differentiate thermoplastics and thermosetting polymers with two examples of each.

Ans-

S.No.	Thermoplastic Polymer	Thermosetting Polymer
1	These are linear or slightly branched long chain molecules.	These are cross-linked or heavily branched molecules
2	These are capable of repeatedly softening on heating and hardening on cooling.	On heating, these undergo extensive cross-linking and become infusible.
3	Intermolecular forces are intermediate of elastomer and fibres.	Intermolecular forces are strongest.
4	These can be reused e.g. polythene, polyvinyl chloride (PVC)	These cannot be reused e.g. bakelite, urea- formaldehyde resin.

Q10- Write the free radical mechanism for the polymerization of ethane?

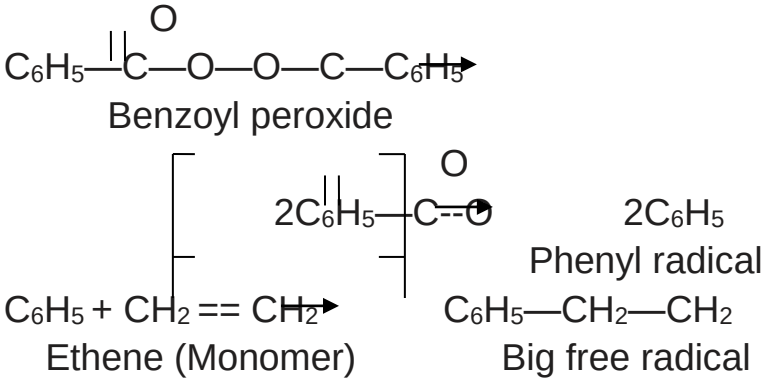
Ans- Alkenes/dienes and their derivatives are polymerized in the presence of a free radical generating initiator (catalyst) like acetyl peroxide, benzoyl peroxide, etc e.g. polymerization of ethene to polythene.

It consist of heating or exposing to light a mixture of ethene with a small amount of benzoyl peroxide (as an initiator).

This process is completed in three steps given below

Step I- Chain Initiating Step

Firstly, the phenyl radical is formed by benzoyl peroxide. Then phenyl radical added to the double bond of ethene molecule (monomer) to form a new and a large free radical through homolysis.



Step II- Chain Propagation Step

The new big free radical thus formed in the chain initiating step reacts with another molecule of etheneto form another bigger sized radical. Thus, the repetition of this sequence with new and bigger radicals tends to carry the reaction forward.

C_6H_5 -- CH_2 -- CH_2 + CH_2 == CH_2

C_6H_5 -- CH_2 -- CH_2 -- CH_2 -- CH_2

→ C_6H_5 – (CH_2 -- CH_2)$_n$-- CH_2 -- CH_2

Step III- Chain Termination Step

Ultimately, the growing free radical chain may get terminated by reactions which consume these free radicals by combination of free radicals in different ways to form polythene.

C_6H_5 – (CH_2 -- CH_2)$_n$-- CH_2 -- CH_2 +

C_6H_5—(CH_2-- CH_2)$_n$-- CH_2-- $\overrightarrow{CH_2}$

C_6H_5—(CH_2-- CH_2)$_n$ -- CH_2 CH_2 –

CH_2—(CH_2 -- CH_2)$_n$ -- C_6H_5

Polythene

Q11- How can you differentiate between addition and condensation polymerization?

Ans- In addition polymerization, the molecules of the same or different monomers add together to form a large polymer molecule without the elimination of simple molecules like H_2O, HCl etc. Condensation polymerisation is a process in which two or more bifuntional molecules undergo a series of condensation reactions with the elimination of some simple molecules like H_2O, HCl, alcohol and leading to the formation of polymers.

Q12-Write names of monomers of the following polymers and classify them as addition and condensation polymers.

(i) Teflon

(ii) Bakelite

(iii) Natural rubber

Ans- (i) Tetrafluoroethene ($CF_2 == CF_2$) is the monomer of teflon. It is an addition polymer.

(ii) Formaldehyde and phenol are the monomers of the bakelite. It is a condensation polymer.

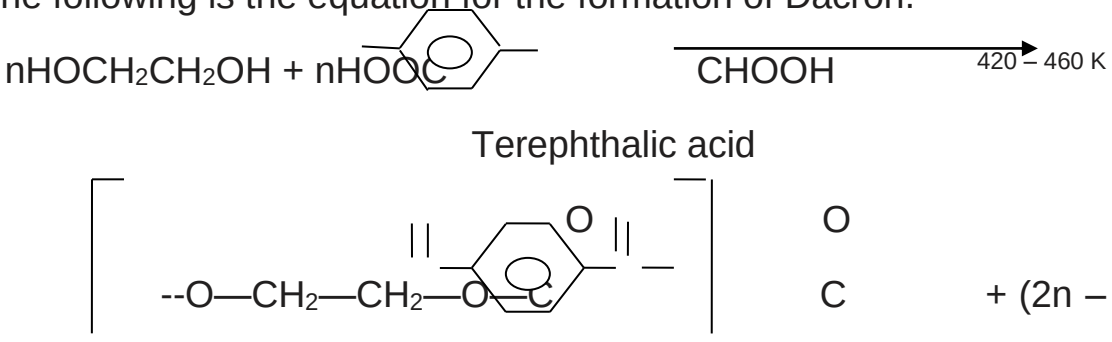
(iii) Isoprene is the monomer of the natural rubber. It is an addition polymer.

Q13- Discuss the main purpose of vulcanization of rubber?

Ans-Vulcanisation is the heating of natural rubber with sulphur and an appropriate additive at a temperature range between 373 K to 415 K. Sulphur forms cross-links at the reactive sites of the double bond and thus rubber gets stiffened i.e. becomes less sticky and plastic, more resistant to swelling by organic liquids and has enhanced elasticity. Physical properties of rub VBer can be impured by vulcanization.

Q14- How is Dacron obtained from ethylene glycol and terephthalic acid?

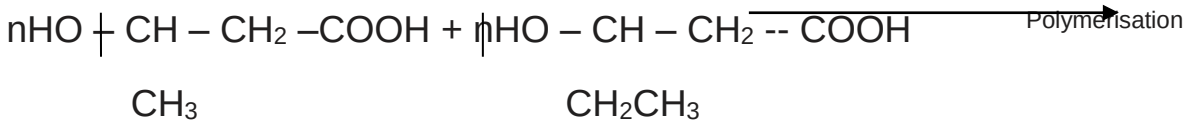
Ans- The following is the equation for the formation of Dacron.



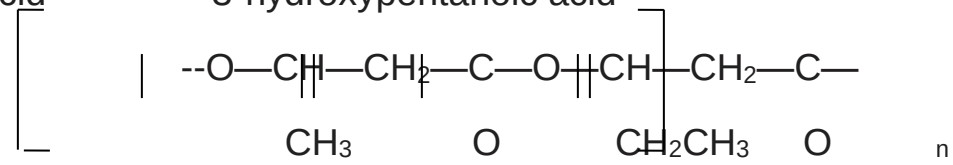
Q15-What is biodegradable polymer? Give an example of a biodegradable aliphatic polymers?

Ans- Biodegradable polymers are those polymers which get decomposed by themselves over a period of time due to environmental degradation by bacteria.

e.g. PHBV (Poly B-hydroxy butyrate-co-B-hydroxy valerate).



3-hydroxybutanoic acid 3-hydroxypentanoic acid



Q16- Give one example of each

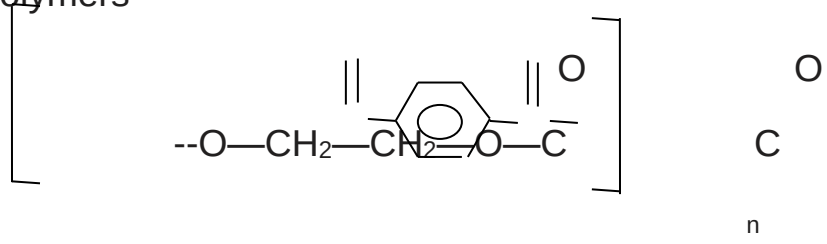
(i) Addition polymers

(ii) Condensation polymers

(iii) Copolymers

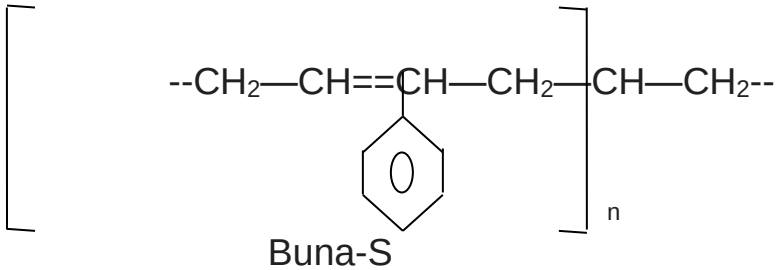
Ans- (i) Addition polymers $(--CH_2—CH_2--)_n$ polyethylene

(ii) Condensation polymers



Dacron

(iii) Copolymers



Buna-S