**#453714**
**Topic:** Polymers and their classification

Explain the terms polymer and monomer.

**Solution**

Polymer is a high molecular mass macro-molecule consisting of repeating structural units derived from monomers. The molar mass of polymer is around $10^3 - 10^7\ u$

There are strong covalent bonds which joints various monomer units in a polymer.

Examples of polymers include Rubber, polythene, Teflon and nylon $6, 6$.

Monomer is a simple molecule capable of undergoing polymerization and leading to the formation of the corresponding polymer. Monomers are reactive molecules that combine with each other in large numbers through covalent bonds to form polymers.

Examples of monomers include ethene, propene, styrene and vinyl chloride.

**#453715**
**Topic:** Preparation of some addition polymers

What are natural and synthetic polymers? Give two examples of each type.

**Solution**

Natural polymers are high molecular mass macromolecules and are found in nature (plants and animals). They are formed by plants and animals.

The examples are proteins, nucleic acids, cellulose, starch etc.

Synthetic polymers are man-made high molecular mass macromolecules. These include synthetic plastics, fibres and rubbers. The two specific examples are polythene and dacron.

**#453716**
**Topic:** Polymers and their classification

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

**Solution**

Homopolymers are formed by the polymerisation of a single monomer. The repeating units of homopolymers are derived only from one monomer. Examples includes polythen which is a homopolymer of ethene.

In copolymers, the repeating units are derived from two types of monomers. Example includes $Buna - S$, which is a copolymer of $1, 3 - butadiene$ and $styrene$.

**#453717**
**Topic:** Polymers and their classification

How do you explain the functionality of a monomer?

**Solution**

Functionality of a monomer is the number of bonding sites present in the monomer.

For example, the monomers ethene and propene have the functionality of $1$ each.

The monomers $1, 3$-butadiene and adipic acid have the functionality of $2$ each.

**#453719**
**Topic:** Polymers and their classification

Define the term polymerisation.

**Solution**

Polymerisation is a process of formation of polymers of a high molecular mass from one or more monomers by linking together repeating structural units with covalent bonds. I these polymers, the molar mass is about $10^3 - 10^7$ u. Thus, ethylene polymerizes to form polythene and tetra fluoro ethylene polymerizes to form teflon.

**#453720**
**Topic:** Polymers and their classification

Is $(NH - CHR - CO)_n$ a homopolymer or copolymer?

**Solution**

$(NH-CHR-CO)_n$ is a homopolymer as it is obtained from a single monomer unit, $NH-CHR-CO$

Note: Homopolymers are formed by the polymerisation of a single monomer.

The repeating units of homopolymers are derived only from one monomer.

In copolymers, the repeating units are derived from two types of monomers.

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**#453722**

**Topic:** Polymers and their classification

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

**Solution**

On the basis of molecular forces present between the chains of various polymers, the classification of polymers is given as follows.

(a) Elastomers (b) Fibres (c) Thermoplastics and (d) Thermosetting plastics.

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**#453723**

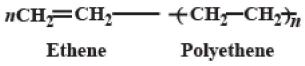
**Topic:** Polymers and their classification

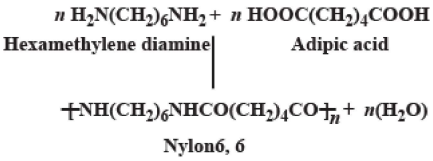
How can you differentiate between addition and condensation polymerisation?

**Solution**

In addition polymerization, the molecules of the same or different monomers add together to form a large polymer molecule.

Condensation polymerization is a process in which two or more bi-functional molecules undergo a series of condensation reactions with the elimination of some simple molecules and leading to the formation of polymers. For example, ethylene is converted into polyethene by addition polymerization and Nylon-$6,6$ is prepared from hexamethylene diamine and adipic acid by condensation polymerization.

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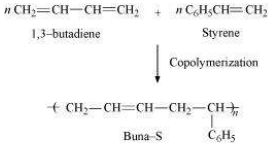
**#453724**

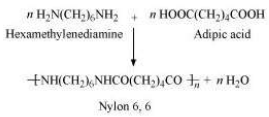
**Topic:** Polymers and their classification

Explain the term copolymerisation and give two examples.

**Solution**

Copolymerisation is a process in which a mixture of more than one monomeric species is allowed to polymerise. The copolymer contains multiple units of each monomer in the chain. The examples are copolymers of $1,3$-butadiene and styrene, hexamethylene diamine and adipic acid (Nylon-$6,6$) and $1,3$-butadiene and acrylonitrile.

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**#453727**

**Topic:** Preparation of some addition polymers

Write the free radical mechanism for the polymerisation of ethene.

**Solution**

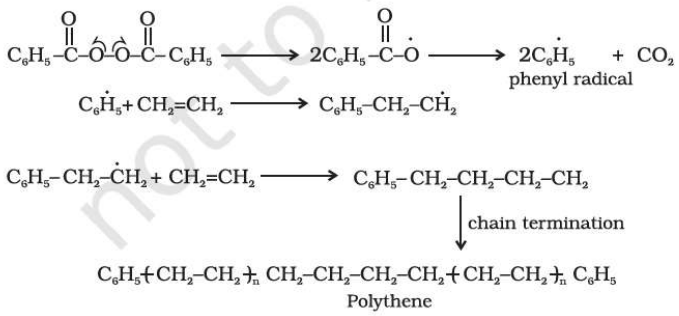
The free radical mechanism for the polymerization of ethene is shown above.

In the chain initiation step, the decomposition of benzoyl peroxide gives benzoyl free radical which further gives phenyl free radical.

Phenyl free radical adds to C=C double bond of ethene and generates a new free radical.

In chain propagating step, the newly generated free radical adds to another ethene molecule to form larger free radical. This process repeats several times.

In the chain termination step, two free radicals combine.




**#453737**

**Topic:** Polymers and their classification

Define thermoplastics and thermosetting polymers with two examples of each.

**Solution**

A thermoplastic polymer can be repeatedly softened on heating and hardened on cooling. Hence, it can be used again and again. The examples are polythene, polypropylene etc.

A thermosetting polymer is a permanent setting polymer as it gets hardened and sets during moulding process and cannot be softened again. The examples are bakelite and melamine formaldehyde polymers.

**#453738**

**Topic:** Some commercially important polymers

Write the monomers used for getting the following polymers.

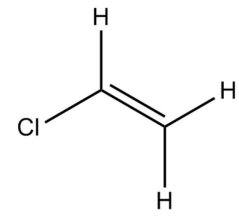
(i) Polyvinyl chloride (ii) Teflon (iii) Bakelite

**Solution**

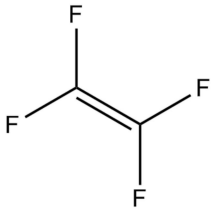
(i) The monomer of polyvinyl chloride is $CH_2 = CHCl$ (vinyl chloride).

(ii) The monomer of teflon is $CF_2 = CF_2$ (tetrafluoroethylene).

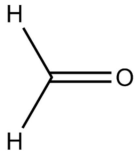
(iii) The monomers involved in the formation of bakelite are $HCHO$ (formaldehyde) and $C_6H_5OH$ (phenol).



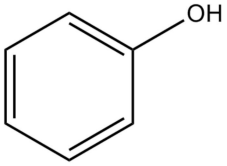

vinyl chloride




tetrafluoroethylene




formaldehyde




Phenol

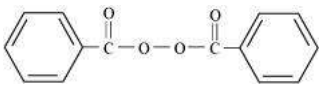
**#453740**

**Topic:** Preparation of some addition polymers

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

**Solution**

Benzoyl peroxide is the initiator used in free radical addition polymerization.



**#453741**

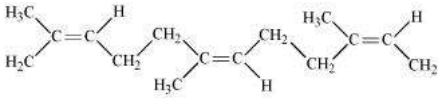
**Topic:** Preparation of some addition polymers

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

**Solution**

Natural rubber is a linear. It is cis-$1, 4$- polyisoprene. The double bonds are located between $C_2$ and $C_3$ of isoprene units. This cis-configuration about double bonds do not allo

the chains to come closer for effective attraction due to weak intermolecular attractions. Hence, the natural rubber has a coiled structure and shows elasticity.



Natural rubber

**#453742**

**Topic:** Preparation of some addition polymers

Discuss the main purpose of vulcanisation of rubber.

**Solution**

Natural rubber has the following drawbacks:

$1)$ It is soft and sticky at room temperature. At high temperatures, $(> \ 335 \ K)$, softness increases.

At low temperatures, $(< \ 283 \ K)$, it is brittle.

Hence, to maintain elasticity, natural rubber can be used in the temperature range of $283 \ K \ - \ 335 \ K$.

$2)$ It can absorb large amounts of water.

$3)$ It's tensile strength is low and it has low resistance to abrasion.

$4)$ It is soluble in non-polar solvents.

$5)$ It is easily attacked by oxidizing agents.

To improve upon these drawbacks, natural rubber is vulcanized. It (along-with sulphur and appropriate additive) is heated at a temperature range between $373 \ K$ and $415 \ K$.

**#453743**

**Topic:** Preparation of some addition polymers

What are the monomeric repeating units of Nylon-6 and Nylon-6,6?

**Solution**

The monomeric repeating unit of Nylon-$6$ polymer is $NH(CH_2)_5CO$ which is derived from caprolactam.

The monomeric repeat unit of Nylon-$6, 6$ polymer is $[NH(CH_2)_6NH - CO(CH_2)_4CO]$ which is derived from the two monomers, hexamethylene diamine, $NH_2(CH_2)_6N$

and adipic acid, $HO - C(O)(CH_2)_4COOH$.

**#453750**

**Topic:** Preparation of some addition polymers

Write the names and structures of the monomers of the following polymers:

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

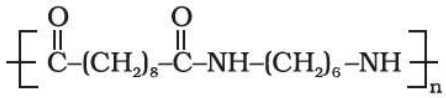
**Solution**

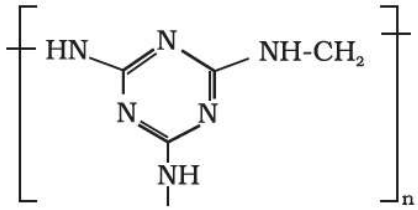
The names and structures of monomers are given below:

| | Polymers | Monomer Names | Monomer Structures |
|---|---|---|---|
| (i) | Buna-S | 1,3-Butadiene | $CH_2 = CHCH = CH_2$ |
| | | Styrene | $C_6H_5CH = CH_2$ |
| (ii) | Buna-N | 1,3- Butadiene | $CH_2 = CHCH = CH_2$ |
| | | Acrylonitrile | $CH_2 = CHCN$ |
| (iii) | Neoprene | Chloroprene | $CH_2 = \underset{\vert}{\overset{Cl}{C}} - CH = CH_2$ |
| (iv) | Dacron | Ethylene glycol | $OHCH_2CH_2OH$ |
| | | Terephthalic acid | $p - HO - C_6H_4 - OH$ |

**#453756**

**Topic:** Preparation of some addition polymers

i) 

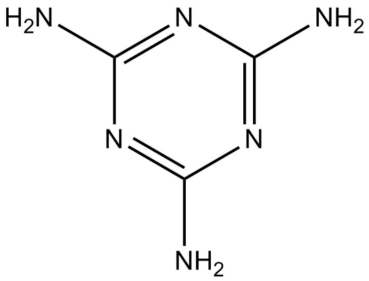
ii) 

Identify the monomer in the following polymeric structures.

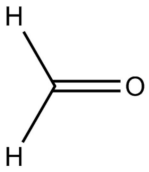
**Solution**

i)In the first case, the monomers are decanoic acid, $HOOC-(CH_2)_8COOH$ and hexamethylene diamine, $NH_2-(CH_2)_6-NH_2$.

(ii) In the second case, the monomers are formaldehyde and melamine whose structures are given above.



Melamine



formaldehyde

**#453771**

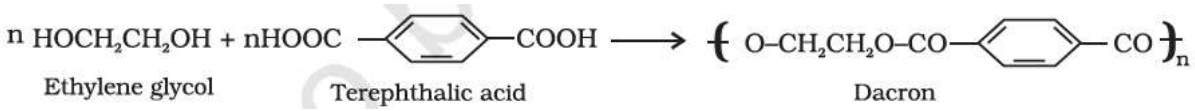
**Topic:** Polymers and their classification

How is dacron obtained from ethylene glycol and terephthalic acid ?

**Solution**

Dacron is obtained by the condensation polymerisation of ethylene glycol and terephthalic acid.

It is an example of polyester. The balanced equation is as shown.



Ethylene glycol Terephthalic acid Dacron

**#453772**

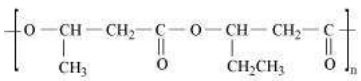
**Topic:** Preparation of some addition polymers

What is a biodegradable polymer ? Give an example of a biodegradable aliphatic polyester.

**Solution**

A biodegradable polymer can be decomposed by bacteria. Non-biodegradable polymer cannot be decomposed by bacteria.

PHBV (Poly- $\beta$-hydroxybutyrate-CO-$\beta$-hydroxyvalerate) is an example of a biodegradable aliphatic polyester.



PHBV