FOCUS NEET/JEE 2019

Class XII

Focus more to get high rank in NEET, JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

UNIT - 8 : Polymers | Chemistry in Everyday Life

POLYMERS

- Polymers are macromolecules having high molecular mass (10^3 – 10^7 u) and are formed by joining of repeating structural units called monomers on a large scale.
- This process of formation of polymers from respective monomers is called polymerisation.
- The polymer may be a long chain or joined in two dimensions forming a sheet.

Types of Polymers

- **Homopolymers :** Polymers made up of only one type of monomer. *e.g.*, polythene, PVC etc.

$$\underset{\text{Ethene}}{n\text{CH}_2=\text{CH}_2} \xrightarrow{\text{Polymerisation}} \underset{\text{Polythene}}{+\text{CH}_2-\text{CH}_2+_n}$$

- **Copolymers :** Polymers made up of two or more types of monomers. *e.g.*, buna-S, nylon 6, 6, etc. The process of formation of copolymer is called copolymerisation.

$$\underset{\text{Hexamethylenediamine}}{n\text{NH}_2(\text{CH}_2)_6\text{NH}_2} + \underset{\text{Adipic acid}}{n\text{HOOC}(\text{CH}_2)_4\text{COOH}} \xrightarrow{\text{Polymerisation}} \underset{\text{Nylon 6, 6}}{+\text{N}-(\text{CH}_2)_6-\text{N}-\text{C}-(\text{CH}_2)_4-\text{C}+_n}$$

Types of Polymerisation Reactions

Addition (Chain-growth) polymerisation

- **Mechanism of free radical addition polymerisation:** This is initiated by organic peroxides or by light. Steps involved are :
  - **Chain initiation :** $\text{Peroxide} \xrightarrow{\text{heat}} \dot{R}$(Radical)
  - **Chain propagation :**

$$R^{\bullet} + \overset{\curvearrowright}{\text{CH}_2=\text{CH}_2} \longrightarrow R-\text{CH}_2-\dot{\text{C}}\text{H}_2$$

$$R-\text{CH}_2-\dot{\text{C}}\text{H}_2 + \overset{\curvearrowright}{\text{CH}_2=\text{CH}_2} \longrightarrow R-\text{CH}_2-\text{CH}_2-\text{CH}_2-\dot{\text{C}}\text{H}_2$$

$$R-\text{CH}_2-\text{CH}_2-\text{CH}_2-\dot{\text{C}}\text{H}_2 \longrightarrow\longrightarrow\longrightarrow R\{\text{CH}_2-\text{CH}_2\}_n\text{CH}_2-\dot{\text{C}}\text{H}_2$$

  - **Chain termination :** By combination

$$2R\{\text{CH}_2-\text{CH}_2\}_n\text{CH}_2-\dot{\text{C}}\text{H}_2 \longrightarrow R\{\text{CH}_2\text{CH}_2\}_n\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2\{\text{CH}_2\text{CH}_2\}_nR$$

or by disproportionation

$$2R\{\text{CH}_2-\text{CH}_2\}_n\text{CH}_2-\dot{\text{C}}\text{H}_2 \longrightarrow \underset{\text{Alkene}}{R\{\text{CH}_2-\text{CH}_2\}_n\text{CH}=\text{CH}_2} + \underset{\text{Alkane}}{R\{\text{CH}_2-\text{CH}_2\}_n\text{CH}_2-\text{CH}_3}$$

e.g., polythene, polystyrene.

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

$$H_2SO_4 \longrightarrow H^+ + HSO_4^-$$

$$H^+ + \text{CH}_2=\text{CH}_2 \longrightarrow \underset{\text{Carbocation}}{\text{CH}_3-\text{CH}_2^+}$$

  - Carbocation formed will undergo addition with several monomers and finally the chain is terminated by combination with a negative ion or loss of a proton, *e.g.*, polyvinyl ether, polyisobutylene, polystyrene, etc.

- **Mechanism of anionic addition polymerisation:** Initiated by strong bases such as $NaNH_2$, C_4H_9Li and Grignard reagent, etc.

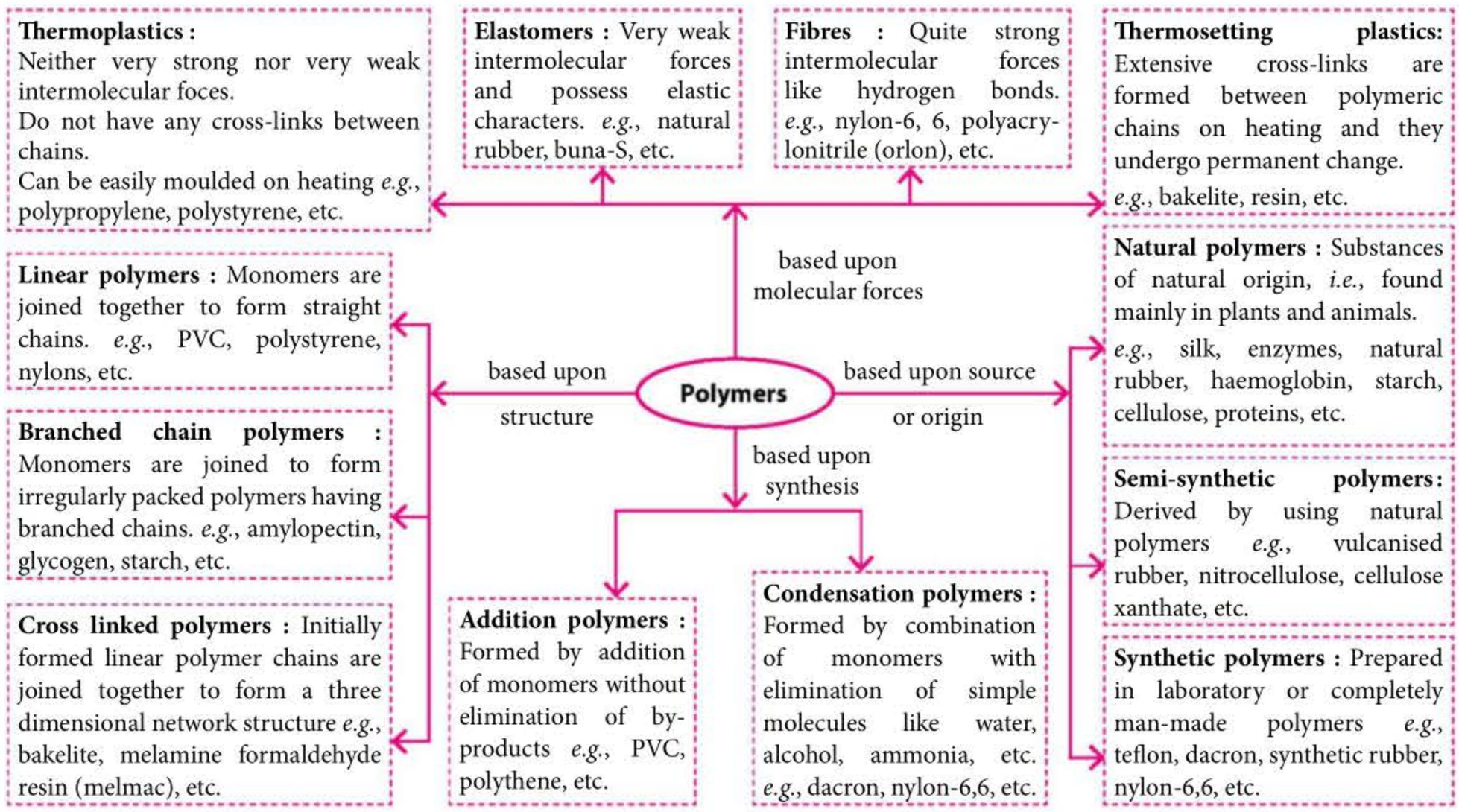
$$B: + CH_2=CH_2 \longrightarrow B-\underset{\text{Carbanion}}{CH_2-CH_2^-}$$

  - The so formed carbanion undergoes addition with number of monomers and finally terminates.
  - This mechanism is more favourable when the monomer alkene have electron withdrawing group to stabilize the intermediate carbanion. *e.g.*, polymerisation of acrylonitrile and methyl methacrylate, etc.

Condensation (Step growth) polymerisation

- These are formed by the condensation of two or more bifunctional monomer units with the elimination of simple molecules like H_2O, NH_3, CO_2, etc.
- The product of each step still contain two functional groups. Thus, the process proceeds by stepwise intermolecular condensation, *e.g.*, formation of nylon, terylene and bakelite, etc.

Classification of Polymers



Rubber

Natural rubber

- It is a linear 1, 4-addition polymer of isoprene and have *cis*-configuration of all double bonds thus, known as *cis*-1, 4-polyisoprene.
- It is insoluble in water, dilute acids and alkalies but soluble in organic solvents like benzene, petrol etc.
  - It has low elasticity and tensile strength.
  - It has weak intermolecular van der Waals' forces.
  - Its natural *trans*-isomer is *gutta-percha* which is non-elastic.

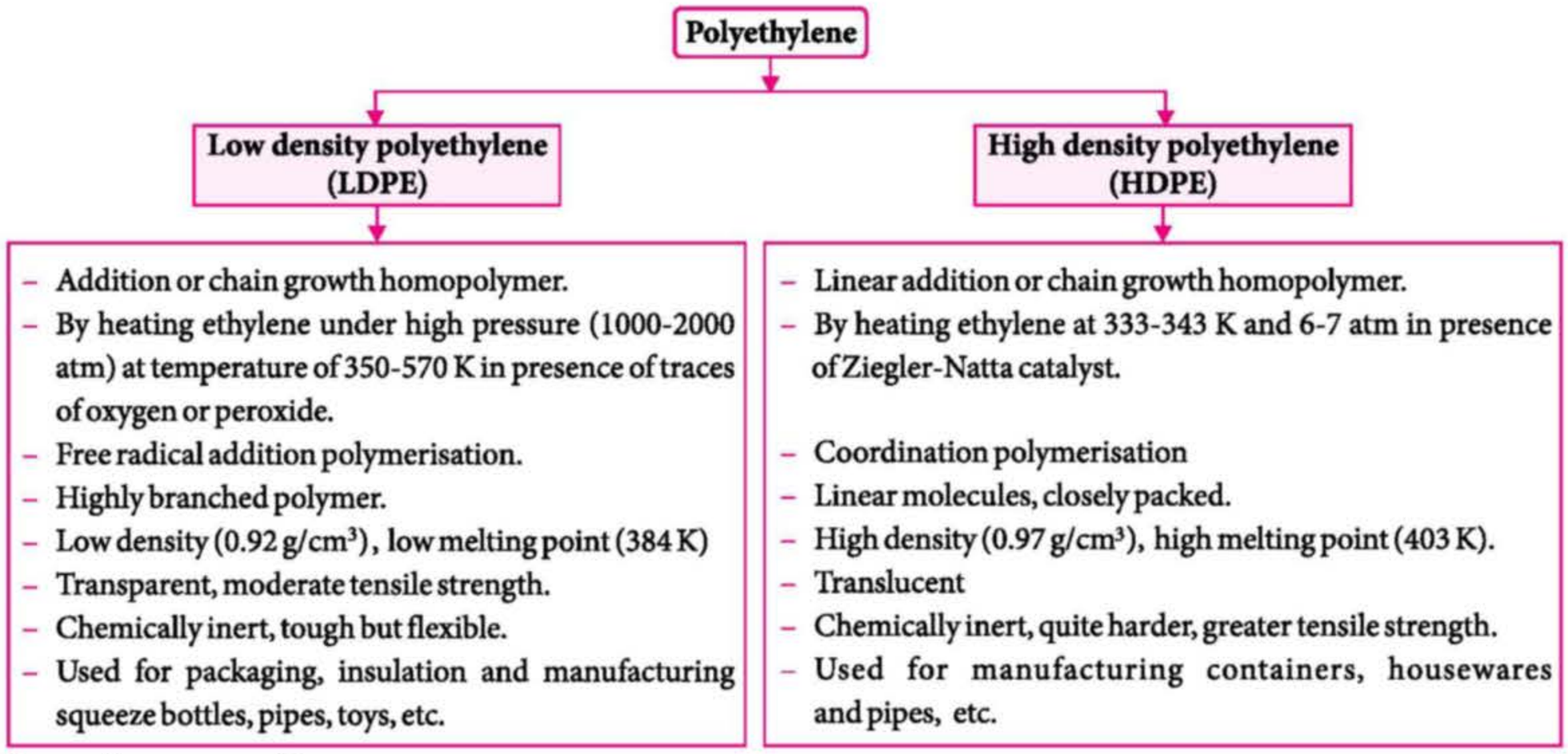
Vulcanisation of rubber

- It is the process of heating natural rubber with sulphur at a temperature of 373-415 K.
  - Sulphur cross-links makes the rubber hard, tough with greater tensile strength.
  - Some additives like carbon black, zinc oxide etc. are used to improve wearing properties.

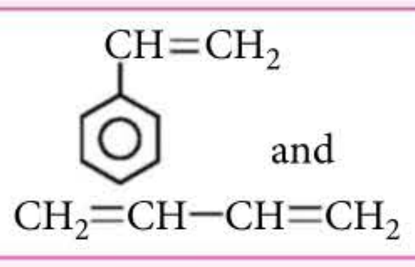
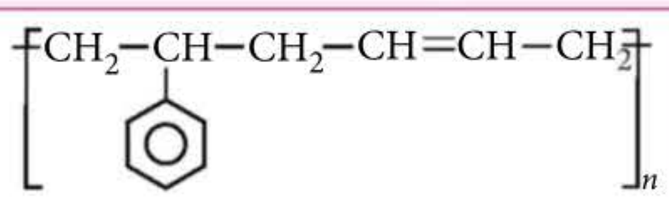
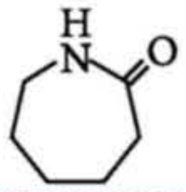
Synthetic rubber

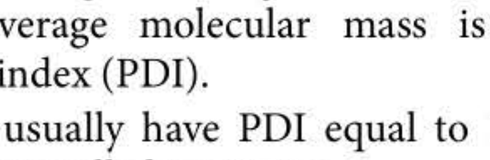
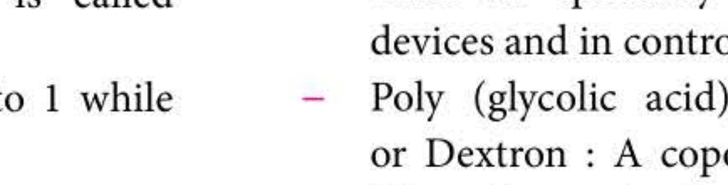
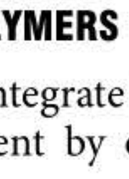
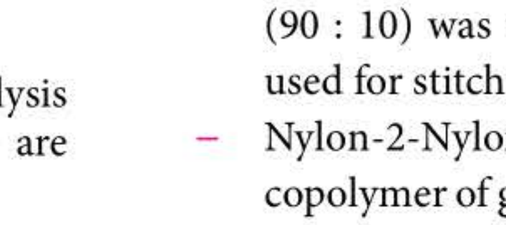
- It is obtained by polymerising certain organic compounds which may have properties similar to rubber and some additional desirable properties. Most of these polymers are derived from butadiene derivatives. These are also vulcanised. For example, neoprene, styrene butadiene rubber (SBR), thiokol, silicones, polyurethane rubber.

Polyethylene



Some Important Polymers

Polymer	Structure of monomer	Structure of polymer	Uses
Polythene	$CH_2=CH_2$	$+CH_2-CH_2+_n$	As insulator, packing material, household and laboratory ware.
Polyvinyl chloride (PVC)	$CH_2=CHCl$	$+CH_2-\underset{\underset{Cl}{\vert}}{CH}+_n$	In manufacture of raincoats, hand bags, leather clothes and vinyl flooring.
Polytetrafluoro - ethylene (PTFE) or Teflon	$CF_2=CF_2$	$+CF_2-CF_2+_n$	As lubricant, insulator and making cooking wares.
Polyacrylonitrile (PAN) or Orlon	$CH_2=CH-CN$	$+CH_2-\underset{\underset{CN}{\vert}}{CH}+_n$	In making synthetic fibres and wool.
Styrene Butadiene Rubber (SBR) or (Buna-S)	 and $CH_2=CH-CH=CH_2$		In making automobile tyres, floor tiles, cable insulation and footwear.
Nitrile rubber (Buna-N)	$CH_2=CHCN$ and $CH_2=CH-CH=CH_2$	$+\underset{\underset{CN}{\vert}}{CH}-CH_2-CH_2-CH=CH-CH_2+_n$	In making oil seals, hose-pipes and tank linings.
Nylon-6 (Perlon-L)		$+\underset{\underset{O}{\Vert}}{C}-(CH_2)_5-\underset{\underset{H}{\vert}}{N}+_n$	In making carpets, ropes and tyre cords.

Nylon-6, 6	$HOOC-(CH_2)_4-COOH$ and $H_2N-(CH_2)_6-NH_2$	$+CO-(CH_2)_4-CONH-(CH_2)_6-NH+_n$	Synthetic fibres, fishing nets, and tyre industries.
Terylene (Dacron)	 and $HOCH_2CH_2OH$		Synthetic fibres, safety belts, tyre cords and tents.
Bakelite (Phenol-formaldehyde resin)	 and HCHO		In making gears, protective coatings and electric fittings.

Molecular Mass of Polymers

- Number average molecular mass, $\bar{M}_n = \frac{\sum N_i M_i}{\sum N_i}$
- Weight average molecular mass, $\bar{M}_w = \frac{\sum m_i M_i}{\sum m_i}$
- The ratio of weight average molecular mass to number average molecular mass is called polydispersity index (PDI).
- Natural fibres usually have PDI equal to 1 while synthetic fibres usually have PDI > 1.

Biodegradable Polymers

- Biopolymers disintegrate by enzymatic hydrolysis and to some extent by oxidation and hence are biodegradable.
- Synthetic polymers are non-biodegradable and hence create disposal problem. To overcome this, biodegradable synthetic polymers have been developed.
  - Poly -β-hydroxybutyrate - co-β-hydroxy-valerate (PHBV) : It is a copolymer of 3-hydroxy-butanoic acid and 3-hydroxypentanoic acid. Used in speciality packaging, orthopaedic devices and in controlled drug release.
  - Poly (glycolic acid) and Poly (lactic acid) or Dextron : A copolymer of PGA and PLA (90 : 10) was the first biodegradable polyester used for stitching of wounds.
  - Nylon-2-Nylon-6 is a step-growth polyamide copolymer of glycine and ∈ -aminocaproic acid.

CHEMISTRY IN EVERYDAY LIFE

Chemicals in Medicines

- Drugs are the chemicals of low molecular masses (~ 100-500 u) which interact with macromolecular targets and produce a therapeutic and useful biological response. These chemicals are called medicines.
- Use of chemicals for therapeutic effect is called chemotherapy.

Classification of Drugs

- Drugs are classified on the basis of