

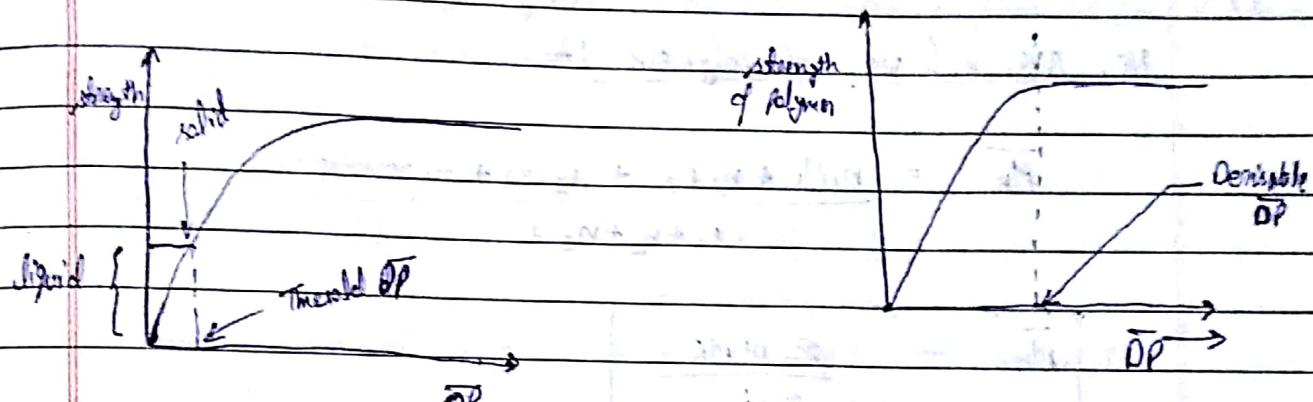
Polymer

Polymer are the macro-molecules which are formed from smaller repeating units called monomers.

→ Monomers are the smaller repeating units of which polymers are formed.

→ It is the process of conversion of monomers into polymers are called polymerization.

Degree of Polymerisation :- It is the no. of repeating unit present in the polymer.



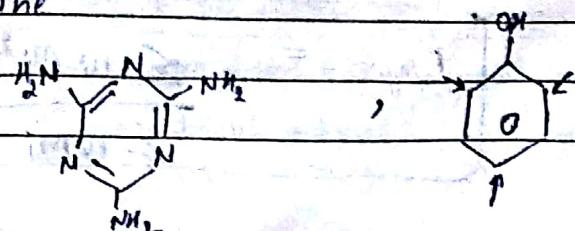
Strength of polymer or Degree of Polymerisation

Functionality of monomers :-

If f is the no. of binding sites present in the monomers, for ex. All, $R-OH$, $R-NH_2$.

Bifunctional \Rightarrow $\begin{array}{c} CH_2-NH_2 \\ | \\ CH_2-NH_2 \end{array}$, $\begin{array}{c} CH_2-OH \\ | \\ CH_2-OH \end{array}$, $\begin{array}{c} H_2N-(CH_2)_6-NH_2 \\ | \\ HOOC-(CH_2)_4-COOH \end{array}$

Trifunctional \Rightarrow Melamine



Significance \Rightarrow

- (i) for polymerisation, monomers have at least two binding sites (bifunctional).
- (ii) Bifunctional monomers give linear and branched chain polymers.
- (iii) Trifunctional polymers give 3-dimensional ^{network} polymers.

Q why avg. mol. wt. of polymer taken?

A It is because some chains are started early and some later due to which polymeric chain of different lengths are formed.

No. avg. mol. wt. of polymers :-

$$\overline{M_n} = \frac{n_1 M_1 + n_2 M_2 + n_3 M_3 + \dots}{n_1 + n_2 + n_3 + \dots}$$

$$\boxed{\overline{M_n} = \frac{\sum n_i M_i}{\sum n_i}}$$

where $n_1, n_2, n_3 =$ no. of monomeric unit present in polymeric chain

The no. avg. mol. wt. of the polymer can be determined by determining the colligative properties such as -

- (i) relative lowering of vapour pressure
- (ii) osmotic pressure
- (iii) elevation in B.P.
- (iv) depression in freezing point

$$\overline{M_{avg}} = \frac{n_1 M_1^2 + n_2 M_2^2 + \dots}{n_1 M_1 + n_2 M_2 + \dots}$$

$$\boxed{\overline{M_{avg}} = \frac{\sum n_i M_i^2}{\sum n_i M_i}}$$

Ø Numerical

1) Calculate the no. of polymer molecule formed from 92 gm of propene. if avg. DP is 100.

$$\text{Sol} - 1 \text{ mole} = 92 \text{ gm} = 6.022 \times 10^{23} \text{ molecules}$$

$$92 \text{ gm monomers} = 6.022 \times 10^{23} \text{ molecules}$$

$$\text{no. of polymer molecule} = \frac{6.022 \times 10^{23}}{100}$$

$$\Rightarrow 6.022 \times 10^{21} \text{ molecules}$$

② Calculate the no. of polymers molecules formed from 18 gm of ethene. if avg. DP is 60.

$$28 \text{ gm} = 6.022 \times 10^{23}$$

$$18 \text{ gm} = \frac{6.022 \times 10^{23} \times 18}{28}$$

$$\text{no. of polymer molecule} = \frac{6.022 \times 10^{23} \times 18}{14.28 \times 60.20}$$

$$= 6.45 \times 10^{21} \text{ molecules}$$

$$\text{Polydispersity index} \rightarrow \frac{\bar{M}_{w,1}}{\bar{M}_n} \quad \frac{\bar{M}_w}{\bar{M}_n}$$

If $\bar{M}_w = \bar{M}_n$ i.e. polymer is monodispersed which means all the polymeric chain of same size.

Q) Calculate the no. avg. and wt. avg. of polymer having 100 molecules of molecular wt. 1000, 200 molecules of mol. wt 2000 and 300 mol. of mol. wt. 3000, also calculate PDI.

$$\text{Sol} - \bar{M}_n = \frac{100 \times 1000 + 200 \times 2000 + 300 \times 3000}{100 + 200 + 300}$$

$$\text{PDI} \rightarrow \frac{10^5 + 4 \times 10^5 + 3 \times 10^5}{600}$$

Classification of Polymer :-

Polymer are classified basically the type of -

ii) on the basis of source \Rightarrow



e.g.

Proteins, DNA,
RNA, cellulose,
starch, amylose,
Amylopectin, silk, wool,
natural rubber

e.g. Polythene, Polypropene
Nylon-6,6, polystyrene,
teflon, decron, Buna-S,
Buna-N, Bakelite,
Urea formaldehyde resin

e.g.- Vulcanized rubber,
cellulose acetate,
cellulose nitrate,
cellulose sulfate

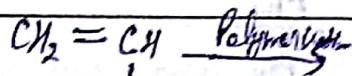
Based on

(iii) mode of polymerization :-

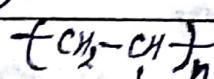
Addition Polymer

Those which prepared by
addition polymerisation

Ex:-



G



G

\Rightarrow With small smaller neutral
molecule like HCl, NH₃, H₂O, N₂S etc.
one removed.

e.g. Nylon-6,6, Nylon-6, Nylon-10, decra,
Bakelite, UF, MF

Ex:-

Monomer

Polymer

If

$\text{C}_2 = \text{H}$ Ethyne

Polyethene

$\text{G} = \text{CH}_3$ Propene

= Cl Vinyl chloride

= OCOCH_3 Vinyl acetate

= CN Acrylonitrile

= Ph styrene

copolymer Polypropene

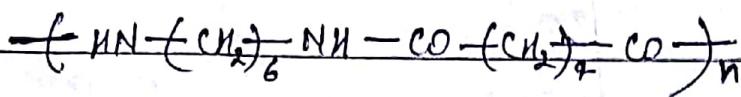
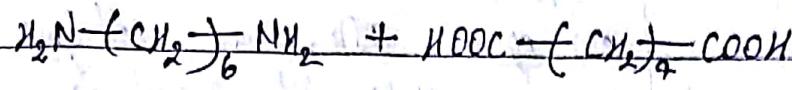
Poly vinyl chloride

Poly vinyl acetate

Poly acrylonitrile

Poly styrene

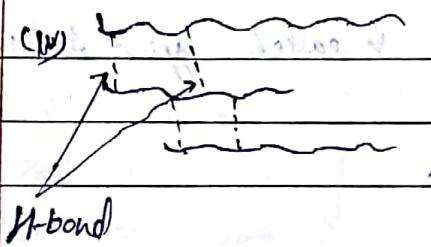
Nylon 6,6



(III) Based on heat treatment →

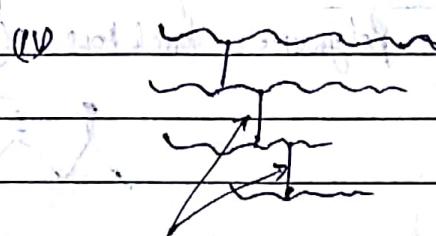
Thermoplastic

- (i) They softens on heating and hardens on cooling
- (ii) they can be remolded & reshaped.
- (iii) Either H-bonding and van der wall forces of attraction



Thermosetting

- (i) They do not softens on heating and hardens on cooling
- (ii) they can't be remolded and reshaped.
- (iii) Cross-linking b/w the polymeric chain, chains are bonded through covalent bond.



(iv) ex - Nylon 66, Polystyrene, Teflon etc.

(v) ex - Bakelite, UF, melamine formaldehyde resin (MF)

(IV) Based on molecular forces ⇒

Four types ⇒ elastomers, fibres, Thermoplastic, Thermoset

Elastomers

Fibres

(i) This type of bonding is weak van der waal forces.

(ii) ex. Natural rubber, Uncrossed rubber, synthetic rubber, Banane-S, Banane-N.

(i) This type of polymers have thread like appearance.

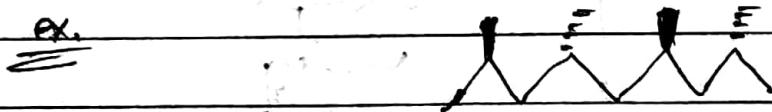
(ii) ex - silk, wool, cellulose nitrate, synthetic wool. (rayon).

(V) Based on tacticity \Rightarrow

(i) Isotactic \Rightarrow If the substituents are present on the same side of polymeric backbone (C-chain) is called isotactic polymer.



(ii) Syndiotactic \Rightarrow If the sub. are present on the alternate side of polymeric backbone (C-chain) is called syndiotactic.



(iii) Astactic \Rightarrow If substituents are randomly arranged around the polymeric backbone (C-chain) is called astactic.



→ Based on structure →

polymers can be classified -

(i) Linear chain polymer :- This type of polymers has linear chain structure.

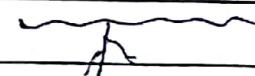
ex. High density polythene, PVC, Teflon etc.



(ii) Branched chain polymer :-

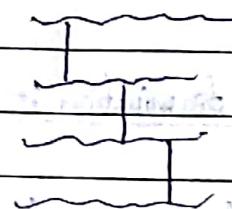
This type of polymers have branches along with the linear structure on which have branched chain structure.

ex. Low density polythene, Polystyrene etc.



(iii) 3-D network → This type of polymers have cross-linkage b/w the polymeric chain.

ex. Bakelite, UF, MF etc.

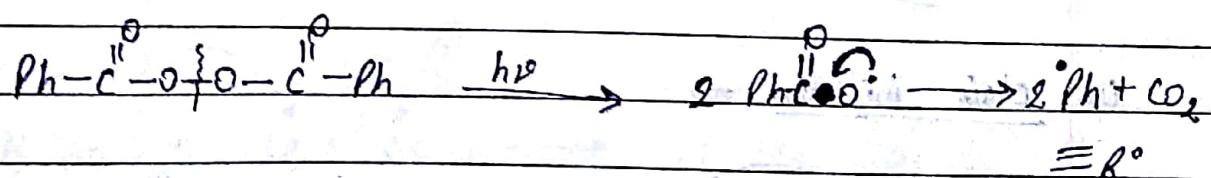


Mechanism of addition polymerisation :-

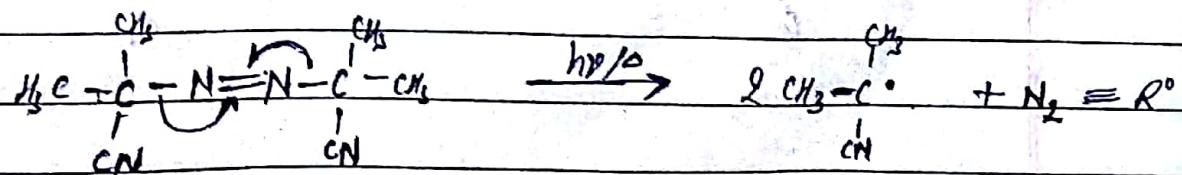
(Chain growth polymerisation)

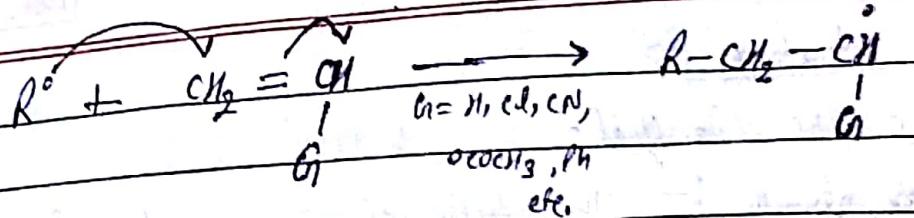
(i) Free radical polymerisation :-

(i) Chain initiation :- $\text{H}_2\text{O}_2 \xrightarrow{\text{hv}/\Delta} 2\dot{\text{OH}} \equiv R^\bullet$

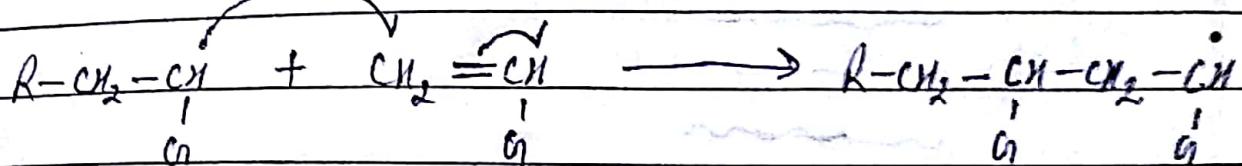


AIBN (Azo Isobutyronitrile)

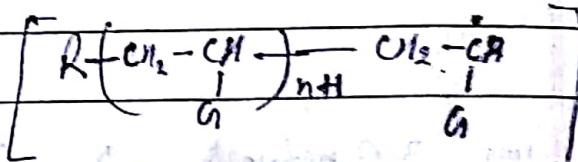




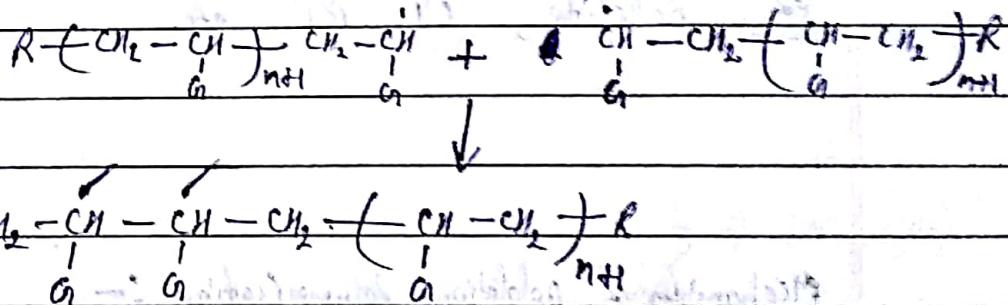
(ii) chain propagation \Rightarrow



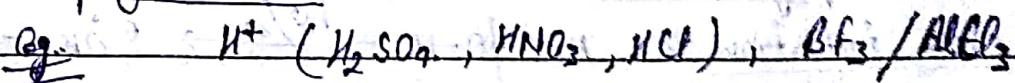
$n(\text{CH}_2=\text{CH})$ $n-1$ steps



(iii) chain termination :-



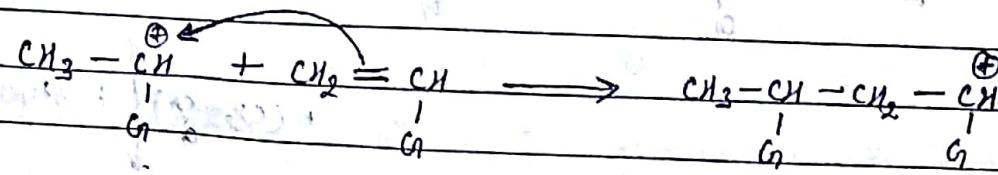
Cationic Polymerization \Rightarrow



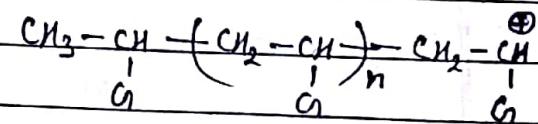
(i) chain initiation \Rightarrow



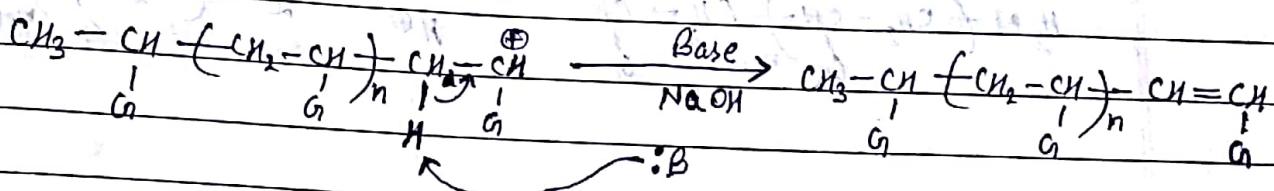
(ii) Chain propagation \Rightarrow



$n (\text{CH}_2 = \underset{\text{G}}{\text{CH}})$ \downarrow n-steps

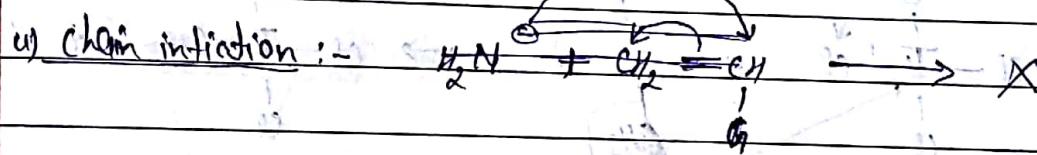


(iii) Chain termination \Rightarrow



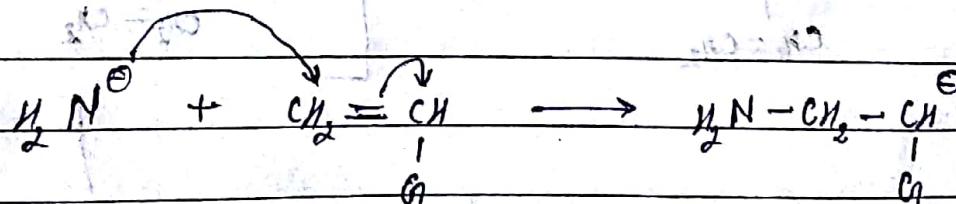
Anionic Polymerisation :-

Initiator $\Rightarrow \text{OH}^\ominus, \text{NH}_2^\ominus, \text{R}^\ominus$

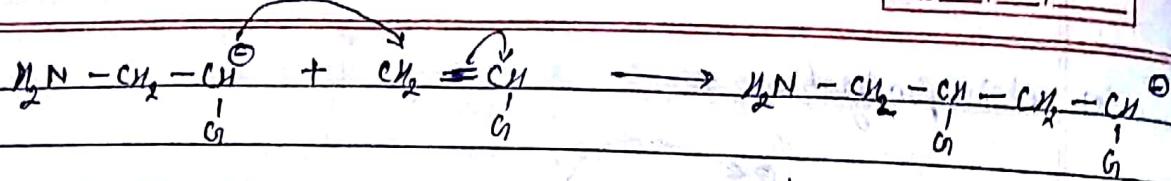


where G = Electron withdrawing group.

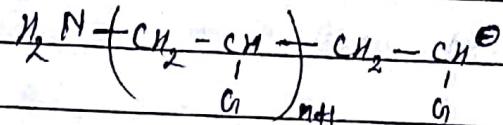
ex:- CN, Ph, $\text{C}''-\text{OCH}_3$



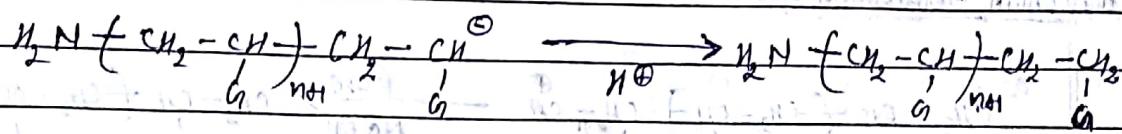
(ii) Chain propagation \Rightarrow



$n(\text{CH}_2=\text{CH})$ | h-steps

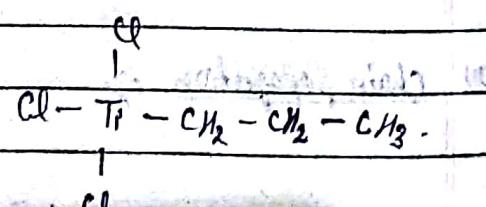
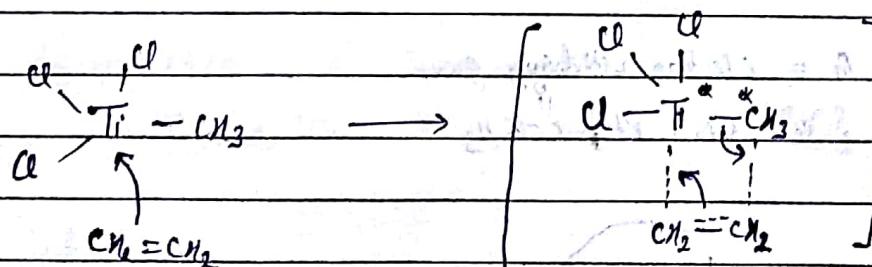
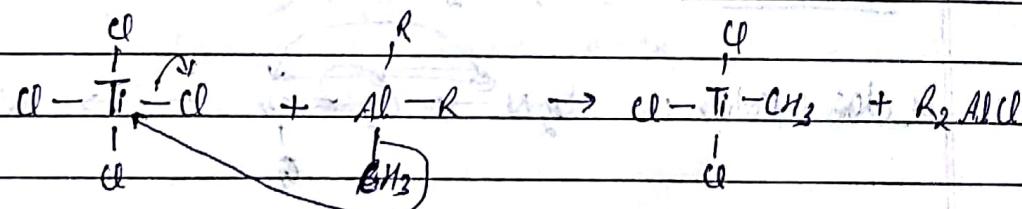


(iii) chain termination \Rightarrow

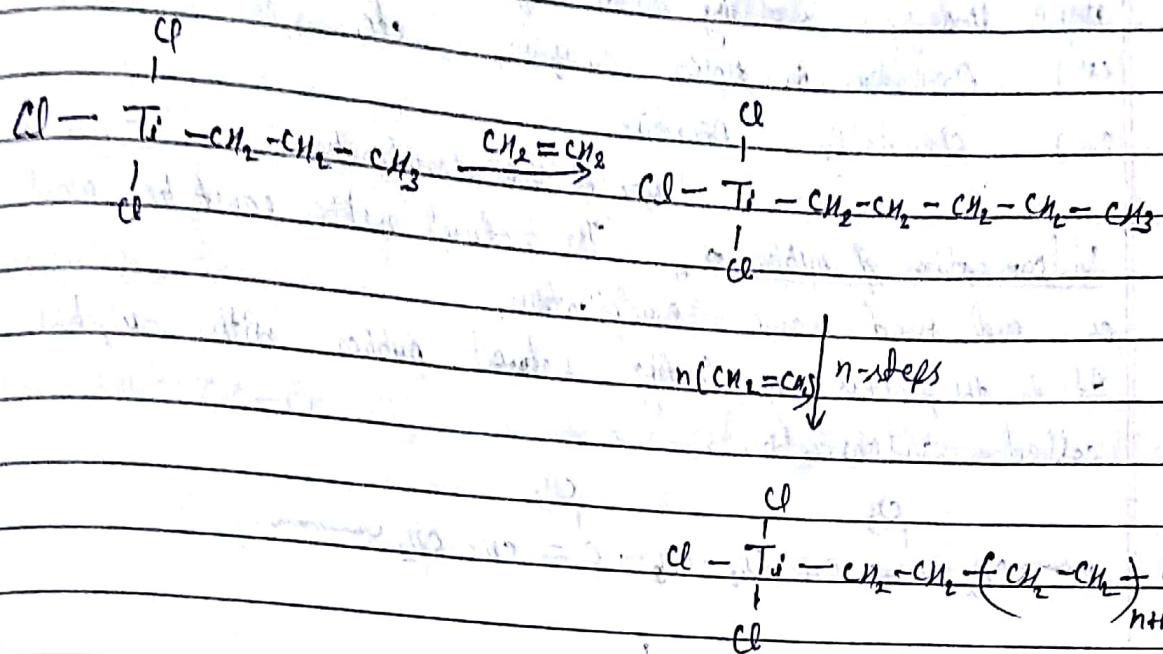


Coordination polymerisation :- Ziegler-Natta catalyst $\rightarrow (\text{TiCl}_3 + R_2\text{AlCl})$

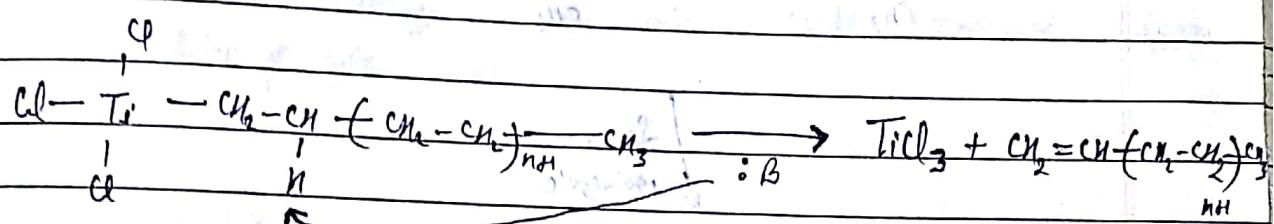
(i) Chain initiation \Rightarrow



Chain Propagation

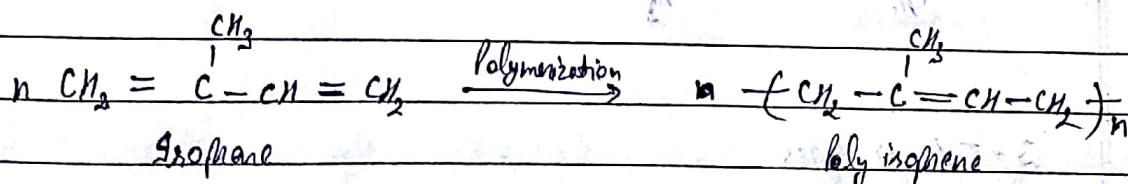


Chain termination \Rightarrow



(I) Elastomers / Rubber :-

\Rightarrow (i) Natural rubber :- Polyisoprene



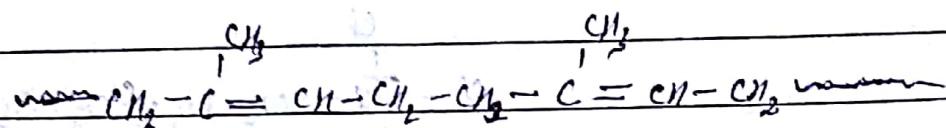
Disadvantages \Rightarrow

- (i) It is highly elastic.
 - (ii) soft and sticky.
 - (iii) Poor working temp. range
 - (iv) Low mechanical strength
 - (v) low tensile strength

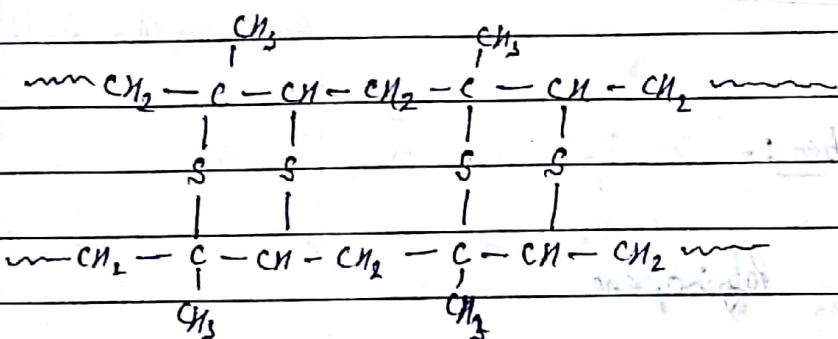
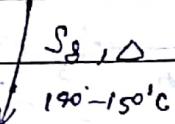
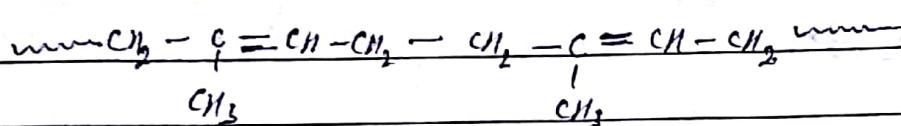
- (vi) Undergo swelling in organic solvent
- (vii) Oxidation in HNO_3 , H_2SO_4 etc.
- (viii) chemically reactive

Vulcanization of rubber \Rightarrow The natural rubber can't be used such as and need some modification.

It is the process of heating natural rubber with sulphur is called vulcanization.



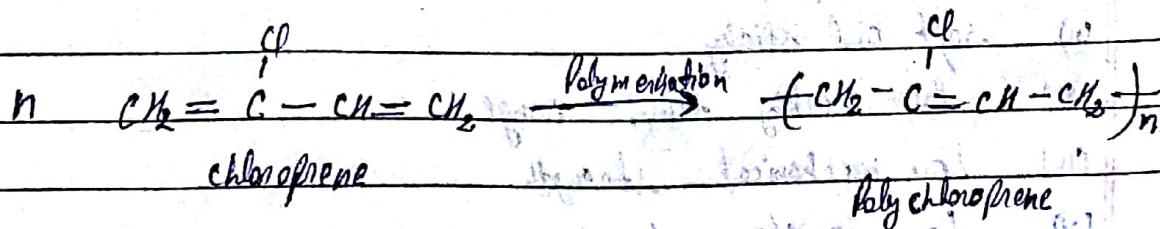
+



3-5% \Rightarrow types

30% Ebonite \Rightarrow air craft / space craft

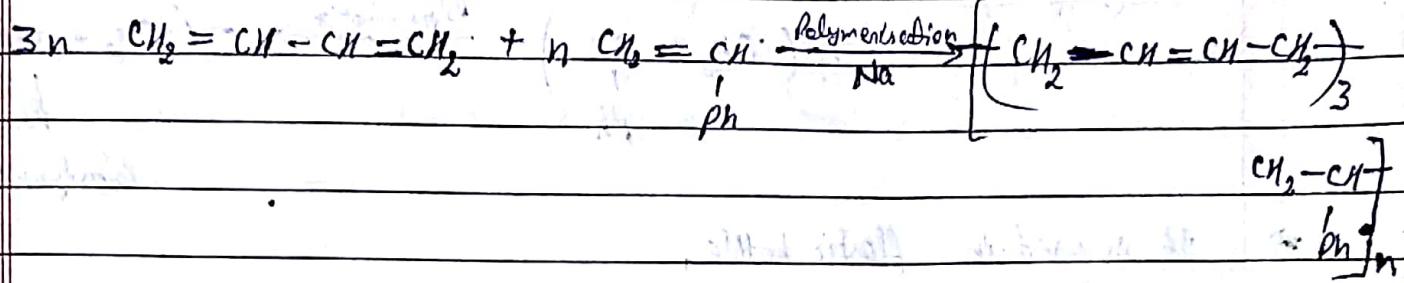
Synthetic rubber \Rightarrow



→ It is used making hair band, rubber band, tyres, shoe soles, carpet, eraser, window hoses.

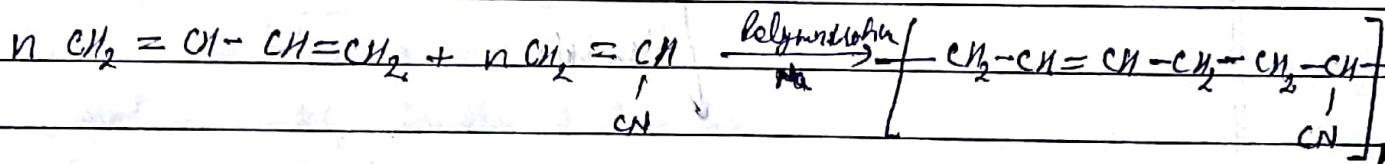
\Rightarrow Bunna-S (Styrene butadiene rubber - SBR)

fication \Rightarrow (3:1)



→ It is used in making shoes, soles, carpet, door mat, tyres, tube of tyres etc.

\Rightarrow Bunna - N (Nitrile Butadiene Rubber - NBR)



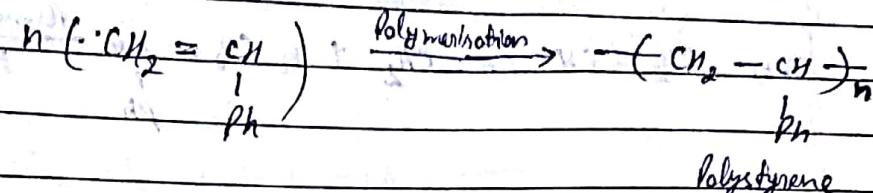
→ It is used in aircraft, space craft, printing roller, conveyor belt, computer components etc.

(II) Thermoplastic \Rightarrow

c) Teflon \Rightarrow $n \text{ CF}_2 = \text{CF}_2$ Polymerisation $\rightarrow (\text{CF}_2 - \text{CF}_2)_n$
tetrafluoroethene link Teflon

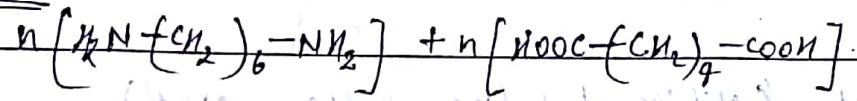
- (i) It is used in cooking of non-sticky cookware.
- (ii) Cable and wire insulation.
- (iii) house hold containers.
- (iv) TV, radio jacket etc.

⇒ Polystyrene ⇒

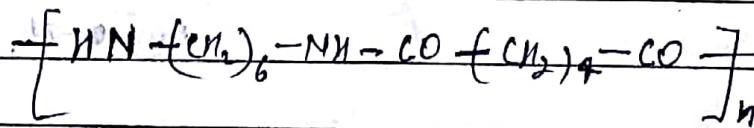


- ⇒ It is used in plastic bottle,
- ⇒ Used in making tiffin box,
- ⇒ Used in making pen.
- ⇒ Used in making house hold container, table, chair etc.

⇒ Nylon 66 :-



↓
Polymerisation

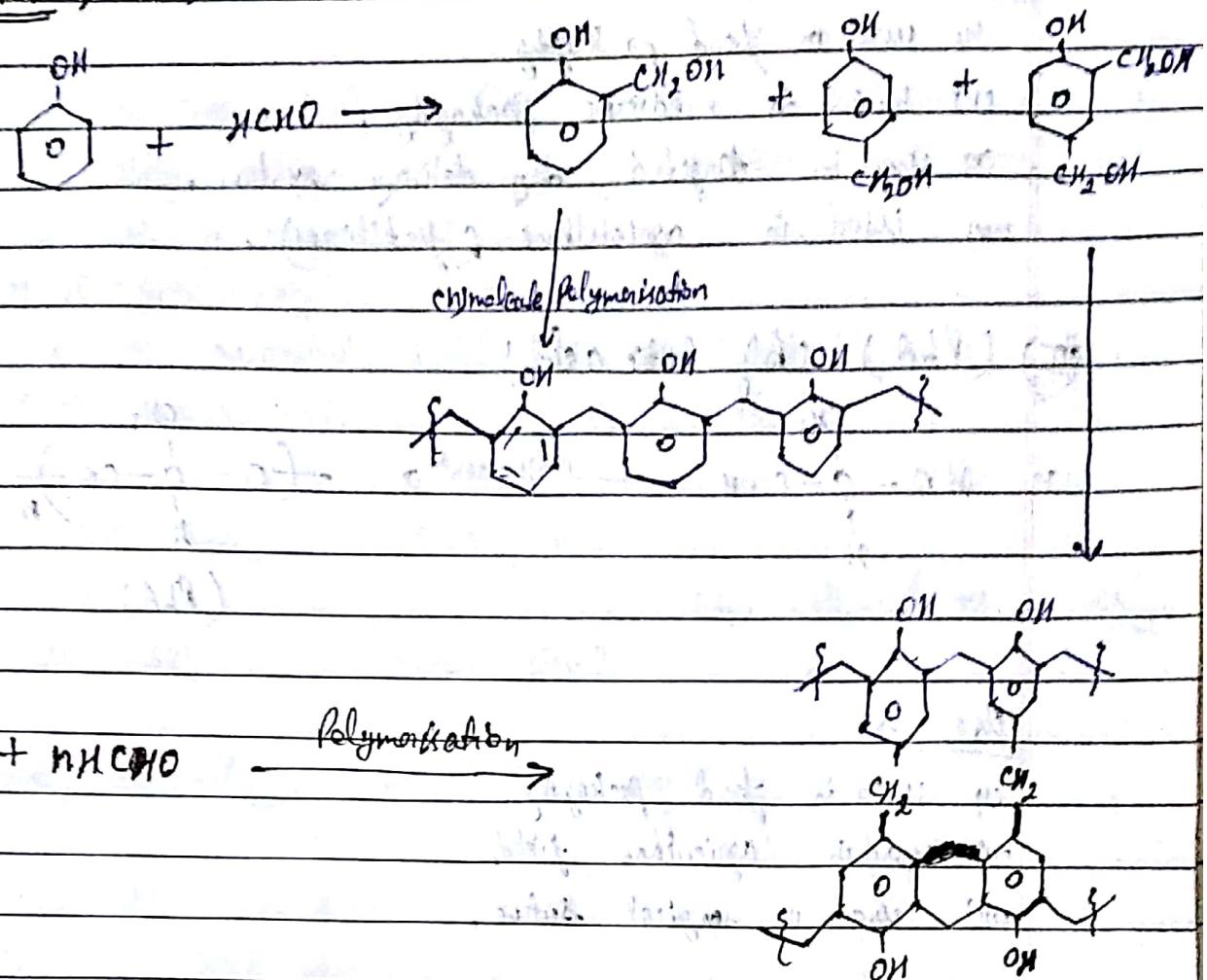


Nylon-66

Uses

- (i) Cloths
- (ii) fibres, Carpet
- (iii) bristle of tooth brush, wash brush
- (iv) toys, bottles, ropes etc.

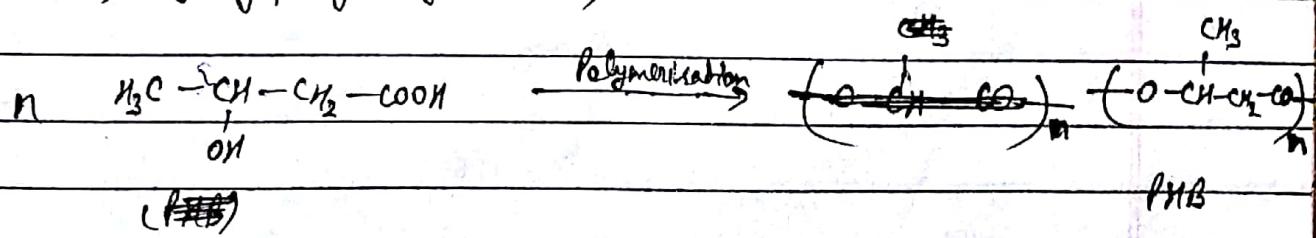
Bakelite \rightarrow (PF)



- (i) making switches, insulation of cables.
- (ii) used in insulation of wires.
- (iii) used in making handles of cookware
- (iv) insulation of electric motors
- (v) used in making gadgets of electric wares.

Biodegradable polymers \Rightarrow

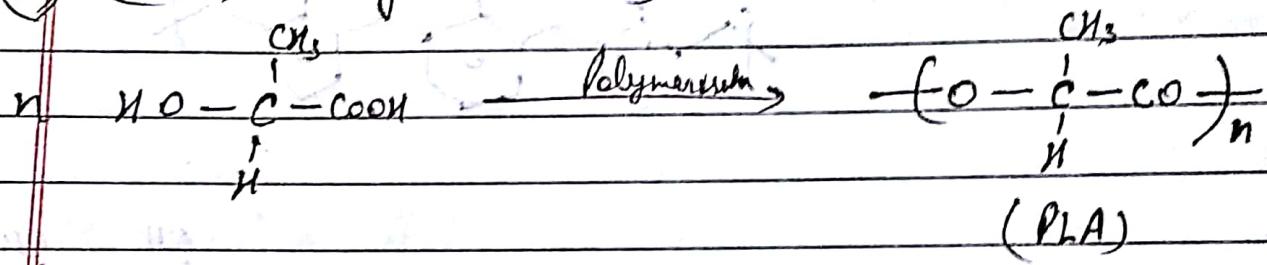
(I) (PHB) (Poly β -hydroxy butyrate)



Uses →

- (i) used in food packaging
- (ii) used in medicine packaging.
- (iii) used in targeted drug delivery system.
- (iv) used in agriculture (fertilizer).

(iii) (PLA) (Poly lactic acid)



Uses →

- (i) used in food packaging.
- (ii) used in agriculture field.
- (iii) used in surgical suture.