2/12/22

CHEMISTRY

UNIT-(4)

Polymer

$$n\,CH_2=CH_2 \xrightarrow{\Delta,\ O_2} -\!\!\left[CH_2-CH_2\right]\!\!-_{n}$$

n → Degree of polymerisatⁿ

↓

indicates no. of monomers joined to form polymer.

$$\boxed{D_p = \frac{M}{m}}$$

M → Molecular wt. of polymer

m → " " " monomer

Dp → Degree of polymerisatⁿ

Page No.			
Date			

Monomer

- **functionality** → no. of bonding sites which a monomer have.

Malonic acid – $HOOC-CH_2-COOH$ → Bifunctional
glycol – $HO-CH_2-CH_2-OH$ → Bifunctional
Penterythritol – 5 'OH' → Pentafunctional
Aniline – Monofunctional ($C_6H_5NH_2$)
CH_3COOH – Monofunctional.

$CH_2=CH_2$ → Bi → $-CH_2-CH_2-$

$CH\equiv CH$ → Tetra → $>CH-CH<$

Types of Polymers (I)

Homopolymers → only one kind of monomers

$-M_1-M_1-M_1-M_1-$

Copolymers → more than one kind of monomers

$-M_1-M_2-M_1-M_1-M_2-$

- Linear
- Branched
- Cross-Link

→ Types of Polymers (II)

III
- **Linear regular copolymer :→** (regular pattern) $-M_1-M_2-M_1-M_2-M_1-M_2-$

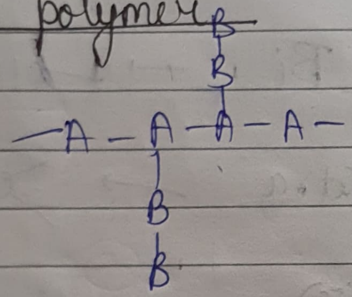
- **Linear irregular copolymer :→** (irregular pattern)

  $-M_1-M_2-M_2-M_1-M_2-$

IV
- **Block-chain polymer**

  $-\underbrace{A-A-A-A}-\underbrace{B-B-B-B}-\underbrace{A-A-A-A}-$

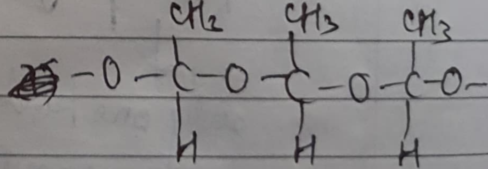
- **Graft polymer**



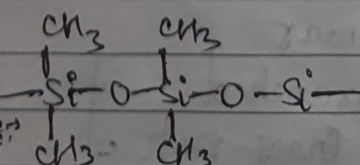
- **Main chain** → one type of monomer
- **Branched chain** → diff. type of monomer

- Homochain polymer.

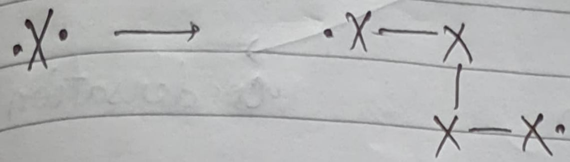
→ **Polyethylene adipate :→**



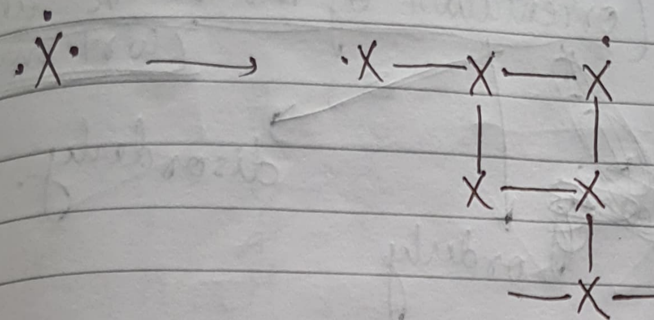
→ **Polydimethyl siloxane :→**



$X\cdot \longrightarrow X-X$



(Linear).



(Cross-linked)

* Min. requirement to make a polymer → **Bi**functional.

Classification of Polymers

* Origin: →

Natural
[obtd. from plants & animals (nature)]

Semi-synthetic
chemical modifications on natural polymers

Synthetic
(man-made)

Page No.
Date

* ## Mode of formation :-

Addition | condensation

* ## Tacticity (orientation of monomeric unit [w.r.t. main chain])

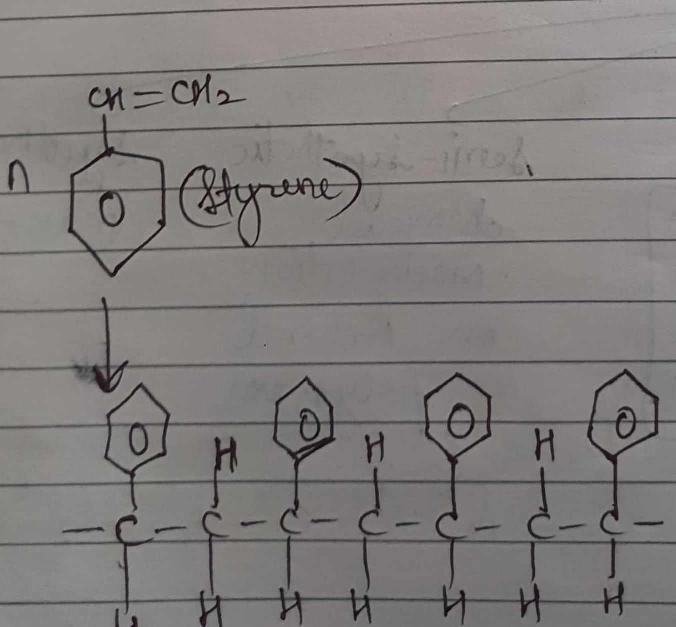
orderly | disorderly

→ ① Isotactic (cis)

→ ② syndiotactic (trans)

→ ③ Atactic (Random)

eg)

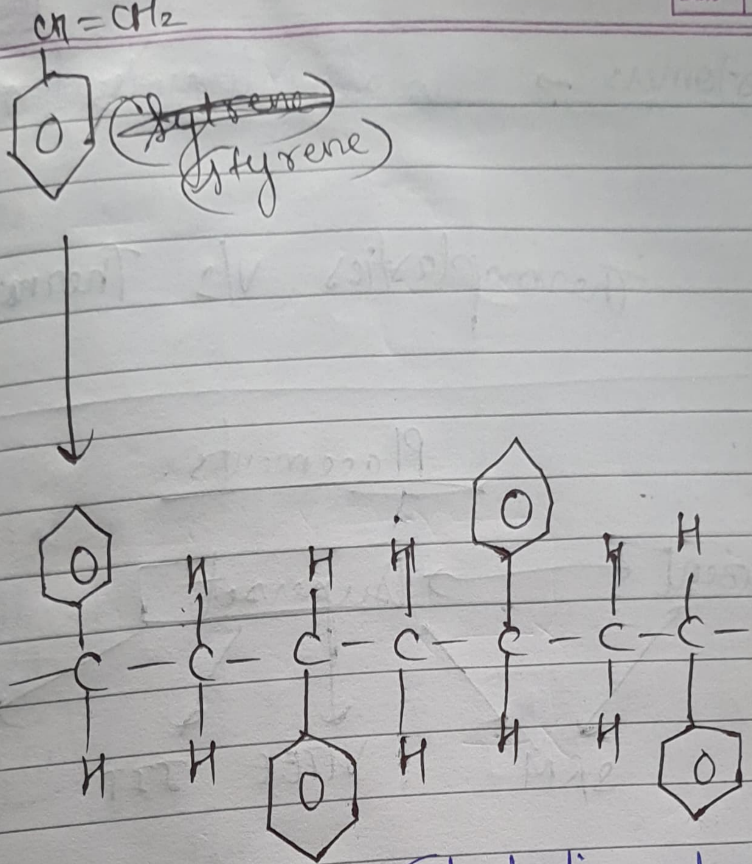


(Isotactic polystyrene)

* Glass Transition Temperature:

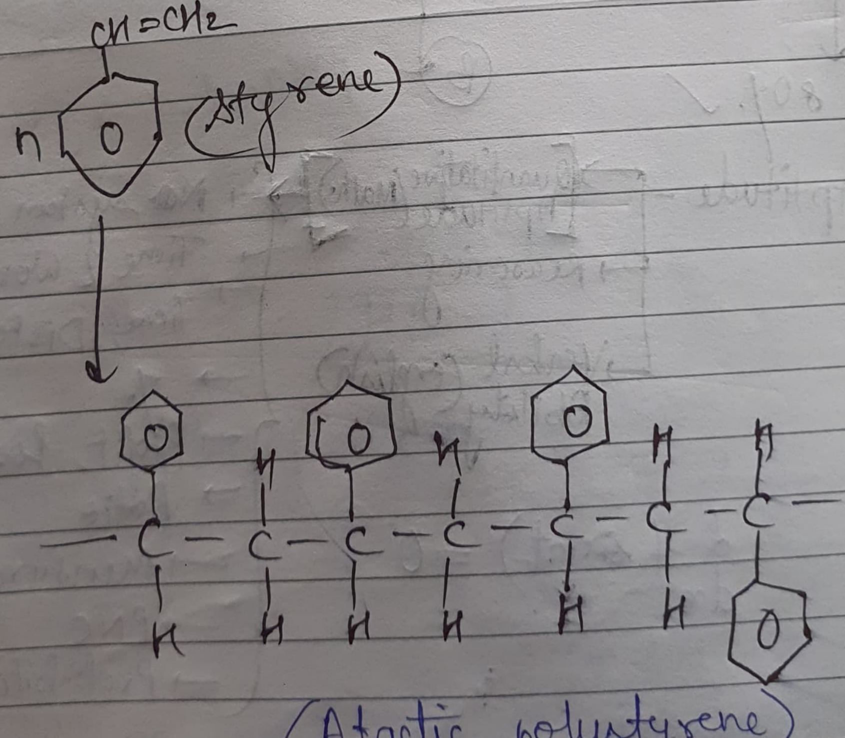
Page No. | Date

eg)



(Syndiotactic polystyrene)

eg)



(Atactic polystyrene)

Date

* Elastomers ⇒ weak intermolecular forces.

Thermoplastics v/s Thermosets

LEO → loss of e^- is oxid^n

GER → gain of e^- is red^n.

Page No. | Date 5|12|22

CHEMISTRY

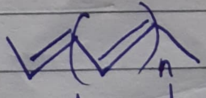
Conducting Polymers

← conducting nature NOT known — 1977 — conducting nature known →

Conducting Polymers

- (A) Intrinsically conducting polymer (C.P.)
  - (a) Conjugated conducting polymer
    - — = — = —
  - (b) Doping/Doped conducting polymer (oxid^n/Red^n)
    - (i) p-type (positive)
      - $\overset{+}{p}$ – Lewis acid (Br_2 / I_2)
      - ↓ oxid^n
    - (ii) n-type (negative)
      - $\overset{-}{n}$ – Lewis base (Na)
- (B) Extrinsically (C.P.) conducting polymer
  - (c) Conducting element filled C.P.
  - (d) Blended C.P.

★ Examples.

(a) $n\,CH \equiv CH$ → 

Acetylene → polyacetylene.

Page No.
Date

(i) $(C_2H_2)_n + \underbrace{3I_2}_{\text{Lewis acid}} \longrightarrow 2[(C_2H_2)_n^{\oplus} \, I_3^{\ominus}]$
[Oxid^n]

(ii) $(C_2H_2)_n + \underbrace{Na}_{\text{Lewis Base}} \longrightarrow (C_2H_2)_n^{\ominus} Na^{\oplus}$
[Red^n]

(c)
- Carbon black
- Metallic Fibres
- Metallic oxides

Applications

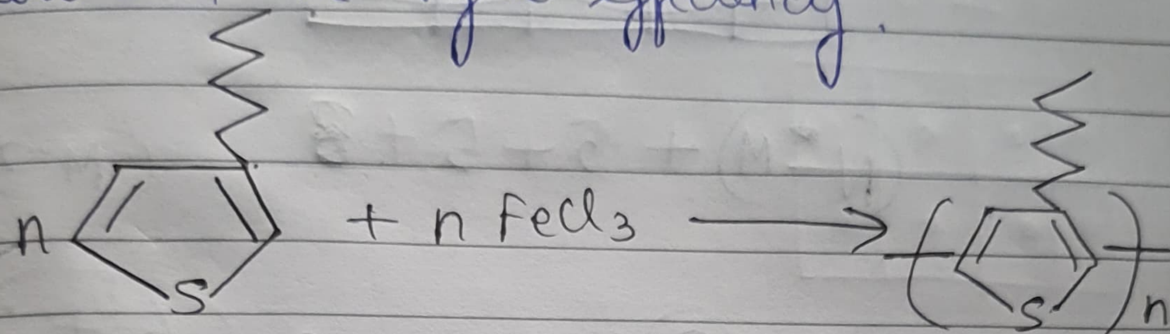
- Rechargeable batteries/cells.
- Solar cells
- Small and very light cells.
- Use in bio-sensors.

P3HT

[Poly (3 hexyl Thiopene)]
(Homo)

- Regioregular property
- used as semiconductor.
- Easy ~~to~~ maintenance
- Low cost & high efficiency.

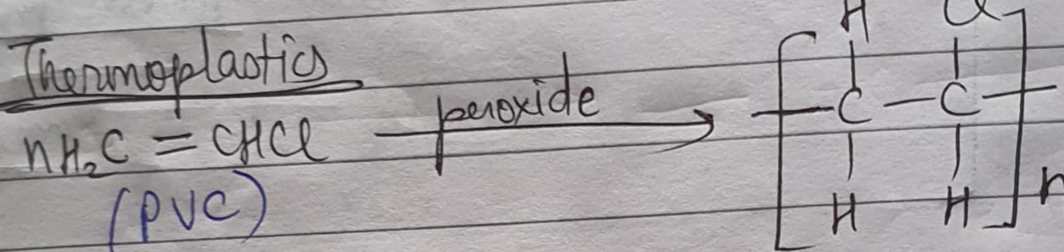
eg)

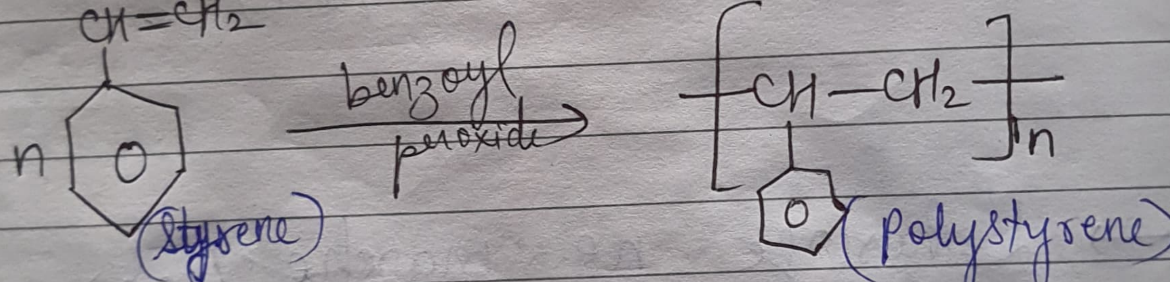


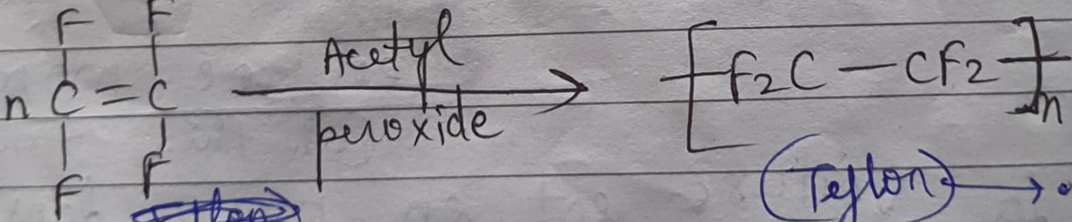
6/12/22

CHEMISTRY

Thermoplastics







(Tetrafluoroethene)

(Teflon) →
- non-sticky
- stable at very high T
- inert for many solvents

Thermosets

Nylon 6,6

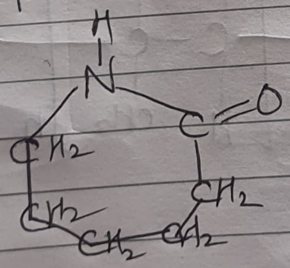
$$H_2N-(CH_2)_6-NH_2 + HOOC-(CH_2)_4-COOH$$
(Hexamethyldiamine) (Adipic acid)

$$\xrightarrow{525\,K,\ P}$$

$$\left[-\overset{H}{\overset{|}{N}}-(CH_2)_6-\overset{H}{\overset{|}{N}}-\underset{O}{\underset{||}{C}}-(CH_2)_4-\overset{O}{\overset{||}{C}}- \right]_n$$

Nylon 6

Caprolactum



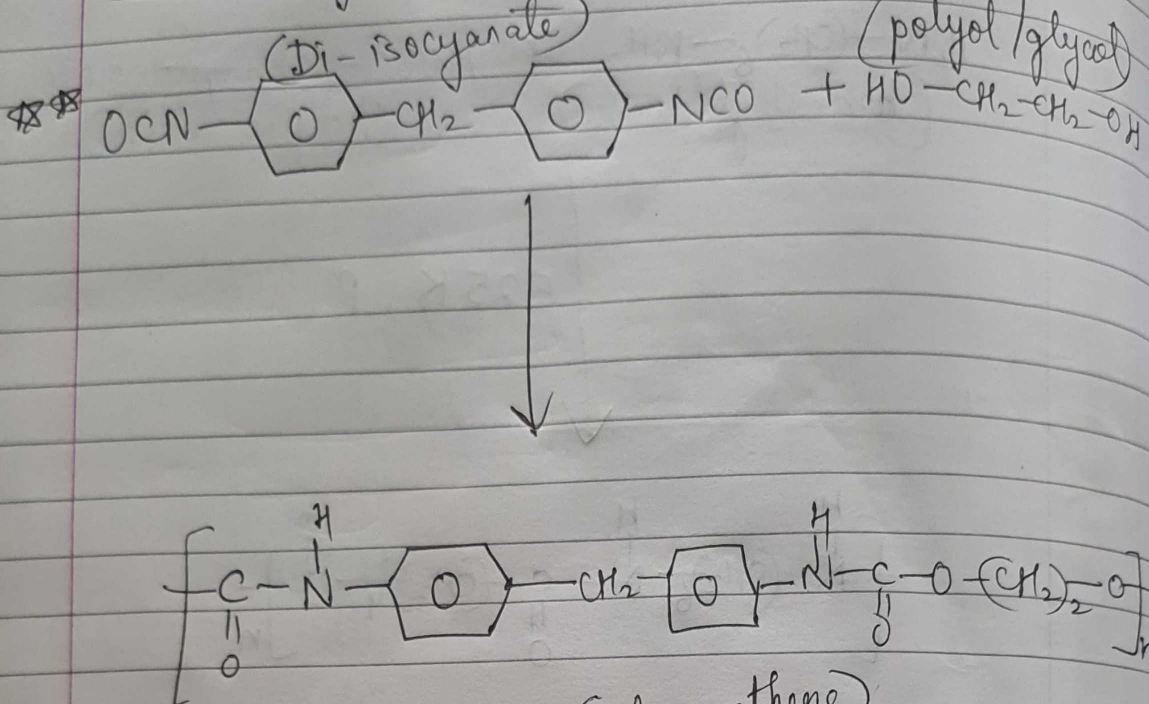
$$\xrightarrow[P]{533-543\,K} \left[-\overset{H}{\overset{|}{N}}-(CH_2)_5-\overset{O}{\overset{||}{C}}- \right]_n$$

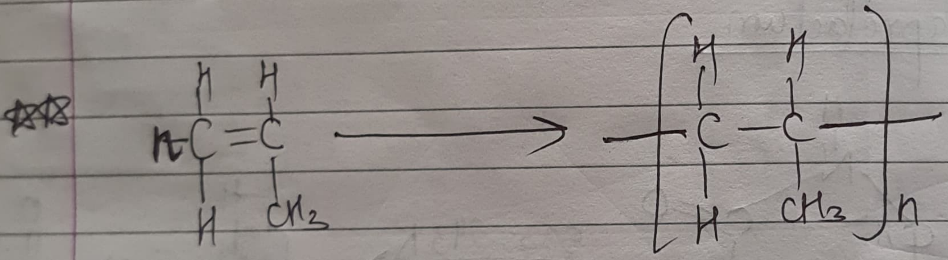
Synthetic Rubber

$$2HC\equiv CH \longrightarrow HC\equiv C-\overset{H}{C}=CH_2 \xrightarrow[343\,K]{HCl} \underset{\text{(Chloroprene)}}{H_2C=CH-\overset{Cl}{C}=CH_2}$$

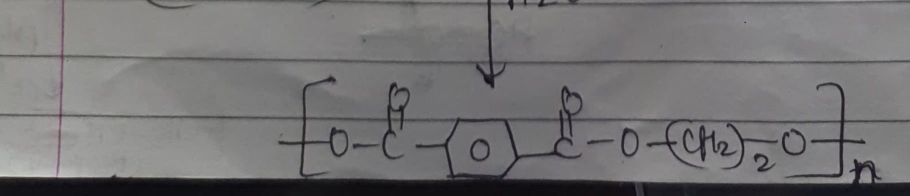
$$\xrightarrow{\text{Polymers}^n} \underset{\text{(Neoprene)}}{\left[CH_2-CH=\overset{Cl}{C}-CH_2 \right]_n}$$

~~Di-isocyanate~~





Terylene → PET



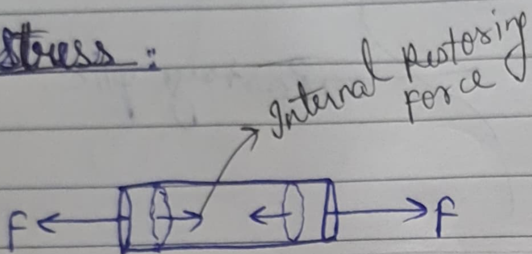
CHEMISTRY

Mechanical Properties of Solids

Solid:

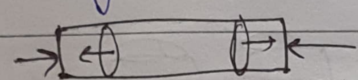
☆☆ **Stress:**

① Tensile:

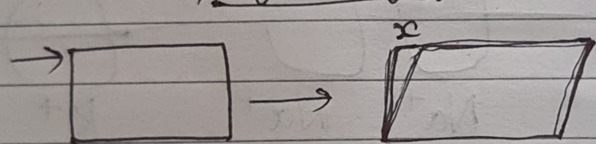


(i) $\boxed{\sigma = \frac{F_R}{A}}$ (Internal Restoring Force) (Unit:→ N/m^2)
A → Area of cross-section

(ii) Compressive



② Shearing:



☆☆ Strain: ~~ratio b/w change in dimension / original dimension.~~

Ratio b/w $\frac{\text{change in dimension}}{\text{original dimension}}$

$$\boxed{\text{Strain} = \frac{\Delta l}{l}}$$

Page No.
Date

Stress ∝ Strain

Stress = E · strain

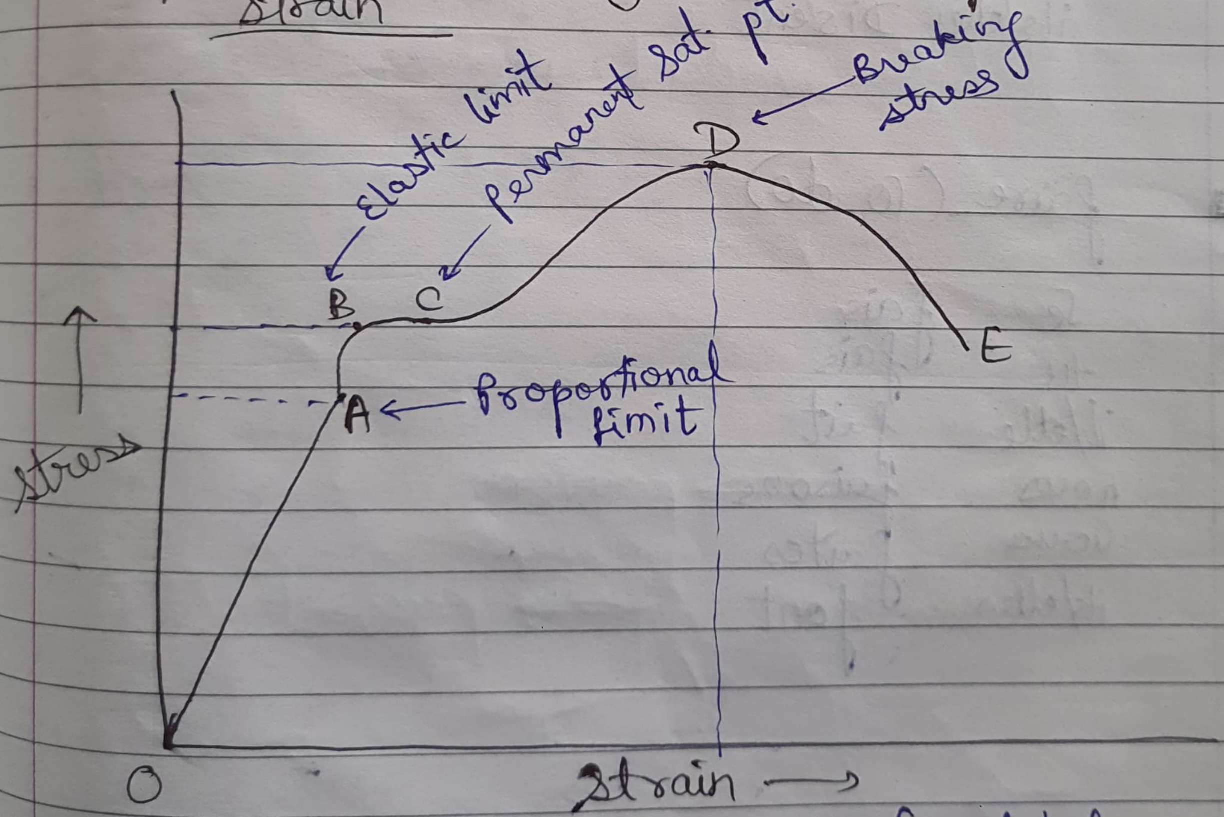
$$E = \frac{\text{stress}}{\text{strain}}$$

elasticity

Young's Modulus (Y) :→

$$\boxed{Y = \frac{\text{Stress}}{\text{strain}}}$$

Graph demonstrating relationship b/w stress & strain



OA → Stress ∝ strain (Hook's law obeyed)
AB → Stress ∝̸ strain
After B point → small stress and large strain

BD → Plastic Region
E → Rupture point

Page No.
Date 8 | 12 | 22

CHEMISTRY

Number avg. mol. wt. method

$$\frac{\text{Total wt. of the polymer}}{\text{no. of mol}}$$

$n_1 \quad n_2 \quad n_3$

$M_1 \quad M_2 \quad M_3$

$$\overline{M_n} = \frac{\Sigma n_i M_i}{\Sigma n_i} = \frac{\Sigma w_i}{\Sigma w_i / M_i}$$

Average wt. mol. wt. method

$$\overline{M_w} = \frac{\Sigma w_i M_i}{\Sigma w_i} = \frac{\Sigma n_i M_i^2}{\Sigma n_i M_i}$$

* 9 moles, $M_1 = 30,000$
* 5 moles, $M_2 = 50,000$

$$\overline{M_n} = \frac{[(9)(30,000) + (5)(50,000)]}{(9+5)}$$

$$= \frac{270000 + 250000}{14}$$

$$= \frac{520000}{14}$$

$=$

Page No.	
Date	

$$\overline{M_w} = \frac{(9)(30{,}000)^2 + (5)(50{,}000)^2}{9(30{,}000) + (5)(50{,}000)}$$

$\boxed{PDI = \frac{M\bar{w}}{M\bar{n}}}$ → tells whether it is homogenous or heterogenous.

Poly-Dispersity Index.

Q. A Poly-Dispersed sample of polystyrene is prepared by mixing 3 ~~samples~~ mono-dispersed samples in the following proportion:→

1. 1gm ; 10,000 M·W.
2. 2gm ; 50,000 M·W
3. 2gm ; 1,00,000 M·W.

Calculate PDI.

Ans $\overline{M_w} = \frac{(1)(10{,}000) + 2(50{,}000) + 2(1{,}00{,}000)}{1+2+2}$

$= \frac{3{,}10{,}000}{5}$

$= 62000$

Page No.
Date

$$\bar{M_n} = \frac{1+2+2}{\left(\frac{1}{10,000} + \frac{2}{50,000} + \frac{2}{1,00,000}\right)}$$

$$= \frac{5}{\frac{10+4+2}{1,00,000}}$$

31250
$\cancel{62,500}$
$\cancel{1,25,000}$
$\cancel{2,50,000}$

$$= \frac{\cancel{5,00,000}}{\cancel{16}\ \cancel{8}\ \cancel{4}\ \cancel{2}}$$

$$= 31,250$$

$$PDI = \frac{\bar{M_w}}{\bar{M_n}}$$

$\cancel{1240}$ 248

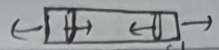
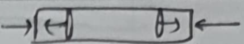
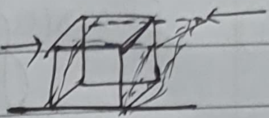
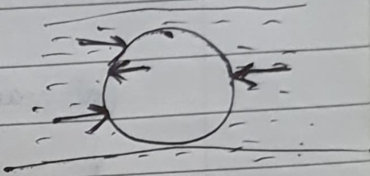
$$= \frac{\cancel{62000}}{\cancel{31250}}$$

$\cancel{625}$
125

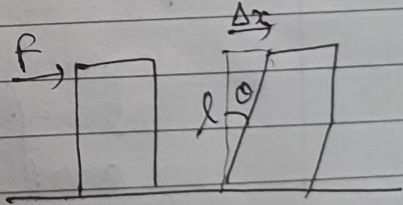
$$= 1.98\ \%$$

Mechanical Properties of Solids

★ Stress

- → Longitudinal
  - → 
    Tensile
  - → 
    Compressive
- → Shearing 
- → Volumetric/Bulk 

★ Strain

- → $\frac{\Delta l}{l}$
- → $\theta = \frac{\Delta x}{l}$ 

- → $\frac{\Delta V}{V}$

Relation b/w stress & strain

stress ∝ strain

stress = E · strain

$$\boxed{E = \frac{\text{stress}}{\text{strain}}}$$

~~Young's Modulus~~

Moduli of Elasticity

(i) Young Modulus → $Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\Delta l / l} \Rightarrow \frac{F}{A} \cdot \frac{\Delta l}{l}$

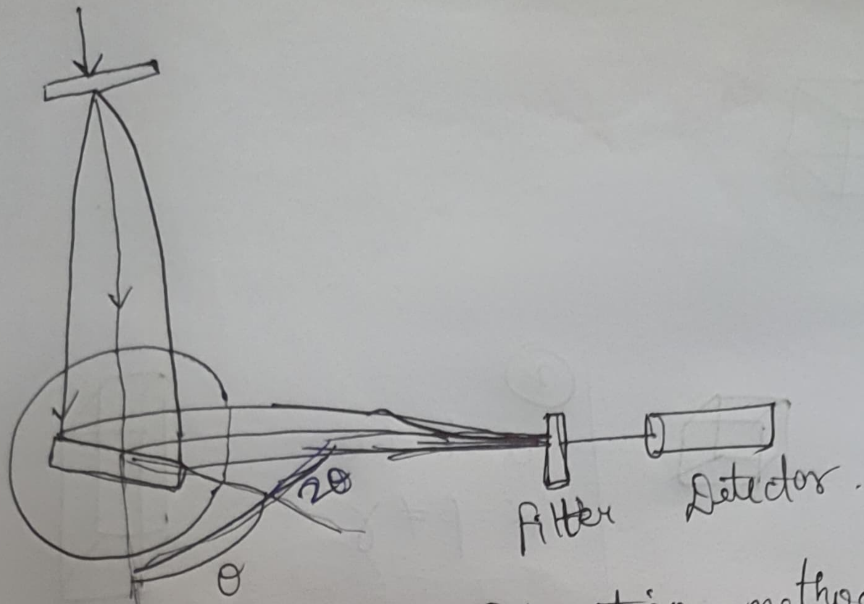
$F \to mg$

$A \to \pi r^2$

(ii) Shearing → $\frac{F/A}{\theta}$

(iii) Bulk / Volume

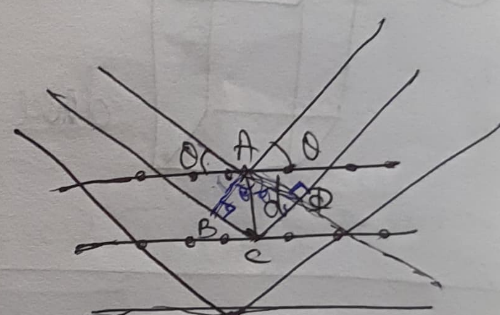
9/12/22



* XRD → X-Ray Diffraction method.

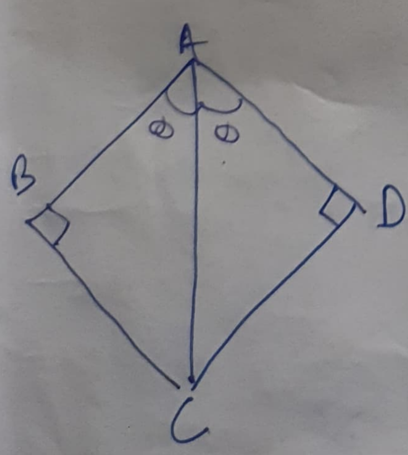
- used to obtain structure / pattern of crystal.
- Source (X-Ray)

$$\boxed{n\lambda = 2d\sin\theta}$$



n = whole no.
λ = wavelength of radiation
d = interplanar spacing

$\sin\theta = \frac{BC}{AC}$

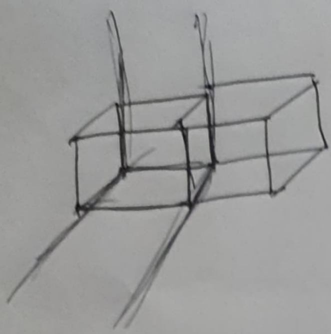


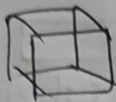
$BC + CD = n\lambda$

$2BC = n\lambda$

$n\lambda = 2\,AC\sin\theta$

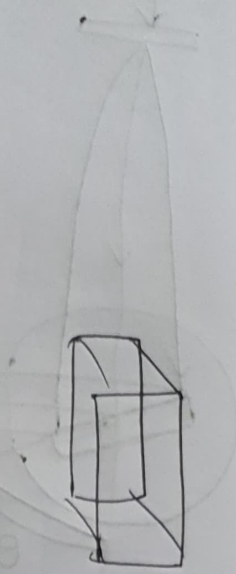
$$\boxed{n\lambda = 2d\sin\theta}$$



(1) $a = b = c$ 

$\alpha = \beta = \gamma$

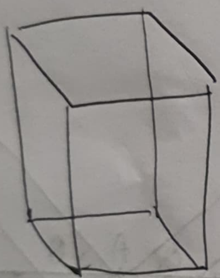
$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

(2) 

$a = b \neq c$

$\alpha = \beta \neq \gamma$

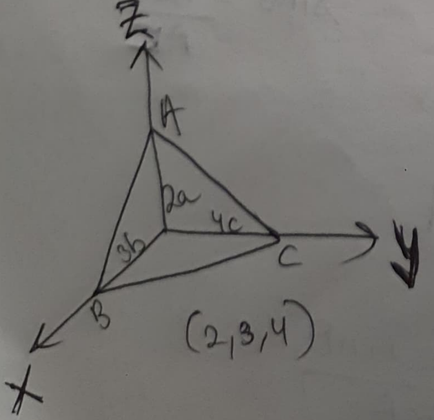
$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2}} + \frac{c}{\sqrt{l^2}}$$

(3) 

$a \neq b \neq c$

$\alpha \neq \beta \neq \gamma$

$$d_{hkl} = \frac{a}{\sqrt{h^2}} + \frac{b}{\sqrt{k^2}} + \frac{c}{\sqrt{l^2}}$$



Q How to obtain mirror indices?

eg ① 2 3 4

② $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{4}$

③ $\frac{6}{12}$ $\frac{4}{12}$ $\frac{3}{12}$

$\Rightarrow$ 6 4 3 $\Rightarrow$ ~~(6, 4, 3)~~ (6 4 3)

eg 1 1 −4

$\frac{1}{1}$ $\frac{1}{1}$ $\frac{-1}{4}$

4 4 −1 $\Rightarrow$ ~~(4, 4, $\bar{1}$)~~ (4 4 $\bar{1}$)

representation of −ve no. in mirror indices.

$-1 \Rightarrow \bar{1}$ ~~(bar)~~
(1 के उपर bar)

~~Q Length of cubic lattice in lithium method in which the separation~~

Q Calculate the mirror indices of mirror ~~pl~~ place which cut the plane at (2a, 3b, c) and (2a, −3b, −3c)

① 2 3 1

$\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{1}$

3 2 6 $\Rightarrow$ ~~(3, 2, 6)~~ (3 2 6)

② 2 −3 −3

$\frac{1}{2}$ $\frac{-1}{3}$ $\frac{-1}{3}$

3, −2, −2 $\Rightarrow$ (3 $\bar{2}$ $\bar{2}$)

Q The parametric of an orthorombic unit cell are

$a = 50$ cm

$b = 100$ cm

$c = 150$ cm

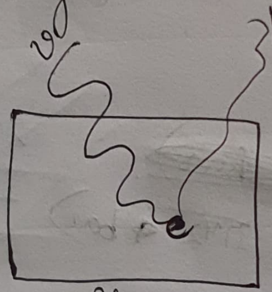
Determine the spacing b/w the 1, 2, 3 plane

Ans
$$\frac{50}{1} + \frac{100}{2} + \frac{150}{3}$$

$$= 50 + 50 + 50 = 150 \text{ cm}$$

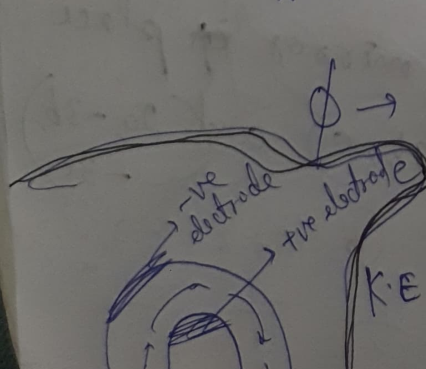
~~Q Calculate the length of a unit cell~~

** (XPS → X-Ray Photon Electron Spectroscopy)



$$h\nu = B.E. + K.E. + \phi$$

ϕ → work fn of instrument.



$$K.E = h\nu - BE - \phi$$

12/12/22

CHEMISTRY

$\gamma = \frac{\text{stress}}{\text{strain}}$
$\text{Strain} = \frac{\Delta l}{l}$
$\text{Stress} = \frac{\text{Force}}{\text{Area}}$

Q1 A wire 2m long and 2mm in diameter when stretched by weight of ~~8kg~~ 8 kg

$\Delta l = 0.24mm$

Find γ, strain & stress.

Ans $l = 2m$

$d = 2mm$

$r = 1mm = 1 \times 10^{-3} m$

$m = 8 kg$

$F = mg = (8 \times 9.8) N$

$\Delta l = 0.24mm = 2.4 \times 10^{-4} m$

- strain $= \frac{\Delta l}{l} = \frac{2.4 \times 10^{-4}}{2} = 1.2 \times 10^{-4}$

$= 0.12mm$

- stress $= \frac{\cancel{8}^{4} \times 9.8}{\cancel{3.14}_{1.57} \times 10^{-6}}$

$\cancel{= 2.5 \times 10^{6}}$

$= 2.5 \times 10^{7} N/m^2$

- $Y = \frac{stress}{strain} = 2.08 \times 10^{11} N/m^2$

Q2 A mild steel wire of radius 0.5mm & length 3m is stretched by a force of 49N. If $Y_{steel} = 2.1 \times 10^{11} N/m^2$. Calculate stress strain, elongation.

$l = 3m$

$r = 0.5mm = 5 \times 10^{-4} m$

$F = 49N$

$$Stress = \frac{f}{A} = 6.238 \times 10^7 \ N/m^2$$

$$Strain = \frac{stress}{Y} = 2.97 \times 10^{-4}$$

$$\Delta l = (strain)(l) = 8.91 \times 10^{-4} m$$

Q3 $l = 1m$

$d = 2mm$

$m = 40kg$

$Y = 7 \times 10^{10} \ N/m^2$

Stress = ? ; Strain = ?

$$stress = \frac{F}{A} = \frac{(40)(9.8) \times 10^{6}}{(3.14)}$$

$$= \frac{(4)(98)(10^{8})}{314}$$

157

$$Strain = \frac{stress}{Y} = \frac{\quad}{7 \times 10^{10}}$$

~~Q4~~

$l = 1.5m$

$r = 0.4mm$

$\Delta l = 1.2mm$

$Y = 12.5 \times 10^{10} N/m^2$

$F = ?$

$$\text{strain} = \frac{\Delta l}{l} = \frac{\cancel{1.2}^{4} \times 10^{-3}}{\cancel{1.5}\,5}$$

$$= 0.8 \times 10^{-3}$$

$$\text{stress} = (\text{strain})(Y)$$

$$= (0.8 \times 10^{-3})(12.5 \times 10^{10})$$

$$= 10 \times 10^{7} = 10^{8}$$

$$\begin{array}{r} 12\overset{(4)}{5} \\ \times\ 8 \\ \hline 1000 \end{array}$$

$$F = \cancel{(10^{8})}(3.14)\cancel{(0.4 \times 10^{-6})}$$

$$(4)(4)\cancel{(10^{-8})}$$

$$= 50.24 N$$

$$\begin{array}{r} 314 \\ \times\ 16 \\ \hline 1884 \\ 314\times \\ \hline 50.24 \end{array}$$

Q5 $\Delta l = ?$

$l = 5m$

strain = 1% of 0.1

$A = 1 mm^2$

$m = 10 kg$, stress = ?

$\frac{1}{100} \times \frac{1}{10} \times 5 = \Delta l$

$\Delta l = 0.005 m = 5 \times 10^{-3} m = 5 mm$

$$\text{Stress} = \frac{(10)(9.8)}{1 \times 10^{-6}} = 98 \times 10^{6} N/m^2$$

$$= 9.8 \times 10^{7} N/m^2$$

14/12/22

CHEMISTRY

COMPOSITES

- Matrix
- Reinforced material
  - Particle
  - Fibres
  - Structural

Matrix + Reinforced material = Composites