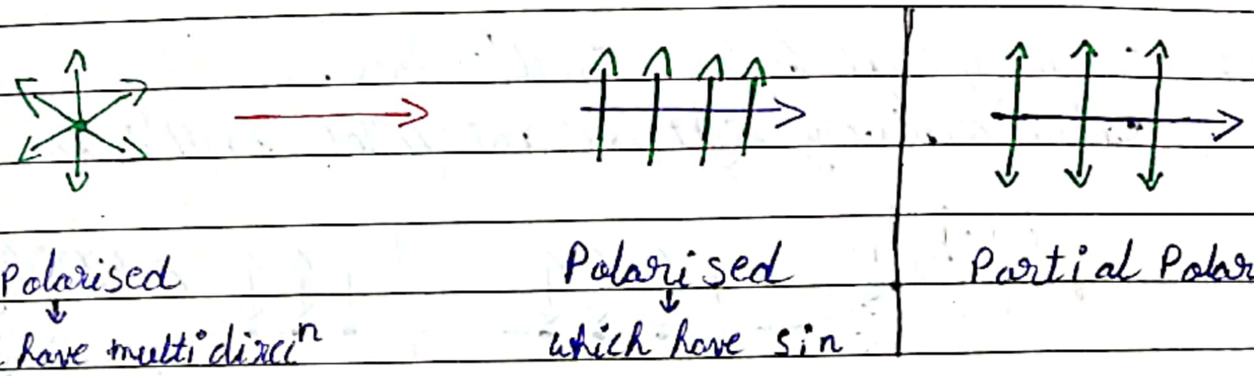
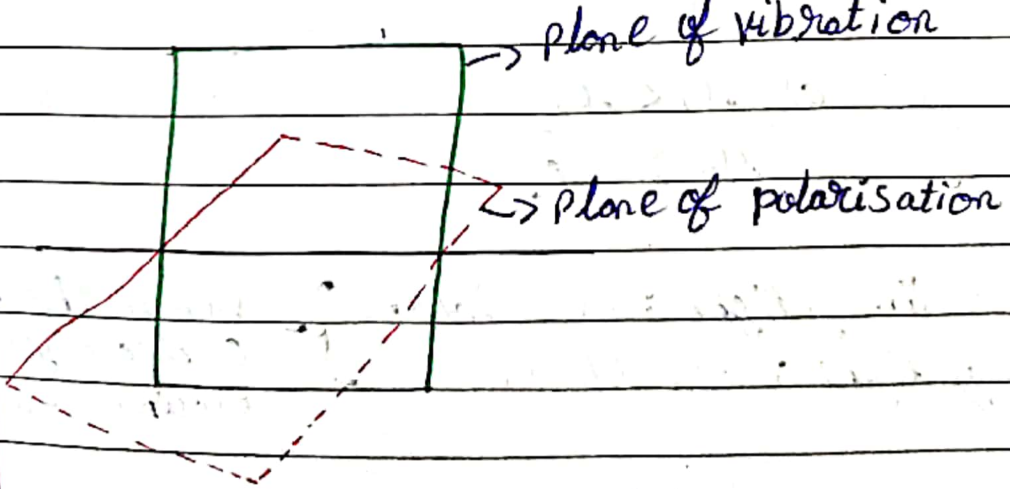
Polarisation

The Phenomenon by which we can convert ~~of~~ unpolarised light to polarised light. Ordinary light has infinite directions of propogation.



⇒ **Plane of vibration :-** The Plane containing dirⁿ of vibration & direction of Propagation of light vector.

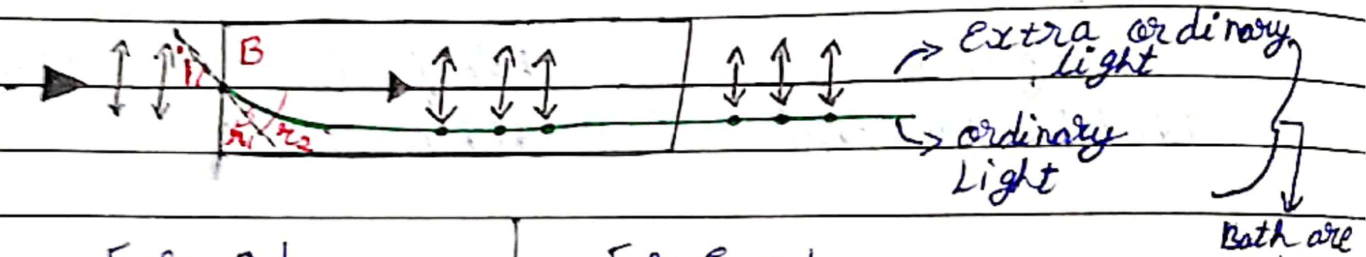


⇒ **Plane of Polarisation :-** A Plane which have the information of direction of Propogation of light.

Double Refraction

When an ordinary light Passes from calloid crystal it give two refracted light. one is ordinary light & other is extra ordinary light.

Note: ordinary light fallows Snell's law.
Extra ordinary light does not fallow Snell's law.



For O.L	For E.O.L
$\mu_o = \dfrac{\sin i}{\sin r_1}$	$\mu_e = \dfrac{\sin i}{\sin r_2}$

as $r_1 < r_2$

$$\boxed{\mu_o > \mu_e}$$

∴ Extra ordinary light move faster.
→ ordinary light move slow.
} ← Due to this behaviour Calcide crystal is Known as -ve crystal.

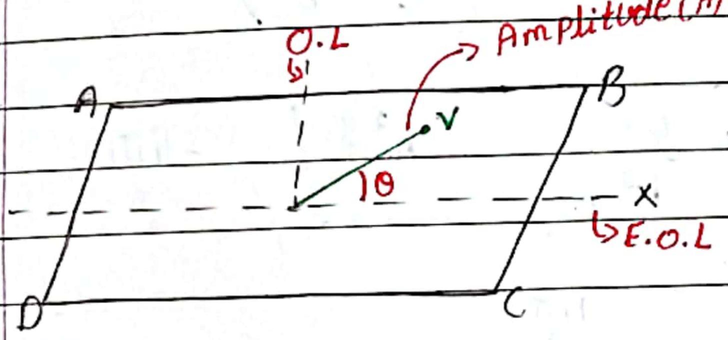
The Crystal in which μ is higher for O.L in comparision of E.O.L it is called as -ve crystal.

Example of -ve crystal :- Calcite, tourmaline, Ruby

Example of +ve crystal :- Quartz, iron ; oxide

Superposition of two linearly Polarised light

Let us consider a Calcite crystal ABCD & a linearly Polarised light.



: θ is the angle made by Polarised light w.r.t optical axis.

we know that,

$$\mu_o > \mu_e$$
$$\text{i.e} \quad V_e > V_o$$

Since EOL moves faster than O.L it must have δ Phase difference.

$x = A\cos\theta \sin(\omega t + \delta)$ —(i)	as we studied in interference
$y = A\sin\theta \sin(\omega t)$ —(ii)	$Y_1 = a\sin\omega t$
	$Y_2 = a\sin(\omega t + \delta)$

Let.

$$A\cos\theta = a \quad , \quad A\sin\theta = b$$

$$x = a\sin(\omega t + \delta) \quad , \quad y = b\sin\omega t$$

$$\frac{x}{a} = \sin\omega t\cos\delta + \cos\omega t\sin\delta$$

$$= \sin\omega t\cos\delta + (1 - \sin^2\omega t)^{\frac{1}{2}}\sin\delta$$

$$= \frac{y}{b}\cos\delta + \left(1 - \frac{y^2}{b^2}\right)^{\frac{1}{2}}\sin\delta$$

$$\left(\frac{x}{a} - \frac{y}{b}\cos\delta\right) = \left(1 - \frac{y^2}{b^2}\right)^{\frac{1}{2}} \sin\delta$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2}\cos^2\delta - \frac{2xy\cos\delta}{ab} = \left(1 - \frac{y^2}{b^2}\right)\sin^2\delta$$

$$\boxed{\frac{x^2}{a^2} - \frac{2xy\cos\delta}{ab} + \frac{y^2}{b^2} = \sin^2\delta} \quad \text{-(iii)}$$

Case 1: When $\delta = \frac{\pi}{2}, \frac{3\pi}{2} \text{ --- } \frac{n\pi}{2}$

$\cos\delta = 0$, $\sin^2\delta = 1$

$$\boxed{\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1}$$ ← This shows condition of eliptical polarised light.

Case 2: When $\theta = 45^\circ$ & $\delta = \frac{n\pi}{2}$

[$\cos 45 = 1/\sqrt{2}$

$\sin 45 = 1/\sqrt{2}$]

$A\cos\theta = a$ & $A\sin\theta = b$

$a = A/\sqrt{2}$ $b = A/\sqrt{2}$

$\therefore a = b$ [Putting in eq^n]

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$\boxed{x^2 + y^2 = a^2}$ or $\boxed{x^2 + y^2 = b^2}$

This shows conditions of circular polarised light.

Case 3: When $\delta = 0$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy\cos\delta}{ab} = \sin^2\delta$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} = 0$$

$$\left(\frac{x}{a} - \frac{y}{b}\right)^2 = 0$$

$$\therefore \quad \frac{x}{a} = \frac{y}{b} \Rightarrow x \cdot \frac{b}{a} = y$$

as $\left.\begin{array}{l} a = A\cos\theta \\ b = A\sin\theta \end{array}\right\} \frac{b}{a} = \tan\theta \Rightarrow$ Slope (m)

$$\boxed{y = mx}$$

This show condition of straight line.

Q = What are the necessary condition for circular light.

(i) $\delta = n\pi/2$

(ii) $\theta = 45°$

(iii) both 1 & 2 ✓

(iv) None of these

Optical Activity

When the polarized light pass through crystal, the Plane of vibration & plane of Polarisation for incident & emerging light is not same.

The substance which shows this Property is called optically active.

There are two types of optically active substance :-

i) Right handed / Dextro-rotatory / Clockwise rotatory :-

The substance rotate the Plane of vibration in the right hand / clockwise direction.

ii) Left handed / Laevo-rotatory / Anticlockwise rotatory :-

These Substances rotate the Plane of vibration in the left hand / anticlockwise direction.

Specific Rotation :- The Specific rotation of an optically active Substance for a given wavelength of light at a given temperature is defined as the rotation (in degree) of Plane of vibration of plane polarised light produced by per unit length of optically active Substance per unit concentration.

i.e $\boxed{S = \frac{\theta}{l \times C}}$: θ is angle of rotation
l is length of sol^n
C is $conc^n$ of sol^n

* SI unit of S is degree/(decimeter)(gram/(centimetre)^3)
= degree $(dm)^{-1}$ $(gm/cc)^{-1}$

case 1: Solid -> $\theta = S \times l$

case 2: Liquid -> $\theta = S \times l \times d$: d = density of sol^n

case 3: Solution -> $\theta = S \times l \times C$ [$C = m/V$]

$$S = \frac{\theta V}{l \times m}$$

NOTE :

(i) In specific rotation => Temperature must be constant
=> wavelength of light must be constant
=> unique solution

(ii) Specific rotation is only for optically active substance.

(iii) l & C should not be changed otherwise vibration change & θ also be changed.

Important Questions

Q = Polarisation shows which light Phenomenon ?

Solⁿ ⇒ Transverse wave.

Q = -ve crystal -> E.O.L (Extra ordinary light) move faster.
+ve crystal -> O.L (ordinary light) move fast.

Q ⇒ Dextero rotatory -> Clockwise
Laevo rotatory -> Anticlockwise

Q ⇒ Example of +ve crystal :- Quartz
Example of -ve crystal :- Calcite

Q ⇒ In double refraction, which light follows Snell's law?

Ans ⇒ ordinary light

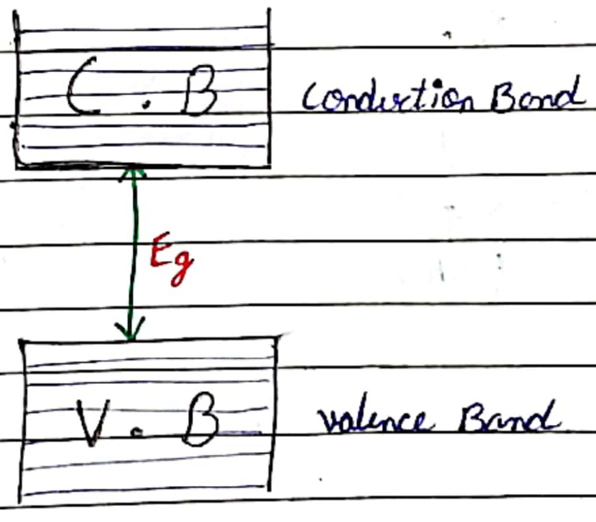
Q ⇒ Optical activity is the Property of substance

Q ⇒ Which type of Polarisation is occured in E.M wave?

Solⁿ ⇒ Circular, Elliptical, Plane, Polarisation, unpolari-
sation

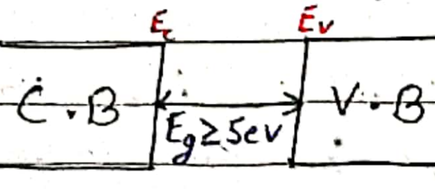
Solid State

* Valence Band :- It is the highest filled Band which includes the e^- of outer most orbit (valence e^-).
* Conduction Band :- It is band above Valence Band which is not completely filled & contains free e^-.
* Energy Band gap : The diff. b/w the highest level of valence Band & lowest level of conduction Band. It is represented by E_g.



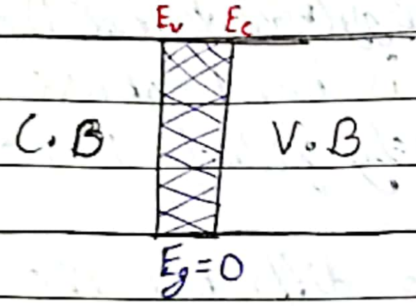
Classification of Solids (Acc to electrical conductivity)

(i) Insulators :: The substance which do not allow current to pass through themselves. The resistivity of insulator is $(10^7 - 10^{18}\,\Omega m)$.

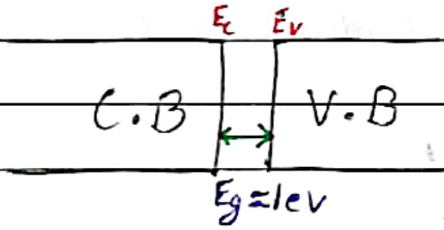


Ex: Plastic, Mica.

(ii) Conductors: The substance which offer negligible resistance in the flow of current. They have sufficient no. of free e^-. The resistivity of conductor is very small ($10^{-6} - 10^{-8}$ Ωm). Ex: copper, silver etc.



(iii) Semiconductors: The substance whose conductivity is lies b/w insulators & conductors. Ex: silicon, germanium etc.



Types of Semiconductor

(i) Intrinsic Semiconductor (Pure): A semiconductor completely in pure form.

(ii) Extrinsic Semiconductor (impure): The semiconductor which have impurity. The process of adding impurity in pure semiconductor is known as dopping.

Generally we add trivalent or pentavalent atoms to increase conductivity of semiconductors.

Date :

* Donor impurities: Pentavalent atoms added to intrinsic semiconductor are known as donor impurity. In this case -ve free charge increases & hence it is called n-type semiconductor.
Ex:- P, As, Bi, Sb etc

* Acceptor impurities: Trivalent atoms added to intrinsic semiconductor are known as acceptor impurity. In this case +ve charge increases & hence it is called P-type semiconductor.
Ex:- Al, B, Ga, In etc.

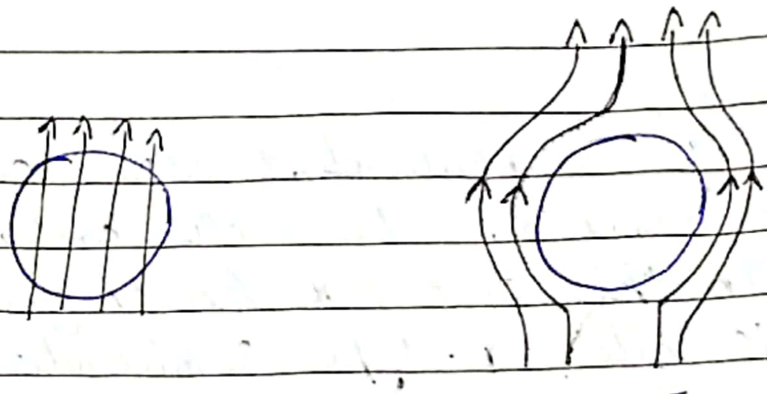
* Critical Temperature (T_c): The temperature at which the electrical resistance is known as critical temperature.

* Superconductivity: It is a Phenomenon observed in several metals or ceramic materials.

When super conductive materials cooled below a certain temperature they show no electrical resistance.

Meissner Effect (Magnetic Property)

The Phenomenon of exclusion of magnetic flux or rejection of line of magnetic induction from the interior of bulk super conductor when they cooled below the transition temperature.



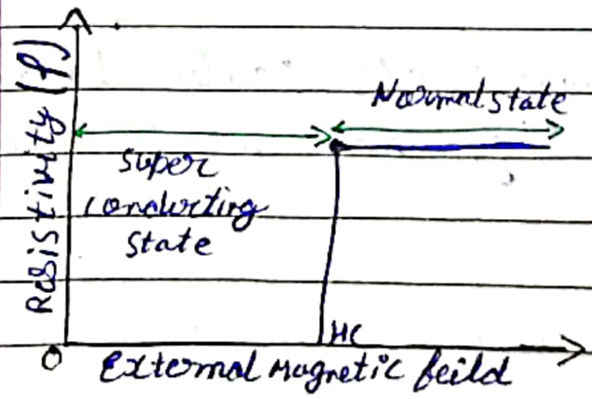
$T > T_c$ $T < T_c$

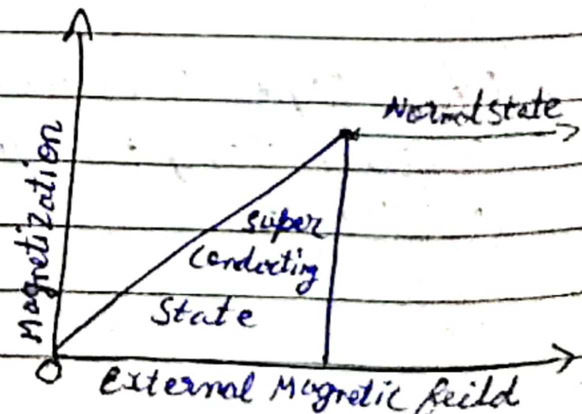
* The Super conducting state is a Perfect diamagnetic state.

Magnetic susceptibility $\chi = \frac{M}{H} = -1$

Types of super conductor

(i) Type I : A super conductor which exhibit complete ~~Miss~~ Meissner effect or which never allow a magnetic flux density or line of magnetic induction to exist in its interior or which is Perfectly diamagnetic.





Also, the super conductor which completely follows Meissner effect is Known as Type I.
Ex: Al, Zn, Sn etc

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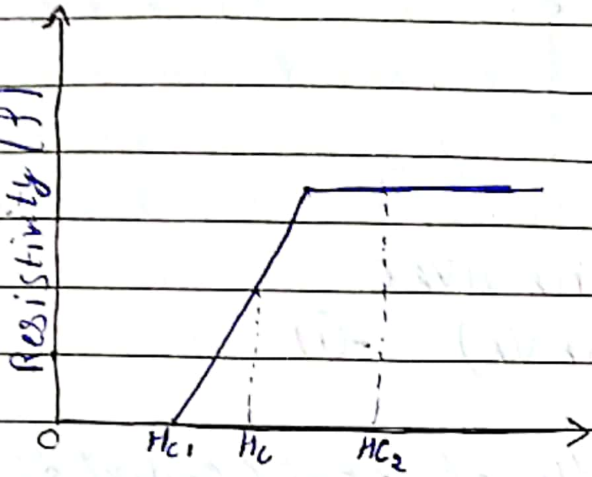
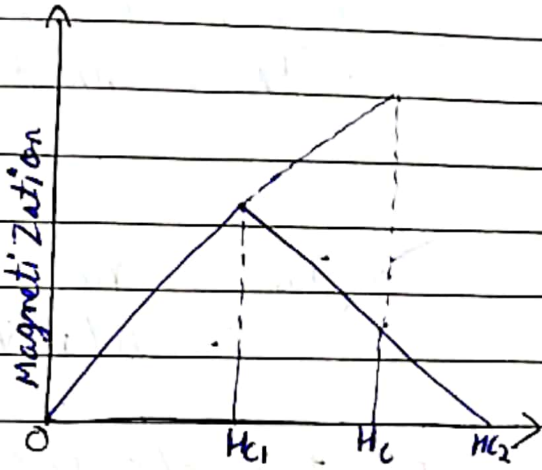
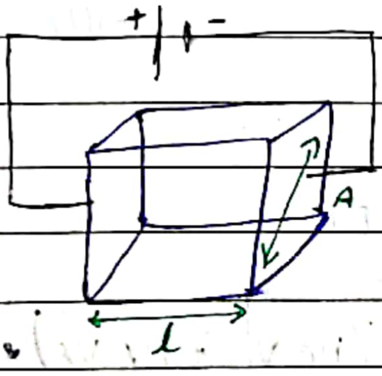
(ii) Type II : A super conductor which follows incomplete or Partial meissner is known as type II Semiconductor. Ex→ NbN, $BaBi_3$ etc.





Conductivity of Super conductor



Let us consider a Semiconductor block of length 'l' & crossection 'A'.

When we apply a Potential diff. V volts then e^- in C.B & holes in V.B moves with velocity V_e & V_h in direction opposite to each other.

If i_e & i_h be the e^- & h^+ current then the total current.

If n_e & n_h be the no. of $\bar{e}$ & h^+ Per unit volume in the conduction band & valence band.

$$I_0 = I_e + I_h$$

$$I_e = n_e A V_e e$$

$$I_h = n_h A V_h e$$

$$I_0 = n_e A V_e e + n_h A V_h e$$
$$= A(n_e V_e e + e n_h V_h) \quad -(i)$$

If ρ be the resistivity of semiconductor then the resistance offered by semiconductor to flow the current from themselves is equal to.

$$R = \rho \frac{l}{A} \quad -(ii)$$

As we know that,

$$V = IR$$

then we have

$$V = eA(n_e V_e + n_h V_h) \cdot \rho \frac{l}{A}$$

$$V = \rho l (n_e V_e + n_h V_h) \cdot e \quad -(iii)$$

The electric feild across the semiconductor is given by :- $E = \frac{V}{l}$

Then we have

$$E = e\rho(n_e V_e + n_h V_h) \quad -(iv)$$

$$\frac{1}{\rho} = e\left(n_e \frac{v_e}{E} + n_h \frac{v_h}{E}\right)$$

we know that

$$\sigma = \frac{1}{\rho} \quad \& \quad \mu_e = \frac{v_e}{E} \quad \& \quad \mu_h = \frac{v_h}{E}$$

$$\boxed{\sigma = e\left(n_e \mu_e + n_h \mu_h\right)}$$

Special case

$$\boxed{T \propto n_e \propto \sigma \propto \frac{1}{\rho}}$$

(i) In n-type semiconductor

$$n_e >> n_h$$

$$\boxed{\sigma = e\, n_e \mu_e}$$

(ii) In P-type semiconductor

$$n_h >> n_e$$

$$\boxed{\sigma = e\, n_h \mu_h}$$

(iii) For intrinsic semiconductor

$$n_h = n_e = n_i$$

$$\boxed{\sigma = n_i . e\left(\mu_e + \mu_h\right)}$$

Page No.
Date :

#	Transition temperature	Critical temperature
	It is the temperature at which a material changes from one crystal state (allotrope) to another.	It is the temperature at & above which vapour of the substance cannot be liquefied, no matter how much pressure is applied.

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