⇨ Microscopic study of Current

Isolated Conductor

$v_T \approx 10^5$ m/s

$\langle \vec{v}_T \rangle = 0$

\# $i = neAv_d$

n = number of free electron per unit volume.

A = Area of Cross-section

e = charge on electron

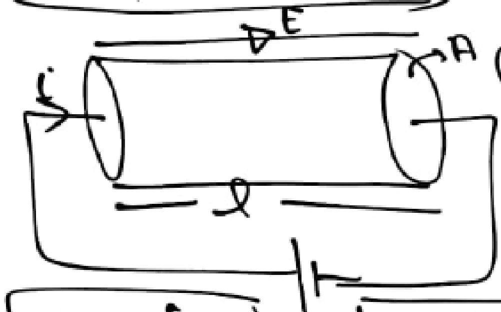
v_d = drift velocity of electron

μ = mobility of electron

$\mu = \frac{v_d}{E} = \frac{\frac{eE}{m}\tau}{E}$

$\mu = \frac{e}{m}\tau$

\#



$E = \frac{V}{l}$

\# $v_T = 10^5$ m/s

$v_d = \frac{eE}{m}\tau \simeq 10^{-3}$ to 10^{-4} m/s

τ = Relaxation Time

\# Current density ($\vec{J}$) ⇒ Vector quantity

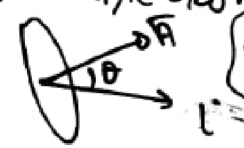
→ dirⁿ → dirⁿ of current.

$i = \vec{J} \cdot \vec{A}$

$i = JA\cos\theta$ $\quad\theta$ = angle b/w $\vec{J}$ & $\vec{A}$

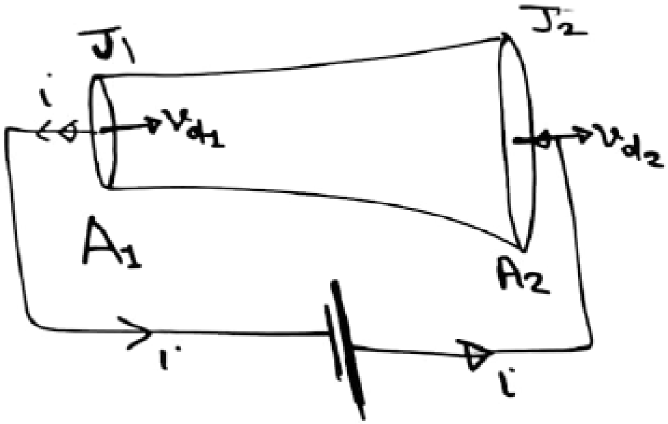
$J = \frac{i}{A\cos\theta}$

OR θ = Angle b/w $\vec{A}$ & dirⁿ of i



$J = \frac{i}{A\cos\theta}$

Q1)



$$\frac{v_{d_1}}{v_{d_2}} = \frac{A_2}{A_1}$$

$$v_{d_1} = \left(\frac{A_2}{A_1}\right) v_{d_2}$$

$\Rightarrow$ Current density

find

J_1 & J_2

v_{d_1} & v_{d_2}

E_1 & E_2

$I_1 = I_2$

$neA_1 v_{d_1} = neA_2 v_{d_2}$

$A_1 v_{d_1} = A_2 v_{d_2}$

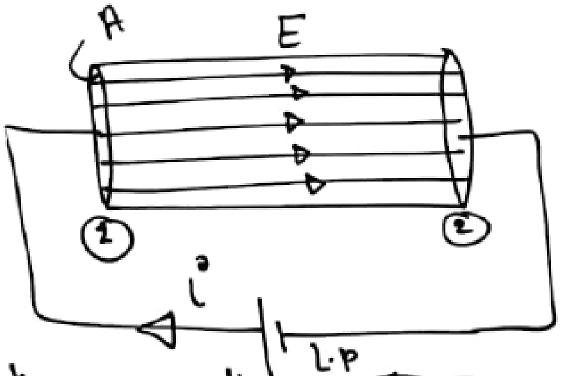
$A_1 < A_2$

$$v_{d_1} > v_{d_2}$$

$J_1 = \frac{I}{A_1}$ $\quad J_2 = \frac{I}{A_2}$

$$J_1 > J_2$$

Q.1)



$E_1 = E_2$

$i = \vec{J} \cdot \vec{A}$

$i_1 = i_2$

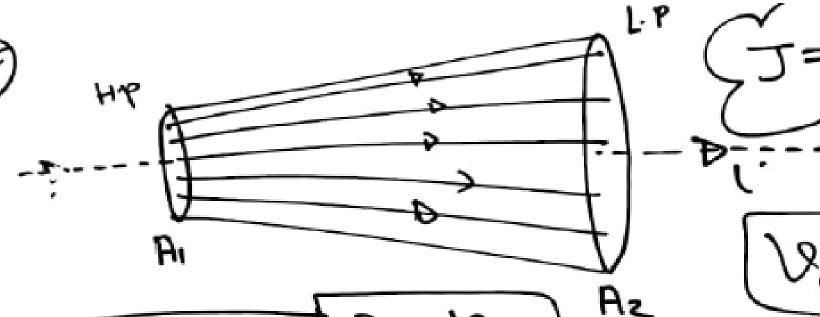
$neA v_{d_1} = neA v_{d_2}$

$v_{d_1} = v_{d_2}$

(#) $J_1 = \frac{i}{A}$ $J_2 = \frac{i}{A}$

$J_1 = J_2$

(#)



$J = \frac{i}{A\cos\theta}$

$v_d = \frac{eE}{m}\tau$

Question

v_{d_1} & v_{d_2}
E_1 & E_2
J_1 & J_2

$E_1 > E_2$

$i_1 = i_2$

$neA_1 v_{d_1} = neA_2 v_{d_2}$

$A_1 v_{d_1} = A_2 v_{d_2}$

$A v_1 = \text{Constant}$

$v_{d_1} > v_{d_2}$

$J_1 = \frac{i}{A_1}$ $J_1 > J_2$

$J_2 = \frac{i}{A_2}$ $A_1 < A_2$

$J_1 > J_2$

$i = neAv_d$

$i = \vec{J} \cdot \vec{A}$

$\Rightarrow \left(\mu = \frac{v_d}{E}\right)$

$\Rightarrow v_d = \frac{eE}{m}\tau$

$\mu = \frac{\frac{eE}{m}\tau}{E} = \frac{e}{m}\tau$

$\mu = \frac{e}{m}\tau$

Unit of μ: $\frac{m/s}{N/C} = \frac{m-C}{N-sec}$

τ = Relaxation time

SI unit – sec

Q (NEET 2020) A particle having drift velocity of 7.5×10^{-4} m/s & electric field of 3×10^{-10} V/m, has a mobility in $(m^2 V^{-1} s^{-1})$

(a) 2.25×10^{15}

(b) 2.5×10^{6} ✓

(c) 2.5×10^{-6}

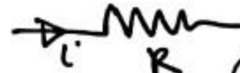
(d) 2.25×10^{-15}

$$\mu = \frac{v_d}{E} = \frac{7.5 \times 10^{-4}}{3 \times 10^{-10}}$$

$$= 2.5 \times 10^{6} \ m^2 V^{-1} s^{-1}$$

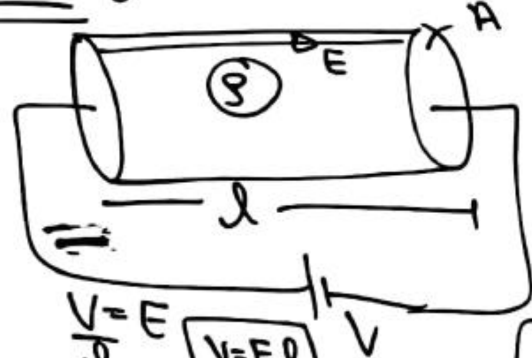
At ~~Alum~~ Normal temperature of a current carrying wire, drift velocity is Approx 10^{-9} mm/sec

Range = mm/sec होता है।



$V = iR$ $\quad i = \frac{V}{R}$ $\quad R = \frac{V}{i}$

Formula of Resistivity [V = IR]



$R = \frac{\rho l}{A}$

$\frac{V}{I} = \frac{\rho l}{A}$

$\frac{V}{l} = E \quad \boxed{V = El}$

$\frac{El}{neAv_d} = \frac{\rho l}{A}$

$\rho = \frac{E}{nev_d} = \frac{E}{ne\left(\frac{eE}{m}\tau\right)} = \frac{m}{ne^2\tau}$

$\rho = \frac{m}{ne^2\tau}$

$\boxed{\rho = \frac{m}{ne^2\tau}}$ → Imp

$\boxed{\rho \propto \frac{1}{n} \ \& \ \rho \propto \frac{1}{\tau}}$

$\boxed{\rho = \frac{m}{ne^2\tau}}$

Resistivity of material

$$\rho = \frac{m}{ne^2\tau}$$

$$R = \frac{\rho l}{A}$$

" m = mass of electron
n = number of free electron per unit volume
e = charge on electron
τ = Relaxation time "

In Conduction Resistance (R) & resistivity (ρ) Increases as increase temperature of Conductor

In Conductor (Imp)

$\rho = \frac{m}{ne^2\tau}$

$T\uparrow \rightarrow n$ increase करेगा।

$\Rightarrow \tau \rightarrow$ Relaxation time decrease होगा.

$\Rightarrow T\uparrow$, v_T = thermal speed of electron ↑ses, due to this $\tau\downarrow$ ses

$\Rightarrow \tau$ dominant करता है,

$\rho\uparrow$ ses

$T\uparrow, (n\uparrow \ \tau\downarrow) \Rightarrow \rho\uparrow, R\uparrow$

$T\downarrow (n\downarrow \ \tau\uparrow) \ \rho\downarrow \ R\downarrow$

⟹ Imp: In Semiconductor

$n \rightarrow$ Low

$$\rho = \frac{m}{ne^2\tau}$$

$T\uparrow, n\uparrow$ $\tau\downarrow$ ⟹ dominant n करेगा

$\rho\downarrow$ seq, $R\downarrow$ seq.

" In Semiconductor, Resistance & Resistivity decreases with increase temperature "

Semiconductor

$T\downarrow$ $n\downarrow$ $\tau\uparrow$, $\rho\uparrow$ $R\uparrow$

NEET / JEE(Mains)

$$R_f = R_1(1 + \alpha \Delta T)$$ For Conductor

$$R_f = R_1(1 - \alpha \Delta T)$$ → For Semiconductor & insulator

⟹ $\alpha = +\text{ve}$ For Conductor

$\alpha = -\text{ve}$ For Semiconductor & insulator

ABLES® KOTA

⇒ Imp **In Semiconductor**

NEET 2020 :- The solids which have the negative temperature co-efficient of resistance are.

(a) Metals.
(b) insulators only.
(c) semiconductor only.
(d) insulators & semiconductors.

$\rho_f = \rho_i(1+\alpha\Delta T)$
$R_f = R_i(1+\alpha\Delta T)$ – for conductor

$R_f = R_i(1-\alpha\Delta T)$ – For insulator & semiconductor
$\rho_f = \rho_i(1-\alpha\Delta T)$

α = temperature co-efficent of Resistance