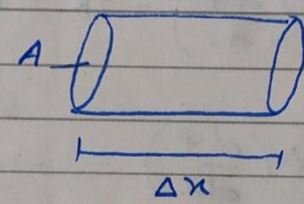
Electric current and resistance

Current & Resistance

$$I = \frac{Q}{t} \quad \text{— (i)}$$



$$Q = Nq \quad \text{— (ii)}$$

N = number of current carriers (electrons) total

q = charge of one carrier

Now

number of carriers per unit volume = n

$$n = \frac{N}{V} = \frac{N}{A\Delta x}$$

$$n = \frac{N}{A\Delta x}$$

$$nA\Delta x = N$$

put this value of N in eq (ii)

$$Q = nA\Delta x\, q$$

~~represt~~

As current carrier are electron in metals so represent charge of electron with 'e'

$$q = e$$

$$Q = nA\Delta x e$$

put this value of Q in eq (i)

$$I = \frac{nA\Delta x e}{t}$$

$$\because \frac{\Delta x}{t} = V_d$$

$$I = nAeV_d$$

here V_d is the drift velocity of electrons

we know that current density

$$J = \frac{I}{A}$$

$$J = \frac{nAeV_d}{A} = neV_d$$

$$J = neV_d$$

as $I = \frac{V}{R}$ (ohm's law)

and

$$R = \rho \frac{L}{A} \quad \text{--- (iii)}$$

$$J = \frac{I}{A}$$

put value of I from ohm's law in J

$$J = \frac{V}{RA}$$

now put value of R from eq (iii)

$$J = \frac{V}{(\rho \frac{L}{A}) A}$$

$$J = \frac{V}{\rho L} \quad \text{--- (iv)}$$

we know that

$$\vec{E} = -\frac{\vec{V}}{d}$$

-ve sign is just showing direction of vectors while write magnitude we ignore the negative sign

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

$$Ed = V$$

put Value of V in eq (iv)

$$J = \frac{Ed}{\rho L}$$

as d and L are length of the same conductor (metal) so

$$d = L$$

$$J = \frac{E\cancel{L}}{\rho \cancel{L}}$$

$$J = \frac{1}{\rho} E$$

$$\text{Conductivity} = \frac{1}{\text{Resitivity}}$$

$$J = \sigma E$$

$$\sigma = \frac{1}{\rho}$$

this is is the microscopic form of ohms law