3. Current Electricity

Drift velocity v_d is defined as the velocity with which the free electrons get drifted towards the positive terminal under the effect of the applied electric field.

$$\vec{v}_d = -\frac{e\vec{E}}{m}\tau$$

Where,

$\vec{E}$ = Intensity of applied electric field

τ = Average relaxation time

m = Mass of each electron

Relation between current and drift velocity:

$I = neAv_d$

Where,

n = Number density of free electrons

A = Cross–sectional area of the conductor

e = Charge on an electron

v_d = Drift velocity

Current density (J):

$$J = \frac{I}{A} = \frac{q}{At} = \frac{ne}{At}$$

We know that $I = neAv_d$ or $\frac{I}{A} = nev_d$

$\therefore J = nev_d$

Ohm's law:

$V = RI$

Where, R is a constant for a given conductor

Electrical resistance:

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

Where, ρ is the specific resistance or electrical resistivity of the material

Conductance and Electrical conductivity:

Conductance $G = \frac{1}{R} = \frac{A}{\rho l}$

Electrical conductivity (σ) is defined as the reciprocal of resistivity.

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

Mobility:

$$\mu = \frac{v_d}{E}$$

Where, E is the electric field

We know that $\rho = \frac{E}{J}$ or $\rho \frac{E}{nev_d}$ or $\rho = \frac{1}{ne\left(\frac{v_d}{E}\right)}$ or $\boxed{\rho = \frac{1}{ne\mu}}$

Series combination of resistors:

$$R_s = R_1 + R_2 + R_3 + \ldots + R_n$$

Parallel combination of resistors:

$$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n}}$$

Temperature dependence of resistance:

$$R = R_0 (1 + \alpha t)$$

Where, α is the temperature coefficient of resistance of the material of the conductor

For metals, the resistance increases with increase in temperature.

Due to high resistance and low temperature coefficient of resistance, alloys are used in preparing standard resistance coils.

Variation of resistivity with temperature:

- The resistivity of a metallic conductor increases with increase in temperature.
- The resistivity of an alloy has a weak dependence on temperature.
- The resistivity of a semiconductor decreases rapidly with increasing temperature.

Internal resistance (r) of a cell is given by $r = \left(\frac{E}{V} - 1\right) R$

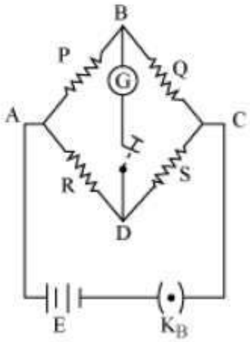
Kirchhoff's laws:

First law $\rightarrow$ In any electrical network, the algebraic sum of the currents meeting at a junction is always zero. $\sum I = 0$

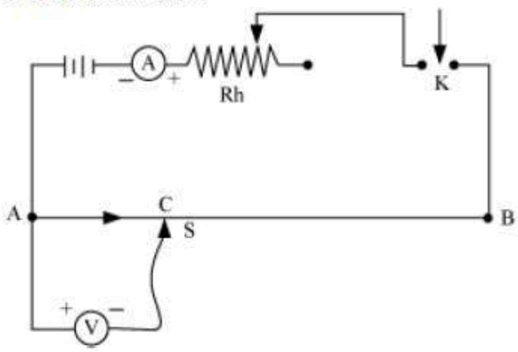
Second law $\rightarrow$ The algebraic sum of all the potential drops and emfs along any closed path in a network is zero.

Wheatstone bridge:

$$\boxed{\frac{P}{Q} = \frac{R}{S}}$$



Potentiometer:



$$\boxed{V \alpha l}$$

- Comparison of emfs using a potentiometer:

  $$\boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}}$$

  Where, l_1 and l_2 are the balancing lengths
- Internal resistance of a cell:

  $$r = \frac{l_1 - l_2}{l_2} R$$