Mind Map–3

@anjit

Series grouping of resistances Equivalent resistance, $R_s = R_1 + R_2 + \ldots + R_n$ In this case same current flows through each resistance but potential difference distributes in the ratio of resistance

Parallel grouping of resistances Equivalent resistance,
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$
In this case same potential acorss each resistance but current distributes in the reverse ratio of their resistances

After stretching, if length increases by n times then resistance will increase by n^2 times i.e., $R_2 = n^2R_1$. Similarly if radius be reduced to $\frac{1}{n}$ times then area of cross-section decreases $\frac{1}{n^2}$ times so the resistance becomes n^4 times i.e., $R_2 = n^4R_1$. After stretching, if length of a conductor increases by x%, then resistance will increase by $2x$% (valid only if $x < 10\%$).

Electric cell Source of energy that maintains continuous flow of charge in a circuit

Groupings of cells

Cells in series Current in the circuit, $I = \frac{n\varepsilon}{R + nr}$

Cells in parallel Current in the circuit current $I = \frac{\varepsilon}{R + \frac{r}{m}}$

Cells in series and parallel i.e. mixed Current in the circuit, $I = \frac{n\varepsilon}{\frac{nr}{m} + R}$

Electrical energy

Jule's heating law

$H \propto I^2$, $\propto R$, $\propto t$ $\Big\}$ $H = I^2Rt$; Electrical Power $= P = \frac{V^2}{R}$

In series combination, power consumed $P_{total} = \frac{P}{n}$

Brightness $\propto$ power $\propto$ V $\propto$ $R \propto \frac{1}{P_{rated}}$

In parallel combination $P_{total} = nP$

Brightness $\propto$ power $\propto$ I $\propto \frac{1}{R}$

On length (ℓ) and area of cross-section (A)

$R \propto l$, $\propto \frac{1}{A}$ $\Big\}$ $R = \rho\frac{l}{A}$

ρ = resistivity

Resistivity depends on the material of the conductor only.

Grouping of resistances

Resistance (R) Obstruction offered to flow of electrons

Resistance, $R \propto \frac{\ell^2}{m}$

ℓ = length and m = mass of conducting wire

Ohm's law If the physical conditions remain same, current $I \propto V \Rightarrow V = IR$

R-electric resistance

Substances which obey obm's law called ohmic and that do not obey called non-ohmic substances.

Dependence of resistance

Colour coding of Resistance $R = AB \times C \pm D\%$ A, B – First two significant figures of resistance C-multiplier D-tolerance to remembers the sequence of colour code **B B Roy Great Britain Very Good Wife**

Meter bridge Based on Wheatstone bridge
$$\frac{P}{Q} = \frac{R}{S} \Rightarrow \frac{l}{100 - l} = \frac{R}{S}$$

Balanced condition of wheatstone bridge
$$\frac{P}{Q} = \frac{R}{S}$$

Kirchhoff's laws

1st law/Junction law Algebraic sum of all the current meeting at a junction is zero i.e $\Sigma I = 0$

2nd law/Loop rule Algebraic sum of changes in potential around any closed loop is zero. $\Sigma^E = \Sigma^{IR}$

Potentiometer used to
(i) Compare emfs
$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$
(ii) Find internal resistance of cell
$$r = \left(\frac{E}{V} - 1\right)S$$

On temperature $R_t = R_0(1 + \alpha t)$ α = temperature coefficient of resistance

Current density (J) Current per unit cross sectional area

(A) $\vec{J} = \frac{I}{A} = \frac{\vec{E}}{\rho}$

Conductivity (σ)

Reciprocal of resistivity $\sigma = \frac{1}{\rho}$

Conductance, $C = \frac{1}{\text{resistance}}$

CURRENT ELECTRICTY

Electric Current (I) The time rate of flow of charge (Q) through any cross-section
$$I = \frac{Q}{t};\ I = \lim_{\Delta t \to 0}\frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$$

Drift velocity (V_d) Average uniform velocity acquired by free electrons $V_d = \frac{i}{neA} = \frac{J}{ne} = \frac{V}{\rho \ell ne}$
$$V_d = \frac{E}{\rho ne}$$
Direction of drift velocity for electrons in a metal is opposite to that of applied electric field

Mobitity (μ) Drift velocity per unit electric field $\mu = \frac{V_d}{E}$

- Using n coductors of equal resistance, the number of possible combinations is 2^{n-1}.
- If the resistances of n conductors are totally different, then the number of possible combinations will be 2^n.
- If n identical resistances are first connected in series and then in parallel, the ratio of the equivalent resistance is given by $\frac{R_s}{R_p} = \frac{n^2}{1}$.
- If a wire of resistance R is cut in n equal parts and then these parts are collected to form a bundle, then equivalent resistance of combination will be $\frac{R}{n^2}$.
- If equivalent resistance of R_1 and R_2 in series and parallel be R_s and R_p respectively, then $R_1 = \frac{1}{2}\left[R_s + \sqrt{R_s^2 - 4R_sR_p}\right]$ and $R_2 = \frac{1}{2}\left[R_s - \sqrt{R_s^2 - 4R_sR_p}\right]$.

Potential gradient (x) Potential difference per unit length of wire $x = \frac{V}{L} = \frac{\text{volt}}{\text{m}}$

where $V = iR = \left(\frac{e}{R + R_h + r}\right)R$ So,
$$x = \frac{V}{L} = \frac{iR}{L} = \frac{i\rho}{A} = \frac{e}{(R + R_h + r)} \cdot \frac{R}{L}$$
(i) Potential gradient directly depends upon
(a) The resistance pre unit length (R/L) of potentiometer wire.
(b) The radius of potentiometer wire (i.e., Area of cross-section)
(c) The specific resistance of the material of potentiometer
(d) The current flowing through potentiometer wire (i)
(ii) potential gradient indirectly depends upon
(a) The emf of battery in the primary circuit
(b) The resistance of rheostat in the primary circuit

Sensitivity of potentiometer
A potentiometer is more sensitive, if it measures a small potential difference more accurately.
(i) The sensitivity of potentiometer is assessed by its potential gradient. The sensitivity is inversely proportional to the ptential gradient.
(ii) In order to increase the sensitivity of potentiometer.
(a) The resistance in primary circuit will have to be decreased.
(b) The length of potentiometer wire will have to be increased

- **When cell is discharging:** When cell is discharging current inside the cell is from cathode to anode. Current $I = \frac{E}{r + R}$

or $E = IR + Ir = V + Ir$ or $V = E - Ir$

When current is drawn from the cell potential difference is less than emf of cell Greater is the current drawn from the cell smaller is the terminal voltage. When a large current is drawn from a cell its terminal voltage is reduced.

- **When cell is charging:** When cell is charging current inside the cell is from anode to cathode. Current $I = \frac{V - E}{r}$ or $V = E + Ir$

During charging terminal potential difference is greater than emf of cell.

When cell is in open circuit: In open circuit

$R = \infty$ $\therefore I = \frac{E}{R + 1} = 0$ So $V = E$

In open circuit terminal potential difference is equal to emf and is the maximum potential difference which a cell can provide.

- **When cell is short circuited:** In short circuit $R = 0$ So $I = \frac{-E}{(R + r)}$ and $V = IR = 0$

In short circuit current from cell is maximum and terminal potential difference is zero.

Power transferred to load by cell:
$$P = I^2R = \frac{E^2R}{(r + R)^2}$$ so, $P = P_{max}$

if $\frac{dP}{dR}$ and $P = P_{max}$ if $r = R$

Power transferred by cell to load is maximum when $r = R$ and
$$P_{max} = \frac{E^2}{4r} = \frac{E^2}{4R}$$