

Formula Sheet

chapter - 3

Current Electricity

1. Electric current

$$I = \frac{q}{t} = \frac{\Delta q}{\Delta t} = \frac{n e}{t}$$

charge on one electron
 $(1.6 \times 10^{-19} \text{ C})$
 $[q = n e]$
 charge $\rightarrow$ no. of electrons

for conductor of length 'l' and cross-section area A

$$q = (n e)(A l)$$

Unit of q $\rightarrow$ coulomb (C)

2. Instantaneous current

$$I = \lim_{\Delta t \rightarrow 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

Unit of I $\rightarrow$ Ampere (A)

also $\int dq = \int I dt$
 or $q = \int I dt$

3. Ohm's law

$$R = \frac{V}{I} = \text{Constant}$$

R $\rightarrow$ Resistance
 V $\rightarrow$ Potential diff.

4. Resistance (R)

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

Unit of R $\rightarrow$ Ohm (Ω)

$\rho \rightarrow$ Resistivity
 l $\rightarrow$ length of conductor
 A $\rightarrow$ cross-section area of conductor

5. Resistivity (ρ)

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

Unit of $\rho \rightarrow$ Ohm-m ($\Omega\text{-m}$)* Resistivity ρ does not depend on l & A of the conductor

$$\frac{R_1 A_1}{l_1} = \frac{R_2 A_2}{l_2}$$

[For two wires of same material]

or $\frac{R_1}{R_2} = \frac{l_1}{l_2} \cdot \frac{A_2}{A_1}$

6. When shape of wire is changed
volume of wire does not change

$$V_1 = V_2$$

$$A_1 l_1 = A_2 l_2$$

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or $\frac{l_1}{l_2} = \frac{A_2}{A_1}$

7. Current density (J)

$$J = \frac{I}{A} \Rightarrow I = \vec{J} \cdot \vec{A} = J A \cos \theta$$

Unit of $J \rightarrow A m^{-1}$

8. Ohm's law in vector form conductivity

$$\vec{J} = \sigma \vec{E}$$

here $\sigma = \frac{n e^2 \tau}{m}$

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or $\vec{E} = \vec{J} \rho$

$[\because \sigma = \frac{1}{\rho}]$

unit of $\sigma \rightarrow \Omega^{-1} m^{-1}$ or $S m^{-1}$ Siemens

9. Drift velocity v_d

$$v_d = \frac{e E \tau}{m}$$

$E \rightarrow$ Electric field,
 $\tau \rightarrow$ Relaxation time

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

unit of $v_d \rightarrow m s^{-1}$

-ve sign shows the
opposite dirⁿ of $\vec{v}_d$ & $\vec{E}$

10. Relation b/w drift velocity and current

$$I = n e A v_d$$

$n \rightarrow$ electron no. density

11. Mobility μ

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

unit of $\mu \rightarrow m^2 V^{-1} s^{-1}$

12. Temperature dependence of Resistivity

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$$\rho_T = \rho_0 [1 + \alpha (T - T_0)] \quad T_0 \rightarrow \text{Reference temp.}$$

also $\rho_2 = \rho_1 [1 + \alpha (T_2 - T_1)]$

$\alpha \rightarrow$ temperature coefficient of resistivity

$$\alpha = \frac{\rho_T - \rho_0}{\rho_0 \Delta T} \quad [\Delta T = T - T_0]$$

For resistance

$$R_T = R_0 [1 + \alpha (T - T_0)]$$

and $\alpha = \frac{R_2 - R_1}{R_1 \Delta T}$ Unit of α $^{\circ}\text{C}^{-1}$

* For unknown temp. if resistance at that temp. is given

$$T = \frac{R_{100} - R_0}{R_T - R_0} \times 100$$

13. Electric Energy (E)

$$E = P \times t$$
$$E = I^2 R t$$
$$E = \frac{V^2}{R} t$$

$E \rightarrow$ Energy $\rightarrow$ in joule (J)
 $P \rightarrow$ Power $\rightarrow$ in watt (W)
 $t \rightarrow$ time $\rightarrow$ in second (s)
 $V \rightarrow$ voltage $\rightarrow$ in volt (V)
 $R \rightarrow$ Resistance $\rightarrow$ in ohm (Ω)

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14. Electric Power (P)

$$P = VI$$
$$P = I^2 R$$
$$P = \frac{V^2}{R}$$

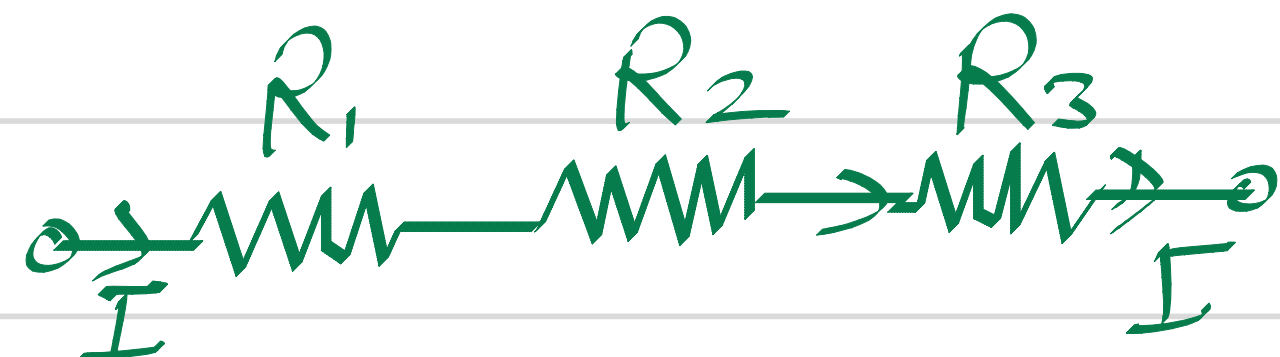
* Power dissipated $P_c = \frac{P^2}{V^2} R$

15. Combination of resistances -

(i) In series (I constant)

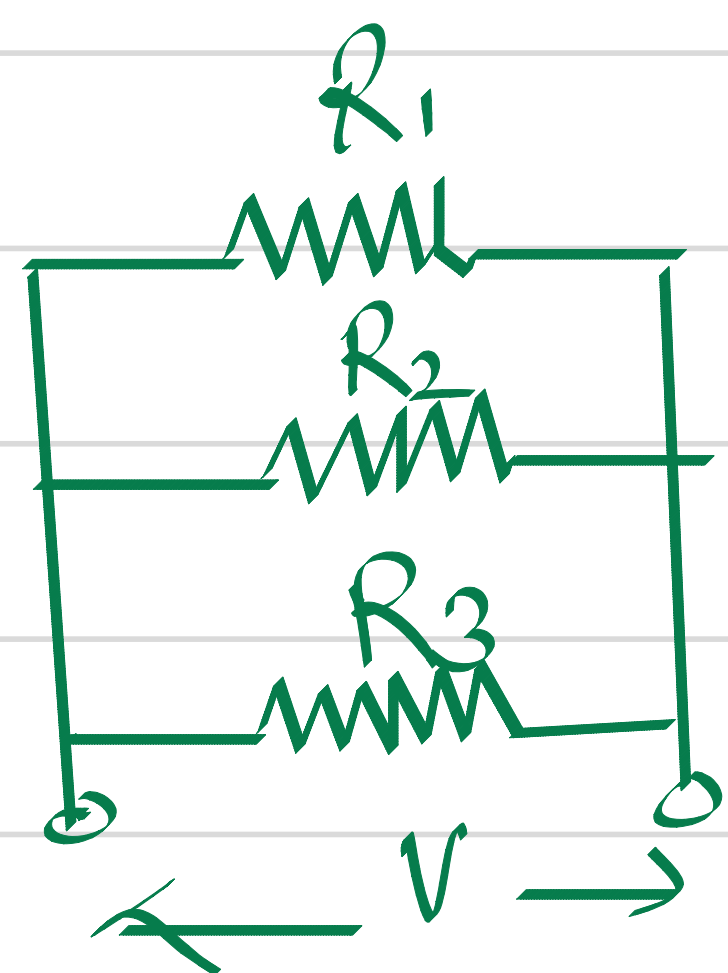
$$R_s = R_1 + R_2 + R_3 + \dots$$

$R_s \rightarrow$ equivalent resistance in series



(ii) In Parallel (V constant)

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$



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* For n identical resistors

$$R_s = nR$$

$$R_p = \frac{R}{n}$$

16. Terminal voltage of an electric cell

$$V = \mathcal{E} - Ir \quad [\text{In closed circuit}]$$

$V \rightarrow$ Terminal voltage in volt (V)

$\mathcal{E} \rightarrow$ emf of cell in volt (V)

$r \rightarrow$ Internal resistance of cell in ohm (Ω)

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here $V = IR$, then

$$IR = \mathcal{E} - Ir$$

or

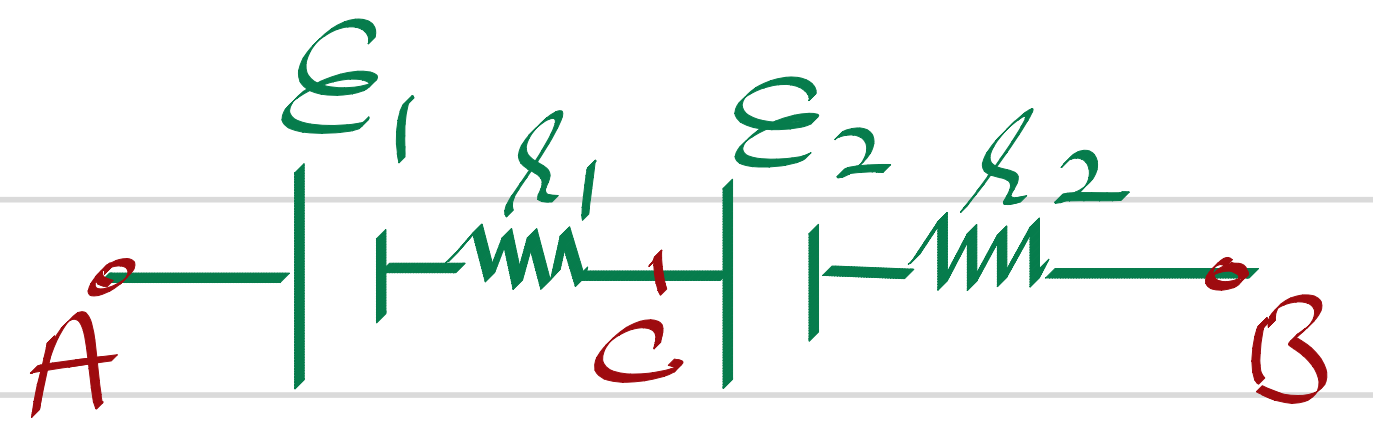
$$I = \frac{\mathcal{E}}{R+r}$$

* When cell is charging

$$V = \mathcal{E} + Ir$$

Grouping of Cells

(I) In Series



$$\epsilon_{eq} = \epsilon_1 + \epsilon_2$$

[ϵ_{eq} → Equivalent emf]

$$r_{eq} = r_1 + r_2$$

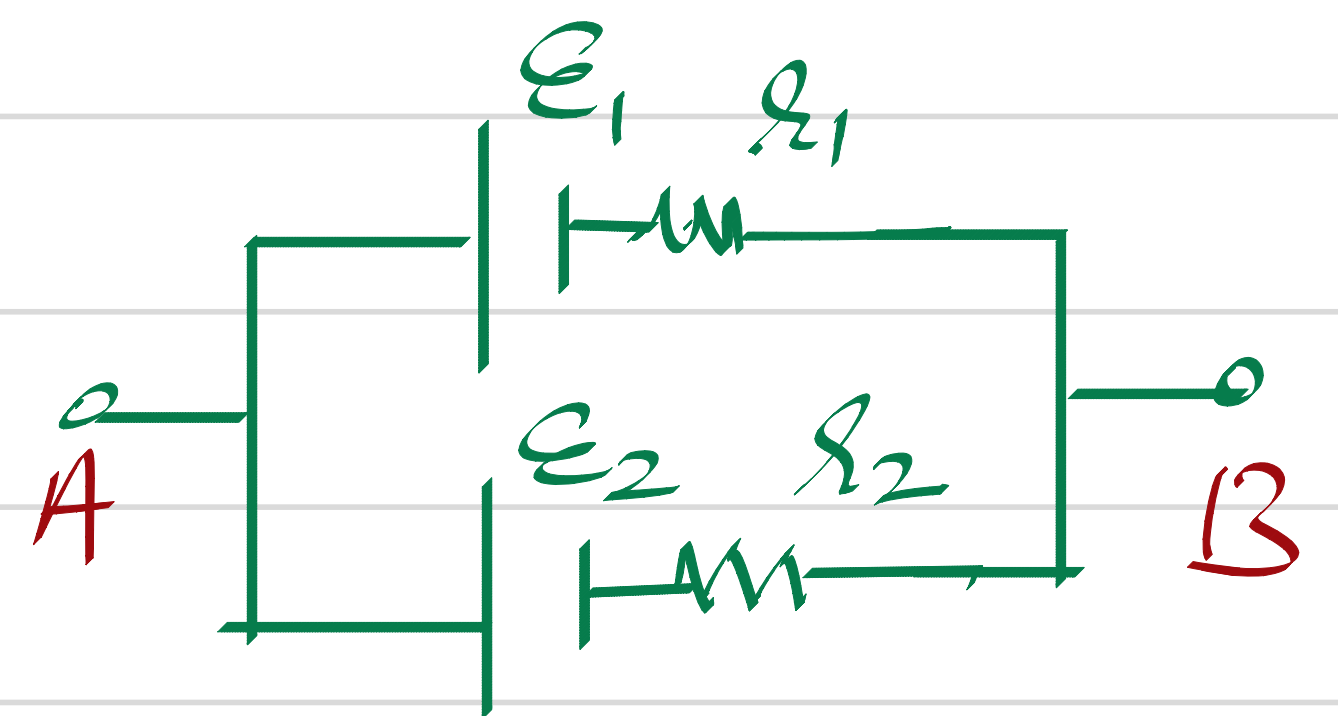
[r_{eq} → Equivalent resistance]

For n identical cells $\epsilon_{eq} = n\epsilon$

$$r_{eq} = nr$$

(II) In Parallel

$$\frac{\epsilon_{eq}}{r_{eq}} = \frac{\epsilon_1}{r_1} + \frac{\epsilon_2}{r_2}$$



$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

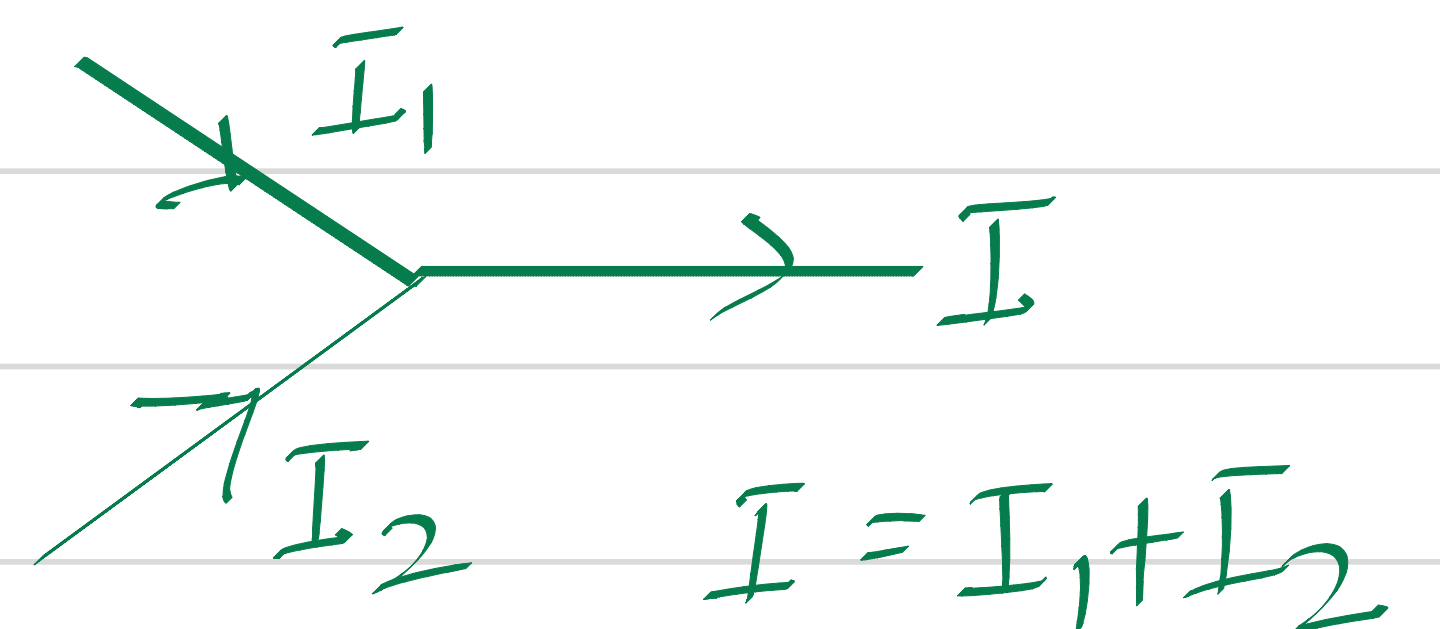
For n identical cell $\epsilon_{eq} = \epsilon$, $r_{eq} = \frac{r}{n}$

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17. Kirchhoff's Rule

(I) Junction Rule

$$\sum I = 0$$



(II) Loop Rule

$$\sum V = 0$$

$$\text{or } \sum V_{\text{source}} - \sum IR = 0$$

$$\text{or } \sum V_{\text{source}} = \sum IR$$

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18. Condition of Balanced Wheatstone Bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

