Formula Sheet
Current Electricity

1. Electric current

$$I = \frac{q}{t} = \frac{\Delta q}{\Delta t} = \frac{ne}{t}$$

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

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

$$q = (ne)(Al)$$

Unit of q → coulomb (C)

2. Instantaneous current

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

Unit of I → Ampere (A)

also $\int dq = \int I\,dt$

or $q = \int I\,dt$

3. Ohm's law

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

R → Resistance
V → Potential diff.

4. Resistance (R)

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

ρ → Resistivity
l → length of conductor
A → cross-section area of conductor

Unit of R → Ohm (Ω)

5. Resistivity (ρ)

$$\rho = \frac{RA}{l}$$

Unit of ρ → Ohm-m (Ω-m)

* Resistivity ρ does not depends 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

$$V_1 = V_2$$

$$A_1 l_1 = A_2 l_2$$

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

7. Current density (j)

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

Unit of $j \to A\,m^{-1}$

8. Ohm's law in vector form

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

here σ (conductivity) $= \frac{ne^2}{m}\tau$

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

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

unit of $\sigma \to \Omega^{-1} m^{-1}$ or $S\,m^{-1}$ (Siemens)

9. Drift velocity v_d

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

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

Vector form $\vec{v_d} = -\frac{e\vec{E}}{m}\tau$

-ve sign shows the opposite dir^n of $\vec{v_d}$ & $\vec{E}$

unit of $v_d \to ms^{-1}$

10. Relation b/w drift velocity and current

$$I = neAv_d$$

$n \to$ electron no. density

11. Mobility μ

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

Unit of $\mu \to m^2V^{-1}s^{-1}$

@jyotisharmaphysics

12. Temperature dependence of Resistivity

$\rho_T = \rho_0 [1 + \alpha (T - T_0)]$ $T_0 \rightarrow$ 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 $°C^{-1}$

* 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)

14. Electric Power (P)

$P = VI$

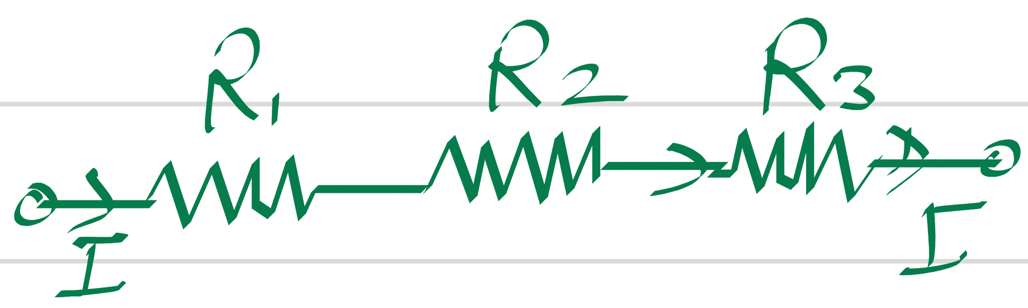
$P = I^2 R$

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

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

15. Combination of resistances -

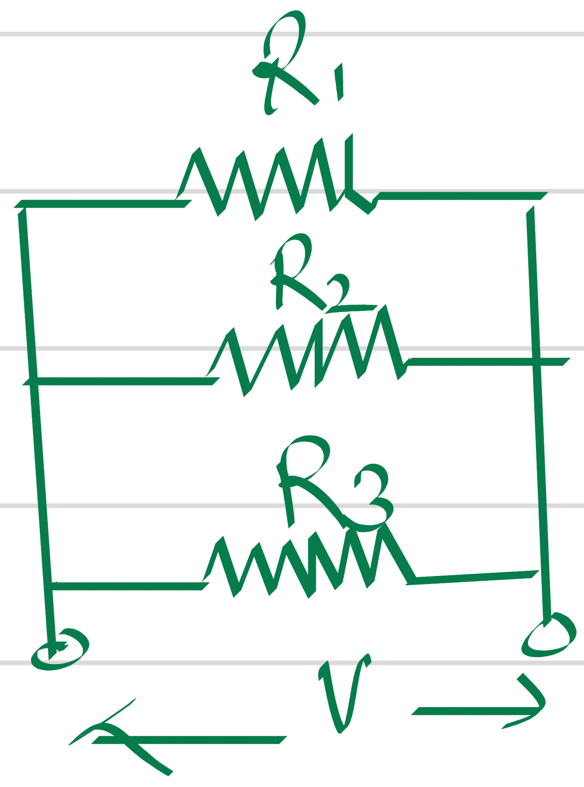
(I) In Series (I constant)



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

$R_s \rightarrow$ equivalent resistance in series

(II) In Parallel (V constant)



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

* For n identical resistors

$$R_s = nR$$

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

16. Terminal voltage of an electric cell

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

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

$\varepsilon \rightarrow$ emf of cell in volt (V)

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

here $V = IR$, then

$$IR = \varepsilon - Ir$$

or

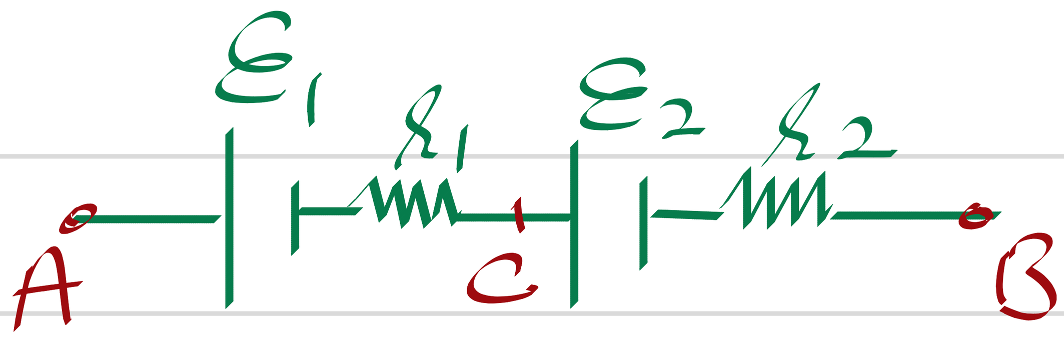
$$I = \frac{\varepsilon}{R + r}$$

* When cell is charging

$$V = \varepsilon + Ir$$

Grouping of Cells

(I) In Series



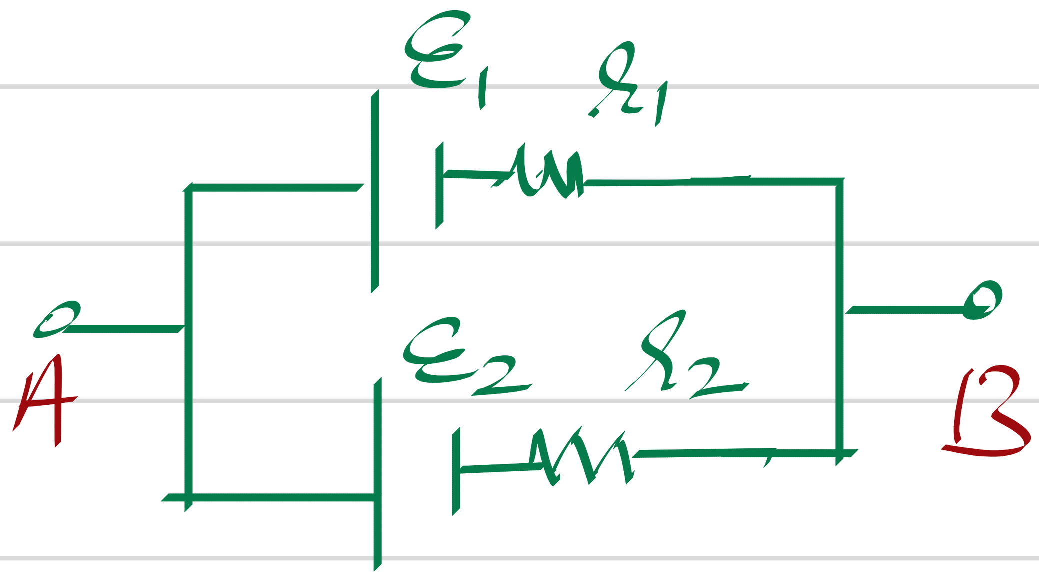
$$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 \qquad [\varepsilon_{eq} \rightarrow \text{Equivalent emf}]$$

$$r_{eq} = r_1 + r_2 \qquad [r_{eq} \rightarrow \text{Equivalent resistance}]$$

For n identical cells $\varepsilon_{eq} = n\varepsilon$, $r_{eq} = nr$

(II) In Parallel

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$$



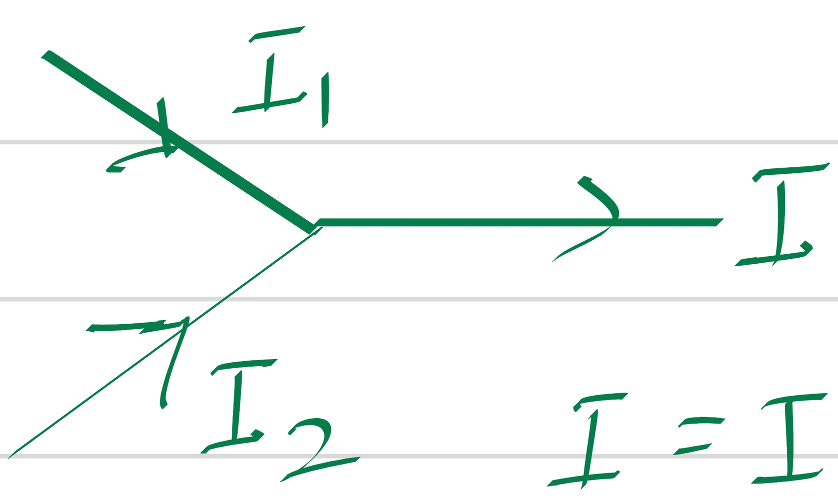
$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

For n identical cell $\varepsilon_{eq} = \varepsilon$, $r_{eq} = \frac{r}{n}$

17. Kirchhoff's Rule

(I) Junction Rule

$$\Sigma I = 0$$



$I = I_1 + I_2$

(II) Loop Rule

$$\Sigma V = 0$$

or $\Sigma V_{source} - \Sigma IR = 0$

or $\Sigma V_{source} = \Sigma IR$

18. Condition of Balanced Wheatstone Bridge

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