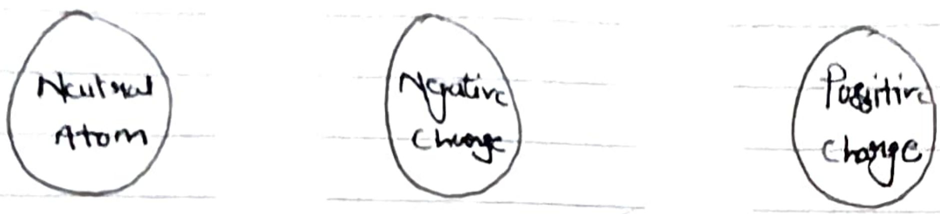
CHAPTER-12

ELECTRICITY

Charge ⇒ It is the intrinsic property of elementary particles due to which they interact with each other.



$N_p = N_e$ $\quad$ $N_p < N_e$ $\quad$ $N_p > N_e$

Type of Charge

1) **Positive Charge** ⇒ It is the charge on a body due to excess of proton.
Its magnitude is $1.6 \times 10^{-19} C$

ii) **Negative Charge** ⇒ It is the charge on a body due to excess of electrons.
Its magnitude is $1.6 \times 10^{-19} C$

Properties of charge

(1) Charges are scalar quantity.

(ii) They interact with each other.

(iii) Charges are quantised.

$$Q = \pm ne$$

$n = 1, 2, 3$

$e = 1.6 \times 10^{-19} C$

$n \neq$ fraction like $\frac{1}{2}, \frac{1}{4}$

(iv) Charges follow simple law of addition.

$$q = q_1 + q_2 + q_3 \dots q_n$$

q_1, q_2, q_3, q_n

Solid

- **Insulator** — It does not conduct electricity
- **Conductor** — It conducts electricity
- **Semiconductor** — It conduct electricity only at high temperature.

Current ⇒ Rate of flow of charges through conductor is called current.

$$I = \frac{dq}{dt}$$

I → Current

dq = Small value of charge

dt = Small value of time.

$$I = \frac{Q}{T}$$

SI unit of current is Ampere [A]

Small unit of current is mA and μA

$1\,mA = 10^{-3} A$

$1\,\mu A = 10^{-6} A$

Ammeter is used to measure electoric current in a circuit.

Ammeter is always connected in series.

Resistance of ammeter is low

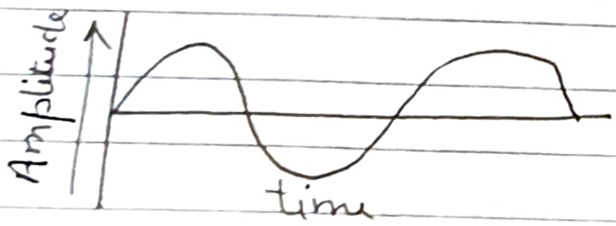
<u>Galvanometer</u> ⇒ It is a device which is used to detect small value of electric current in the circuit.

It is also connected in series.

<u>Electric Current</u>

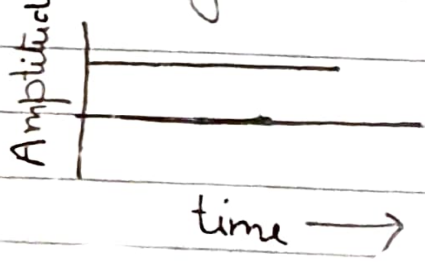
<u>Alternating Current</u>

The magnitude of alternating current is changing continously and direction reverses periodically.



<u>Direct current</u>

The magnitude of direct current does not change with change in time.



Electric Circuit :- It is close and continuous path through which electrons can move.

Component Of Circuit and their symbol

(i) Resistance 

(ii) Variable resistance OR Rheostat 

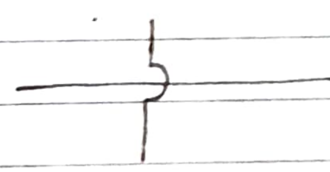
(iii) Electric cell 

(IV) Electric Battery 

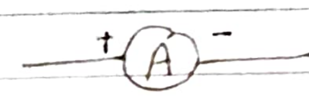
(V) Open Key  (Switch off)

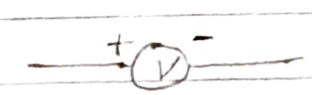
(VI) Close Key  [Switch on]

(VII) A wire joint 

(VIII) Wire crossing without joining 

IX Electric Bulb 

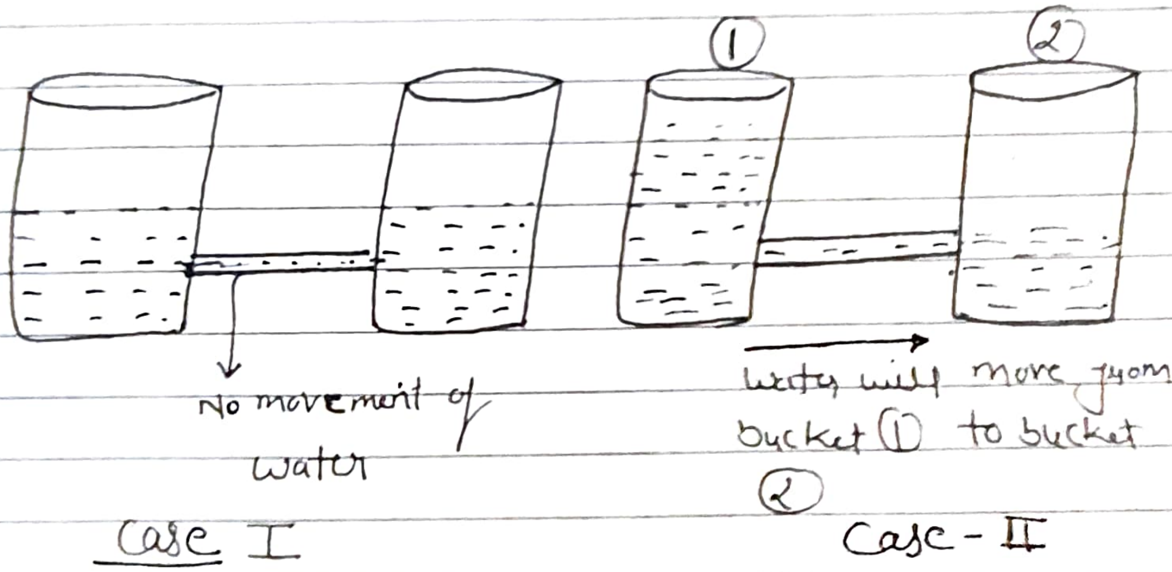
X Ammeter 

XI Voltmeter 

The direction of current is opposite to the direction of flow of electron.

⇒ Direction of flow of electron will be from negative terminal of the battery to positive terminal of the battery.

⇒ Direction of current will be from positive terminal to negative terminal of the battery.



From the above two cases we can see that in order to move water from one bucket to other bucket we need difference of water level i.e potential difference.

It is defined as the amount of work done in moving a unit charge from one point to another point in the conductor.

$$V = \frac{W}{Q} = \frac{\text{Work done}}{\text{Charge}} = \frac{\text{Joule}}{\text{Coulomb}}$$

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

SI unit = JC^{-1} or Volt (V)

$$\boxed{V = JC^{-1}}$$

Important points

* Electric potential difference is a scalar quantity.
* Electric potential difference is measured by voltmeter.
* Voltmeter is always connected in parallel in the circuit.
* The resistance of voltmeter is high.

The potential across any two points in a conductor is said to be one volt if one joule of work is done to move one coulomb of charge b/w two points

$$V = \frac{W}{Q}$$

$$V = \frac{1}{1} = 1JC^{-1}$$

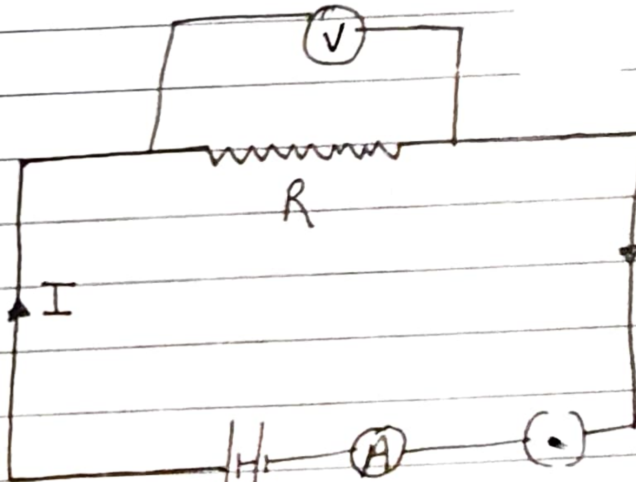
One Ampere ⇒ The current flowing through a conductor is said to be one volt ampere if one coulomb of charge flows through it in one second.

$$I = \frac{Q}{T} = \frac{1}{1} = 1Cs^{-} = 1A$$

According to ohm's law the potential difference across the ends of a conductor is directly proportional to the current flowing through the conductor provided that physical parameters like length cross-sectional area and temperature remain constant.

$$V \propto I$$

$$V = IR$$



where

V = Potential difference

I = current

R = Resistance.

Resistance ⇒ It is the property of conductor due to which it resist the flow of charges through it.

SI unit of Resistance = Ω [ohm]

Factors Affecting Resistance ⇒

(1) It is directly proportional to length of wire

$R \propto l$ —— (1)

(2) It is inversely proportional to cross-sectional area

$R \propto \frac{1}{A}$ —— (2)

Combining (1) and (2) equation

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

$R = \frac{\rho l}{A}$ where ρ = Resistivity.

Resistivity ⇒ It is the resistance offered by a conductor having unit length and unit cross-sectional area.

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

$$\rho = \frac{RA}{l} = \frac{\Omega m^2}{m} = \Omega m$$

$$\boxed{\rho = \Omega m}$$

Resistivity does not depends upon length of wire and cross-sectional area.

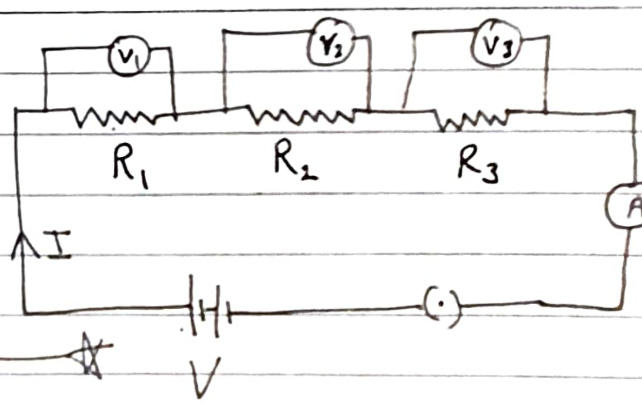
Resistivity depends upon temprature

For Metal → It increases with increase in temp
For Semiconductor ⇒ It decreases with increase in temp

Combination Of Resistances

Series Resistances ⇒ In this resistances are not directly connected to the terminal of battery and same current flow through them.

★ Since voltage is different in series connection so



$V = V_1 + V_2 + V_3$ ——★

from Ohm's law

$V = I R_s$ {R_s = effective resistance in series connection}

$V_1 = I R_1$
$V_2 = I R_2$
$V_3 = I R_3$

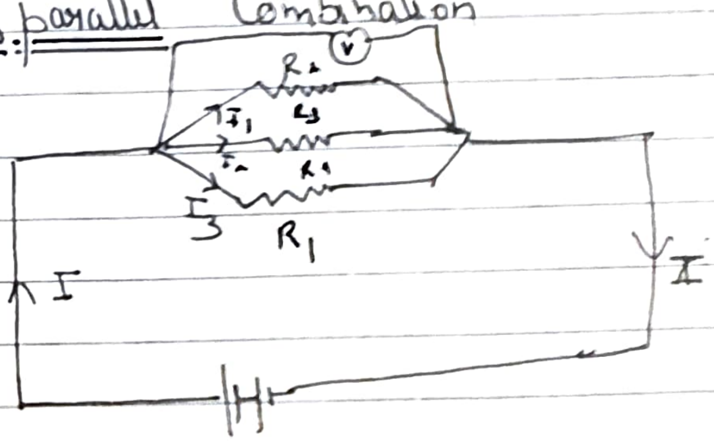
Putting the value of V_1, V_2, V_3 and V in (*) equation

$I R_s = I R_1 + I R_2 + I R_3$

$$R_s = R_1 + R_2 + R_3$$

Parallel Combination ⇒ In this type of combination current divides and voltage remain same.

Equivalent Resistance In parallel Combination



from the diagram

$I = I_1 + I_2 + I_3$ —(*)

from Ohm's law

$V = I R_p$ {R_p = Equivalent resistance in parallel combination}

$$I = \frac{V}{R_p}$$

$$I_1 = \frac{V}{R_1} \qquad I_3 = \frac{V}{R_3}$$

$$I_2 = \frac{V}{R_2}$$

Putting the values of I, I_1, I_2, and I_3 in * equation

$$\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

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

Heating Effect Of Electric Current

Whenever electric current flow through conductor then due to collision b/w the electron and with positive charge ion heat is generated.

Joule's law of Heating

According to Joule the heat produced in a conductor is ~~directly~~

(1) Is directly proportional to square of current

$$H \propto I^2 \quad \text{---} (1)$$

$$I = \frac{V}{R_p}$$

$$I_1 = \frac{V}{R_1} \qquad I_3 = \frac{V}{R_3}$$

$$I_2 = \frac{V}{R_2}$$

Putting the values of I, I_1, I_2, and I_3 in ☆ equation

$$\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

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According to Joule the heat produced in a conductor is ~~directly~~

1) Is directly proportional to square of current

$$H \propto I^2 \quad \text{—— (1)}$$

(2 It is directly proportional to resistance of conductor

$H \propto R$ --- (2

(3 It is directly proportional to the time for which current is passed

$H \propto t$ --- (3

Combining equation (1), (2) and (3)

$H \propto I^2 R t$

$H = K I^2 R t$

$K = 1$

$H = I^2 R t$

Power ⇒ It is the rate at which a device consumes energy

$$P = \frac{\text{Work}}{\text{time}}$$

Work = Heat = $I^2 R t$

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

$P = I^2 R$

$P = V I$

$V = IR$

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

1 kilowatt hour = 1000 J/s × 60 × 60 s

1 kWh = 3.6×10^6 J

One watt → It is the power of a device which consumes one joule of energy in one second.