GRAVITY CLASSES

"Come Gravity Feel Success"

11th & 12th BOARD
(NEET & JEE)

5th - 10th (All Subject)

NOTES

PHYSICS

Directors
ER. AMIR SIR
ER. ASAD SIR

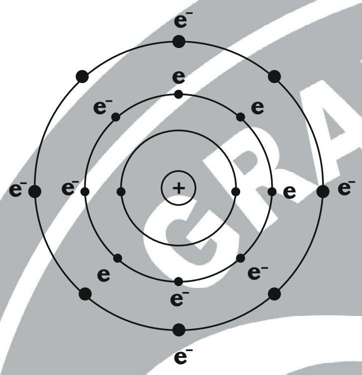
7004166363
7717752909

Address:
Blue star campus,
patther ki masjid, patna - 6

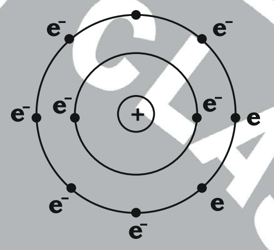
ELECTRICITY

Electricity (Study of Charges)	
Static Electricity	Current Electricity
Def:- Study of Charges at Rest.	Def:- Study of charges at Motion

Conductor	**Insulator**
Material that allows charge to flows.	Material that don't allows to flow charge.
Ex.- Metal, Iron	Ex.- Non-Metal, Glass, Rubber, Woods etc.

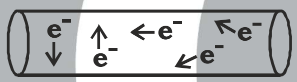


Large Atom (Conductor)



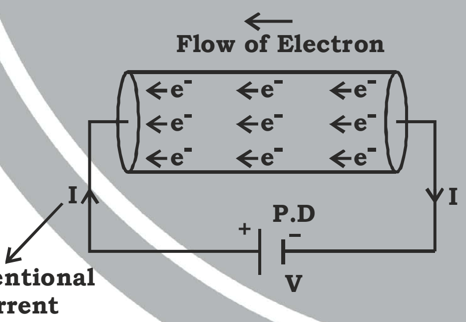
Small Atom (Insulator)

→ **No Cell Connected:-**



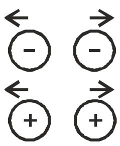
Free Charge Carrier:-
(i) Water
(ii) Temperature (Room)
(iii) Wind

→ **Cell Connected:-**

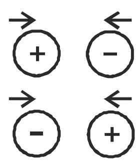


➢ **Electric Charge (q):-** A physical entity which is defined by excess or defficiency of electron on a body.

(i) Like charges repel



(ii) Unlike charges attract each other.



→ It is a scalar quantity.
→ S.I. unit of charge is coulomb (c).
→ Magnitude of charge on one.
→ Proton (+ve charge) = e = $+1.6 \times 10^{-19}$ C
→ Electron (-ve charge) = e = -1.6×10^{-19} C

GRAVITY CLASSES GC

As charge on one electron = 1.6×10^{-19} C

∴ Charge on n electron = $n \times 1.6 \times 10^{-19}$ C

i.e. $\boxed{q = n \times e}$

n = Number of electrons
q = Charge
e = Value of 1 e^- (1.6×10^{-19} C)

➢ **Electric Current (I):-** The amount of charge 'Q' flowing through a particular area of cross-section in unit time 't'.

-Or-

The rate of flow of electric current.

- It is a scalar quantity.
- S.I. unit of current is **Ampere (A).**

$$\boxed{I = \frac{Q}{t}}$$

Where, I = Current
Q = Charge
t = time

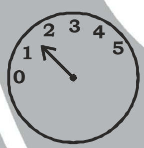
$$\boxed{1A = \frac{1\,\text{Coulomb}}{1\,\text{Second}}}$$

✳ 1A is defined as transfer of 1 coulomb of charge per second through the circuit.

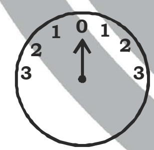
Note:- Direction of electric current is taken as opposite to the flow of electrons.

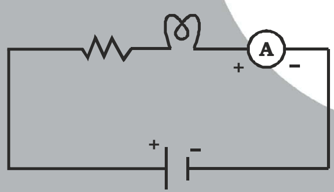
And in circuit diagram current will flow from $\boxed{+ve}$ terminal to $\boxed{-ve}$ terminal.

→ Current is measured by a device called **Ammeter** +–(A)–− and is always connect in series.



(i) **Galvanometer** +–(G)–− [Small current and Direction]





Q. A current of 1A is drawn by a filament of an electric bulb. Find the number of electrons passing through a cross-section of the filament in 16 sec ?

Sol. Given I = 1A, t = 16 sec, Number of electrons (n) = ?

We know,

$$I = \frac{Q}{t} \Rightarrow \quad 1 = \frac{Q}{16} \Rightarrow \quad \boxed{Q = 16\,C},$$

$$Q = ne$$

$$16c = n\left(1.6 \times 10^{-19}\right)$$

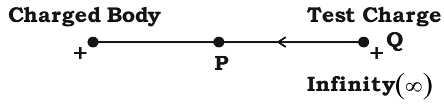
$$n = \frac{16}{1.6 \times 10^{-19}}$$

$$= \frac{160}{16} \times 10^{+19}$$

$$= 10 \times 10^{19}$$

$$\boxed{n = 10^{20}}$$

➢ **Electric Potential (V):-** The amount of W.D (W) when a unit +ve charge (q) is moved from infinity to a point.



$$\boxed{V = \frac{W}{q}} \rightarrow \frac{\text{Joule(J)}}{\text{Coulomb(C)}}$$

or $\boxed{W = Vq}$

→ It is a scalar quantity.

→ S.I. unit is **volt (V) = J/C**.

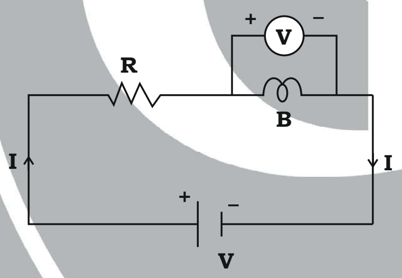
➢ **Electric Potential Difference (ΔV):-** It measures the work done (W) per unit charge. It is defined as the difference in electric potential between two points in an electric field, equal to the work done per unit quantity of charge in moving it from one point to another in an electric static field.

$$\boxed{\begin{gathered}\text{Potential Difference} = \Delta V = \frac{W}{Q} \\ \text{or } V_b - V_a = \frac{W_{AB}}{Q}\end{gathered}}$$

→ It is a **Scalar Quantity**.

→ S.I. unit is $\left(\frac{\text{Joule}}{\text{Coulomb}}\right) = V$.

- The electric potential difference between two points in a circuits is measured using a device called voltmeter or $\overset{+}{-}\!\!(V)\!\!\overset{-}{-}$.
- Voltmeter always connected in **parallel** in the circuit.



Q. How much work is done in moving a charge of 2C from a point of 118 V to a point at 128 V ?

Sol. $Q = 2C$, $V_A = 118\ V$, $V_B = 128\ V$, $W = ?$

Now, $\Delta V = V_B - V_A = (128 - 118)V \Rightarrow 10V$

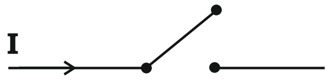
$\Delta V = \frac{W}{Q}$ $\qquad$ $W = 10V \times 2C$

$W = \Delta V \times Q$ $\qquad$ $\boxed{W = 20\ J}$

➢ **Electric Current:-** A closed and continuous path through which electric current flows is known as electric circuits. It has various components including a source of current (a cell or battery) a load (bulb or any appliance), key (to open or close a circuit), fuse etc. all connected through wires. These wires are generally made of copper.

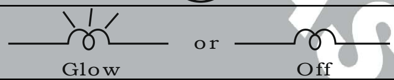
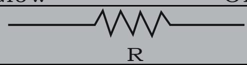
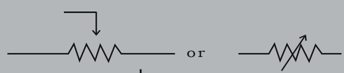
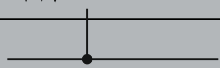
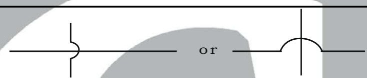
- When key/switch is closed then circuit is called **closed circuit** (i.e. current will flow).

- When key/switch is open then circuit is called **open circuit** (i.e. current would not flow).



(Cannot flow in Air)

➢ **Circuit Diagram:-** It is the pictorial representation of a circuit in which different electrical components of the circuit are presented by their symbol.

Components	Symbol
Cell	
Battery/Combination of Cell	
Switch Open	
Switch Closed	
Ammeter	
Voltmeter	
Electric Bulb	
Resistance (R)	
Variable Resistance (R)	
Joint Wire	
Wire Crossing Not Joining	

➢ **Ohm's Law:-** According to this law, the electric current flowing through a conductor is directly proportional to the potential difference applied across it ends, providing the physical condition (such as temperature) remains unchanged.
i.e.:- If V is the p.d across the ends of a conductor through which current I flows then accroding to Ohm's Law.

$\mathbf{V \propto I}$ **[at, temperature constant]**

$\boxed{\mathbf{V = IR}}$

Where,

V = Potential Difference
R = Resistance
I = Current

It means $R \propto \frac{1}{I}$ **[R is inversely proportional to I if V → Constant]**

So, if resistance is doubled, then current gets halfed and it resistance is halved, then current gets doubled.

➢ **Resistance (R) or Symbol (Ω) Ohm:-** It is that property of a conductor by virtue of which it opposes/resists the flow of charge through it.

∗ Enemy of Current.

→ It is a **scalar quantity**.

→ S.I. unit is **Ohm** (Ω) or $\left(\frac{\textbf{Volt}}{\textbf{Ampere}}\right)$

from Ohm's Law

$V = IR$

$$\boxed{R = \frac{V}{I}}$$

➢ **Factors on which resistance of conductor depends.**

(i) Directly proportional to length (l) of conductor.

i.e. $R \propto l$ ...... (i)

(ii) Inverly proportional to area of cross section (A) of conductor.

i.e. $R \propto \frac{1}{A}$ or $\frac{1}{\pi r^2}$ ...... (ii)

(iii) Nature of material.

(iv) Temperatuure.

Comparing eq. (i) and eq (ii)

$$R \propto l \propto \frac{1}{A}$$

$$R \propto \frac{l}{A} \text{ or } \frac{l}{\pi r^2}$$

$$\boxed{R = \delta\frac{l}{A}} \text{ or } \frac{\delta l}{\pi r^2} \Rightarrow \delta = \frac{RA}{l} \Rightarrow \frac{\Omega m^2}{m} = \Omega m \ \ \textbf{S.I. unit}$$

Where, R = Resistivity or Specific Resistance.

Unit of Resistivity (Ω.m)

➢ **Specific Resistance (δ) or Resistivity (δ):-** Specific resistance of a material is the resistance of a wire of that material of unit length and unit area of cross-section.

Specific Resistance of Some Substances at 20^0 C		
Substance		Specific Resistance (Ωm)
M	Silver	1.63×10^{-8}
E	Copper	1.73×10^{-8}
T	Aluminum	2.63×10^{-8}
A	Lead	2.8×10^{-8}
L	Iron	9.8×10^{-8}
	Steel	20×10^{-8}
Semi Conductor	Graphite	0.2×10^{-5}
	Germanium	0.6×10^{-5}
	Silicon	2.3×10^{-5}
Insulator	Wood	$10^8 - 10^{11}$
	Glass	$10^{10} - 10^{14}$
	Diamond	Nearly 10^{14}
	Polythene	Nearly 10^{16}
Alley	Brass	6.6×10^{-8}
	Magnesium	44×10^{-8}

❖ Resistivity of metallic conductor does not depend on the or thickness of wire.

❖ Metals have low resistivity. So, they are the best conductor of current.

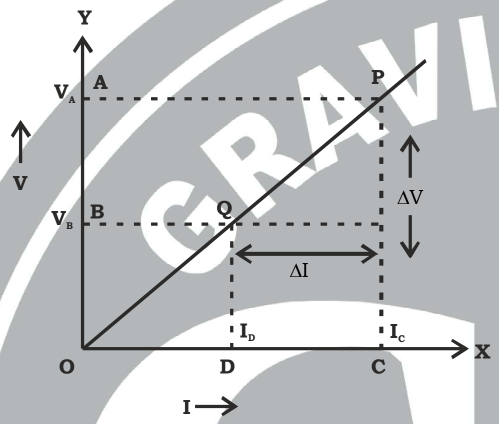
➢ **Conductivity (σ):-** The reciprocal of specific resistance or resistivity is known as conductivity.

It is represented by the symbol σ (sigma).

i.e $$\sigma = \frac{1}{\delta} = \frac{1}{\left(\frac{Ra}{l}\right)} = \frac{l}{Ra}$$

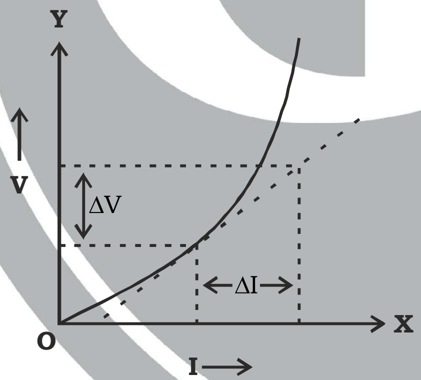
It's S.I unit is $\frac{1}{\text{Ohm} - \text{meter}}$ or **ohm^{-1} meter^{-1}** or **$\Omega^{-1}m^{-1}$.**

➢ **V-I Graph (Ohm's Laws).**



$$R = \frac{V}{I} = \frac{\Delta V}{\Delta I} = \frac{V_A - V_B}{I_C - I_D} = \text{Slope of V v/s I Graph}$$

➢ **Non-Ohmic Resistors:-**



Graph for V v/s I for non-ohmic conductor. Ex.- LED, Transistor, Junction diote etc.

Note:- For an Ohmic resistor, it is necessary that straight line on V-I graph passes through the origin; but for a non-ohmic resistor, it is not necessary that the curve on V-I graph must pass through the origin.

→ **Alloy** have higher resistivity than that of their constituent metals. They do not oxidise easily at higher temperature this is why they are used to make heating elements of device such as iron, heaters etc.

→ **Tungsten** is almost used exclusively for filaments of bulbs, whereas copper and aluminium are generally used for electric transmission lines.

Tungsten [90 – 95% – Tungsten + Ni + Fe]	
Replacing 'Fe' with cobalt to enhance Resistance	Adding cobalt to enhance strength and ductility

Nichrome [80% Nickel, 20% Chromium]

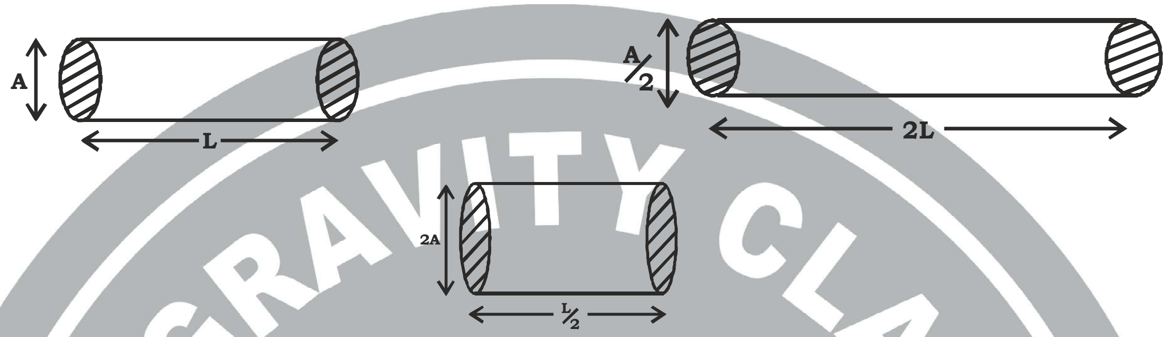
S.S → Fe + Cr + Ni + C

Solder → Pb + Sn

$$\left.\begin{array}{l}\textbf{Brass} \rightarrow Cu + Zn \\ \textbf{Bronze} \rightarrow Cu + Sn\end{array}\right\} \rightarrow \text{Utensil, Coins, Bells etc}$$

Nickel Steel → Fe + Ni (Electric Wire)

Q. All three are made up of same material. which of them highest resistance ?



Sol. δ will be same for all (Because material is same)

(i) $R_1 = \delta\left(\frac{L}{A}\right)$

(ii) $R_2 = \delta\left(\frac{2L}{A/2}\right) \Rightarrow 4\left(\frac{\delta L}{A}\right) = 4(R_1)$

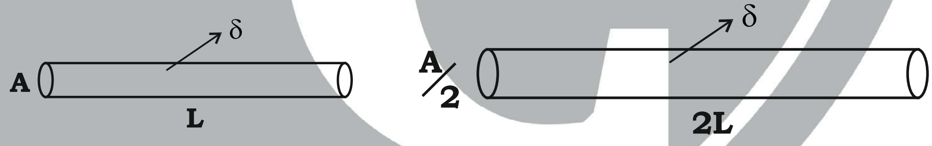
(iii) $R_3 = \delta\left(\frac{L/2}{2A}\right) \Rightarrow \frac{1}{4}\left(\frac{\delta L}{A}\right) = \frac{(R_1)}{4}$

Hence, $R_2 > R_1 > R_3$ (R_2 Have Highest Resistance)

Q. A piece of wire of resistance $20\,\Omega$ is drawn out so that its length is increased to twice its original length. Calculate resistance of wire in the new situation.

Sol. Initially, let length = l, Cross-section area = A, Resistivity = δ

$R_i = \frac{\delta l}{A} = 20$



Now, $R_f = \delta\left(\frac{2L}{A/2}\right) = 4\left(\frac{\delta L}{A}\right) \Rightarrow 4(20) = 80\Omega$

Q. The potential difference between the terminals of an electric heater is 60V when it draws a current of 4A from the source. What current will the heater draw if potential difference is increased to 120V.

Sol. Initially, V = 60V, I = 4A

So, $V = IR \Rightarrow 60 = 4(R) \Rightarrow \boxed{R = 15\Omega}$

Finally, V' = 120V, R = 15V, i = ? [$\because$ wire size is not changing so 'R' will be same]

Again Ohm's Law,

$V = I'R$ $\qquad$ $I' = \frac{120}{15}$

$120 = I'(15)$ $\qquad$ $\boxed{I' = 8A}$

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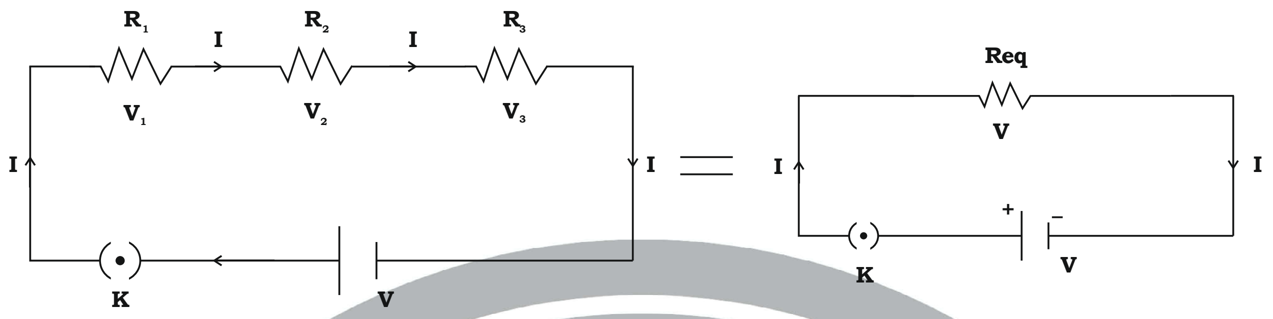
➢ **Series Combination:-** All resistance will attached end to end and same current will flow in these resistance.



Equivalent Resistance ← $R_{eq} = R_1 + R_2 + R_3 + \dots\dots$

- Equivalent resistance is the sum of all the resistance connected in series.
- Equivalent resistance is greater than the resistance of either resistor. So if we have to maximize the resistance just attach in series.
- In series with every resistance.

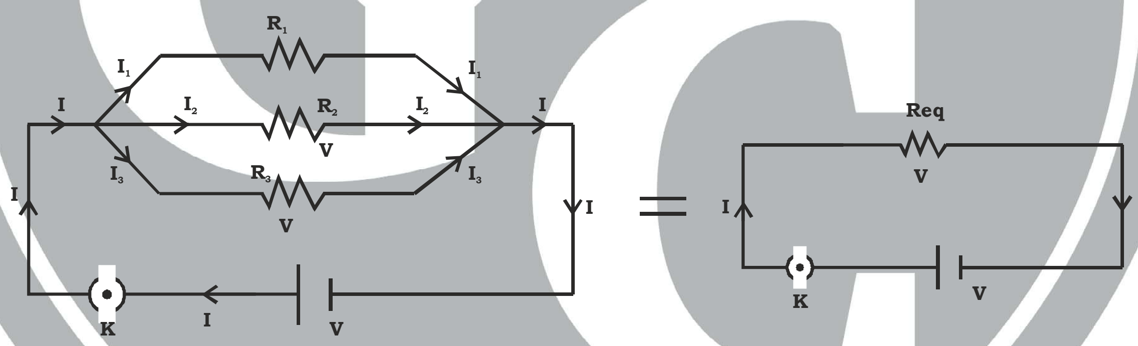
V → Different **I → Same**

✳ **Disadvantages:-**

(i) If any component fails to work then the circuit will break and none of them will work.

(ii) We can't connect bulb and heater in series because they need different values of current.

➢ **Parallel Combination:-** All the resistance will attached parallely and potential difference will be same across each resistance.



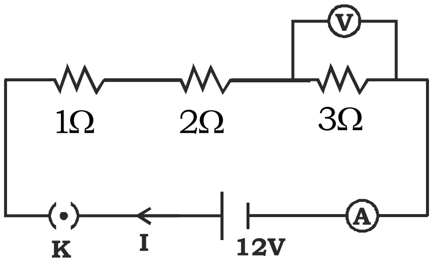
Equivalent Resistance ← $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots\dots$

- The equivalent resistance is less than the resistance of either resistor.
  And when we have to minimize the resistance in circuit then we attach in parallel.
- In parallel across each resistance have **V → Different** **I → Same**
- As it divides the current among the components (electric gadgets), so that they can have necessary amount of current to operate properly. This is the reason of connecting electrical appliances in parallel combination in household circuits.

Q. Find (i) Reading of Amphere.

(ii) Reading of Voltmeter.

(iii) Current across 1Ω resistor.



Sol. Since they all are in series

$\therefore$ I → Same and V → Different

(i) Now, $R_{eq} = R_1 + R_2 + R_3 = 6\Omega$

By Ohm's Law

$V = IR_{eq}$

$12 = I(6)$

$\boxed{I = 2A} \rightarrow$ Reading of (A)

(ii) Voltmeter will give potential difference (V) across 3Ω resistance and we already know current (I) = 2A.

$\therefore$ Again by Ohm's Law,

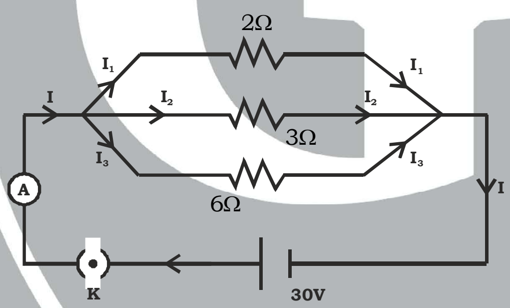
V = IR

V = 2 × 3

$\boxed{V = 6\,V} \rightarrow$ Reading of (V)

(iii) 2A ($\because$ all will have some current as they are in series).

Q. Find the current in each resistane and in ammeter.



Sol. Since they all in parallel

$\therefore$ V → Same and I → Different

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \Rightarrow \boxed{\mathbf{R_{eq} = 1\Omega}}$$

Now, By Ohm's aw,

$V = IR_{eq}$ | $30 = I(1)$ | $\boxed{I = 30\,A} \rightarrow$ Reading in Ammeter (A)

As they all are in parallel.

$\therefore$ All will have same V i.e. 30V

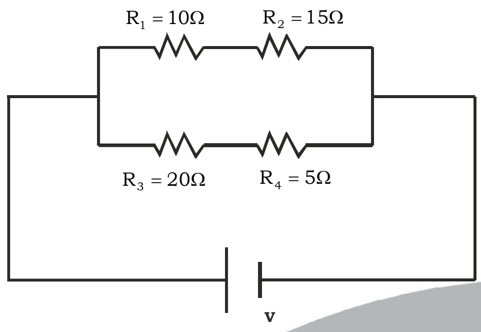
Now, We will find current in all by using simply Ohm's Laws:-

for 2Ω, $I_1 = \frac{V}{R} \Rightarrow \frac{30}{2} \Rightarrow 15A$

for 3Ω, $I_2 = \frac{V}{R} \Rightarrow \frac{30}{3} \Rightarrow 10A$

for 6Ω, $I_3 = \frac{V}{R} \Rightarrow \frac{30}{6} \Rightarrow 5A$

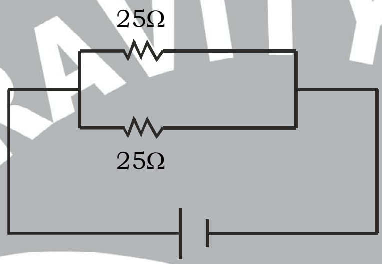
Q. Calculate net resistance of Circuit.



Sol. R_1 and R_2 in series $\Rightarrow R_1 + R_2 \Rightarrow 25\,\Omega$

R_3 and R_4 in series $\Rightarrow R_3 + R_4 \Rightarrow 25\,\Omega$

Now both in parallel.



$$\frac{1}{R_{eq}} = \frac{1}{25} + \frac{1}{25}$$

$$\boxed{\mathbf{R_{eq} = 12.5\,\Omega}}$$

∗ $\boxed{R_{eq} = \dfrac{R_1 . R_2}{R_1 + R_2}}$ Shortcut formula for only two resistance in parallel connection.

- **Heating effect of Electric Current:-** In an electric circuit, to maintain the flow the source continuously has to provide the energy some part of this supplied energy helps in maintainint the current rest of its may be dissipated in form of heat. this is known as heating effect of electric current.
- **Joule's Law of Heating:-** This law implies that the heat produced in a resistor is:-

(i) Heat is directly proportional to square of current in resistance.

i.e. $\boxed{\mathbf{H \propto I^2}}$ ....(i)

(ii) Directly proportional to resistance in circuit.

i.e. $\boxed{\mathbf{H \propto R}}$ ....(ii)

(iii) Directly proportional to the time for which current flows.

i.e. $\boxed{\mathbf{H \propto t}}$ ....(iii)

from eq (i), (ii) and (iii)

$\boxed{\mathbf{H = I^2Rt}}$

- **Practical Applications of Heating Effect:-**

(i) To Produce Light (Electric Bulb):- It has a filament made of tungsten due to high resistivity and high melting point of tungsten, when voltage is applied across the filament it gets heated to a very high temperature. It then becomes white hot and starts radiating heat and light.

(ii) Electric Fuse:- It is used as a safety device in household circuit. It consists of an alloy (Resistivity) of [Lead (50%) + Tin (50%)]. Which has appropriate melting point when the current flowing through the circuit exceeds the safe limit, the temperature of fuse wire increases the fuse wire melts and breaks the circuit. This helps to protect the circuit elements from hazards caused by currents.

Q. 200 J of heat is produced 10 sec in a 5Ω resistance. Find the potential difference across the resistor .

Sol. Given, H = 200 J, t = 10 s, $R = 5\Omega$, V = ?

From, Joule's Law,

$H = I^2Rt$

$200 = I^2 \times 5 \times 10$ $\quad \frac{200}{5\times10} = I^2$ $\quad \boxed{I = 2A}$

Now for V,

Using Ohm's Law

$V = IR$

$V = (2)(5)$ $\quad \boxed{V = 10\,V}$

- **Power (P):-** It is defined as the amount of electric change consumed in a circuit per unit time.

  or

  Rate of doing work, it is W.D in unit time.

  i.e. $\boxed{\mathbf{P = \frac{W}{t}}}$ or $\boxed{\mathbf{P = \frac{E}{t}}}$

→ It is a scalar quantity.

→ S.I. unit is **watt (W)**.

Now, we have

$\boxed{\mathbf{P = \frac{W}{t} = \frac{F}{t}}}$ .....(i)

We knew,

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

$Q = (It)$ .....(ii)

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

$\boxed{W = VQ}$ .....(iii)

$\boxed{W = V(It)}$ [using eq (ii)] .....(iv)

$P = \frac{W}{t} = \frac{VIt}{t}$ [using eq (iv) in eq (i)]

$\boxed{\mathbf{P = VI}}$ .....(v)

We know from Ohm's Law

$V = IR$ .....(vi)

$P = VI$

$P = (IR)I$ [Using eq (vi) in eq (v)]

$\boxed{\mathbf{P = I^2R}}$ .....(vii)

Again from Ohm's law

$V = IR$

$I = \frac{V}{R}$ .....(viii)

$P = VI$

$P = V\left(\frac{V}{R}\right)$ [Using eq (viii) in eq (v)]

$\boxed{P = \frac{V^2}{R}}$ So finally, $\boxed{\mathbf{P = VI = I^2R = \frac{V^2}{R} = \frac{w}{t} = \frac{E}{t}}}$

1 kilowatt (KW) = 10^3 w.
1 megawatt (MW) = 10^6 w.
1 Gigawatt (GW) = 10^9 w.
1 Horse Power (HP) = 746 w.

- **Commercial unit of electrical energy**

1 kWh = 1000 Wh.
= 1000 × 3600 Ws.
= 36 × 10^5 Ws.
= 3.6 × 10^6 Ws.
or

$\boxed{1kwh = 3.6 \times 10^6 J}$ [$\because$ ws = J]

→ Number of units consumed by electric appliance.

Q. An electric bulb runs from the 220V mains. The current flowing through it is 0.6A. At what rate is the electrical energy transformed by the bulb? How much energy is transformed in 2 minutes ?

Sol. Given, V = 220V, I = 0.6A, t = 2 min, t = 120 sec

Energy Transformed / Power(P) = $VI \Rightarrow 200 \times 0.6 \Rightarrow 132\,W$.

Energy Transformed (E) = $Pt \Rightarrow 132 \times 120 \Rightarrow 15840\,J$.

Q. An electric Refrigerator rated 500w operates 6 hrs/day. What is the cost of energy to operate it for 30 days at Rs. 4.5 per kwh ?

Sol. Energy consumed (E) by refrigerator in 30 days.

$E = \underbrace{500\,W}_{P} \times \underbrace{6\,hr/day \times 30\,days}_{t}$

$E = 90000\,Wh$

$E = 90\,kWh$

$\therefore$ Cost of energy to operate the refrigerator for 30 days.

$= 90\,kWh \times 4.5$ per kWh

$= Rs.\,405$

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