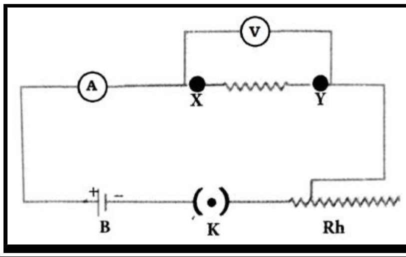
UNIT – 4
ELECTRICITY



I. Choose the best answer

1. Which of the following is correct?
   a) Rate of change of charge is electrical power. **b) Rate of change of charge is current.**
   c) Rate of change of energy is current. d) Rate of change of current is charge.
2. SI unit of resistance is **[SEP – 2021]**
   a) mho b) joule **c) ohm** d) ohm meter
3. In a simple circuit, why does the bulb glow when you close the switch?
   a) The switch produces electricity **b) Closing the switch completes the circuit**
   c) Closing the switch breaks the circuit d) The bulb is getting charged
4. Kilowatt hour is the unit of **[AUG – 2022, MDL – 19]**
   a) resistivity b) conductivity **c) electrical energy** d) electrical power

II. Fill in the blanks

1. When a circuit is open, **current** cannot pass through it.
2. The ratio of the potential difference to the current is known as **resistance**.
3. The wiring in a house consists of **parallel** circuits.
4. The power of an electric device is a product of **current** and **potential difference**.
5. LED stands for **Light Emitting Diode**.

III. True or False. If false correct it.

1. Ohm's law states the relationship between power and voltage. **[False]**
   Ohm's law states the relationship between **current and **potential difference**.*
2. MCB is used to protect household electrical appliances. **[True]**
3. The SI unit for electric current is coulomb. **[False]**
   The SI unit for electric current is **ampere.*
4. One unit of electrical energy consumed is equal to 1000 kilowatt hour. **[False]**
   One unit of electrical energy consumed is equal to **1 kilowatt hour.*
5. The effective resistance of three resistors connected in series is lesser than the lowest of the individual resistances. **[False]**
   Effective resistance of three resistors in series is **greater than **highest** of individual resistances.*

IV. Match the items in Column-I to the items in Column-II

[PTA – 5]

Column I	Column II	Answer
(i) Electric current	(a) volt	**i - (e) ampere**
(ii) Potential difference	(b) ohm metre	**ii - (a) volt**
(iii) Specific resistance	(c) watt	**iii - (b) ohm metre**
(iv) Electrical power	(d) joule	**iv - (c) watt**
(v) Electrical energy	(e) ampere	**v - (d) joule**

V. Assertion and Reason type questions

Mark the correct choice as

a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.
b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
c) If the assertion is true, but the reason is false.
d) If the assertion is false, but the reason is true.

1. **Assertion:** Electric appliances with a metallic body have three wire connections.
   Reason : Three pin connections reduce heating of the connecting wires.
   Ans. (c) ***The assertion is true, but the reason is false.***

2. **Assertion:** In a simple battery circuit the point of highest potential is the positive terminal of the battery.
   Reason : The current flows towards the point of the highest potential.
   Ans. (c) ***The assertion is true, but the reason is false.***

3. **Assertion:** LED bulbs are far better than incandescent bulbs.
   Reason : LED bulbs consume less power than incandescent bulbs.
   Ans. (a) ***Both the assertion and the reason are true and the reason is the correct explanation of the assertion.***

VI. Very short answer questions

1. Define the unit of current.

❖ SI unit of current is ampere (A). Current through a conductor is one ampere, when a charge of one coulomb flows across its cross-section, in one second.

$$1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

2. What happens to the resistance, as the conductor is made thicker?

❖ ***Resistance decreases.*** Because resistance is inversely proportional to area of cross section.

3. Why is tungsten metal used in bulbs, but not in fuse wires?

❖ Tungsten having high melting point won't melt easily. Hence, it is not used in fuse wire.
❖ But it is used in bulbs where it has to bear high heat.

4. Name any two devices, which are working on the heating effect of the electric current.

❖ Fuse wire, electric iron, toaster, oven, etc,.

VII. Short answer questions

1. Define electric potential and potential difference.

Electric potential: It is the amount of work done in moving a unit positive charge from infinity to that point against the electric force.

Potential difference: It is the amount of work done in moving a unit positive charge from one point to another point against the electric force.

$$\text{Potential Difference (V)} = \frac{\text{Work done (W)}}{\text{Charge (Q)}}$$

2. What is the role of the earth wire in domestic circuits?

- Earth wire act as protective conductor and saves us from electric shocks.
- When a live wire accidentally touches the metallic body of the appliance, earth wire provides a low resistance path to the current and sends it from the body to the earth.

3. State Ohm's law.

At a constant temperature, the steady current 'I' flowing through a conductor is directly proportional to the potential difference 'V' between the two ends of the conductor.

$$I \propto V \quad \Rightarrow \quad V = IR$$

Where R → Resistance of the material.

4. Distinguish between the resistivity and conductivity of a conductor.

Resistivity (ρ)	Conductivity (σ)
i) It is the resistance of a conductor of unit length and unit area of cross section.	i) It is the reciprocal of electrical resistivity.
ii) Its unit is **ohm metre** (Ωm).	ii) Its unit is **mho metre^{-1}**.
iii) It is the measure of resisting power.	iii) It is the measure of ability to pass the current.

5. What connection is used in domestic appliances and why?

Domestic appliances are connected in parallel.

Reason:
- Disconnection of one circuit does not affect other circuit
- Each appliance gets an equal voltage.

VIII. Long answer questions

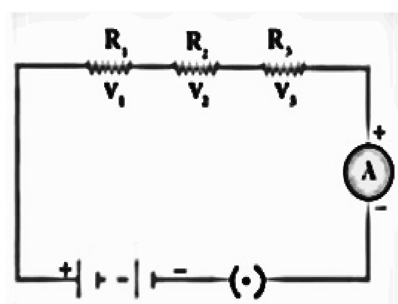
1. With the help of a circuit diagram, derive the formula for the resultant resistance of three resistances connected: a) in series and b) in parallel

a) Resistance in Series :

R_1, R_2 and R_3 are the resistors in series, R_s = resultant resistance,

V_1, V_2 and V_3 are potential differences. Current is same and let it be I.

According to ohm's law,



$$V_1 = IR_1 \longrightarrow (1)$$
$$V_2 = IR_2 \longrightarrow (2)$$
$$V_3 = IR_3 \longrightarrow (3)$$
$$V = IR_s \longrightarrow (4)$$

The sum of the potential differences of each resistor is

$$V = V_1 + V_2 + V_3 \longrightarrow (5)$$
$$IR_s = IR_1 + IR_2 + IR_3$$
$$\mathbf{R_s = R_1 + R_2 + R_3}$$

∴ When resistors are in series, resultant resistance is the sum of individual resistances.

b) Resistance in parallel : **[PTA – 4]**

R_1, R_2 and R_3 are the resistors in parallel, R_p = resultant resistance.

Potential difference is same for all resistors.

Current I at A divides into I_1, I_2 and I_3.

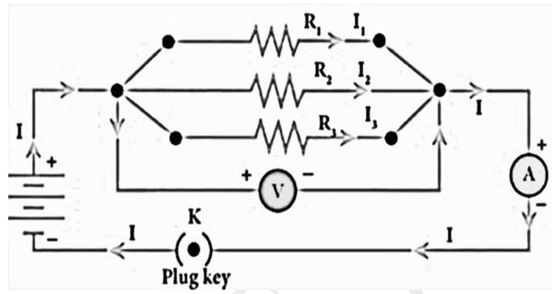
According to ohm's law,

$I_1 = \frac{V}{R_1}$ .... (1)

$I_2 = \frac{V}{R_2}$ .... (2)

$I_3 = \frac{V}{R_3}$ .... (3)

$I = \frac{V}{R_P}$ .... (4)



Total current is

$I = I_1 + I_2 + I_3$.......................... (5)

$$\Rightarrow \frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

∴ When resistors are in parallel, the sum of the reciprocals of individual resistance is equal to the reciprocal of resultant resistance.

2. a) What is meant by electric current? **[MAY - 2022,PTA – 1]**

It is the rate of flow of charges in a conductor. (or) It is the amount of charges flowing in any cross section of a conductor in unit time.

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

b) Name and define its unit. (or) Define the unit of electric current. **[MAY - 2022,PTA– 1]**

- ❖ SI unit of electric current is ampere (A).
- ❖ Current flowing through a conductor is said to be one ampere, when a charge of one coulomb flows across any cross-section of a conductor, in one second.

$$1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

c) Which instrument is used to measure the electric current? How should it be connected in a circuit? **[MAY - 2022,PTA– 1]**

Ammeter. It should be **connected in series** in a circuit.

3. a) State Joule's law of heating. (Or) Write two properties of the heat produced in any resistor, according to the Joules Law of heating.

Joules' law of heating states that the heat produced in any resistor is

- ❖ directly proportional to the square of the current.
- ❖ directly proportional to the resistance.
- ❖ directly proportional to the time.

$$H = I^2 R t$$

b) An alloy of nickel and chromium is used as the heating element. Why?

(i) It has high resistivity and high melting point.
(ii) It is not easily oxidized.

c) How does a fuse wire protect electrical appliances?

❖ When a large current passes, the fuse wire melts due to joule's heating effect. Hence, the circuit gets disconnected. Thus, electric appliances are saved from any damage.

4. Explain about domestic electric circuits.(circuit diagram not required) [SEP – 2020]

Source :

Electricity produced in power stations is distributed to domestic circuits through overhead and underground cables. Power supply is brought to main-box from a distribution panel.

Main-box :

Meter : Used to record the consumption of electrical energy.

Fuse box : Contains fuse wire or miniature circuit breaker (MCB). Used to protect appliances.

Types of wires :

❋ ***Live wire*** has red insulation. ❋ ***Neutral wire*** has black insulation.

Domestic electric circuit :

❖ Alternating current with electric potential of 220 V is supplied.
❖ Live wire connected via main fuse and neutral wire enter into electricity meter.
❖ These wires then enter into main switch.
❖ ***There are two separate circuits :***
 ☞ **5 A rating** – for low power rating appliances. ***Ex :*** Tube lights, Bulbs, Fans
 ☞ **15 A rating** – for high power rating appliances. ***Ex :*** AC, Fridge, Heaters
❖ Circuits are in parallel. Disconnection of one will not affect the other. Each get equal voltage.

5. a) What are the advantages of LED TV over the normal TV? [PTA – 6]

❖ It has brighter picture quality.
❖ It is thinner in size.
❖ It uses less power
❖ It consumes less energy.
❖ Its life span is more.
❖ It is more reliable.

5. b) List the merits of LED bulb. [PTA – 1]

❖ There is no loss of energy in the form of heat.
❖ It requires low power.
❖ It is not harmful to environment.
❖ It is cost efficient and energy efficient.
❖ Many colours are available.
❖ Mercury and other toxic materials are not required.

IX. Numerical problems

1. An electric iron consumes energy at the rate of 420 W when heating is at the maximum rate and 180 W when heating is at the minimum rate. The applied voltage is 220 V. What is the current in each case?

Given : V = 220 V, P_{max} = 420 W, P_{min} = 180 W

Solution : P = VI

$I_{max} = \frac{P_{max}}{V} = \frac{420}{220} = \frac{21}{11} = 1.909$ A & $I_{min} = \frac{P_{min}}{V} = \frac{180}{220} = \frac{9}{11} = 0.818$ A

2. A 100 watt electric bulb is used for 5 hours daily and four 60 watt bulbs are used for 5 hours daily. Calculate the energy consumed (in kWh) in the month of January.

Solution :

No. of days in January month = 31 days

Energy consumed by one 100 W bulb = $P \times t \times \text{no. of days used} \times \text{no. of bulbs}$

$= 100 \times 5 \times 31 \times 1 = 15500$

$= 15.5$ kWh.

Energy consumed by four 60 W bulb = $P \times t \times \text{no. of days used} \times \text{no. of bulbs}$

$= 60 \times 5 \times 31 \times 4 = 37.2$ kWh

∴ Total energy consumed = 15.5 + 37.2 = 52.7 kWh

3. A torch bulb is rated at 3 V and 600 mA. Calculate its

a) Power b) Resistance c) Energy consumed if it is used for 4 hour.

Given : V = 3 V; I = 600 mA = 0.6 A

Solution :

a) Power : $P = VI = 3 \times 0.6 = 1.8$ watt

b) Resistance : $R = \frac{V}{I} = \frac{3}{0.6} = 5\ \Omega$

c) Energy consumed if it used for 4 hour.

E = power × time = 1.8 × 4 = 7.2 watt hour

4. A piece of wire having a resistance R is cut into five equal parts.

a) How will the resistance of each part of the wire change compared with the original resistance?

b) If the five parts of the wire are placed in parallel, how will the resistance of the combination change?

c) What will be the ratio of the effective resistance in series connection to that of the parallel connection?

Solution :

a) length of each part $L' = \frac{L}{5}$

Resistance of each part, $R' = \frac{\rho L'}{A} = \frac{\rho L}{5A} = \frac{R}{5}$

∴ Resistance of each part is reduced to one-fifth of the original resistance.

b) If the five parts are placed in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$\frac{1}{R_P} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{25}{R}$$

$$\Rightarrow R_P = \frac{R}{25}$$

∴ Resistance of each part is reduced to one-twenty-fifth of the original resistance.

c) If the five parts are connected in series, Resistance $R_S = R$

$$\frac{R_S}{R_P} = \frac{R}{\frac{R}{25}} = \frac{R \times 25}{R} = \frac{25}{1}$$

∴ Ratio is $R_s : R_p = 25 : 1$

X. HOTS questions

1. Two resistors when connected in parallel give the resultant resistance of 2 ohm; but when connected in series the effective resistance becomes 9 ohm. Calculate the value of each resistance.

Given: $R_P = 2\,\Omega$ $R_S = 9\,\Omega$

Solution :

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2}$ .... (1)

$R_s = R_1 + R_2 = 9\,\Omega$ .... (2)

$R_2 = 9 - R_1$ .... (3)

Substitute (3) in (1)

$\frac{1}{R_1} + \frac{1}{9 - R_1} = \frac{1}{2}$

$\frac{9 - \cancel{R_1} + \cancel{R_1}}{R_1(9 - R_1)} = \frac{1}{2}$

$\frac{9}{R_1(9 - R_1)} = \frac{1}{2}$

$18 = 9R_1 - R_1^2$

$R_1^2 - 9R_1 + 18 = 0$

$(R_1 - 3)(R_1 - 6) = 0$

$R_1 = 3\,\Omega$ (or) $R_1 = 6\,\Omega$

$R_2 = 9 - 3 = 6\,\Omega$ (or) $R_2 = 9 - 6 = 3\,\Omega$

∴ Resistance of the two resistors are **3 Ω** and **6 Ω.**

2. How many electrons are passing per second in a circuit in which there is a current of 5 A?

Given : I = 5 A ; Time, t = 1 s ; $e = 1.6 \times 10^{-19}$ C **[MDL – 19]**

Solution : $I = \frac{Q}{t} = \frac{ne}{t}$ [∵ Q = ne]

$n = \frac{It}{e} = \frac{5 \times 1}{1.6 \times 10^{-19}}$ ⇒ $n = 3.125 \times 10^{19}$ electrons

∴ **3.125×10^{19}** electrons are passing per second.

3. A piece of wire of resistance 10 ohm is drawn out so that its length is increased to three times its original length. Calculate the new resistance.

Given : R = 10 Ω; Original length = L; Increased length = 3 L

Solution : If length is increased to 3 times the original length at constant volume, area of cross section is decreased to 3 times the original area. ∴ $A' = \frac{A}{3}$

New Resistance, $R' = \frac{\rho L'}{A'} = \frac{\rho 3L}{\frac{A}{3}} = 9\frac{\rho L}{A} = 9R = 9 \times 10 = 90\,\Omega$

∴ The new resistance is **90 Ω.**