PETIT SEMINAIRE HIGHER SECONDARY SCHOOL – PUDUCHERRY

UNIT – 4 ELECTRICITY

STD: X SELF – EVALUATION

I. Choose the best answer:

1. Which of the following is correct? **(B) Rate of change of charge is current**
2. SI unit of resistance is **(C) Ohm**
3. In a simple circuit, why does the bulb glow when you close the switch? **(B) Closing the switch completes the circuit.**
4. Kilowatt hour is the unit of **(C) electrical energy**

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 writing in a house consists of **Parallel** circuits.
4. The power of an electric device is a product of **Electric current and Potential difference**
5. LED stands for **Light Emitting Diode**

III. State whether the following statements are true or false: If false correct the statement:

1. Ohm's law states the relationship between power and voltage. **- False**
   Correct statement: Ohm's law states the relationship between current and voltage (potential difference).
2. MCB is used to protect house hold electrical appliances. - **True**
3. The SI unit for electric current is the coulomb - **False**
   Correct statement: The SI unit for electric current is ampere. (or) The SI unit for electric charge is the coulomb.
4. One unit of electrical energy consumed is equal to 1000 kilowatt hour. **- False**
   Correct statement: 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**
   Correct statement: The effective resistance of three resistors

connected in parallel is lesser than the lowest of the individual resistances. (or) The effective resistance of three resistors connected in series is greater than the highest of the individual resistances.

IV. Match the following:

S.No	Column 1	Column 2
1	Electric current	ampere
2	Potential difference	volt
3	Specific resistance	ohm meter
4	Electrical power	watt
5	Electrical energy	joule

V. Assertion & Reasoning:

1. Assertion: Electric appliances with a metallic body have three wire connections. Reason: Three pin connections reduce heating of the connecting wires.

   C) If 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.

   C) If 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.

   A) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

VI. Very Short answers questions:

1. Define the unit of current.

   The SI unit of electric current is ampere (A). The 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.

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

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

   Decreases: The resistance decreases as the conductor is made thicker.

   Reason: Resistance is inversely proportional to area of cross section A.

i.e., $R \alpha \frac{1}{A}$ - here, $A = \pi r^2$, where r is the radius which determines the thickness.

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

   Tungsten has high melting point, it can bear high heat for glowing. But in fuse wire, the wire used in it should melt. So a metal (wire) which has low melting point should be used in a fuse wire, but not tungsten wire.

4. Name any two devices, which are working on the heating effect of the electric current.
   - ➤ Electric iron box
   - ➤ Electric heater
   - ➤ Electric toaster

VII. Short Answers Questions:

1. Define electric potential and potential difference.

   Electric potential:

   The electric potential at a point is defined as the amount of work done in moving a unit positive charge from infinity to that point against the electric force.

   Electric potential difference:

   The electric potential difference between two points is defined as the amount of work done in moving a unit positive charge from one point to another point against the electric force.

$$\text{Potential difference (V)} = \frac{\text{workdone (W)}}{\text{charge (Q)}}$$

2. What is the role of the earth wire in domestic circuits?
   - The earth wire provides a low resistance path to the electric current.
   - The earth wire sends the current from the body of the appliances to the earth, whenever a live wire accidentally touches the body of metallic electric appliances.
   - Thus, the earth wire serves as a protective conductor, which saves us from electric shocks.

3. State Ohm's law?

   Ohm's law states that, at a constant temperature, the steady temperature 'I' flowing through a conductor is directly proportional to the potential difference 'V' between two ends of the conductor. V α I, V = IR.

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

S.No	Resistivity	Conductivity
1	Electric resistivity of a material is defined as the resistance of a conductor of unit length and unit of cross section.	The reciprocal electrical resistivity of a material is called its electrical conductivity.
2	It's unit is ohm metre	It's unit is mho metre^{-1}
3	It is a measure of the resisting power of a specified material to the passage of an electric current. It is a constant for a given material.	It is a measure of its ability to pass the current through it.

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

   (i) All the circuits in a house are connected in parallel, so that the disconnection of one circuit does affect the other circuit.

   (ii) One more advantage of the parallel connection of circuits is that each electric appliance gets equal voltage.

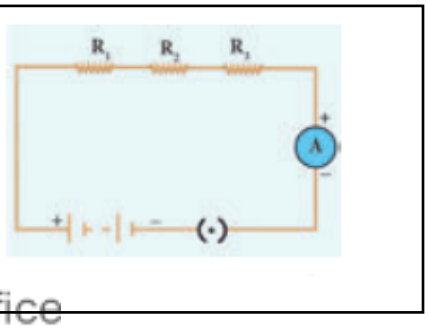
VIII. Answer in detail:

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:

   Let three resistances R_1, R_2 and R_3 be connected in series. The current flowing through them be I. According to Ohm's law, the potential differences V_1, V_2 and V_3 across R_1, R_2 and R_3 respectively are given

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



The sum of the potential differences across the ends of each resistor is given by

$$V = V_1 + V_2 + V_3 \quad \rightarrow \quad (1)$$

Substituting the values of V_1, V_2 and V_3 in above equation (1),

$$V = IR_1 + IR_2 + IR_3 \quad \rightarrow \quad (2)$$

The effective resistance of the series – combination of the resistor be Rs. Then

$$V = IR_s \quad \rightarrow \quad (3)$$

Combining equations (2) and (3), you get

$$IR_s = IR_1 + IR_2 + IR_3$$

$$R_s = R_1 + R_2 + R_3$$

The resistors are connected in series, their equivalent resistance or an effective resistance is equal to the sum of the individual resistances.

b) Resistance in parallel:

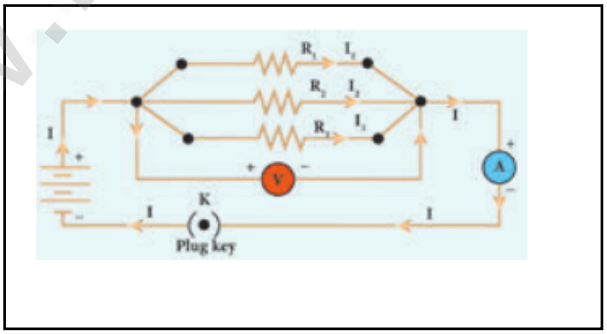
Consider that three resistors R_1, R_2 and R_3 are connected across two common points A & B. The potential difference across each resistance is the same and equal to the potential difference between A and B. This is measured using the voltmeter. The current I arriving at A divides into three branches I_1, I_2 and I_3 passing through R_1, R_2 and R_3 respectively.

According to the Ohm's law, you have

$$I_1 = \frac{V}{R_1}$$

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

$$I_3 = \frac{V}{R_3}$$



The total current through the circuit is given by

$$I = I_1 + I_2 + I_3 \quad \rightarrow \quad (1)$$

Substituting the values of I_1, I_2 and I_3 in above equation (1),

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \rightarrow \quad (2)$$

Let the effective resistance of the parallel combination of resistors be Rp then,

$$I = \frac{V}{R_p} \quad \rightarrow \quad (3)$$

Combining equations (2) and (3)

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

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

Thus, when a number of resistors are connected in parallel, the sum of the reciprocals of the individual resistance is equal to the reciprocal of the effective or equivalent resistance.

2. (a) What is meant by electric current?

Electric current is defined as the rate of flow of charges in a conductor.

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

(b) Name and Define its unit.

The SI unit of electric current is ampere (A).

The current flowing through a conductor is said to be one ampere, when a charge of one coulomb flow 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?

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

3. (a) State Joule's law of heating.

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

- Directly proportional to the square of the current passing through the resistor.
- Directly proportional to the resistance of the resistor.
- Directly proportional to the time for which the current passing through the resistor.

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

It has high resistivity; It has a high melting point; It is not easily oxidized.

(c) How does a fuse wire protect electrical appliances?

When a large current passes through the circuit, the fuse wire melts due to joule's heating effect and hence the circuit gets disconnected therefore, the circuit and the electric appliances are saved from any damage. The fuse wire is made up of a material whose melting point is relatively low.

4. Explain about domestic electric circuits. (Circuit diagram not required)
    - The first stage of the domestic circuit is to bring the power supply to the main box from a distribution panel, such as a transformer.
    - Important components of the main box are (i) a fuse box and (ii) meter.
    - Meter is used to record the consumption of electrical energy.
    - Fuse box contains either a fuse wire or a miniature circuit breaker (MCB).
    - Fuse wire or a MCB is a protect the household electrical appliances from overloading due to excess current.
    - The electricity is brought to house by two insulated wires. The other wire has a black insulation and is called the neutral wire.
    - The electricity supplied to your house is actually an alternating current having an electrical potential at 220 V. Both the live wire and the neutral wire enter into box where the main switch, which is used to discontinue the electricity supply whenever required.
    - After the main switch, these wires are connected to live wires of two separate circuits.
    - One circuit is of a 5 A rating. The other circuit is of a 15 A rating.
    - It should be noted that all the circuits in a house are connected in parallel, so that the disconnection of on circuit does not affect the other circuit.
5. a) What are the advantages of LED TV over the normal TV?

    Advantages of LED Tv:
    - It has brighter picture quality.
    - It is thinner in size
    - It used less power and consumes very less energy.
    - Its life span is more.
    - It is more reliable.

    b) List the merits of LED bulb?

    Merits of LED bulb:

- As there is no filament, there is no loss of energy in the form of heat. It is cooler than the incandescent bulb.
- Led bulbs have significantly low power requirement.
- It is not harmful to the environment.
- It is cost efficient and energy efficient.
- A wide range of colours is possible here.
- Mercury and other toxic material are not required.

IX. Numerical problems:

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

   Applied voltage (V) = 220 V

When heating is at the maximum rate, the rate at which energy consumed

P = 420 W

P = VI

$$I = \frac{P}{V} = \frac{420}{220} = 1.9 \text{ A}$$

When heating is at the minimum rate, the rate at which energy consumed

P = 180 W

P = VI

$$I = \frac{P}{V} = \frac{180}{220} = 0.8 \text{ A}$$

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.

   January month = 31 days

   No. of 60 W bulb = 4

   Used hour for 60 W bulbs = 5 hours

   Used hour for 100 W bulbs = 5 hours

   Energy consumed in January month for 100 W bulb = 100 x 31 x 5 = 15500

   = 15.5 KWh (1 KWh = 1000 W)

   Energy consumed in January month for 60 W bulb = 60 x 31 x 5 x 4

   = 37.2 KWh (1 KWh = 1000 W)

   Total Energy consumed = $E_1 + E_2$

   = 15.5 + 37.2 = 52.7 KWh

3. A torch bulb is rated at 3 V and 600 mA. Calculate it's a) power b) resistance c) energy consumed if it is used for 4 hour.

   a. V = 3V; I = 600 x 10^{-3} A

      Power (P) = VI = 3 x 600 x 10^{-3}

      P = 3 x 0.6 = 1.8 watt

   b. Resistance (R) = $\frac{V}{I} = \frac{3}{0.6}$ = 5 Ω

   c. Energy = power x time

      E = 1.8 x 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?

      Resistance = R

      The wire is cut into 5 equal parts resistance of each part = $\frac{R}{5}$ Ω

      The resistance of any conductor is directly proportional to the length of the conductor. R α l

      The resistance of each part of the wire is reduced five times of original resistances.

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

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

$$R_1 = R_2 = R_3 = R_4 = R_5 = \frac{R}{5}$$

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

$$R_p = \frac{R}{25}\Omega$$

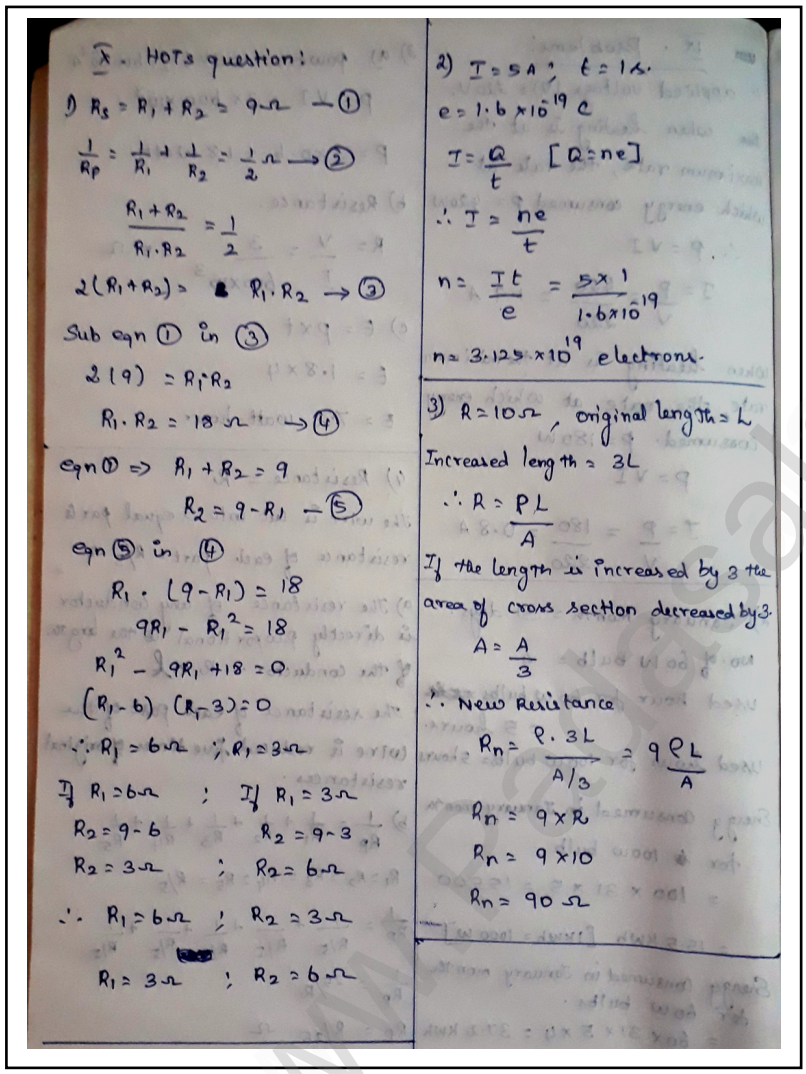
   c. What will be ratio of the effective resistance in series connection to that of the parallel combination?

$$R_s = \frac{R}{5} + \frac{R}{5} + \frac{R}{5} + \frac{R}{5} + \frac{R}{5} = \frac{5R}{5}$$

$$R_s = R\ \Omega$$

$$\therefore R_s : R_p = \frac{R_s}{R_p} = \frac{R}{\frac{R}{25}} = \frac{25}{1} = 25 : 1$$

X. HOT's Question:



X. HOTs question:

1) $R_s = R_1 + R_2 = 9\Omega$ — ①

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2}\Omega$ → ②

$\frac{R_1 + R_2}{R_1 \cdot R_2} = \frac{1}{2}$

$2(R_1 + R_2) = R_1 \cdot R_2$ → ③

Sub eqn ① in ③

$2(9) = R_1 R_2$

$R_1 \cdot R_2 = 18\Omega$ → ④

eqn ① ⇒ $R_1 + R_2 = 9$

$R_2 = 9 - R_1$ — ⑤

eqn ⑤ in ④

$R_1 \cdot (9 - R_1) = 18$

$9R_1 - R_1^2 = 18$

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

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

$\therefore R_1 = 6\Omega$; $R_1 = 3\Omega$

If $R_1 = 6\Omega$; If $R_1 = 3\Omega$

$R_2 = 9 - 6$ $R_2 = 9 - 3$

$R_2 = 3\Omega$; $R_2 = 6\Omega$

$\therefore R_1 = 6\Omega$; $R_2 = 3\Omega$

$R_1 = 3\Omega$; $R_2 = 6\Omega$

2) $I = 5A$; $t = 1s$.

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

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

$\therefore I = \frac{ne}{t}$

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

$n = 3.125 \times 10^{19}$ electrons.

3) $R = 10\Omega$, original length = L

Increased length = $3L$

$\therefore R = \frac{\rho L}{A}$

If the length is increased by 3 the area of cross section decreased by 3.

$A = \frac{A}{3}$

∴ New Resistance

$R_n = \frac{\rho \cdot 3L}{A/3} = 9\frac{\rho L}{A}$

$R_n = 9 \times R$

$R_n = 9 \times 10$

$R_n = 90\Omega$