CHAPTER 11

Electricity

Level - 1

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (A) is correct.

Explanation: Maximum resistance is obtained when resistors are connected in series.

$$R_{max} = \frac{1}{5}+\frac{1}{5}+\frac{1}{5}+\frac{1}{5}+\frac{1}{5} = 1\,\Omega$$

2. Option (C) is correct.

Explanation: Slope for I-V graph: 1/R is least for R_3.

Hence, R_3 has the greatest resistance value.

3. Option (D) is correct.

Explanation: The resistance of a wire is inversely proportional to its cross-sectional area and directly proportional to its length. Therefore, to minimise the resistance of the wire, you would want to maximise the cross-sectional area and minimise the length.

Among the given options:

(A) $\frac{D}{2}$ and $\frac{L}{4}$ $\rightarrow$ Cross-sectional area: $\left(\frac{D}{2}\right)^2 = \frac{D^2}{4}$,

Length: $\frac{L}{4}$

(B) D/4 and 4L $\rightarrow$ Cross-sectional area: $(D/4)^2 = D^2/16$, Length: 4L

(C) 2D and L $\rightarrow$ Cross-sectional area: $(2D)^2 = 4D^2$, Length: L

(D) 4D and 2L $\rightarrow$ Cross-sectional area: $(4D)^2 = 16D^2$, Length: 2L

The option (D) maximises the cross-sectional area 16 times and increase the length only moderately.

4. Option (C) is correct.

Explanation: Combination I: Two resistors of 2Ω each in parallel. Equivalent resistance,

$$\frac{1}{R_{eq}} = \frac{1}{2\Omega}+\frac{1}{2\Omega}$$

$$\Rightarrow \quad R_{eq} = \frac{2\Omega}{2} = 1\Omega$$

Combination II: Three resistors of 3Ω each in parallel. Equivalent resistance,

$$\frac{1}{R_{eq}} = \frac{1}{3\Omega}+\frac{1}{3\Omega}+\frac{1}{3\Omega}$$

$$R_{eq} = \frac{3\Omega}{3}$$

$$\Rightarrow \quad R_{eq} = 1\Omega.$$

Combination III: Two resistor of 4Ω, 2Ω are in series so, resistance of branch R′ = 4+2 ⇒ 8 Ω There are two such branches in parallel. Hence,

$$\frac{1}{R_{eq}} = \frac{1}{8}+\frac{1}{8}$$

$$\Rightarrow \quad R_{eq} = \frac{8\Omega}{2} = 4\Omega$$

Combination IV: Two resistors of 0.5Ω each in parallel. Equivalent resistance,

$$\frac{1}{R_{eq}} = \frac{1}{0.5\Omega}+\frac{1}{0.5\Omega}$$

$$\Rightarrow \quad R_{eq} = \frac{0.5\Omega}{2} = 0.25\Omega$$

Hence, Combination I and II have 1 Ω resistance only.

5. Option (A) is correct.

Explanation: $H = I^2Rt$

I = 5 A, R = 20 Ω, t = 30 s

$H = (5)^2 \times 20 \times 30 = 15000$ J

6. Option (C) is correct.

Explanation: When too many electrical appliances are connected to a single socket, the total resistance of the circuit decreases because the appliances are typically connected in parallel. According to Ohm's Law, I = V/R, if the resistance decreases while the voltage remains constant, the current drawn from the source increases. If the current exceeds the rated value of the circuit, it can cause overheating or even short-circuiting.

7. Option (D) is correct.

Explanation: When four identical resistors of resistance 8Ω are connected in series, the total resistance R_S can be calculated using the formula $R_S = n \times R$, where n is the number of resistors and R is the resistance of each resistor. In this case, $n = 4$ and $R = 8\Omega$, so $R_S = 4 \times 8\Omega = 32\Omega$.

When the same resistors are connected in parallel, the effective resistance R_P can be calculated using the formula $\frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$, where R is the resistance of each resistor. Substituting the values, we get $\frac{1}{R_P} = \frac{1}{8\Omega} + \frac{1}{8\Omega} + \frac{1}{8\Omega} + \frac{1}{8\Omega} = \frac{1}{2\Omega}$.

Therefore, $R_P = 2\Omega$.

$$\frac{R_S}{R_P} = \frac{32}{2} = 16$$

8. Option (A) is correct.

Explanation: The wiring with a 15 A current rating can handle the load and avoid overheating or damage as devices with higher power ratings require a higher current to function.

9. Option (C) is correct.

Explanation: Least count of any scale is the value measured by a single division on it.

10 div = 1.5 V

So, 1 div = 1.5 / 10 = 0.15 V

Hence, least count = 0.15 V

Reading shown = least count × no. of div. = 0.15 × 12 = 1.8 V

Hence, Reading shown = 1.8 V

10. Option (B) is correct.

Explanation: Ammeter: Measures the current flowing through the circuit. It must be connected in series with the resistor to ensure the entire current flowing through the resistor also passes through the ammeter.

Voltmeter: Measures the potential difference (voltage) across the resistor. It must be connected in parallel with the resistor to measure the voltage drop across it.

This arrangement ensures accurate verification of Ohm's law, which states V = IR, where V is the voltage, I is the current, and R is the resistance.

11. Option (B) is correct.

Explanation: Heat dissipated in a resistive circuit:

$H = I^2Rt$

where, H: Heat dissipated, I: Current, R: Resistance, t: Time

If the current I is doubled, the new heat dissipated becomes:

$H_{new} = (2I)^2Rt = 4I^2Rt = 4H$

The percentage change in heat dissipated is calculated as:

$$\text{Percentage change} = \frac{(H_{new} - H)}{H} \times 100$$

$$= \frac{(4H - H)}{H} \times 100 = 300\%$$

12. Option (B) is correct.

Explanation: Both the bulbs will receive the same current as they are connected in series.

13. Option (B) is correct.

Explanation: If V is constant, then H is inversely proportional to R because $H = V^2t/R$. Therefore, H will double if R is reduced to half.

14. Option (B) is correct.

Explanation: Relation between Q, I, t:

Here, 'Q' represents the charge in a body.

'I' represents the current carried in Ampere.

't' represents the time in seconds.

The formula between these three quantities, i.e., Electric Charge, Time, and Electric Current is:

$$Q = I \times t$$

Electric Charge = Electric Current × time

Relation between W, V, Q:

Here, 'Q' represents the charge in a body.

'W' represents the work done to carry the charge Q.

'V' represents the potential difference across the wire.

The amount of work done i.e. Win carrying a charge Q is calculated by the product of the charge i.e. Q and the potential difference, i.e., V

The formula between these three quantities, i.e., Electric Charge, Potential Difference and Work done in carrying the charge across it is:

Work Done = Electric Charge × Potential Difference

$$W = V \times Q$$

15. Option (D) is correct.

Explanation: The rating of fuse wire must be slightly greater than the current flowing through the device.

Given, P = 1 kW = 1000 W, Voltage (V) = 220 V

Current (I) = P / V = 1000 / 220 = 4.5 A

Therefore, fuse wire of rating 5 A should be used.

16. Option (A) is correct.

Explanation: Heating elements in electrical devices need to efficiently convert electrical energy into heat. This requires the material to have properties that allow it to withstand high temperatures and maintain its structural integrity.

Resistivity: High resistivity means the material can generate more heat when a current passes through it.

Melting Point: High melting point ensures the material can withstand the high temperatures generated without melting.

17. Option (C) is correct.

Explanation: The resistance of a wire is influenced by its length, cross-sectional area and material, but does not depend on its shape.

18. Option (C) is correct.

Explanation: According to Ohm's Law, I = V/R, where I is the current, V is the voltage and R is the resistance. As the resistance increases, the current decreases.

19. Option (B) is correct.

Explanation: Possible combinations are:

All in series: $2\,\Omega + 2\,\Omega + 2\,\Omega = 6\,\Omega$

All in parallel: $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}=\frac{3}{2}=0.67\,\Omega$

Two in series and one in parallel = $2+2+\frac{1}{2}=4.5\Omega$

Two in parallel and one in series = $\frac{1}{2}+\frac{1}{2}+2=3\Omega$

So, she will not be able to get 0.75 Ω with combinations of given resistors.

20. Option (A) is correct.

Explanation: The resistance R of a wire is given by

$$R = \rho \times A/l$$

where ρ is the resistivity, l is the length, and A is the cross-sectional area. For wire Y, the length is $2l$ and the radius is $2r$, so the area $A = \pi(2r)^2 = 4\pi r^2$.

Therefore, $R_Y = \rho \times 4\pi r^2//2l = 2R$.

The resistivity ρ remains the same for the same material. Hence, the correct row in the table is I: Resistance 2/R, Resistivity ρ.

21. Option (C) is correct.

Explanation: When the resistance of R increases, the current in the circuit decreases according to the Ohm's law (V = IR). As the current decreases, the voltage drop across R(V_2) will increase because of its higher resistance, while the voltage across the other component (V_1) will decrease as the current is smaller.

Assertion-Reason Questions (1 Mark)

1. Option (C) is correct.

Explanation: The commercial unit of electrical energy is kilowatt-hour (kWh). It is equal to the energy consumed in the circuit at the rate of 1 kilowatt for 1 h. Reason is false as 1 kWh = 3.6×10^6 J and not 10^8 joule (J).

2. Option (B) is correct.

Explanation: The current rating of a circuit is determined based on the total current drawn by all connected appliances to ensure the safety of the wiring and prevent overloading. Appliances with metallic bodies are connected to an earth wire for safety, reducing the risk of electric shocks due to faulty appliances. So, while both statements are true, they are not directly linked as cause and effect.

3. Option (A) is correct.

Explanation: The given assertion and reason are related to Ohm's law. Ohm's law states that the current flowing through a conductor is directly proportional to the potential difference applied across its ends, provided its temperature and other physical conditions remain constant. This can be mathematically represented as:

V = IR, where V is the potential difference, is the current flowing, and R is the resistance of the conductor.

4. Option (B) is correct.

Explanation: When resistances are connected between the same two points, it means that the current has multiple paths to flow through. This type of connection is called parallel connection. In a parallel connection, the voltage across each resistance is the same, while the current divides among the resistances. The total resistance in a parallel connection is less than the smallest individual resistance. When resistances are connected in parallel, the effective resistance decreases compared to a single resistance. The reason for this decrease in resistance is that when resistances are in parallel, the total current divides among the resistances, resulting in a lower overall resistance. By adding more resistances in parallel, the total resistance can be further reduced. Therefore, the reason given in the statement is correct. When the resistance is to be decreased, connecting the individual resistances in parallel is an effective method.

Level - 2

CASE BASED QUESTIONS (4 Mark)

1. (i) Properties of electric fuse:

(1) Low melting point: The fuse wire in an electric fuse is made of a material with a low melting point. This property allows the fuse to melt quickly when a current higher than the rated value passes through it, breaking the circuit.

(2) Good conductivity: While in a solid state, the fuse wire should still have good electrical conductivity to allow normal current to pass through without significant resistance.

(ii) Properties of heating elements:

(1) High resistance: Heating elements are designed to have high electrical resistance, which facilitates the conversion of electrical energy into heat energy when current flows through them.

(2) Good heat resistance: Heating elements should have good heat resistance to withstand the elevated temperatures generated during their operation.

(iii) (a) Principle: The electric fuse works on the principle of the heating effect of electric current. When a current higher than the rated value flows through the fuse wire, it heats up due to its electrical resistance.

Fuse wire's capability to save appliances:

(1) Low melting point: The fuse wire is chosen to have low melting point.

(2) Quick melting: When an excess current flows through the circuit, the fuse wire quickly reaches its melting point, causing it to melt and break the circuit.

(3) Interrupts the current: By breaking the circuit, the fuse interrupts the flow of excessive current, preventing it from reaching and potentially damaging electrical appliances.

(4) Protects devices: The fuse acts as a sacrificial element, sacrificing itself by melting to protect the electrical appliances and devices connected to the circuit.

(5) Safety measure: The use of a fuse is a safety measure to prevent fire hazards and protect electric equipment from damage due to high current or faults in the circuit.

OR

(b) Given:

P = 1100 W; V = 220 V, I = ?

P = VI

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

$$= \frac{1100\ W}{220\ V} = 5A$$

Now, if an electric fuse rated at 5 A is connected in this circuit, it will operate normally. The fuse is designed to handle a current of up to 5A. Since, the current flowing in the circuit is exactly 5A, the fuse will not blow and the circuit will continue to operate without any issues. However, if the current were to exceed 5A, the fuse would blow, interrupting the circuit and preventing damage to the electrical components.

2. (i) (1) When key K_1 is closed, only bulb A will glow.

(2) When key K_2 is closed, bulbs B, C, D and E glow simultaneously.

(ii)

$$\text{Current (I)} = \frac{\text{Power (P)}}{\text{Voltage (V)}} = \frac{11}{55} = 0.2\ A$$

(iii)(a) (1) Using Ohm's law, V = IR

$$\text{Resistance of bulb B} = \frac{\text{Voltage (V)}}{\text{Current (I)}}$$

$$= \frac{55V}{0.2A} = 275\ \Omega$$

(2) Total resistance of the combination of bulbs B, C, D and E

Since bulbs are connected in series, their equivalent resistance will be:

Total resistance (R_{total}) = 4 × R = 4 × 275 Ω

= 1100 Ω

OR

(b) Bulb A will keep glowing with same brightness. Other bulbs, i.e., B, D and E will stop glowing.

Reason: As the bulbs B, D and E are connected in series with bulb C, so no current will flow through them and thus they will not glow. The bulb A remains unaffected as it is connected in parallel combination.

3. (i) $R_s = 4\Omega + 6\Omega + 16\Omega = 26\ \Omega$

(ii) $\frac{1}{R_p} = \frac{1}{8} + \frac{1}{8} = \frac{2}{8}$

$R_p = 4\ \Omega$

(iii)(a) Total resistance = 26 Ω + 4 Ω = 30 Ω

Potential difference = V = 6V

$$\text{Current, } I = \frac{V}{R}$$

$$= \frac{6}{30} = \frac{1}{5} = 0.2\ A$$

OR

(b) 16 Ω

Justification: According to Ohm's law, when same current flows, the potential difference across a higher resistance is always higher.

Potential difference across 16 Ω ⇒ V = IR = 0.2 × 16 = 3.2 V

Potential difference across 8 Ω = V = IR_{Total} = 0.2 × 4 = 0.8 V

4. (i) $A_1 = A_3$

Since both are connected in series.

(ii) $A_2 < A_3$ Since they are in different branches.

(iii)(a)

$V_1 = IR_1$

$$\frac{1}{R_1} = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}$$

$$R_1 = \frac{3}{2} = 1.5\Omega$$

$V_1 = 1 \times 1.5\ \Omega = 1.5\ V$

OR

(b)

$R_T = R_1 + R_2 + R_3$

$R_1 = 1.5\ \Omega$

$$R_2 = \frac{\text{Resistance}}{\text{No. of resistors}} = \frac{3}{3} = 1\Omega$$

$$R_3 = \frac{3}{4} = 0.75\Omega$$

$R_T = 1.5\ \Omega + 1 + 0.75 = 3.25\ \Omega$

5. (i) The net resistance is: $R_1 + \left(\frac{R_2 \times R_3}{R_2 + R_3}\right) + R_4$

$$= 15 + \left(\frac{30 \times 15}{30 + 15}\right) + 15$$

$$= 15 + 10 + 15$$

$$R = 40\,\Omega$$

(ii) (a) Voltage drop across R_4 = Net current × R_4

$$\text{Net current} = \frac{V}{R}$$

$$= \frac{20}{40}$$

$$= 0.5\text{ A}$$

$$\text{Voltage drop across } R_4 = 0.5 \times 15$$

$$= 7.5\text{ V}$$

OR

(b) Power dissipated by the resistor R_1 is given by:

$$P = I^2Rt$$

$$I = \frac{V}{R} = \frac{20}{40}$$

$$I = 0.5\text{ A}$$

Therefore, Power = $(0.5)^2 \times 15 = 3.75$ W

(iii) Net current will decrease because R_3 is connected in parallel and removing it will increase the net resistance in the circuit thereby reducing the net current.

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

$$R = \frac{12}{6} = 2\,\Omega$$

(ii) $R_A = \frac{12}{2} = 6\,\Omega$

$$R_B = \frac{12}{4} = 3\,\Omega$$

(iii) (a) For the given circuit, $R \propto l$ and $\rho \propto 1/l$

The resistance of 'A' is twice that of 'B' and so the current in both will not be the same but in the ratio of 1:2, so the current in 'A' will be 2A and that in 'B' will be 4A

$$I_A = \frac{V}{R_A} = \frac{12}{6} = 2\text{A}$$

$$IB = \frac{V}{R_B} = \frac{12}{3} = 4\text{A}$$

OR

(b) Resistivity is defined as the resistance offered by a conductor of unit length and unit cross-sectional area.

$$\sigma = R \times \frac{A}{l}$$

Factors affecting the resistivity of a conductor are:

(1) Nature of the material

(2) Temperature

Level - 3

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. (i) P = VI

= 230 × 3.5 = 805 W

(ii) $I \propto \frac{1}{R}$, so half the resistance means double the current.

Therefore, current in Y = 7.0 A

2. For series, total resistance is R + 2R = 3R

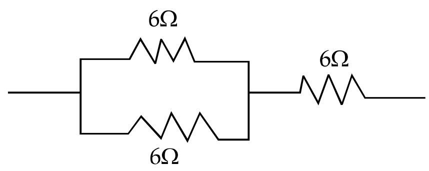
$$P_1 = \frac{V^2}{3R}$$

For parallel, total resistance is $\frac{2R}{3}$.

$$P_2 = \frac{V^2}{\frac{2R}{3}} = \frac{3V^2}{2R}$$

$$\frac{P_1}{P_2} = \frac{2}{9}$$

3. To get the desired resistance of 9 Ω, we should connect the two resistors in parallel and one resistor in series.

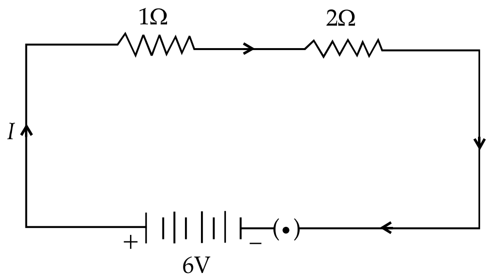


Resistance of two resistors connected in parallel

$$= \frac{6 \times 6}{6 + 6} = 3\Omega$$

The third 6 Ω is in series with 3 Ω. Hence, the equivalent resistance of the circuit is 6 Ω + 3 Ω = 9 Ω

4.



Total Resistance = 1Ω + 2Ω = 3Ω

Total applied voltage (V) = 6V

$$\text{Circuit Current (I)} = \frac{V}{R} = \frac{6V}{3\Omega} = 2A$$

Power consumed across 2 Ω resistor

$$= I^2R = 2^2 \times 2 = 8\text{ W}$$

5. $R_S = R_1 + R_2 + R_3$

$= 1 + 2 + 3 = 6\,\Omega$

As V = IR

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

$$I = \frac{2}{6}$$

$$I = \frac{1}{3}\text{ A}$$

Hence, V(voltage across 3W)

$$V = IR = \frac{1}{3} \times 3 = 1\text{ volt}$$

6. Wire A will offer more resistance to the flow of current in the circuit.

This is because resistance is inversely proportional to the area of cross section. So if the diameter is more than resistance is less. Wire A has less diameter, so it has a higher resistance.

7. Given, Charge, q = 500 coulomb

Current, I = 25 mA = 25×10^{-3} A

Let assume that 't' seconds be the time in which electric source will be discharged completely.

We know,

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

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

$$t = \frac{500}{25 \times 10^{-3}}$$

$$t = \frac{500 \times 10^3}{25}$$

$$t = 20 \times 10^3$$

$$\Rightarrow t = 20000\text{ s}$$

$$\Rightarrow t = \frac{20000}{3600}\text{ h}$$

$$\Rightarrow t = \frac{200}{36}\text{ h}$$

$$\Rightarrow t = \frac{50}{9}\text{ h}$$

$$\Rightarrow t = 5\frac{5}{9}\text{ h}$$

Hence, the time in which the electric source will be discharged completely is $5\frac{5}{9}$ h.

8. From the graph, slope of wire A is greater than slope of wire B.

For the conductor of the same dimensions greater the resistance, greater is the resistivity.

9. The change in the current flowing through the electrical component can be determined by Ohm's Law.

According to Ohm's law

$$V = IR$$

V: applied voltage

I: current

R: resistance

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

Now potential difference becomes one fourth,

$$V' = \frac{V}{4}$$

So current will be: $I' = \frac{(V/4)}{R}$

$$\Rightarrow I' = \frac{V}{4R}$$

$$\Rightarrow I' = \frac{I}{4}$$

When the potential difference is one fourth, the current through the component also decreases to one fourth of its initial value.

10. The fuse will melt and its not possible to operate electric oven under these conditions.

Given that,

Power of electric oven, P = 3 kW = 3000 W

Voltage supply, V = 220 volts.

$$P = VI$$

where, I is flow of electric current, P is the power in watt and V is voltage.

So, on substituting the values, we get

$$3000 = 220 \times I$$

$$I = \frac{3000}{220}$$

$\Rightarrow \quad I \approx 13.64$ A

As the current rating is only 10A and the oven draws a current of 13.6 A, which is more than current rating. Hence, the oven will stop working.

11. From Ohm's law, we have $V = IR$

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

Given V = 12 V and $R_1 = 2\,\Omega$, $R_2 = 8\,\Omega$ and $R_3 = 4\,\Omega$

Therefore, net resistance

$$R = R_1 + \frac{R_2 \times R_3}{R_2 + R_3}$$

$$= 2 + \left(\frac{8 \times 4}{8 + 4}\right)$$

$$= 2 + \frac{32}{12} = 2 + 2.67$$

$R = 4.67\,\Omega$

$$I = \frac{12}{4.67}$$

$I = 2.57$ A

She can use ammeter S to measure the current in the circuit.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. (i) $R \propto l$

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

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

(ii) $R = \rho\frac{l}{A}$

$\rho = R\frac{A}{l}$ for A = 1 m^2 and l = 1m, we have ρ = R

Hence, resistivity is the resistance offered by a wire of length 1 m having a cross sectional area of 1 m^2.

2. It prevents damage to the appliances and the electric circuit from overloading and short circuitiing.

Here P = 3 kW = 3000 W, V = 220 V, I = ?

P = VI

$$I = \frac{P}{V} = \frac{3000\text{ W}}{220\text{ V}} = 13.63\text{A}$$

13.63 A > Rating of fuse 5A, therefore fuse wire will melt and break the circuit.

3. (i) Ohm's law: The potential difference, V across the ends of a given metallic wire in an electric circuit is directly proportional to the current flowing through it, provided its temperature remains the same.

Required formula: $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

(ii) $R_{eq} = R + \frac{R}{2} = \frac{3R}{2}$

4. (i) The three resistors are connected in series. So, the total resistance is

$R_1 + R_2 + R_3 = 2 + 4 + 6 = 12\,\Omega$

(ii) The current I is determined using Ohm's law.

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

$$I = \frac{6}{12} = 0.5\text{ A}$$

Reading in the ammeter is 0.5 A

(iii) Reading of the voltmeter

V = IR

V = 0.5 A × 4 Ω = 2 V

5. Overloading occurs due to increase in voltage or if too many appliances are connected to a single socket. It happens when an excessive amount of electric current flows through the wire. It results in overheating of the wires and can cause damage to the circuit and appliances.

Causes: (1) Increase in voltage beyond the design limits of the circuit.

(2) Excessive appliances connected to a single socket or circuit.

(3) Contact be tween live and neutral wire. (any two)

Measures to avoid overloading:

(1) Too many electric appliances of high power rating should not be connected to single socket.

(2) Use good quality wires.

(3) Use good quality devices (any one)

6. (i) Alternating current can be transmitted over the long distances without the loss of energy. Also, alternating voltage can be stepped up and stepped down using transformer.

(ii) The type of current used in household supply is alternating current (AC), whereas the current given by a battery of dry cells is direct current (DC). AC current changes its direction periodically, while DC current flows in one constant direction.

(iii) An electric fuse is a safety device made of a metal wire with a low melting point. It prevents damage as follows:

(1) Overloading: When excessive current flows through the circuit, the fuse wire heats up due to the high resistance of the material. If the current exceeds the fuse's rated value, the wire melts and breaks the circuit, stopping the flow of electricity.

(2) Short Circuiting: In case of a short circuit, where the resistance drops significantly, the current increases rapidly. This causes the fuse to blow immediately, cutting off the power supply and protecting the circuit and appliances from damage.

7. (i) Given V = 240 V and R = 100 Ω

Therefore, Power (P) = $\frac{V^2}{R} = \frac{(240)^2}{100} = 576$ W

Energy consumed by bulb A = $P \times t$

$$E = 576 \times 4 \times 7 \times 60 \times 60$$

$$E = 58,060.8 \text{ kJ}$$

(ii) When bulbs A and B are connected in series:

$$R_{net} = R_1 + R_2 = 100 + 100$$

$$R_{net} = 200\ \Omega$$

Total power consumed by bulb A when connected in series with bulb B

$$P_{tot} = \frac{V^2}{R_{net}} = \frac{(240)^2}{200} = 288 \text{ W}$$

$$P_A = \frac{P_{tot}}{2} = 144 \text{ W}$$

Power consumed by bulb A when connected without bulb B to 240 V

$$P_A = \frac{V^2}{R} = \frac{(240)^2}{100} = 576 \text{ W}$$

As $P_A' < P_A$, the brightness of the bulb A decreases when connected in series with bulb B.

8. (i) The current will flow through the additional wire that connects the points L and M (avoiding the bulb) as it offers a path of least/lower resistance as compared with the bulb.

(ii)
$$\frac{3}{10} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{...(i)}$$

$$R_1 + R_2 = 15,$$

$$R_1 = 15 - R_2$$

Substituting in (i)

$$\frac{3}{10} = \frac{(15 - R_2 + R_2)}{(15 - R_2)R_2}$$

$$15R_2 - R_2^2 = \frac{150}{3} = 50$$

$$R_2^2 - 15R_2 + 50 = 0$$

$R_2 = 10\ \Omega, R_1 = 5\ \Omega$ or $R_1 = 10\ \Omega, R_2 = 5\ \Omega$

9. Ohm's Law states that the current (I) flowing through a conductor is directly proportional to the potential difference (V) across its ends, provided the physical conditions (e.g., temperature) remain constant.

$$V = IR$$

where R is the resistance of the conductor.

Factors on which the resistance of a cylindrical conductor depends:

(1) Length of the conductor (L): Resistance is directly proportional to the length of the conductor ($R \propto L$).

(2) Cross-sectional area (A): Resistance is inversely proportional to the cross-sectional area $\left(R \propto \frac{1}{A}\right)$

Calculation for the new resistance: If the wire is melted and redrawn to double its original length:

The volume of the wire remains constant ($V_{old} = V_{new}$).

Let the original length be L, the original cross-sectional area be A and the new length be 2L.

$$V = L \cdot A = 2L \cdot A_{new}$$

Thus,

$$A_{new} = \frac{A}{2}$$

Resistance is given by:

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

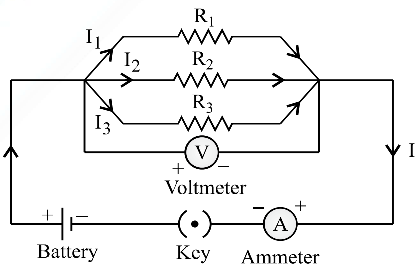
where *r* is the resistivity of the material.

For the new wire:

$$R_{new} = \rho\frac{2L}{A_{new}} = \rho\frac{2L}{A_{new}} = 4 \cdot \rho\frac{L}{A} = 4R$$

The resistance of new wire is 4R.

10.



The figure given above shows a circuit consisting of three resistors R_1, R_2, and R_3. Suppose the total current flowing in the circuit is I, then the current passing through resistance R_1 will be I_1, the current passing through resistance R_2 will be I_2 and the current passing through resistance R_3 will be I_3 Thus, the total current I is given as:

$$I = I_1 + I_2 + I_3 \quad \text{...(i)}$$

Since the potential difference across all the resistors is the same, so applying Ohm's law to each resistor we get:

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

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

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

11. R_2 and R_3 are in parallel.

So, $$R_{Parallel} = \frac{R_2 \times R_3}{R_2 + R_3}$$

$$= \frac{10 \times 10}{10 + 10} = \frac{100}{20} = 5\Omega$$

Now, R_1, $R_{parallel}$ and R_4 are in series

$$R_{total} = 5 + 5 + 5 = 15\ \Omega$$

The equivalent resistance of the circuit is 15 Ω.

12. (i) Electric power is the rate at which electrical energy is consumed or produced in an electric circuit. It is mathematically expressed as:

$$P = VI$$

where:

P is the electric power,

V is the potential difference, and

I is the current.

The SI unit of electric power is watt (W).

(ii) The two bulbs are connected in parallel across a 220 V mains. The total current is the sum of the currents drawn by each bulb. Using the power formula:

$$P = VI \Rightarrow I = \frac{P}{V}$$

For the 100 W bulb:

$$I_1 = \frac{P_1}{V} = \frac{100}{20} = 0.4545\text{A}$$

For the 60 W bulb:

$$I_2 = \frac{P_2}{V} = \frac{60}{220} = 0.2727\text{A}$$

$$I_{Total} = 0.4545 + 0.2727$$
$$= 0.7272\text{ A or } 0.73\text{ A}$$

13. (i) Joule's law of heating states that the heat dissipated across a resistor is directly proportional to the square of the current flowing through it, resistance of the conductor and duration of flow of current.

i.e., $H = I^2Rt$

(ii) Given,

Resistance (R) = 5 Ω

Voltage (V) = 6 V

Time (t) = 10 s

From Ohm's law:

$$V = IR$$
$$6 = I \times 5$$
$$I = \frac{6}{5} = 1.2\text{ A}$$

Energy dissipated (H) = I^2Rt

Substituting we get,

$$H = 1.2 \times 1.2 \times 5 \times 10 = 72\text{ J}$$

Hence, energy dissipated = 72 J

14. (i) Given:

Length (l) of the metal wire = 2m

Area of cross section (A) = $1.55 \times 10^{-6}\text{m}^2$

Resistivity (ρ) of the metal = $2.8 \times 10^{-8}\ \Omega$-m

Resistance of a conductor is given by:

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

Thus, putting all the values, we get

$$R = \frac{2.8 \times 10^{-8}\Omega \times 2\text{m}}{1.55 \times 10^{-6}\text{m}^2}$$

$$R = \frac{5.6 \times 10^{-2}}{1.55}$$

$$R = 3.61 \times 10^{-2}\ \Omega$$

Thus, the resistance of the metal wire is $3.61 \times 10^{-2}\ \Omega$

(ii) Alloys are used in electrical heating devices rather than pure metals because the resistivity of an alloy is more than the resistivity of pure metal. Also, the melting point of an alloy is high, so it does not melt or oxidise easily even at a higher temperature.

15. Given,

Power P = 4 kW,

Voltage, V = 220 V

(i) Since, P = VI.

Therefore current $I = \frac{P}{V} = \frac{4\text{ kW}}{220\text{ V}} = 18.18$ A.

(ii) Energy consumed in 2h = Pt = 4 kW × 2h = 8 kWh.

(iii) Cost of energy consumed = 8 × 4.50 = ₹ 36

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i) P.d. across 4 Ω resistor = p.d. across R_2 as both are in parallel.

1.5(A) × 4(Ω) = 6V

(ii) Total current through 4Ω and R_2 = 2.0 A (given)

Current through 4Ω = 1.5 A (given)

Hence, current through R_2 = 2 – 1.5 = 0.5 A

Using Ohm's law for R_2, we get

$$6\text{V} = 0.5\text{ A} \times R_2$$

Hence $R_2 = \frac{6}{0.5} = 12\Omega$

(iii) P.d. across R_1 = Total p.d. – (p.d. across R_2) – (p.d. across 2.0 Ω)

p.d. across 2.0 Ω = 2 × 2 = 4V

p.d. across R_2 = 6V (calculated before)

Hence, p.d. across R_1 = 12 – 6 – 4 = 2V

Current through R_1 = 2A

Using Ohm's Law, we get

$$R_1 = \frac{2V}{2A} = 1\Omega$$

2. (i) P = IV

$$I = \frac{P}{V} = \frac{24W}{12V} = 2A$$

Current in lamp A = 2A

(ii) Voltmeter reading = 12 V

Lamp A and Lamp B are in parallel.

Hence, p.d. across the arm containing A = p.d. across arm containing B

= 12 V (from A)

(iii) P.d. across R_2 + p.d. across B = 12 V

p.d. across B = 6V (given)

Hence p.d. across R_2 = 12 V – 6V = 6V

Current through R_2 = Current through B = 3 A (given)

Use of $R = \frac{V}{I}$

$$R_2 = \frac{6V}{3A} = 2\Omega$$

(iv) Current through R_1 = Total Current

= 3A + 2A = 5A

p.d. across R_1 = 15V – 12V = 3V

$$R_1 = \frac{3V}{5A} = 0.6\Omega$$

3. (i) Electric power is the rate at which electrical energy is dissipated or consumed. It is the rate of supplying energy to maintain the flow of current through a circuit.

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

(ii) (A) Energy consumed = 11 units

(1 unit = 1 kWh)

E = 11 kWh = 11 × 1000 = 11000 W

$$\text{Power, } P = \frac{\text{Electrical energy consumed}}{\text{Time}}$$

$$P = \frac{11\text{ kWh}}{5\text{h}} = 2.2\text{ kWh or } 2200\text{ W}$$

Thus, the power rating of the oven is 2200 W or 2.2 kW

(B) $I = \frac{P}{V}$

$$= \frac{2200}{220} = 10A$$

(C) $R = \frac{V^2}{P}$

$$= \frac{(220)^2}{2200} = 22\Omega$$

4. (i) $R = \rho\frac{l}{A}$

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

$$= \text{Ohm} \times \frac{(\text{metre})^2}{\text{metre}}$$

= ohm metre/Ωm

(ii) Here l = 3 m, A = 4 × 10^{-7} m^2, R = 60Ω

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

$$= \frac{60 \times 4 \times 10^{-7}}{3}$$

= 80 × 10^{-7} (Ωm)

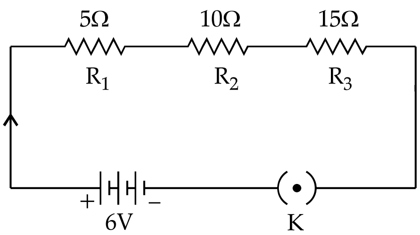
(iii) Resistivity will not change because resistivity does not depend on the dimension of the conductor and only depends on the nature of the material.

5. (i) Current becomes one-third of its initial value.

Ohm's law helps us in answering this question.

Ohm's law states that the potential difference across the ends of a conductor is directly proportional to the current flowing through it, provided its temperature remains the same.

(ii)



Total voltage, V = 4 × 1.5 V = 6 V

Total resistance, $R_s = R_1 + R_2 + R_3$

= 5Ω + 10Ω + 15Ω = 30Ω

(I) Current, $I = \frac{V}{R} = \frac{6V}{30\Omega} = 0.2A$

(II) V = IR = 0.2 A × 10Ω = 2 V

6. (i) When 1 joule of work is done to move a charge of 1 coulomb from one point to other.

(ii) d = 0.2 mm = 2×10^{-4} m; R = 14 Ω

$\rho = 1.6 \times 10^{-8}$ Ωm; $A = \frac{\pi d^2 R}{4}$

$$R = \frac{\rho l}{A} = \frac{4\rho l}{\pi d^2} \text{ or } l = \frac{\pi d^2 R}{4\rho}$$

$$l = \frac{22}{7} \times \frac{(2 \times 10^{-4})^2}{4 \times 1.6 \times 10^{-8}} \times 14$$

= 27.5 m

When the diameter is doubled , $d = 2d$, $A' = 4A$

$$\frac{R'}{R} = \frac{A}{A'} \text{ or } R' = \frac{RA}{A'} = \frac{RA}{4A}$$

$$\frac{R'}{14} = \frac{A}{4A}$$

R′ = 3.5 Ω

Change (14.0 – 3.5) = 10.5 Ω

7. (i) The resistance R of a conductor the shape of a cylinder, of length l and area of cross section A is given as:

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

where ρ is a constant, which is known as the electrical resistivity of the material of conductor.

SI unit of resistivity ρ is Ω-m.

(ii) electrical resistivity (ρ) of the material of the wire is:

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

where R = resistance (3 Ω)

L = length of the wire (120 cm=1.2 m)

A = cross-sectional area of the wire

The wire is cylindrical so the cross-sectional area is given by:

$A = \pi r^2$

The radius r is half the diameter.

$$r = \frac{\text{diameter}}{2} = \frac{0.4 \text{ mm}}{2}$$

= 0.2 mm= 0.2×10^{-3} m

Substitute r into the formula for A.

$A = \pi(0.2 \times 10^{-3})^2$

$= \pi \times 0.04 \times 10^{-6}$

$= 1.2566 \times 10^{-8}$ m^2

Rearrange the formula for R:

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

Substitute the known values (R = 3Ω, A = 1.2566 × 10^{-8} m^2, L = 1.2 m)

$$\rho = 3 \times \frac{1.2566 \times 10^{-8}}{1.2}$$

$\rho = 3.1415 \times 10^{-8}$ Ωm

8. (i) Given,

Power (P) = 880 W [when heating is at the maximum rate]

Power (P) = 330 W [when heating is at the minimum rate]

Voltage (V) = 220 V

Case I : When heating is at the maximum rate

We know,

P = VI

Substituting we get,

880 = 220 × I

$$I = \frac{880}{220} = 4A$$

From V = IR

Substituting we get,

220 = 4 × R

$$R = \frac{220}{4} = 55\Omega$$

Hence, when heating is at the maximum rate, I = 4 A and R = 55 Ω

Case II : When heating is at the minimum rate

Substituting we get current (I),

330 = 220 × I

$$I = \frac{330}{220} = 1.5 \text{ A}$$

Substituting we get resistance (R),

220 = 1.5 × R

$$R = \frac{220}{1.5} = 146.6\ \Omega$$

Hence, when heating is at the minimum rate, I = 1.5 A and R = 146.6 Ω

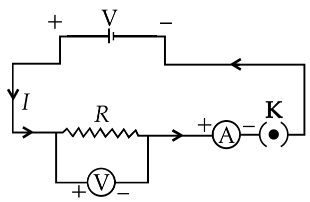
(ii) When the electric circuit is purely resistive, that is, a configuration of resistors only connected to a battery; the source energy continually gets dissipated entirely in the form of heat. This is called heating effect of electric current.

(iii) $H = I^2Rt$

This is known as Joule's law of heating.

9. (i) Current flowing through a conductor is directly proportional to the potential difference.

$V \propto I$



(ii) The ammeter should have a low resistance to make it easy for all the current to flow through the circuit without energy loss or heat loss. This means it does not impede or alter the flow of electric current.

(iii) We know that V = IR or $\frac{1}{R} = \frac{I}{V}$ = slope of graph given. The resistance increases as the slope decreases. Graph B clearly has a greater slope than graph A. As a result, B has less resistance than A. As far as we are aware combined series resistance is consistently greater than combined parallel resistance. As a result, A and B are series and parallel combinations, respectively.

10. (i) Ohm's Law states that the current flowing through a conductor is directly proportional to the potential difference applied across it, provided the temperature, pressure and other physical conditions remain constant.

Mathematically, Ohm's Law can be represented as:

$$V = IR$$

Where,

V = Potential difference (measured in volts, V)

I = Current flowing through the conductor (measured in amperes, A)

R = Resistance of the conductor (measured in ohms, Ω)

(ii) The physical quantity determined by the slope of the V-I curve given in the diagram is resistance (R).

The slope of the V-I curve is given by:

$$\text{Slope} = \frac{\Delta V}{\Delta I}$$

From the graph, we can see that the slope of the line is equal to 7.5 Ω. Therefore, the resistance of the conductor is 7.5 Ω.

(iii) 1 kilowatt-hour (kWh) is equal to the energy consumed by a device of 1 kilowatt (kW) power in one hour.

1 kilowatt-hour = 1000 watts × 3600 seconds

1 kilowatt-hour = 3,600,000 joules (J)

= 3.6×10^6 J

Therefore, 1 kilowatt-hour is equal to 3.6×10^6 joules.

11. (i) Resistance is the quality of a conductor that causes it to resist the flow of an electric current through it. It is the proportion of the potential difference between ends to the current flowing. Its SI unit is ohm (Ω).

(ii) Resistance of the conductor depends upon:

(1) Length,

(2) Area,

(3) Resistivity,

(4) Temperature (any two)

(iii)(1) $R = \frac{\rho l}{A}$

where, ρ = electrical resistivity

l = length of the conductor

A = cross-sectional area of the conductor

Hence if the length is double then

$$\Rightarrow \quad R_1 = \rho\frac{(2l)}{A}$$

$$\therefore \quad R_1 = 2(R)$$

So, if the length of the resistance gets doubled, then resistance also gets doubled.

(2) Now when the radius is double then

$$\Rightarrow \quad R_2 = \frac{\rho l}{A}$$

$$\Rightarrow \quad R_2 = \frac{\rho l}{\pi(2r)^2}$$

$$\therefore \quad R_2 = \frac{1}{4}(R)$$

So, if the radius gets doubled then resistance will be $\left(\frac{1}{4}\right)^{th}$ of initial resistance.

12. (i) No, the bulbs will not glow with the same brightness.

In Series Circuit: When the three bulbs are connected in series, the total resistance of the circuit increases (since resistances in series add up). The current through each bulb is the same because the current has only one path to flow. However, the voltage across each bulb is reduced because the source voltage is divided among the three bulbs. This results in lower power dissipation (P = VI) in each bulb, so the bulbs will glow dimmer.

In Parallel Circuit: When the three bulbs are connected in parallel, each bulb receives the full source voltage because they are connected directly across the source. The total resistance of the circuit decreases (since resistances in parallel combine as $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$. This allows more current to flow through the circuit. Each bulb operates at its rated power $\left(P = \frac{V^2}{R}\right)$, so they glow with full brightness.

(ii) In the Series Circuit: No, the remaining bulbs will not glow. In a series circuit, the current flows through all components in a single path. If one bulb gets fused, it breaks the circuit, stopping the flow of current to all other bulbs.

In the Parallel Circuit: Yes, the remaining bulbs will continue to glow. In a parallel circuit, each bulb is connected independently to the source. If one bulb gets fused, the current still flows through the other branches, allowing the remaining bulbs to operate normally.