ELECTRICITY

Q. 1. A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R', then the ratio R/R' is -

(a) 1/25
(b) 1/5
(c) 5
(d) 25

ANSWER:-

(d) 25

Solution: Resistance of a piece of wire is directly proportional to its length. If the piece of wire has a resistance and the wire is cut into five equal parts.

The resistance of each part = R/5

All the five parts are connected in parallel. Hence, equivalent resistance (R') is given as

$$\frac{1}{R'} = \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5}$$

$$\Rightarrow \frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{25}{R}$$

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

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

Hence, the option (d) is correct.

Q. 2. Which of the following terms does not represent electrical power in a circuit?

(a) I^2R
(b) IR^2
(c) VI
(d) V2/R

ANSWER:-

(b) IR_2

Solution: We know that electric power is given by P = VI ……………(i)

So, the option (c) is correct.

According to Ohm's law, V = IR……………………(ii)

Now putting the value of V from (ii) in (i), we get

Power P = (IR) × I = I^2 R

So, the option (a) is correct.

Now putting the value of I from (ii) in (i), we get

Power P = V(V/R) = V^2/R

So, the option (d) is correct.

Hence, the option (b) does not represent electrical power in a circuit.

Q. 3. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be -

(a) 100 W
(b) 75 W
(c) 50 W
(d) 25 W

ANSWER:-

(d) 25W

Solution: Given- V = 220 V and P = 100 W

Energy consumed by bulb $= P = \frac{V^2}{R}$

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

$R = \frac{(220)^2}{100} = 484\Omega$

The resistance of the bulb remains constant if the supply voltage is reduced to 110 V. If the bulb is operated on 110 V, then the energy consumed by it is given by the expression for power

$P = \frac{V^2}{R} = \frac{(110)^2}{484} = \frac{12100}{484} = \underline{25}W$

Hence, the option (d) is correct.

Q. 4. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be-

(a) **1:2**

(b) **2:1**

(c) **1:4**

(d) **4:1**

ANSWER:-

(c) 1:4

Solution: Heat produced in the circuit is inversely proportional to the resistance R. Let R_s and R_p be the equivalent resistances of the wires if connected in series and parallel respectively. Let R be the resistance of each wire.

If the resistors are connected in parallel, the net resistance is given by

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

$$\Rightarrow \frac{1}{R_P}=\frac{2}{R}$$

$$\Rightarrow R_P=\frac{R}{2}$$

If the resistors are connected in series, the net resistance is given by

R_s = R+R = 2R

Hence, for same potential difference V, the ratio of heat produced in the circuit is given by

$$\frac{H_S}{H_P}=\frac{\frac{V^2}{R_c}t}{\frac{V^2}{R_P}t}=\frac{R_P}{R_S}=\frac{\underline{R2}}{\underline{2R}=\frac{1}{4}}=1:4$$

Therefore, the ratio of heat produced in series and parallel combinations is 1:4. Hence, the option (c) is correct.

Q. 5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

ANSWER:-

To measure the potential difference, a voltmeter should be connected in parallel.

Q. 6. A copper wire has a diameter of 0.5 mm and resistivity of 1.6× 10^{-8} Ω m. What will be the length of this wire to make its resistance 10Ω? How much does the resistance change if the diameter is doubled?

ANSWER:-

Given- ρ is resistivity of copper $=1.6\times10^{-8}\Omega$ m, R = 10Ω, radius of wire r = 0.5/2 mm = 0.25 mm = 0.00025 m, A= $\pi r^2 = 3.14 \times (0.00025)^2 = 0.000000019625$ m^2

Need to find- Change in resistance

Resistance (R) of a copper wire of length l and cross-section A is given by the expression,

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

$$\Rightarrow l = \frac{RA}{\rho} = \frac{10 \times 0.000000019625}{1.6 \times 10^{-8}} = 122.72\text{m}$$

If the diameter (radius) is doubled, the new radius r = 0.5 mm = 0.0005 m

$A = \pi r^2 = 3.14 \times (0.0005)^2 = 0.000000785\ \text{m}^2$

So, the new resistance will be

$$R' = \frac{\rho l}{A} = \frac{1.6 \times 10^{-8} \times 122.72}{0.000000785} = 2.5\Omega$$

$$\frac{R'}{R} = \frac{2.5}{10} = \frac{1}{4}$$

$$\Rightarrow R' = \frac{1}{4} R$$

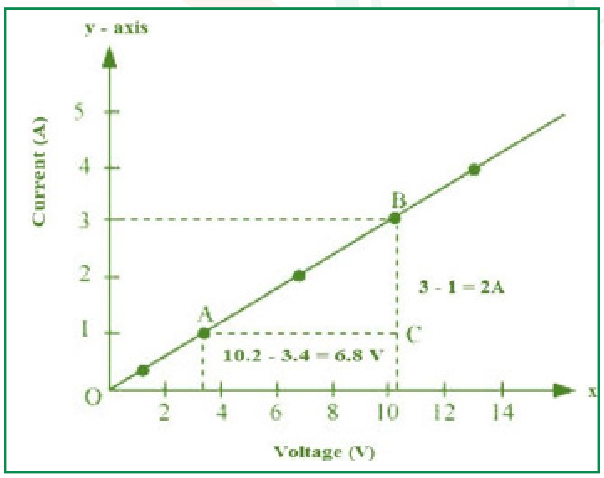
Hence, the new resistance will become ¼ times the original resistance.

Q. 7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below -

(amperes)	0.5	1.0	2.0	3.0	4.0
(volts)	1.6	3.4	6.7	10.2	13.2

Plot a graph between V and I and calculate the resistance of that resistor.

ANSWER:-



The slope of the line gives the value of resistance (R)

$$\text{slope} = \frac{1}{R} = \frac{BC}{AC} = \frac{2}{6.8}$$

$$\Rightarrow R = \frac{6.8}{2} = 3.4\Omega$$

Q. 8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

ANSWER:-

Given – V = 12 V and I = 2.5 mA = 0.0025 A

Need to find- Resistance of the resistor (R)

According to Ohm's law, V = IR

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

$$R = \frac{12}{0.0025} = 4800\Omega = 4.8K\Omega$$

Q. 9. A battery of 9 V is connected in series with resistors of 0.2Ω, 0.3Ω, 0.4Ω, 0.5Ω and 12Ω, respectively. How much current would flow through the 12Ω resistor?

ANSWER:-

Total resistance of resistors when connected in series is given by

$R = R_1 + R_2 + R_3 + R_4 + R_5$

$\Rightarrow R = 0.2\Omega + 0.3\Omega + 0.4\Omega + 0.5\Omega + 12\Omega = 13.4\Omega$

According to Ohm's law, V = 1R

$$\Rightarrow I = \frac{V}{R} = \frac{9}{13.4} = \underline{\underline{0.67A}}$$

There is no current division occurring in a series circuit. So, the current through the 12Ω resistor will be same as 0.67 A.

Q. 10. How many 176Ω resistors (in parallel) are required to carry 5 A on a 220 V line?

ANSWER:-

Let the total number of resistors be x.

Given - Current I = 5 A and Potential Difference V = 220 V

According to Ohm's law, V = IR

$$\Rightarrow k = \frac{V}{I} = \frac{220}{5} = 44\Omega$$

Now for x number of resistors of resistance 176Ω, the equivalent resistance of the resistors connected in parallel is 44Ω.

$$\frac{1}{44} = \frac{1}{176} + \frac{1}{176} + \frac{1}{176} + \frac{1}{176} + .. \text{ to } x \text{ times}$$

$$\Rightarrow \frac{1}{44} = \frac{x}{176}$$

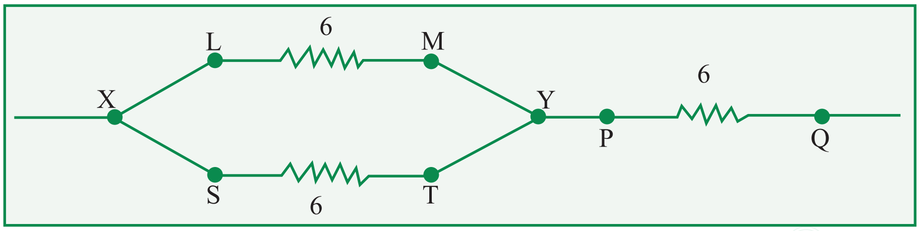
$$\Rightarrow x = \frac{176}{44} = 4$$

Therefore, 4 resistors of 176Ω are required to draw the given amount of current.

Q. 11. Show how you would connect three resistors, each of resistance 6Ω, so that the combination has a resistance of (i) 9Ω, (ii) 4Ω.

ANSWER:-

(i) To get total 9 Ω resistance from three 6 Ω resistors, we should connect two resistors in parallel and the third resistor in series with the resultant. The combination is given as follows:



Total resistance in parallel is given by

$$\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2}$$

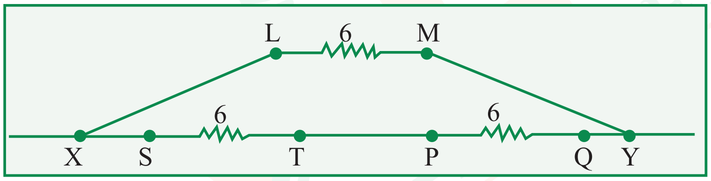
$$\Rightarrow \frac{1}{R_{12}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$$

$$\Rightarrow R_{12} = 3\Omega$$

Now R_{12} and 6Ω are connected in series, so the net resistance is given by

$R = R_{12} + 6\Omega = 3\Omega + 6\Omega = 9\Omega$

(ii). To get total 4Ω resistance from three 6Ω resistors, we should connect two resistors in series and the third resistor in parallel with the resultant. The combination is given as follows:



Total resistance in series is given by

$R_{12} = R_1 + R_2 = 6\ \Omega + 6\ \Omega = 12\ \Omega$

Now R_{12} and 6Ω are connected in parallel, so the net resistance is given by

$$\frac{1}{R} = \frac{1}{R_{12}} + \frac{1}{6}$$

$$\Rightarrow \frac{1}{R} = \frac{1}{12} + \frac{1}{6} = \frac{3}{12} = \frac{1}{4}$$

$$\Rightarrow R = 4\Omega$$

Q. 12. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

ANSWER:-

For one bulb:

Power P = 10 W and Potential difference V = 220 V

Using the relation for R, we have

$$R = \frac{V^2}{P} = \frac{(220)^2}{10} = 4840\Omega$$

Let the total number of bulbs be x.

Given that:

Current I = 5 A and Potential Difference V = 220 V

According to Ohm's law, V = IR

$$\Rightarrow K = \frac{V}{I} = \frac{220}{5} = 44\Omega$$

Now, for number of bulbs of resistance 176Ω, the equivalent resistance of the resistors connected in parallel is 44Ω.

$$\frac{1}{44} = \frac{1}{4840} + \frac{1}{4840} + \frac{1}{4840} + .. \text{ to } x \text{ times}$$

$$\Rightarrow \frac{1}{44} = \frac{x}{4840}$$

$$\Rightarrow x = \frac{4840}{44} = 110$$

Therefore, 110 bulbs of 4840Ω are required to draw the given amount of current.

Q. 13. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

ANSWER:-

Given- Potential difference V = 220 V and resistance of each coil R = 24Ω

When the coil is used separately, the current in the coil is given by

$$I = \frac{V}{R} = \frac{220}{24} = \frac{55}{6} = 9.16\text{A}$$

When the two coils are connected in series, the net resistance is given by

$R = R_1 + R_2 = 24\Omega + 24\Omega = 48\Omega$

Now, the current in the coil is given by

$$I = \frac{V}{R} = \frac{220}{48} = \frac{55}{12} = 4.58\text{A}$$

When the two coils are connected in parallel, the net resistance is given by

$$\frac{1}{R} = \frac{1}{24} + \frac{1}{24} = \frac{2}{24} = \frac{1}{12}$$

$\Rightarrow R = 12\Omega$

Now, the current in the coil is given by

$$I = \frac{V}{R} = \frac{220}{12} = \frac{55}{3} = 18.33\text{A}$$

Q. 14. Compare the power used in the 2Ω resistor in each of the following circuits:

(i) a 6 V battery in series with 1Ω and 2Ω resistors, and

(ii) a 4 V battery in parallel with and 2Ω resistors.

ANSWER:-

Given- Potential difference, V = 6 V

(i). 1Ω and 2Ω resistors are connected in series. Therefore, equivalent resistance of the circuit, R = 1 + 2 = 3Ω

According to Ohm's law,

V = IR

$$\Rightarrow I = \frac{V}{R} = \frac{6}{3} = 2A$$

In series combination, the current in the circuit remains constant. Therefore power is given by

$P = I^2 R = (2)^2 \times 2 = 8$ W

(ii). 1Ω and 2Ω resistors are connected in parallel.

$$\Rightarrow I = \frac{V}{R} = \frac{6}{3} = 2A$$

In parallel combination, the voltage in the circuit remains constant. Therefore, power is given by

$$P = \frac{V^2}{R} = \frac{4^2}{L} = 8W$$

Hence, in both the cases power remains same as 8 W.

Q. 15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

ANSWER:-

For the lamp one: Power P_1 = 100 W and Potential difference V = 220 V

Therefore,

$$I_1 = \frac{P_1}{V} = \frac{100}{220} = 10.4.5\text{A}$$

For the lamp two:

Power P_2 = 60 W and Potential difference V = 220 V Therefore,

$$I_2 = \frac{P_2}{V} = \frac{60}{220} = 0.273\text{A}$$

So, the net current drawn from the supply is given by

$I = I_1 + I_2 = 0.455 + 0.273 = 0.728$ A

Q. 16. Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?

ANSWER:-

Energy consumed by an electrical appliance is given by H =Pt

For the TV set: Power W = 250 W and time t = 1 hour = 3600 seconds

So, energy consumed H = 250 × 3600 = 900000 J

For the toaster: Power W = 1200 W and time t = 10 minutes = 600 seconds

So, energy consumed H = 1200 × 600 = 720000 J

Hence, TV set uses more energy than toaster.

Q. 17. An electric heater of resistance 44Ω draws 5 A from the service mains for 2 hours. Calculate the rate at which heat is developed in the heater.

ANSWER:-

Given- I = 15 A, R = 8Ω and time t = 2 hours

Need to find- rate at which heat is developed in the heater

Heat developed in the heater is given by $H = I^2 Rt$

The rate at which heat is developed is given by

$$H = \frac{I^2 Rt}{t} = I^2 R = (15)^2 \times 8 = 1800\text{J / s}$$

Q. 18. Explain the following.

(a) Why is the tungsten used almost exclusively for filament of electric lamps?

(b) Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?

(c) Why is the series arrangement not used for domestic circuits?

(d) How does the resistance of a wire vary with its area of cross-section?

(e) Why are copper and aluminium wires usually employed for electricity transmission?

ANSWER:-

(a) Tungsten has a very high melting point and resistivity, which means it doesn't burn easily at high temperatures. Since electric lamps glow at very high temperatures, tungsten is used as the heating element in electric bulbs.

(b) The conductors in electric heating devices like bread toasters and electric irons are made of alloys because alloys have higher resistivity than pure metals. This higher resistivity allows them to produce more heat and prevents them from burning easily.

(c) In a series circuit, the voltage is divided among the components. Each component receives only a small portion of the total voltage, which reduces the current and causes the devices to heat up. This is why series arrangements are not used in domestic circuits.

(d) Resistance (R) of a wire is inversely proportional to its area of cross-section (A):

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

(e) Copper and aluminium wires have low resistivity. They are good conductors of electricity. Hence, they are usually employed for electricity transmission.