Science

(Chapter 12)(Electricity)
Class - 10

Exercises

Question 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 1:
Resistance of a piece of wire is directly proportional to its length. If the piece of wire has a resistance R 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.

Question 2:
Which of the following terms does not represent electrical power in a circuit?
(a) I^2R (b) IR^2 (c) VI (d) V^2/R

Answer 2:
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^2R
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.

Question 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 3:

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

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

Here, V = 220 V and P = 100 W

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

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

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

Hence, the option (d) is correct.

Question 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 4:

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

$$\frac{H_S}{H_P} = \frac{\frac{V^2}{R_s}t}{\frac{V^2}{R_P}t} = \frac{R_P}{R_s} = \frac{R/2}{2R} = \frac{1}{4} = 1:4$$

Therefore, the ratio of heat produced in series and parallel combinations is 1:4.

Hence, the option (c) is correct.

Question 5:

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

Answer 5:

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

Question 6:

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

Answer 6:

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

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

Where, ρ is resistivity of copper = 1.6×10^{-8} Ω m

R = 10 Ω, radius of wire r = 0.5/2 mm = 0.25 mm = 0.00025 m

$$A = \pi r^2 = 3.14 \times (0.00025)^2 = 0.000000019625\ m^2$$

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

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

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

So, the new resistance will be

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

Now

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

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

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

Question 7:

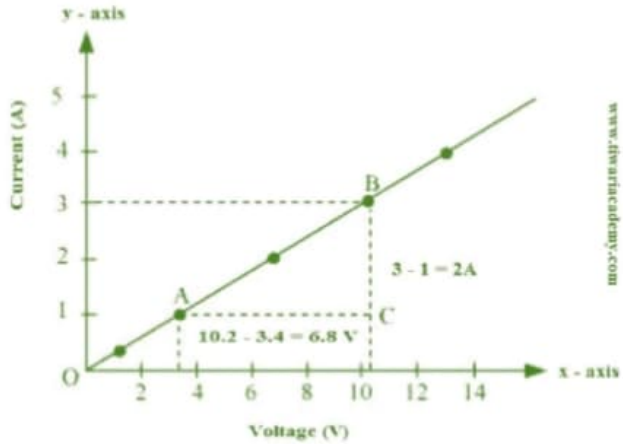
The values of current *I* flowing in a given resistor for the corresponding values of potential difference *V* across the resistor are given below –

I (amperes)	0.5	1.0	2.0	3.0	4.0
V (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 7:

The plot between voltage and current is called *VI* characteristic. The voltage is plotted on *x*-axis and current is plotted on *y*-axis.



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

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

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

Question 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 8:

According to Ohm's law, V = IR

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

Here, V = 12 V and I = 2.5 mA = 0.0025 A

Therefore,

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

Question 9:

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

Answer 9:

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 = IR

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

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

Question 10:

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

Answer 10:

Let the total number of resistors be x.

Given that:

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

According to Ohm's law, V = IR

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

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

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

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

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

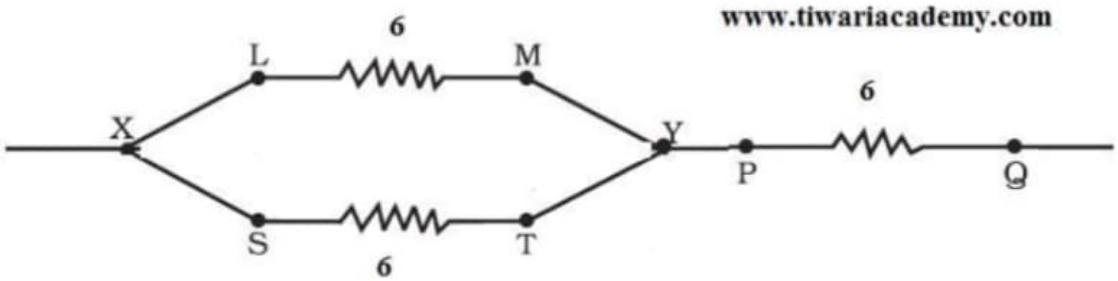
Therefore, 4 resistors of 176 Ω are required to draw the given amount of current.

Question 11:

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

Answer 11:

(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

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

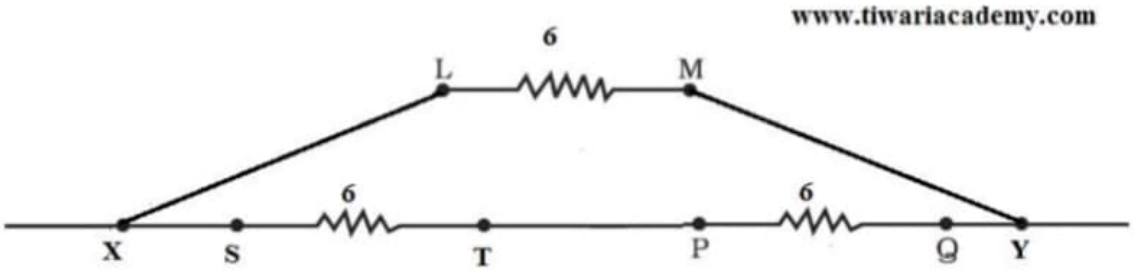
$$\Rightarrow \frac{1}{R_{12}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$$

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

Now R_{12} and 6 Ω 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 4 Ω resistance from three 6 Ω 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 6 Ω are connected in parallel, so the net resistance is given by

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

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

$$\Rightarrow R = 4\ \Omega$$

Question 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 12:

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

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

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

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

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

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

Therefore, 110 bulbs of $4840\ \Omega$ are required to draw the given amount of current.

Question 13:

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

Answer 13:

Given that:

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

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

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

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

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

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

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

Question 14:

Compare the power used in the 2 Ω resistor in each of the following circuits:
(i) a 6 V battery in series with 1 Ω and 2 Ω resistors, and (ii) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.

Answer 14:

Given that:
Potential difference, $V = 6$ V
(i). 1 Ω and 2 Ω resistors are connected in series. Therefore, equivalent resistance of the circuit, $R = 1 + 2 = 3\ \Omega$
According to Ohm's law,
$V = IR$

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

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

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

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

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

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

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

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

Question 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 15:

For the lamp one:

Power P_1 = 100 W and Potential difference V = 220 V

Therefore,

$$I_1 = \frac{P_1}{V} = \frac{100}{220} = 0.455\ A$$

For the lamp two:

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

Therefore,

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

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

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

Question 16:

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

Answer 16:

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.

Question 17:

An electric heater of resistance 8 Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

Answer 17:

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

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

The rate at which heat is developed is given by

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

Question 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 18:

a) The melting point and resistivity of tungsten are very high. It does not burn readily at a high temperature. The electric lamps glow at very high temperatures. Hence, tungsten is mainly used as heating element of electric bulbs.

b) The conductors of electric heating devices such as bread toasters and electric irons are made of alloy because resistivity of an alloy is more than that of metals. It produces large amount of heat and do not burn easily.

c) There is voltage division in series circuits. Each component of a series circuit receives a small voltage for a large supply voltage. As a result, the amount of current decreases and the device becomes hot. Hence, series arrangement is not used in domestic circuits.

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

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

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

Question 1:

What does an electric circuit mean?

Answer 1:

An electric circuit is the pathway in which current can flow. It consists of electric devices, switching devices, source of electricity, etc. that are connected by conducting wires.

Question 2:

Define the unit of current.

Answer 2:

The unit of electric current is ampere (A). *When 1 C of charge flows through a conductor in 1 s, it called 1 ampere (A) current.*

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