Board – CBSE | Class – 10th | Topic – Electricity

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) $\frac{1}{25}$ (b) $\frac{1}{5}$ (c) 5 (d) 25

Ans. (d) The Resistance of a piece of wire is proportional to its length. A piece of wire has a resistance R. The wire is cut into five equal parts.

Therefore, Resistance of each part = $\frac{R}{5}$

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

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

$$\frac{1}{R'} = \frac{25}{R}$$

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

Therefore, the ratio $\frac{R}{R'}$ is 25.

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

(a) I^2R (b) IR^2 (c) VI (c) $\frac{V^2}{R}$

Ans. (b) Electrical power is given by the expression, P = VI … (i)

According to Ohm's law, V = IR … (ii)

Where,

V = Potential difference

I = Current

R = Resistance

∴ P = VI

From equation (i), it can be written

P = (IR) × I

$\therefore P = I^2R$

From equation (ii), it can be written

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

$\therefore P = V \times \frac{V}{R}$

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

$\therefore P = VI = I^2 R = \frac{V^2}{R}$

Power P cannot be expressed as IR^2.

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

Ans. (d) The expression gives energy consumed by an appliance,

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

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

Where,

Power rating, P = 100 W

Voltage, V = 220 V

Resistance, 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 as

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

Therefore, the power consumed will be 25 W.

4. Two conducting wires of the same material and equal lengths and 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

Ans. (c) The Joule heating is given by H = i^2Rt

Let R be the Resistance of the two wires.

The equivalent resistance of the series connection is $R_S = R + R = 2R$

If V is the applied potential difference, then it is the voltage across the equivalent Resistance.

$$V = i_s \times 2R$$

$$\Rightarrow i_s = \frac{V}{2R}$$

The heat dissipated in time t is,

$$H_s = i_s^2 \times 2R \times t = \left(\frac{V}{2R}\right)^2 \times 2R \times t \Rightarrow H_s = \frac{V^2 t}{2R}$$

The equivalent resistance of the parallel connection is $R_p = \frac{1}{\frac{1}{R}+\frac{1}{R}} = \frac{R}{2}$

V is the applied potential difference across this R_p.

$$V = i_p \times \frac{R}{2}$$

$$\Rightarrow i_p = \frac{2V}{R}$$

The heat dissipated in time t is,

$$H_p = i_p^2 \times \frac{R}{2} \times t = \left(\frac{2V}{R}\right)^2 \times \frac{R}{2} \times t$$

$$\Rightarrow H_p = \frac{2V^2 t}{R}$$

So, the ratio of heat produced is,

$$\frac{H_s}{H_p} = \frac{\frac{V^2 t}{2R}}{\frac{2V^2 t}{R}} = \frac{1}{4}$$

Note. H α R also H α i^2 and H α t. In this question, t is the same for both circuits. But the current through the equivalent Resistance of both the circuit is different. We could have solved the directly using H α R if the current was also the same. As we know the voltage and resistance of the circuits, we have calculated I in terms of voltage and Resistance and used it in the equation $H = i^2 Rt$ to find the ratio.

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

Ans. A voltmeter should be connected in parallel to the points to measure the potential difference between two points.

6. A copper wire has a diameter of 0.5 mm and resistivity of $1.6 \times 10^{-8}\ \Omega$ 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?

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

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

Where,

The resistivity of copper, $\rho = 1.6\times10^{-8}\ \Omega\, m$

Area of the cross-section of the wire, $A = \pi\left(\frac{Diameter}{2}\right)^2$

Diameter= 0.5 mm = 0.0005 m

Resistance, R = 10 Ω

Hence, the length of the wire,

$$l = \frac{RA}{\rho} = \frac{10\times3.14\times\left(\frac{0.0005}{2}\right)^2}{1.6\times10^{-8}} = \frac{10\times3.14\times25}{4\times1.6} = 122.72\ m$$

If the diameter of the wire is doubled, new diameter = 2 × 0.5 = 1 mm = 0.001 m

Therefore, resistance R.'

$$R' = \rho\frac{l}{A} = \frac{1.6\times10^{-8}\times122.72}{\pi\left(\frac{1}{2}\times10^{-3}\right)^2}$$

$$= \frac{1.6\times10^{-8}\times122.72\times4}{3.14\times10^{-6}} = 250.2\times10^{-2} = 2.5\ \Omega$$

Therefore, the length of the wire is 122.7 m, and the new Resistance is 2.5 Ω

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 –

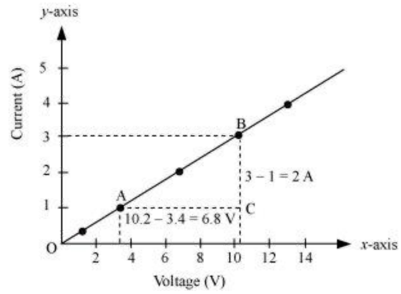
I (amperes)	0.5	1.0	2.0	3.0	4.0
V (volts)	1.6	3.4	6.7	10.2	13.2

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

Ans. The plot between voltage and current is called IV characteristic. The voltage is plotted on the x-axis, and the current is plotted on the y-axis. The values of the current for different values of the voltage are shown in the given table.

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

The IV characteristic of the given resistor is plotted in the following figure.



The slope of the line gives the value of Resistance (R) as,

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

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

Therefore, the resistance of the resistor is 3.4 Ω.

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.

Ans. Resistance (R) of a resistor is given by Ohm's law as,

$$V = IR$$

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

Where,

The potential difference, V = 12 V

Current in the circuit, I = 2.5 mA = $2.5\times10^{-3} A$

$$R = \frac{12}{2.5\times10^{-3}} = 4.8\times10^{3}\Omega = 4.8\ k\Omega$$

Therefore, the resistance of the resistor is $4.8\ k\Omega$.

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?

Ans. There is no current division occurring in a series circuit. Current flow through the component is the same, given by Ohm's law as

$$V = IR$$

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

Where,

R is the equivalent Resistance of resistances 0.2Ω, 0.3Ω, 0.4Ω, 0.5Ω, and 12 Ω. These are connected in series. Hence, the sum of the resistances will give the value of R.

R = 0.2 + 0.3 + 0.4 + 0.5 + 12 = 13.4 Ω

Potential difference, V = 9 V

$$I = \frac{9}{13.4} = 0.671\ A$$

Therefore, the current that would flow through the 12 Ω resistor is 0.671 A.

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

Ans. For x number of resistors of Resistance 176 Ω, the equivalent resistance of the resistors connected in parallel is given by Ohm's law as

$$V = IR$$

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

Where,

Supply voltage, V = 220 V

Current, I = 5 A

Equivalent Resistance of the combination = R, given as

$$\frac{1}{R} = x \times \left(\frac{1}{176}\right)$$

$$R = \frac{176}{x}$$

From Ohm's law,

$$\frac{V}{I} = \frac{176}{x}$$

$$x = \frac{176 \times I}{V}$$

$$= \frac{176 \times 5}{220} = 4$$

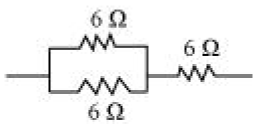
Therefore, four resistors of 176 Ω are required to draw the given amount of current.

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.

Ans. If we connect the resistors in series, then the equivalent resistance will be the sum of the resistors, i.e., 6 Ω + 6 Ω + 6 Ω = 18 Ω, which is not desired. If we connect the resistors in parallel, then the equivalent resistance will be

$\frac{6}{2} = 3\Omega$ Hence, we should either connect the two resistors in series or parallel.

(i) Two resistors in parallel

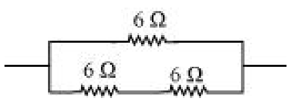


Two 6 Ω resistors are connected in parallel. Their equivalent resistance will be

$$\frac{1}{\frac{1}{6}+\frac{1}{6}} = \frac{6\times6}{6+6} = 3\Omega$$

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

(ii) Two resistors in series



Two 6 Ω resistors are in series. Their equivalent resistance will be the sum 6 + 6 = 12 Ω

The third 6 Ω resistor is in parallel with 12 Ω. Hence, equivalent Resistance will be

$$\frac{1}{\frac{1}{12}+\frac{1}{6}} = \frac{12\times6}{12+6} = 4\ \Omega$$

Therefore, the total Resistance is 4Ω.

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 across the two wires of the 220 V line if the maximum allowable current is 5 A?

Ans. The expression gives resistance R1 of the bulb,

$$P_1 = \frac{V^2}{R_1}$$

$$R_1 = \frac{V^2}{P_1}$$

Where,

Supply voltage, V = 220 V

Maximum allowable current, I = 5 A

Rating of an electric bulb $P_1 = 10\ W$

$$R_1 = \frac{(220)^2}{10} = 4840\ \Omega$$

According to Ohm's law,

V = I R

Where,

R is the total resistance of the circuit for x number of electric bulbs

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

Resistance of each electric bulb, $R_1 = 4840\Omega$

$$\therefore \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_1} + \ ...up\ to\ x\ times$$

$$\frac{1}{R} = \frac{1}{R_1} \times x$$

$$x = \frac{R_1}{R} = \frac{4840}{44} = 110$$

Therefore, 110 electric bulbs are connected in parallel.

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 resistances, which may be used separately, in series, or parallel. What are the currents in the three cases?

Ans. Supply voltage, V = 220 V

Resistance of one coil, R = 24Ω

(i) Coils are used separately

According to Ohm's law,

$$V = I_1 R_1$$

Where,

I_1 is the current flowing through the coil

$$I_1 = \frac{V}{R_1} = \frac{220}{24} = 9.166\ A$$

Therefore, 9.16 A current will flow through the coil when used separately.

(ii) Coils are connected in series

Total Resistance, $R_2 = 24\ \Omega + 24\Omega = 48\Omega$

According to Ohm's law,

$$V = I_2 R_2$$

Where,

I_2 is the current flowing through the series circuit

$I_2 = \frac{V}{R_2} = \frac{220}{48} = 4.58\ A$

Therefore, 4.58 A current will flow through the circuit when the coils are connected in series.

(iii) Coils are connected in parallel

Total Resistance, R_3 is given as $\frac{1}{\frac{1}{24}+\frac{1}{24}} = \frac{24}{2} = 12\ \Omega$

According to Ohm's law,

$V = I_3 R_3$

Where,

I_2 is the current flowing through the circuit

$I_3 = \frac{V}{R_3} = \frac{220}{12} = 18.33\ A$

Therefore, 18.33 A current will flow through the circuit when coils are connected in parallel.

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.

Ans. (i) Potential difference, V = 6 V

1 Ω and 2 Ω resistors are connected in series. Therefore, equivalent Resistance of the circuit,

R = 1 + 2 = 3 Ω

According to Ohm's law,

V = IR

Where,

I is the current through the circuit

$I = \frac{6}{3} = 2A$

This current will flow through each circuit component because there is no division of current in series circuits. Hence, the current flowing through the 2 Ω resistor is 2A. The expression gives power,

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

(ii) Potential difference, V = 4 V

12 Ω and 2 Ω resistors are connected in parallel. The voltage across each component of a parallel circuit remains the same. Hence, the voltage across 2 Ω resistor will be 4 V.

Power consumed by 2 Ω resistor is given by

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

Therefore, the power used by the 2 Ω resistor is 8 W.

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

Ans. Both the bulbs are connected in parallel. Therefore, the potential difference between them will be 220 V because no division of voltage occurs in a parallel circuit.

Current drawn by the bulb of rating 100 W is given by,

Power = Voltage × current

Current = $\frac{Power}{Voltage} = \frac{100}{220} A$

Similarly, current drawn by the bulb of rating 60 W is given by,

Power = Voltage × current

Current = $\frac{Power}{Voltage} = \frac{60}{220} A$

Hence, current drawn from the line = $\frac{100}{220} + \frac{60}{220} = 0.727 A$

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

Ans. The expression gives energy consumed by an electrical appliance,

H = Pt

Where,

Power of the appliance = P

Time = t

Energy consumed by a TV set of power 250 W in 1 h = 250 × 3600 = $9\times10^5 J$

Energy consumed by a toaster of power 1200 W in 10 minutes = 1200 × 600

= $7.2\times10^5 J$

Therefore, the energy consumed by a 250 W TV set in 1 h is more than the energy consumed by a toaster of power 1200 W in 10 minutes.

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

Ans. The expression gives the rate of heat produced by a device for power as

$P = I^2 R$

Where,

Resistance of the electric heater, R = 8 Ω

Current drawn, I = 15 A

$P = (15)^2 \times 8 = 1800\, J/s$

Therefore, heat is produced by the heater at the rate of 1800 J/s.

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?

Ans. (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 a heating element of electric bulbs.

(b) The conductors of electric heating devices such as bread toasters and electric irons are made of alloy because the resistivity of an alloy is more than that of metals. It produces a large amount of heat.

(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, the series arrangement is not used in domestic circuits.

(d) Resistance (R) of a wire is inversely proportional to its area of cross-section (A), i.e.,

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

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