NCERT X CLASS PHYSICS
Chapter-3 - 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
Sol. (D)

Q.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
Sol. (B)

Q.3 An electric bulb is rated 220V and 100W. When it is operated on 110V, the power consumed will be –
(A) 100W (B) 75W (C) 50W (D) 25W
Sol. (D)

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
Sol. (C)

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

Q.6 A copper wire has diameter 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 10Ω? How much does the resistance change if the diameter is doubled ?
Sol. (a) Diameter, d = 0.5 mm

Radius, $r = \frac{0.5}{2}\text{ mm} = 0.25\text{ mm} = \frac{0.25}{1000}\text{ m} = 0.25 \times 10^{-3}\text{ m}$

Area of cross section, $A = \pi r^2 = \frac{22}{7} \times (0.25 \times 10^{-3})^2 = 0.1964 \times 10^{-6}\text{ m}^2$

Resistance, R = 10Ω, Resistivity, $\rho = 1.6 \times 10^{-8}\ \Omega$ m, Length, ℓ = ?

We know that $R = \frac{\rho\ell}{A}$; $\ell = \frac{RA}{\rho} = \frac{10 \times 0.1964 \times 10^{-6}}{1.6 \times 10^{-8}} = \frac{1964}{16} = 122.75$ m

(b) The area of cross section, $A_1 = \pi r^2 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$

Its resistance, $R_1 = \frac{\rho\ell}{A_1} = \frac{4\rho\ell}{\pi d^2}$ .... (1)

When the diameter is doubled, area of cross section,

$$A_2 = \pi\left(\frac{2d}{2}\right)^2 = \pi d^2$$

Its resistance, $R_2 = \frac{\rho\ell}{A_2} = \frac{\rho\ell}{\pi d^2}$ ..... (2)

From eq. (1) and (2), $\frac{R_2}{R_1} = \frac{\rho\ell}{\pi d^2} \times \frac{\pi d^2}{4\rho\ell} = \frac{1}{4}$ or $R_2 = \frac{1}{4}R_1$

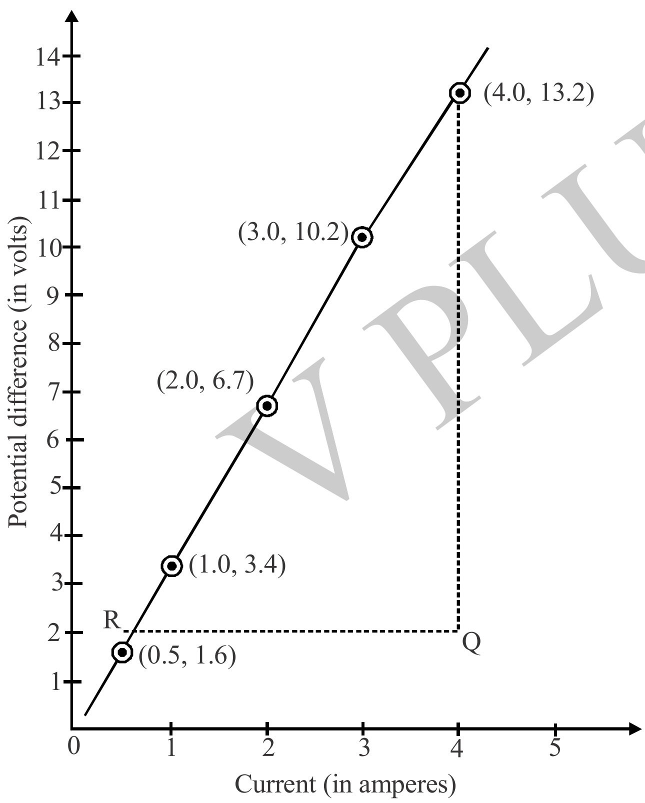
Thus, on doubling the diameter, the area of cross section becomes 4 times and the resistance becomes one fourth.

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 –

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.

Sol.



$$\text{Resistance} = \frac{\text{Coordinates on Y-axis}}{\text{Coordinates on X-axis}} = \frac{Y_2 - Y_1}{X_2 - X_1} = \frac{(13.2 - 1.6)\ V}{(4.0 - 0.5)\ A} = \frac{11.6\ V}{3.5\ A} = 3.31\ \Omega$$

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.

Sol. Potential difference, V = 12 V

Current, I = 2.5 mA = 2.5×10^{-3} A

We know that V = I R

$$R = \frac{V}{I} = \frac{12}{2.5 \times 10^{-3}} = 4.8 \times 10^{3}\,\Omega = 4.8\ \text{k}\Omega$$

Q.9 A battery of 9V 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?

Sol. Resistors are connected in series.

So, equivalent resistance, R = 0.2 Ω + 0.3 Ω + 0.4 Ω + 0.5 + 12 Ω = 13.4 Ω

Potential difference, V = 9 V

Current, through the circuit $I = \frac{V}{R} = \frac{9}{13.4} = 0.67\ \text{A}$

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

Sol. Current, I = 5 A

Potential difference, V = 220 V

Resistance of parallel circuit, $R = \frac{V}{I} = \frac{220}{5} = 44\ \Omega$

Let no. of resistors = n

In parallel, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \text{n times}$

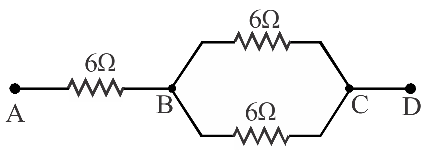
$$\frac{1}{44} = \frac{1}{176} + \frac{1}{176} + ...\ \text{n times}$$

$$\frac{1}{44} = \frac{n}{176} \Rightarrow n = \frac{176}{44}\ ;\ n = 4$$

Number of required resistors = 4.

Q.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.

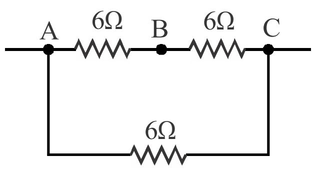
Sol. (i) In order to get a resistance of 9 Ω, we connect the given resistors (each of resistance of 6 Ω) in the following way. Resistance between B and C



$$\frac{1}{R} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}\ ;\ R = 3\Omega.$$

Resistance of the combination = 6Ω + 3Ω = 9Ω

(ii) In order to get a resistance of 4 Ω, we connect two resistors in series and third in parallel shown in figure.



Resistors AB and BC are in series, therefore,

$R_s = 6\Omega + 6\Omega = 12\Omega$

Now, R_s is parallel with the third (6Ω)

$\therefore$ Equivalent resistance of combination (R_p) is given by

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{12} = \frac{2+1}{12} = \frac{3}{12} = \frac{1}{4} \; ; \; R_p = 4\Omega$$

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?

Sol. Potential difference, V = 220 V

Power of each bulb, P = 10 W

Resistance of each bulb, $R = \frac{V^2}{P} = \frac{220 \times 220}{10} = 4840\ \Omega$

Total resistance in the circuit, $R' = \frac{V}{I} = \frac{220}{5} = 44\ \Omega$

Let n be the number of bulbs to be connected in parallel to obtain resistance R'.

$$\frac{1}{R'} = \frac{1}{R} + \frac{1}{R} + \text{....n times} \; ; \; \frac{1}{R'} = \frac{n}{R}$$

$$n = \frac{R}{R'} = \frac{4840}{44} = 110$$

Required no. of bulbs = 110

Q.13 A hot plate of an electric oven connected to a 220V 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 ?

Sol. Potential difference, V = 220 V

Resistance of each coil, R = 24 Ω

Case I : When coils A and B are used separately, current through each coil,

$$I = \frac{V}{R} = \frac{220}{24} = 9.2\ A$$

Case II : When coils A and B are connected in series, the equivalent resistance in the circuit.

$R_s = 24 + 24 = 48$

Current, $I = \frac{V}{R_s} = \frac{220}{48} = 4.6\ A$

Case III : When coils A and B are connected in parallel, the equivalent resistance (R_P) is given by

$$\frac{1}{R_p} = \frac{1}{24} + \frac{1}{24} = \frac{2}{24} \; ; \; R_p = 12\ \Omega$$

Current, $I = \frac{V}{R_p} = \frac{220}{12} = 18.3\ A$

Q.14 Compare the power used in the 2Ω resistor in each of the following circuits:
(i) a 6 V battery in series with 1 Ω and 2 Ω resistors, and (ii) a 4 V battery in parallel with 12Ω and 2Ω resistors.

Sol. (i) Equivalent resistance of I Ω and 2 Ω in series, R = 1Ω + 2Ω = 3Ω

Potential difference, V = 6 V

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

Current in series circuit is same.

∴ Current in 2Ω resistor = 2 A

Power in 2Ω resistor, $P = I^2R = 2^2 \times 2 = 8W$

(ii) Potential difference across 2Ω resistor = 4 V

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

P : P' = 8W : 8W = 1 : 1

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?

Sol. We know that, $P = \frac{V^2}{R} \quad \therefore\ R = \frac{V^2}{P}$

Resistance of 1st lamp, $R_1 = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\ \Omega$

Resistance of 2nd lamp, $R_2 = \frac{220 \times 220}{60} = \frac{2420}{3}\ \Omega$

Since, two lamps are connected in parallel, so its equivalent resistance is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{484} + \frac{3}{2420} = \frac{5+3}{2420} = \frac{8}{2420}$$

$$R = \frac{2420}{8}\ \Omega$$

Current drawn from the line, $I = \frac{V}{R} = \frac{220 \times 8}{2420} = 0.73\ A$

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

Sol. Energy used by TV. set

$E_1 = P \times t = 250\ W \times 1h = 250\ Wh$

Energy used by toaster,

$E_2 = P \times t = 1200 \times \frac{10}{60} = 200\ Wh$

Thus, T.V. set uses more energy than toaster.

Q.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.

Sol. Here, $R = 8\Omega$, $I = 15A$, $t = 2h = 2 \times 60 \times 60s$

Heat developed, $H = I^2 Rt = (15)^2 \times 8 \times 2 \times 60 \times 60$ J

The rate at which heat is developed is power.

$$\text{Power} = \frac{\text{Heat developed } (I^2Rt)}{\text{Time taken (t)}} = \frac{15 \times 15 \times 8 \times 2 \times 60 \times 60}{2 \times 60 \times 60} = 1800 \text{ J/s}$$

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?

Sol. (a) The pure tungsten has high resistivity and a high melting point (nearly 3000°C), so when electric current passed through the filament then the electrical energy is converted to heat and light energy.

(b) The resistivity of an alloy is generally higher than that of pure metal which form the alloy. Since resistivity changes less rapidly with changes in temperature, they do not oxidise (burn) readily at high temperatures. Therefore, the conductors of electric heating devices, such as toasters and electric irons, are made of an alloy rather than a pure metal.

(c) The series arrangement is not used for domestic circuit because:

(i) If connected in series total resistances will increase. Therefore, current flowing through the circuit will be low.

(ii) If one appliance is switched off or gets damaged than all other appliances will also stop working because their electricity supply will be cut off.

(d) The resistance of a wire is inversely proportional to its cross-sectional area. Thus, a thick wire has less resistance, and a thin wire has more resistance.

(e) Copper and aluminium wires are usually employed for electricity transmission because copper and aluminium have very low resistivities.