CHAPTER 11

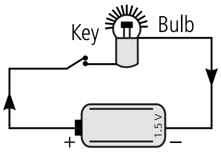
Electricity

NCERT FOCUS

ANSWERS

Topic 1

1. A continuous conducting pathconsisting of some electric components connected between the two terminals of a battery is called an electric circuit.



A simple electric circuit consisting of a bulb,a key, copper-connecting wires and a dry cell is shown in figure.

2. Unit of electric current is ampere (A).

When 1 coulomb of charge flows through a conductor for 1 second, then the electric current flowing through the conductor is 1 ampere.

3. Total charge, $Q = 1$ C

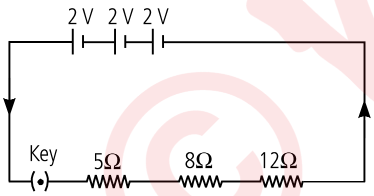
Charge of an electron, $q = 1.6 \times 10^{-19}$ C

No. of electrons constituting 1 C of charge

$$= \frac{1\,\text{C}}{1.6 \times 10^{-19}\,\text{C}} = \frac{1}{1.6 \times 10^{-19}}$$

$= 6.25 \times 10^{18}$ electrons

4. The schematic circuit diagram is shown below:



Topic 2

1. A battery consisting of one or more electric cells is used to maintain a potential difference across a conductor.

2. Potential difference between two points in a current-carrying conductor is said to be 1 volt if 1 joule of work is done to carry a charge of 1 coulomb from one point to the other, *i.e.*,

$$1\,\text{volt} = \frac{1\,\text{joule}}{1\,\text{coulomb}} = 1\,\text{J C}^{-1}$$

3. Given: Charge, $Q = 1$ C

Applied voltage, $V = 6$ V

Work done in moving a charge of 1 C under the voltage of 6 V = 1 C × 6 V = 6 J

Thus, an energy of 6 J should be given during the passage of one coulomb of charge through a 6 V battery.

Topic 3

1. The resistance (R) of a conductor depends upon :

(i) its length (l), *i.e.*, $R \propto l$

(ii) its cross-sectional area (A) *i.e.*, $R \propto 1/A$

(iii) nature of material

(iv) temperature

2. The current flows more easily through a thick wire than through a thin wire. This is due to the reason that the resistance, R of a thick wire of large area of cross-section, A is less than that of a thin wire as $R \propto \frac{1}{A}$.

3. When the potential difference across the two ends of the electrical component becomes half of its former value, then the current through it also becomes half. Since $I = V/R$, when potential difference becomes $V/2$, current becomes $I/2$ as the resistance (R) of the component remains constant.

4. **(a)** Iron is a better conductor than mercury as resistivity (ρ) for iron ($10.0 \times 10^{-8}\ \Omega$ m) is less than that for mercury ($94 \times 10^{-8}\ \Omega$ m).

(b) Silver is the best conductor as its resistivity (ρ) is the least, *i.e.*, $1.60 \times 10^{-8}\ \Omega$ m.

5. Given diameter of the wire, $D = 0.5$ mm

$= 0.5 \times 10^{-3}$ m

resistivity of copper, $\rho = 1.6 \times 10^{-8}$ ohm m

required resistance, $R = 10$ ohm

$$\text{As } R = \frac{\rho l}{A} \Rightarrow l = \frac{RA}{\rho} = \frac{R(\pi D^2/4)}{\rho} = \frac{\pi R D^2}{4\rho}$$

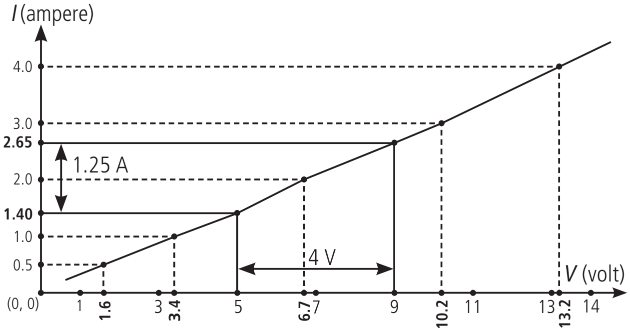
$[\because\ A = \pi r^2 = \pi(D/2)^2 = \pi D^2/4]$

$$\therefore\ l = \frac{3.14 \times 10 \times (0.5 \times 10^{-3})^2}{4 \times 1.6 \times 10^{-8}}\,\text{m} = 122.7\,\text{m}$$

$$\text{Since, } R = \frac{\rho l}{\pi D^2/4} = \frac{4\rho l}{\pi D^2} \Rightarrow R \propto 1/D^2.$$

When D is doubled, R becomes $\frac{1}{4}$ times.

6. The $V-I$ graph is shown in figure.



For finding R consider any two sets of values for V and I

For $V_1 = 10.2$, $I_1 = 3$

$V_2 = 3.4$, $I_2 = 1$

Therefore, $R = \frac{10.2-3.4}{3-1} \Rightarrow R = 3.4\,\Omega$

The value of R obtained from the graph depends upon the accuracy with which the graph is plotted.

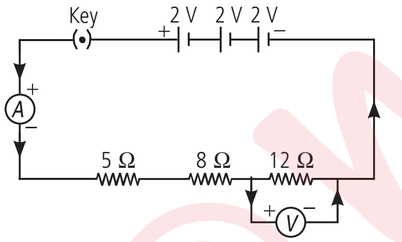
7. Here, $V = 12$ V, $I = 2.5$ mA $= 2.5 \times 10^{-3}$ A

Resistance of the resistor,

$$R = \frac{V}{I} = \frac{12\text{ V}}{2.5\times10^{-3}\text{ A}} = 4800\,\Omega = 4.8\,\text{k}\Omega$$

Topic 4

1 The completed circuit diagram is given below:



For the whole circuit,

Total resistance = 5 Ω + 8 Ω + 12 Ω = 25 Ω

Total applied voltage = 2 V + 2 V + 2 V = 6 V

Then, current flowing through the resistors,

$$I = \frac{V}{R} = \frac{6\text{ V}}{25\,\Omega} = 0.24\text{ A}$$

So, the ammeter will show a reading of 0.24 A.

Using ohm's law, $V = IR$

Voltage across the 12 Ω resistor

= 0.24 A × 12 Ω = 2.88 V

So, the voltmeter will show a reading of 2.88 V.

2. **(a)** For a parallel combination,

$$\frac{1}{R} = \frac{1}{1\,\Omega} + \frac{1}{10^6\,\Omega} = \frac{10^6+1}{10^6\,\Omega}$$

$$R = \frac{10^6\,\Omega}{10^6+1} \simeq 1\,\Omega$$ (1 is negligible as compared to 10^6)

(b) For the other parallel combination, we can write

$$\frac{1}{R} = \frac{1}{1\Omega} + \frac{1}{10^3\,\Omega} + \frac{1}{10^6\,\Omega}$$

$= 1\,\Omega^{-1} + 0.001\,\Omega^{-1} + 0.000001\,\Omega^{-1}$

$\simeq 1.001\,\Omega^{-1}$

$$R = \frac{1}{1.001}\,\Omega = 0.999\,\Omega \simeq 1\,\Omega$$

3. Resistance of the electric lamp, $R_1 = 100\ \Omega$

Resistance of toaster, $R_2 = 50\ \Omega$

Resistance of water filter, $R_3 = 500\ \Omega$

Since R_1, R_2 and R_3 are connected in parallel, their equivalent resistance (R_p) is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500}$$

$$= \frac{5+10+1}{500} = \frac{16}{500}$$

or $R_p = \frac{500}{16} = \frac{125}{4}\,\Omega$

Current through the three appliances, *i.e.*,

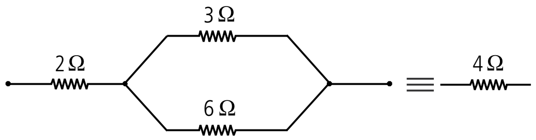
$$I = \frac{V}{R_p} = \frac{220\text{V}}{(125/4)\,\Omega} = 7.04\text{ A}$$

Since the electric iron is connected to the same source (*i.e.*, 220V), it takes as much current as all three appliances, *i.e.*, I, its resistance is equal to R_p, *i.e.*, $\frac{125}{4}\,\Omega = 31.25\,\Omega$.

4. (i) When a number of electrical devices are connected in parallel, each device gets the same potential difference as provided by the battery and it keeps on working even if other devices fail. This is not so in case the devices are connected in series because when one device fails, the circuit is broken and all devices stop working.

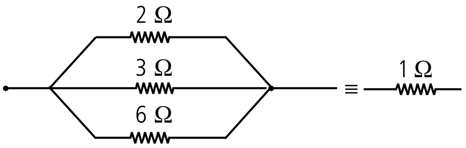
(ii) Parallel circuit is helpful when each device has different resistance and requires different current for its operation as in this case the current divides itself through different devices. This is not so in series circuit where same current flows through all the devices, irrespective of their resistances.

5. **(a)** Following combination will give a total resistance of 4 Ω.



Thus, the resistances of 3 Ω and 6 Ω are connected in parallel and this combination is combined with 2 Ω resistance in series.

(b) We can get a total resistance of 1 Ω by connecting all the three resistances in parallel.



6. **(d) :** Resistance of each one of the five parts $= \frac{R}{5}$

Resistance of five parts connected in parallel is given by

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

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

7. A voltmeter is always connected in parallel across the points between which the potential difference is to be determined.

8. Since all the resistors are in series,

So equivalent resistance,

$$R_s = 0.2\ \Omega + 0.3\ \Omega + 0.4\ \Omega + 0.5\ \Omega + 12\ \Omega$$
$$= 13.4\ \Omega$$

Current flowing through the circuit,

$$I = \frac{V}{R_S} = \frac{9\text{ V}}{13.4\ \Omega} = 0.67\text{ A}$$

In series, same current (I) flows through all the resistors. Thus, current flowing through 12 Ω resistor = 0.67 A

9. Let there be n resistors in parallel. Then the equivalent resistance is given by,

$$R = \frac{176\ \Omega}{n} \quad \text{... (i)}$$

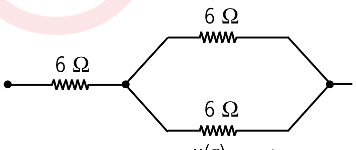
From Ohm's law, $R = \frac{V}{I} = \frac{220\text{ V}}{5\text{ A}}$ ... (ii)

From equation (i) and (ii)

$$\therefore \quad \frac{176\ \Omega}{n} = \frac{220\text{ V}}{5\text{ A}} \quad \text{or} \quad n = 4$$

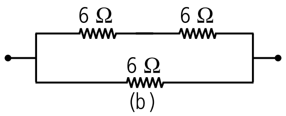
So, four resistors of 176 Ω each are required.

10. **(a)** The resistance of the combination is higher than each of the resistances. We can obtain 9 Ω by coupling 6 Ω and 3 Ω in series. A parallel combination of two 6 Ω resistors is equivalent to 3 Ω. So, to obtain 9 Ω, we have two connect two 6 Ω resistors in parallel and then connect the third 6 Ω resistor in series to the parallel combination as shown in figure (a)



(a)

(b) To obtain a combination of 4 Ω, we have to connect two 6 Ω resistors in series and then connect the third 6 Ω resistor in parallel to the series combination as shown in the figure (b).



(b)

Topic 5

1. Alloys are used for making the coils in electric toaster and electric iron because alloys have higher melting point than pure metals. So, the coils made from alloys do not melt or get deformed and alloys do not get oxidised or burn readily at high temperatures.

2. The cord of an electric heater is made of thick copper wire and has much lower resistance than its element. For the same current (I) flowing through the cord and the element, heat produced (I^2Rt) in the element is much more than produced in the cord. Consequently, the element becomes very hot and glows whereas the cord does not become hot and as such does not glow.

3. Here, $Q = 96000$ C,

$t = 1\text{ h} = 60 \times 60 = 3600\text{ s}$, $V = 50$ V

Heat produced, $H = VIt = \frac{VQ}{t}t = QV$

$= 96000\text{ C} \times 50\text{ V} = 48 \times 10^5$ J.

4. Resistance, $R = 20\ \Omega$

Current, $I = 5$ A,

Time, $t = 30$ s

Heat generated $= I^2Rt = (5\text{ A})^2 \times 20\ \Omega \times 30$ s

$= 25 \times 20 \times 30\text{ J} = 15000\text{ J} = 15$ kJ

5. Rate at which energy is delivered by a current is called electric power.

Electric power is determined by

(a) the potential difference across the conductor

(b) the current.

6. Here, $I = 5$ A, $V = 220$ V,

$t = 2\text{ h} = 2 \times 60 \times 60 = 7200$ s

Power, $P = VI = 220 \times 5 = 1100$ W

Energy consumed, H

$H = VIt = 220 \times 5 \times 7200 = 7920000$ J

7. **(b) :** Electrical power, $P = VI = (IR)I = I^2R = V^2/R$

Obviously, IR^2 does not represent electrical power in a circuit. Thus, option (b) is the correct answer.

8. **(d) :** Resistance of the bulb

$$= \frac{V^2}{P} = \frac{(220\text{ V})^2}{100\text{ W}} = 484\ \Omega$$

Then, power consumed at 110 V

$$= \frac{V^2}{R} = \frac{(110\text{ V})^2}{484\ \Omega} = 25\ \Omega$$

9. (i) Since 6 V battery is in series with 1 Ω and 2 Ω resistors, current in the circuit,

$$I = \frac{6\text{ V}}{1\ \Omega + 2\ \Omega} = \frac{6\text{ V}}{3\ \Omega} = 2\text{ A}$$

Power used in 2 Ω resistor,

$P_1 = I^2R = (2A)^2 \times 2\ \Omega = 8\ W$

(ii) Since 4 V battery is in parallel with 12 Ω and 2 Ω resistors, potential difference across 2 Ω resistor, $V = 4$ V.

Power used in 2 Ω resistor,

$$P_2 = \frac{V^2}{R} = \frac{(4\,V)^2}{2\Omega} = 8\ W$$

Clearly, $\frac{P_1}{P_2} = \frac{8\ W}{8\ W} = 1$

10. Since both the bulbs are connected in parallel and to a 220 V supply, the voltage across each bulb is 220 V. Then

Current drawn by 100 W bulb,

$$I_1 = \frac{\text{Power}}{\text{Voltage applied}} = \frac{100\,W}{220V} = 0.454\,A$$

Current drawn by 60 W bulb,

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

Total current drawn from the supply line,

$I = I_1 + I_2 = 0.454\ A + 0.273\ A$

$= 0.727\ A \simeq 0.73\ A$

11. Energy consumed by TV set = 250 W × 1 h

$= 250\ J\ s^{-1} \times 60 \times 60\ s = 900,\ 000\ J$

Energy consumed by toaster = 1200 W × 10 min

$= 1200\ J\ s^{-1} \times 10 \times 60\ s = 720,\ 000\ J$

Thus, the TV set will use more energy.

12. Resistance, $R = 8\ \Omega$, Current, $I = 15$ A, Time, $t = 2$ h

Rate of generation of heat $= I^2 \times R$

$= (15\ A)^2 \times 8\ \Omega = 15 \times 15 \times 8\ W = 1800\ W$

13. **(c) :** Since both the wires are made of the same material and have equal lengths and equal diameters, they have the same resistance. Let it be R.

When connected in series, their equivalent resistance is given by

$R_s = R + R = 2R$

When connected in parallel, their equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \quad \text{or} \quad R_p = \frac{R}{2}$$

Further, electrical power is given by , $P = \frac{V^2}{R}$

∴ Heat produced in series, $H_s = \frac{V^2}{R_s} \times t$

Heat produced in parallel, $H_p = \frac{V^2}{R_p} \times t$

Thus, $\frac{H_s}{H_p} = \frac{V^2/R_s}{V^2/R_p} = \frac{R_p}{R_s} = \frac{R/2}{2R} = \frac{1}{4}$

or $H_s : H_p = 1 : 4$