Chapter - 12

Electricity

Q 1. What does an electric circuit mean?

Ans. An electric circuit is a continuous and closed path of an electric current. If the electric circuit is complete, electric current can flow through the circuit. If the circuit is broken anywhere or switch of the circuit is turned off, the current stops flowing.

Q 2. Define the unit of current.

Ans. SI unit of electric current is 1 ampere. Rate of flow of 1 coulomb of charge per second across a cross-section of a conductor constitutes 1 ampere current.

Q 3. Calculate the number of electrons constituting one coulomb of charge.

Ans. We know that value of charge on an electron e = 1.6×10^{-19} C.

$\therefore$ Number of electrons constituting 1 C of charge $n = \frac{1C}{1.6 \times 10^{-19} C} = 6.25 \times 10^{18}$

Q 4. Name a device that helps to maintain a potential difference across a conductor.

Ans. Potential difference across a conductor can be maintained by means of a battery consisting of one or more cells.

Q 5. What is meant by saying that the potential difference between two points is 1 V?

Ans. The potential difference between two points is 1 volt, if 1 joule of work is done to move a charge of 1 coulomb from one point to another.

Q 6. How much energy is given to each coulomb of charge passing through a 6 V battery?

Ans. Given that potential difference V = 6 V

Charge Q = 1C

$\therefore$ Energy given = Total work done = Q.V = 1 C $\times$ 6 V = 6 J.

Q 7. On what factors does the resistance of a conductor depend?

Ans. The resistance of a conductor depends on (i) its length (ii) its area of cross-section and (iii) the nature of the material of the conductor.

Q 8. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why ?

Ans. The current is flowing more easily through a thick wire as compared to a thin wire of the same material, when connected to the same source. It is due to the reason that resistance of a thick wire is less than that of thin wire.

Q 9. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half of its former value. What change will occur in the current through it?

Ans. Here resistance R of the electrical component remains constant but the potential difference across the two ends of the component decreases to half of its value i.e., V′ = $\frac{V}{2}$.

Hence, as per Ohm's law new current $I' = \frac{V'}{R} = \frac{V/2}{R} = \frac{V}{2R} = \frac{1}{2}$.

So, the new current is half of its original value.

Q10. Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?

Ans. Coils of electric toasters and electric irons are made of an alloy due to the following two reasons:

(i) Resistivity of an alloy is generally higher than that of pure metals, hence for a given resistance we need a coil of lesser
length.

(ii) At high temperature, an alloy does not oxidised (burn) readily. Hence, coil of an alloy has longer life.

Q11. Use the data in Table 12.2 to answer the following

(a) Which among iron and mercury is a better conductor? **(b)** Which material is the best conductor?

Ans. (a) Iron is a better conductor than mercury because resistivity of iron is lesser than that of mercury.

(b) Silver is the best conductor because its resistivity is the least.

Q12. Draw a schematic diagram of a circuit consisting of a battery of three cells of 2 V each, a 5 Ω resistor, an 8 Ω resistor, and a
12Ω resistor, and a plug key, all connected in series.

Ans. The schematic diagram of the circuit is shown in following Fig.

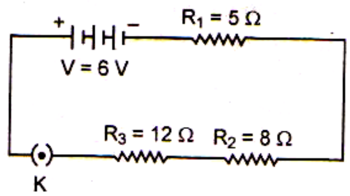

Fig. 12.01

Q13. Redraw the circuit of Question 1, putting in an ammeter to measure the current through the resistors and a voltmeter to
measure the current through the resistors and a voltmeter to measure the potential difference across the 12 Ω resistor.

What would be the readings in the ammeter and the voltmeter?

Ans. The redrawn circuit is shown in fig, Here, ammeter A has been joined in series of the circuit and voltmeter V is joined in
parallel to 12 Ω resistor.

Here total voltage of battery V = 3 × 2 = 6 V

Total resistance $R = R_1 + R_2 + R_3 = 5 + 8 + 12 = 25\ \Omega$

∴ Ammeter reading = Current flowing in the circuit

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

∴ Voltmeter reading = Potential difference across 12 Ω resistor

$$V' = IR_3 = 0.24 \times 12 = 2.88V$$

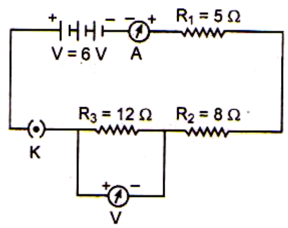

Fig. 12.02

Q14. Judge the equivalent resistance when the following are connected in parallel:

(a) 1 Ω and 10^6Ω **(b)** 1Ω, 10^3 Ω and 10^6Ω

Ans. When resistance R_1, R_2, R_3......are joined in parallel, the resultant resistance in parallel arrangement R_P is given by

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots$$

(a) When R_1 = 1 Ω, R_2 = 10^6 Ω

$$\frac{1}{R_P} = \frac{1}{1} + \frac{1}{10^6} = 1 + 10^{-6} = 1$$

⇒ R_P = 1Ω.

(b) When R_1 =1 Ω, R_2 = 10^3 Ω and R_3 = 10^6 Ω

$$\frac{1}{R_P} = \frac{1}{1} + \frac{1}{10^3} + \frac{1}{10^6} = 1 + 10^{-3} + 10^{-6} = 1$$

∴ R_P = 1 Ω

Q15. An electric lamp of 100 Ω a toaster of resistance 50 Ω and a water filter of resistance 500 Ω are connected in parallel to a 220 V source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it?

Ans. Here voltage of given voltage source V = 220 V.

As three gadgets of resistance R_1 = 100 Ω, R_2 = 50 Ω and R_3 = 500 Ω have been connected in parallel across the voltage source, hence their equivalent resistance R_P is given by

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500} = \frac{5+10+1}{500} = \frac{16}{500}$$

⇒ $R_P = \frac{500}{16}\Omega$ = 31.25 Ω

∴ Resistance of electric iron, which draws as much current as all three appliances taken together = R = R_P = 31.25 Ω

Current passing through electric iron $I = \frac{V}{R} = \frac{220V}{31.25\Omega} = 7.04A.$

Q16. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?

Ans. Following are the advantages of connecting electrical devices in parallel with the battery:

(i) Voltage across each electrical device is same and the device can take current as per its resistance.

(ii) Separate on/off switches can be applied across each device.

(iii) Total resistance in parallel circuit decreases, hence a greater current may be drawn from the cell.

(iv) If one electrical device is damaged then other devices continue to work properly.

Q17. How can three resistors of resistances 2Ω, 3Ω and 6Ω be connected to give a total resistance of **(a)** 4 Ω **(b)** 1 Ω?

Ans. (a) If we connect resistances of 3Ω and 6Ω in parallel and then resistance of 2Ω is connected is series of the combination,

then the total resistance of combination is 4 Ω as shown in fig. (a)

Here $$\frac{1}{R'} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}.$$

⇒ R′ = 2 Ω

and total resistance R = 2Ω + R′ = 2 + 2 = 4 Ω.

(b) If all the three resistance are joined in parallel as sown in fig. (b), we have

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

⇒ R = 1 Ω

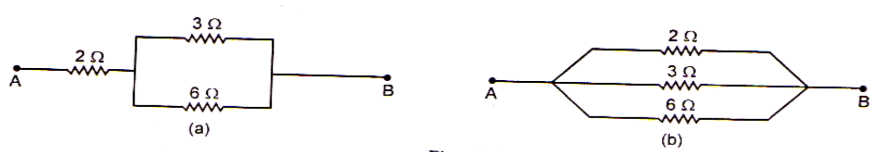

Fig. 12.03

Q18. What is (a) the highest (b) the lowest total resistance that can be secured by combinations of four coils of resistance 4 Ω,

8 Ω, 12 Ω and 24 Ω?

Ans. (a) To obtain highest resistance, all the four resistance must be connected in series arrangement. In that case

$$R_S = R_1 + R_2 + R_3 + R_4 = 4 + 8 + 12 + 24 = 48\ \Omega.$$

(b) To obtain lowest resistance, all the four resistances must be connected in parallel arrangement. In that case

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24} = \frac{6+3+2+1}{24} = \frac{12}{24}$$

$$R_P = \frac{24}{12}\Omega = 2\ \Omega$$

Q19. Why does the cord of an electric heater not glow while the heating element does?

Ans. Cord and electric heater are joined in series and carry same current when joined to voltage source. As resistance of cord is extremely small as compared to that of heater element, hence, heat produced $H = I^2Rt$ is extremely small in cord but much larger in heater element. So, the heater element begins to glow but cord does not glow.

Q20. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.

Ans. Here charge transferred Q = 96000 C, time t = 1 hour = 60 × 60 s = 3600 s and potential difference V = 50V

$\therefore$ Heat generated H = VIt = V.Q = 50 × 96000 = 4800000 J

= 4.8×10^6 J

Q21. An electric iron of resistance 20 Ω takes a current of 5A. Calculate the heat developed in 30 s.

Ans. It is given that resistance of electric iron R = 20 Ω, current drawn by iron I = 5A and time t = 30 s.

$\therefore$ Heat generated H = $I^2Rt = (5)^2 \times 20 \times 30$ = 15000 J.

Q22. What determines the rate at which energy is delivered by a current?

Ans. Electric power determines the rate at which energy is delivered by a current?

Q23. An electric motor takes 5 A from a 220 V line. Determine the power of the motor and the energy consumed in 2 h.

Ans. It is given that current drawn by electric motor I = 5A, the line voltage V = 220 V and time t = 2 h.

$\therefore$ Power of the motor P = VI = 220 V × 5A = 1100 W

and the energy consumed E = Pt = 1100 W × 2h = 2200 W h or 2.2 kW h.

Q24. A piece of wire of resistance R is cut in to five equal parts. These parts are then connected in parallel. If the equivalent

resistance of this combination is R′ , then the ratio $\frac{R}{R'}$ is :

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

Ans. (d) 25.

[**Hint:** When a wire of resistance R is cut in five equal parts, resistance of each part $R_1 = \frac{R}{5}\Omega$. Now, all these pieces are

joined in parallel hence

$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_1} + ...times = \frac{5}{R_1} or R' = \frac{R_1}{5} = \frac{1}{5} \times \frac{R}{5} = \frac{R}{25}$$

$$\therefore \frac{R}{R'} = \frac{R}{(R/25)} = 25.]$$

Q25. Which of the following terms does not represent electrical power in a circuit?

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

Ans. (b) IR^2.

[**Hint:** Electrical power P = VI = $I^2R = \frac{V^2}{R}$ However, IR^2 does not represent the power.]

Q26. 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) 25 W

[**Hint:** As rating of bulb is 220 V, 100 W, hence P = VI = $\frac{V^2}{R}$.

$\therefore$ Resistance of bulb filament R = $\frac{V^2}{P} = \frac{220 \times 220}{100} = 484\Omega$

When the bulb is operated at a voltage V′ = 110 V, the power consumed is

$$P' \frac{V'^2}{R} = \frac{110 \times 110}{484} = 25W.]$$

Q27. 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

Ans. (c) 1 : 4

[**Hint:** As two conducting wires have equal lengths, equal diameters (i.e, equal cross – section area) and are of the same material, their resistances are same. Thus, $R_1 = R_2 =$ R (say). In series arrangement, $R_S = R_1 + R_2 = 2R$ and in parallel arrangement $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$ or $R_P = \frac{R}{2}$

When joined across a voltage source in series heat produced in time t

$H_S = \frac{V^2}{R_S}.t = \frac{V^2 t}{(2R)} = \frac{V^2 t}{2R}.$

and in parallel arrangement

$$H_P = \frac{V^2}{R_P}.t = \frac{V^2 t}{\left(\frac{R}{2}\right)} = \frac{2V^2 t}{R}$$

$\therefore \frac{H_S}{H_P} = \frac{\frac{V^2 t}{2R}}{\frac{2V^2 t}{R}} = \frac{1}{4}$ or $H_S : H_P = 1 : 4$]

Q28. However is a voltmeter connected in the circuit to measure the potential difference between two points?

Ans. A voltmeter is always connected in the circuit across the points, between which the potential difference is to be measured.

Q29. 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?

Ans. It is given that diameter of wire D = 0.5 mm = 5×10^{-4} m, resistivity $\rho = 1.6 \times 10^{-8}\Omega$ m and resistance R = 10 Ω.

As $R = \frac{\rho l}{A} = \frac{4\rho l}{\pi D^2}$, hence $l = \frac{\pi D^2 R}{4\rho}$

∴ Length of wire $l = \frac{22 \times (5\times10^{-4})^2 \times 10}{7 \times 4 \times 1.6 \times 10^{-8}} = 122.5m$

If the diameter of wire is doubled D′ = 2D and hence, A′= $\frac{\pi D'^2}{4} = \frac{\pi}{4}(2D^2) = 4 \times \frac{\pi D^2}{4} = 4A.$

For a given length and given material resistance is inversely proportional to the cross- section area of the wire i.e., $R \alpha \frac{1}{A}$.

∴ $\frac{R'}{R} = \frac{A}{A'}$ or $R' = \frac{RA}{A'} = \frac{R'A}{4A} = \frac{R}{4} = \frac{10}{4} = 2.5\Omega$

Q30. 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. From the given data the I-V graph has been plotted, which is a straight line as shown in fig.

To find resistance of the given resistor we take two points A and B on the graph, then

Resistance of resistor $R = \frac{V_A - V_B}{I_A - I_B}$.

$= \frac{12V - 6V}{3.5A - 1.75A} = \frac{6V}{1.75A} = 3.4\Omega$

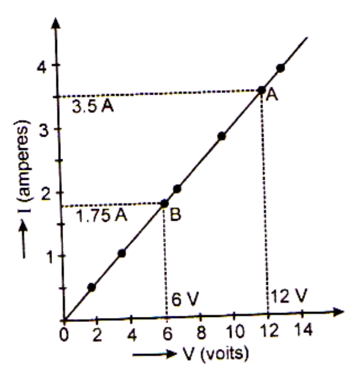

Fig. 12.04

Q31. 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. Given that voltage of battery V = 12 V

Circuit current I =2.5 mA = 2.5×10^{-3} A

$\therefore$ Value of resistance R = $\frac{V}{I}=\frac{12}{2.5\times10^{3}}$ = 4800 Ω.

Q32. 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?

Ans. Here potential difference V = 9 V

Resistance joined in series are R_1 = 0.2Ω, R_2 = 0.3Ω, R_3 = 0.4Ω, R_4 = 0.5Ω and R_5 = 12Ω

$\therefore$ Total series resistance $R_S = R_1 + R_2 + R_3 + R_4 + R_5$

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

$\therefore$ Current in the circuit I = $\frac{V}{R_S}=\frac{9V}{13.4\Omega}=0.67A.$

In a series circuit same current flows through all the resistance, hence current o f0.67 A will flow through 12 Ω resistor.

Q33. How many 176Ω resistors (in parallel) are required to carry 5A on a 220 V line?

Ans. Let n resistors of 176Ω are joined in parallel. Then their combined resistance R_P is given by

$\frac{1}{R_P}=\frac{1}{176}+\frac{1}{176}......$ n times = $\frac{n}{176}$ or R_P = $\frac{176}{n}\Omega$

It is given that V = 220 V and I = 5 A.

$\therefore$ $R_P = \frac{V}{I}$ or $\frac{176}{n}=\frac{220}{5}=44$

$\Rightarrow$ $n=\frac{176}{44}=4.$

Q34. Show how you would connect three resistors, each of resistors 6Ω, so the combination has a resistance of (i) 9Ω (ii) 4Ω.

Ans. It is given here that $R_1 = R_2 = R_3 = 6\Omega$

(i) To get a net resistance of 9Ω we join three resistance as shown in fig. (a). Here resistance of parallel combination of two 6Ω resistors is

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

$\therefore$ Net resistance = R′ + 6 = 3 + 6 = 9Ω

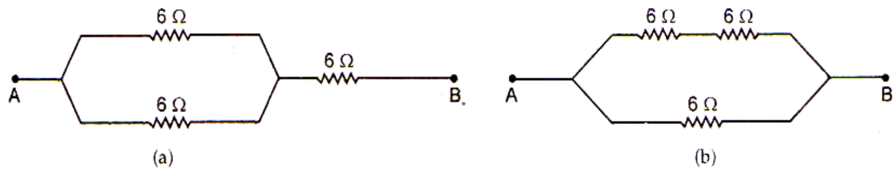

Fig. 12.05

$= 12\Omega$

(ii) When we connect two resistors in series having a combined resistance $R_0 = 6 + 6 = 12\Omega$ in parallel with the third

resistance of 6Ω fig. (b), the net resistance will be

$$\frac{1}{R} = \frac{1}{12} + \frac{1}{6} = \frac{1+2}{12} = \frac{3}{12} = \frac{1}{4} \Rightarrow R = 4\Omega$$

Q35. 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 5A?

Ans. As each bulb is rated as 10 W, 220 V, it draws a current

$$I = \frac{P}{V} = \frac{10W}{220V} = \frac{1}{22}A.$$

As the maximum allowable current is I_{max} = 5A and all lamps are connected in parallel, hence maximum number of bulbs

joined in parallel with each other

$$n = \frac{I_{max}}{I} = \frac{5A}{\frac{1}{22}A} = 5 \times 22 = 110.$$

Q36. 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?

Ans. It is given that potential difference V = 220 V.

Resistance of coil A (R_A) = Resistance of coil B (R_B) = 24 Ω

(i) When either coil A or coil B is used separately the current

$$I = \frac{V}{R_A} = \frac{V}{R_B} = \frac{220V}{24\Omega} = 9.2A$$

(ii) When the two coils are used in series, total resistance $R_S = R_A + R_B = 24 + 24 = 48\ \Omega$

∴ Current flowing $I = \frac{V}{R_S} = \frac{220V}{48\Omega} = 4.6A$

(iii) When the two coils are used in parallel, total resistance R_P is given by

$$\frac{1}{R_P} = \frac{1}{R_A} + \frac{1}{R_B} = \frac{1}{24} + \frac{1}{24} = \frac{1}{24} = \frac{1}{12}$$

$\Rightarrow$ R_P = 12Ω

$\therefore$ Current flowing $I = \frac{V}{R_P} = \frac{220V}{12\Omega} = 18.3A.$

Q37. 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 2Ω resistors.

Ans. (i) When a 2 Ω resistor is joined to a 6 V battery in series with 1 Ω and 2Ω resistors, total resistance of the combination

$$R_S = 2 + 1 + 2 = 5\Omega$$

$\therefore$ Current in the circuit I_1 = $\frac{6V}{5\Omega} = 1.2\Omega$

$\therefore$ Power used in the 2Ω resistor P_1 = $I_1^2 R$ = $(1.2)^2 \times 2$ = 2.88 W.

(ii) When 2 Ω resistor is joined to a 4 V battery in parallel with 12Ω and 2 Ω resistor, current flowing in 2Ω resistor is

independent of the other resistors.

$\therefore$ Current flowing through 2 Ω resistor I_2 = $\frac{4V}{2\Omega} = 2A$

$\therefore$ Power used in the 2 Ω resistor P_2 = $I_2^2 R$ = $(2)^2 \times 2$ = 8 W

$\therefore$ $$\frac{P_1}{P_2} = \frac{2.88W}{8W} = 0.36:1.$$

Q38. 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?

Ans.

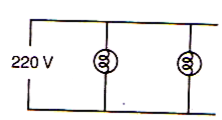

Fig. 12.06

Current drawn by 1st lamp rated 100 W at 220 V

$$I_1 = \frac{P_1}{V} = \frac{100}{200} = \frac{5}{11}A$$

and current drawn by 2nd lamp rated 60 W at 220 V

$$I_2 = \frac{P_2}{V} = \frac{60}{220} = \frac{3}{11} A$$

In parallel arrangements the total current = $I_1 + I_2 = \frac{5}{11} + \frac{3}{11} = \frac{8}{11} A.$

Q39. Which uses more energy, a 250 W TV set in 1 hour, or a 1200 W toaster in 10 minute?

Ans. Energy used by a TV set of power P_1 = 250 W in time t_1 = 1 h

$$E_1 = P_1 t_1 = 250 \text{ W} \times 1\text{h} = 250 \text{ Wh}$$

and energy used by a toaster of power P_2 = 1200 W in time t_2 = 10 min = $\frac{10}{60} h = \frac{1}{6} h$

$$E_2 = P_2 t_2 = 1200 \text{ W} \times \frac{1}{6} h = 200 Wh$$

Thus, it is evident that TV set has used more energy.

Q40. An electric heater of resistance 8Ω draws 15 A from the service mains for 2 hours. Calculate the rate at which heat is
developed in the heater.

Ans. Given that resistance of electric heater R = 8Ω
Current drawn by heater I = 15 A

∴ Rate at which heat is developed in the heater = $\frac{H}{t} = \frac{I^2 Rt}{t} = I^2 R$

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

Q41. 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) For filament of electric lamp we require a strong metal with high melting point. Tungsten is used exclusively for
filament of electric lamps because its melting point is extremely high (3380 ^{o}C).

(b) Conductors of electric heating devices are made of an alloy rather than a pure metal due to the following reasons:

(i) Resistivity of an alloy is generally higher than that of pure metals, hence for a given resistance we need a conductor
of less length.

(ii) At high temperatures, an alloy does not oxidize (burn) readily. Hence, heating element prepared from an alloy has
longer life.

(c) Series arrangement is not used for domestic circuits due to following reasons:

(i) In series arrangement is not same current will flow through all the appliances, which is not required.

(ii) Total resistance of domestic circuit will be sum of the resistances of all appliances and hence current drawn by the
circuit will be less.

(iii) We cannot use independent on/off switches with individual appliances.

(iv) All appliances are to be used simultaneously even if we not need them .

(d) Resistance (R) of a wire is inversely proportional to its cross-section area (A). Thus: $R\alpha\frac{1}{A}$

(e) Copper and aluminium wires are usually employed for electricity transmission because these are extremely good
conductors having a low value of resistivity. Moreover, these are ductile and can be drawn in the form of fine wires.