Solution

ELECTRICITY NUMERICAL

Class 10 - Science

Section A

1. We know that, $V=\frac{W}{Q}$
   Therefore, the amount of work done in moving 1.5 C charge across a p.d. of 4 V is,
   W = VQ
   = 4 $\times$ 1.5 J
   = 6 J
2. Equivalent resistance $=R_1+R_2=1\Omega+2\Omega=3\Omega$
   $I=\frac{\mathrm{V}^7}{R}$
   $=\frac{6\text{ V}}{1\Omega+2\Omega}=\frac{6\text{ V}}{3\Omega}=2\text{ A}$
   Electric power, P = I^2R
   $=(2\text{ A})^2\times 2\Omega=4\times 2\text{ W}=8\text{ W}$
3. Here, l = 150 cm; a = 0.015 cm^2; R = 3.0 Ω
   Specific resistance, $\rho=\frac{\mathrm{R}a}{l}$
   $=\frac{3.0\times 0.015}{150}$
   = 0.0003 Ωcm
4. P = VI
   = 220V $\times$ 0.50 A
   = 110 J/s
   = 110 W
   The power of the bulb is 110W.
5. We know that, $I=\frac{ne}{t}$
   $\Rightarrow n=\frac{It}{e}$
   Here I = 1 A, t = 1 s and e = 1.6 $\times$ 10^{-19} C
   $\therefore$ Number of electrons, n = $\frac{\mathrm{I}t}{e}$
   $=\frac{1\times 1}{1.6\times 10^{-19}}$
   = 6.25 $\times$ 10^{18}
6. While glowing, I = 450 mA = 0.45 A, V = 6 volt
   Using Ohm's law, Resistance of bulb, $\mathrm{R}=\frac{\mathrm{V}}{\mathrm{I}}=\frac{6}{0.45}=13.33\Omega$
   The reason for the difference in resistance of bulb when cold (R = 2.5 Ω) and while glowing (R = 13.33 Ω), is that the resistance of filament of bulb increases with the increase in temperature.
7. Here, I = 5.0 A, R = 44 Ω, V = ?
   Using Ohm's law, V = IR
   = 5.0 $\times$ 44 = 220V
8. Power = 3kw = 3000 W
   Voltage = 220 V
   Current = 10 A
   Formula
   P = I $\times$ V
   I = $\frac{3000}{220}$
   = 13.636 = 13.64 A
   Here, the current 13.64 A leads the domestic electric current 10 A which causes overloading and potential dafety issues. So, use a circuit with higher current rate and ensure the aplliances maych the circuit's capacity.
9. The total energy consumed by the refrigerator in 30 days would be
   400 w $\times$ 8.0 hour/day $\times$ 30 days = 96000 W h
   = 96 kWh

Thus the cost of energy to operate the refrigerator for 30 days is

96 kW h × ₹ 3.00 per kWh = ₹ 288.00

10. We are given, I = 0.5 A; t = 10 min = 600 s.

we have,

Q = I × t

= 0.5 A × 600 s

= 300 C

Hence, the amount of electric charge that flows through the circuit is 300 C

Section B

11. a. X_1 = 3 Ω; X_2 = 3 Ω

$\frac{1}{x_2} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$

Total resistance R = X_1 + X_2 = 3 Ω + 3 Ω = 6 Ω

b. Current through ammeter A, $I = \frac{V}{R} = \frac{6V}{6\Omega} = 1 \text{ A}$

c. Potential difference across 3 Ω = 1A × 3 Ω = 3 V

Potential difference across $6\Omega = \frac{1}{2}\text{ A} \times 6\Omega$ = 3 V

12. For first wire

$R_1 = \rho\frac{l}{A} = 4\Omega$

Now for the second wire

$R_2 = \rho\frac{l/2}{2A} = \frac{1}{4}\rho\frac{l}{A}$

$R_2 = \frac{1}{4}R_1$

$R_2 = 1\Omega$

The resistance of the new wire is 1Ω

13. (i) When a 2Ω resistor is joined to a 6 V battery in series with 1Ω and 2Ω resistors. Total resistance (R_s) = 2 + 1 + 2 = 5Ω.

∴ Current (I_1) = 6V/5Ω = 1.2 A

∴Power used in 2 Ωresistor,P_1 = I_1^2R =$(1.2)^{2}$× 2= 2.88 W

(ii) When 2Ω resistor is joined to a 4 V battery in parallel with 12Ω resistor and 2Ω resistors, the current flowing in 2Ω is independent of the other resistors.

∴ Current flowing through 2Ω resistor,I_2= 4 V/ 2Ω = 2 A

Power used in 2Ω resistor,P_2 = I_2^2R =$(2)^2$× 2= 8 W

∴ The required ratio,P_1/P_2 = 2.88/8 = 0.36 : 1

14. **Case I:** R = 5Ω

Let the area of cross-section be ‘a' and length be 'l'.

We know that, R = $\text{P} \cdot \frac{1}{a}$

Where ρ is the specific resistance of the wire.

$\therefore 5 = \rho\frac{l}{a}$ ...(i)

Case II: R_1 = ?

Here, length = 31, area of cross-section = 4a

$\therefore \text{R}_1 = \rho\frac{3l}{4a}$ ...(ii)

Dividing equation (ii) by (i), we get

$\frac{\text{R}_1}{5} = \frac{\rho\cdot 3l}{4a} \times \frac{a}{\rho\cdot l}$

$\therefore R_1 = 5 \times \frac{3}{4} = 3.75\Omega$

15. Let current through each bulb be I.

P = VI, 10 = 220 I

I = $\frac{1}{22}$ A

Let n such bulbs be connected in series.

Current through n bulbs = 5A

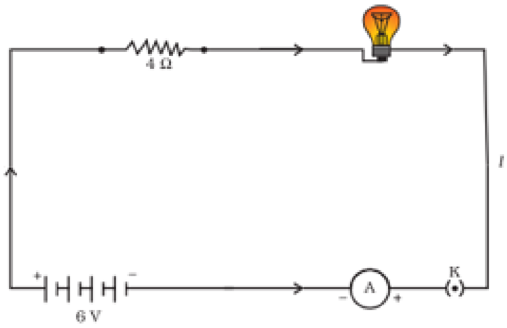
n (current in 1 bult) = 5

n$\frac{1}{22}$ = 5

n = 110

110 such bulbs can be lighted within allowable limit of 5A.

16. Figure: An electric lamp connected in series with a resistor of 4 Ω to a 6 V battery.



a. The resistance of electric lamp, R1 = 20 Ω,

The resistance of the conductor connected in series, R2 = 4 Ω.

Then the total resistance in the circuit R =R1 + R2 Rs = 20 Ω + 4 Ω = 24 Ω.

The total potential difference across the two terminals of the battery V = 6 V.

b. Now by Ohm's law, the current through the circuit is given by I = V/Rs = 6 V/24 Ω = 0.25 A.

17. i. To get the smallest resistance, all the 5Ω resistors must be connected in parallel.

Smallest resistance = $\frac{5}{50}$ = 0.1Ω

ii. To get the largest resistance, the 5 Ω resistors must be connected in series. Largest resistance = 5 $\times$ 50 = 250Ω.

18. Given: R_1 = 10 Ω; R_2 = 20 Ω; R_3 = 30 Ω

According to Ohm's law,

V = IR

Given V = 12 V

a. Current through resistor R_1:

$$I_1 = \frac{V}{R_1} = \frac{12}{10} = 1.2 \text{ A}$$

Current through resistor R_2:

$$I_2 = \frac{V}{R_2} = \frac{12}{20} = 0.6 \text{ A}$$

Current through resistor R_3:

$$I_3 = \frac{V}{R_3} = \frac{12}{30} = 0.4 \text{ A}$$

b. Total circuit resistance, R

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$
$$\frac{1}{R} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30}$$
$$\frac{1}{R} = \frac{11}{60}$$
$$R = \frac{60}{11} = 5.45\Omega$$

c. The total current in the circuit is I = $I_1 + I_2 + I_3$

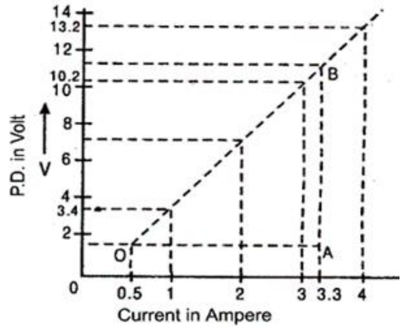
= 1.2 + 0.6 + 0.4 = 2.2 A

19. Graph between I and V is as shown in figure. Since graph is almost a straight line, the slope of line between any two points give the resistance. Slope of say OB is:

R = $\frac{AB}{OA} = \frac{BC-AC}{DA-OD}$

$$\frac{AB}{OA} = \frac{12-1.6}{3.3-0.5} = \frac{10.4}{2.8} = \frac{104}{28}$$

$R = 3.7O$



20. Energy consumed (in kWh) = power (in kW) × time (h) = 2.2 kW × 3h = 6.6 kWh

Power = 2.2 kW = 2.2 × 1,000 W = 2,200 W

But Power = Voltage × Current

2,200 = 220 × I

$I = \frac{2200}{220} = 10\ A$

Section C

21. i. It is given that potential difference (V) = 220 V.

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

When either coil A or B is used separately, the current (I) $= \frac{V}{R} = \frac{220\text{ V}}{24\Omega}$ = 9.2 A

When two coils are used in series, total resistance, $R_S = R_A + R_B$

$= R_A + R_B = 24 + 24 = 48\Omega$

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

When the two coils are joined in parallel, total resistance (R_p) $= \frac{1}{24} + \frac{1}{24} = \frac{2}{24}$

ii. I = 10 A, V = 220 V

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

$= \frac{220}{10}$

= 22 Ω

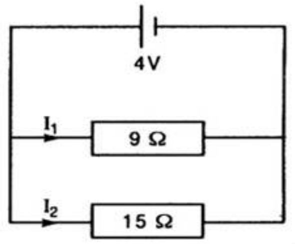
22. Resistor of 6Ω and 3Ωare in series therefore, combined resistance of these two is

$R_1 = 6 + 3 = 9\Omega$

Again 12W and 3W are in series. The combined resistance of these two is

$R_2 = 12 + 3 = 15\Omega$

Now 9Ω and 15Ω are in parallel to each other. Fig. (a) is the equivalent circuit.



Therefore, the combined resistance of full circuit is

$\frac{1}{R} = \frac{1}{9} + \frac{1}{5} = \frac{5+3}{45} = \frac{8}{45}\ or\ R = \frac{45}{8} = 5.6\Omega \ldots\ldots..(i)$

V = 4 volt

∴ P.D. across 9 Ω as well as across 15 Ω is 4 V

Current along 9Ω resistor (and hence through 6Ω resistor)

$I_1 = \frac{V}{R_1} = \frac{4}{9}\ A = 0.44\ A \ldots\ldots.(ii)$

Current along 15Ω resistor (and hence through 12Ω resistor)

$I_2 = \frac{V}{R_2} = \frac{4}{15}\ A$

Potential difference across 12Ω wire = $12I_2$

$= 12 \times \frac{4}{15} = \frac{16}{5} = 3.2V \ldots\ldots\ldots.\ (iii)$

23. Current in the circuit = 0.25 A

Current through 4Ω wire = 0.25 A

a. P.D. across 4Ω = 0.25 × 4 = 1V
b. P.D. across 3Ω = 0.25 × 3 = 0.75 V

24. i. Here I = 2.5 mA = 2.5×10^{-3}A; V = 12 volt; R = ?

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

R = $\frac{12}{2.5\times10^{-3}} = \frac{12}{25\times10^{-4}}\ \frac{120000}{25} = 4800\Omega$

ii. According to the question, H = 320 J, t = 10s, R = 2Ω, I = ?

We know that, H = I^2Rt

$\Rightarrow I = \sqrt{\frac{H}{Rt}}$

$= \sqrt{\frac{320}{2 \times 10}}$

= 4A

Thus, the amount of current flowing through the resistor is 4 A.

25. i. Combined resistance of 100Ω, 50Ω and 500Ω in parallel

i.e. R_p is given by $\frac{1}{RP} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500} = \frac{5+10+1}{500} = \frac{125}{4} = 31.25$

Resistance of electric iron = 31.25Ω

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

ii. Energy consumed $E_1 = P_1 t_1$ = 250 W $\times$ 1h = 250$\frac{J}{S}$ $\times$ 3600s

E_1 = 900000J

$E_2 = P_2 t_2$ = 12000W $\times$ 10 min

E_2 = 1200 $\frac{J}{S}$ $\times$ 600s

E_2 = 720000J

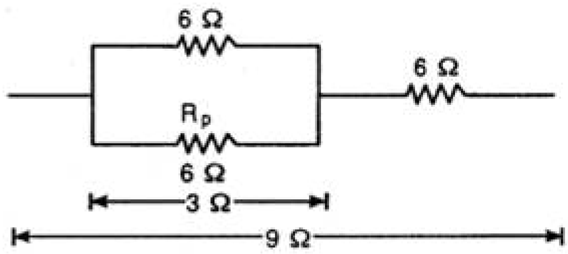
$\therefore$ 250Ω TV set consumes more energy.

26. a. When two resistors each of 6Ω are connected in parallel give Rp:

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

$R_p = 3\Omega$

When this combination is connected in series with third resistor of 6Ω, it gives a total of 6 + 3 = 9Ω



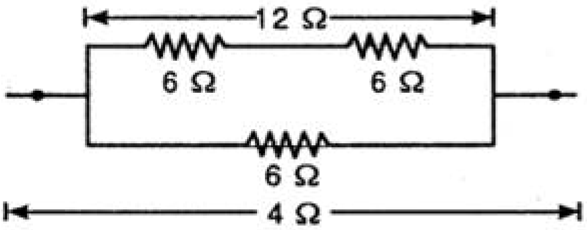
Connected in parallel

b. When two resistors each of 6Ω are connected in series it gives rise to 6 + 6 = 12Ω

This 12Ω in parallel with 6Ω given R'_p

$\frac{1}{R'p} = \frac{1}{12} + \frac{1}{6} = \frac{2+1}{12} = \frac{3}{12} = \frac{1}{4}$

$R'_p = 4\Omega$



Connected in series

27. a. **Statement of Joule's law**

Joule’s law of heating states that, when a current 'i' passes through a conductor of resistance ‘R’ for time ‘t’ then the heat developed in the conductor is equal to the product of the square of the current, the resistance and time.

Mathematical explanation

Let H be the heat produced when a current 'i' passes through a conductor of resistance ‘r’ for time ‘t’ then

i. $H \propto i^2$

ii. $H \propto R$

iii. $H \propto t$

$\therefore H \propto i^2 Rt$

$\Rightarrow H = i^2 Rt$

b. Here V = 6V and R = 5Ω

The current flowing through the resistor I = $\frac{V}{R} = \frac{6V}{5\Omega}$ = 1.2 A

$\therefore H = I^2 RT = (1.2)^2 \times 5 \times 10$ = 72J

28. $P_1 = \frac{1000W}{1000}$ = 1kW

t_1 = 5 h

$P_2 = \frac{400W}{1000}$ = 0.4 kW

t_2 = 10 h

No. of days n = 30

Energy consumed by heater:

$E_1 = P_1 \times t_1 \times n$ = 1 kW × 5 h × 30 = 150 kWh

Energy consumed by refrigerator:

$E_2 = P_2 \times t_2 \times n$ = 0.4 kW × 10 h × 30 = 120 kWh

Total energy = (150 + 120) kWh = 270 kWh

We know that 1kWh = 1unit, so

270 kWh = 270 units

Cost of 1 unit is Rs. 6.00

Total cost = 270 × 6 = Rs. 1620

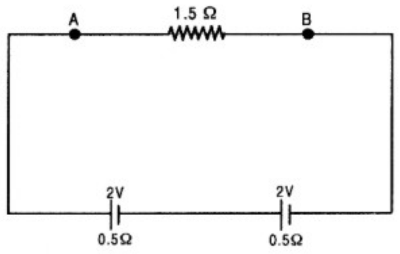
29. ResisOKtance, 1Ω and 2Ω are in series and combined resistance i.e. 1 + 2 = 3Ω in parallel with 3Ω.

Hence total resistance of the combination is $\frac{1}{R} = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}\ or\ R = \frac{3}{2} = 1.5\Omega$

i. Total resistance of the circuit = R + r = 1.5 + 0.5 = 2Ω
ii. Total current through ammeter = $\frac{E}{R+r} = \frac{2}{2} = 1A$
iii. In second case total e.m.f.= 2 + 2 = 4V

Total resistance = 1.5 + 0.5 + 0.5 = 2.5Ω

Current through circuit in second case = $\frac{4}{2.5} = \frac{40}{25} = \frac{8}{5} = 1.6\ A$



30. Here R_1 = 2Ω; R_2 = 6Ω

Combined resistance R_s when connected in series is

$R_s = R_1 + R_2$ = 2 + 6 = 8 ohm

When connected in parallel, the combined resistance R_p is

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2} + \frac{1}{6} = \frac{3+1}{6} = \frac{4}{6} = \frac{2}{3}$

R_p = 1.5 Ohm

Section D

31. a. Relation between resistance and electrical resistivity of the material of conductor in the shape of a cylinder of length and area of cross-section is

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

Here, R = resistance, ρ = electrical resistivity of material, l = length and A = area of cross-section

Thus, electrical resistivity, $\rho = \frac{RA}{l}$ .....(i)

Putting the units of R, A and l in equation (i), we get,

$\rho = \frac{\Omega \times m^2}{m}$

$\rho = \Omega \times m$

Thus, SI unit of resistivity (ρ) is Ω m

b. Given that,

Resistance, R = 100 ohm, Length, l = 5 m, Area A = 3×10^{-7} m^2

The resistivity of the metal is,

$\rho = \frac{RA}{l}$

$\rho = \frac{100 \times 3 \times 10^{-7}}{5}$

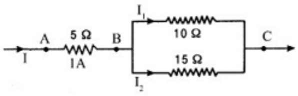
ρ = 6 × 10^{-6} Ω m

Hence, the resistivity of the metal is ρ = 6 × 10^{-6} Ω m

32. Let us first find the total resistance. Now resistance of 10 Ω and 15 Ω are in parallel.

If R_p is the effective resistance between B and C, then

$\frac{1}{R_p} = \frac{1}{10} + \frac{1}{15} = \frac{3+2}{30} = \frac{5}{30} Or\ R_p$ = 6 Ω



Again AB and BC are in series.

Therefore, the total resistance = Resistance between A and B plus resistance between B and C.

i.e. Total resistance = 5 Ω + 6 Ω = 11 Ω

Potential difference between A and B = IR = 1 × 5 = 5 V

Potential difference between B and C = 1 × 6 = 6 V

Potential difference between A and C = 1 × 11 = 11 V

Current through A and B = 1 A

This current divides into two parts, one part I_1 passing through 10 Ω and other part I_2 passing through 15 Ω each producing a P.D. of 6V (between B and C)

∴ I_1 (10) = 6 or $I_1 = \frac{6}{10}$ = 0.6 A and I_2(15) = 6 or $I_2 = \frac{6}{15}$ = 0.4 A

33. i. P = 40 W

V = 220 V

P = VI

I = $\frac{P}{V} = \frac{40W}{220\text{ V}}$

= 0.18 A

Hence the current drawn by the bulb is 0.18 A

ii. R = $\frac{V^2}{R}$

= $\frac{220 \times 220}{40}$

= 1210 Ω

iii. P = 25 W

V = 220 V

P = VI

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

= $\frac{25}{220}$ = 0.113 A

iv. R = $\frac{V^2}{R}$

= $\frac{220 \times 220}{25}$

= 1936 Ω

v. Yes there is a change in current and resistance

34. (a) (i) Resistivity - Since the Resistivity is a property of a substance, hence it remains the same for both the wires.

(ii) Resistance - As both the wires are of different cross sectional areas, so both wires are considered as different objects and will have different resistances.

(b) (i) ∵ R = $\frac{\rho L}{A}$

For wire A $(R_1) = \frac{\rho l}{A_1}$

For wire B $(R_2) = \frac{\rho l}{A_2}$

$\frac{R_2}{R_1} = \frac{A_1}{A_2}$ (∵Resistance is inversely proportional to the area of cross section of the conductor.)

$\because R_1 = 4R_2$

$\frac{A_1}{A_2} = 1:4$

(ii) $\left(\frac{r_1}{r_2}\right)^2 = \frac{1}{4}$ (∵Ratio of the radii of wire is square root the ratio of the area)

$r_1 : r_2 = 1:2$

35. i. Electric power : Rate at which electrical energy is dissipated or consumed / Rate of supplying energy to maintain the flow of current through a circuit.

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

ii. a. (1 unit = 1kWh)

Power, $P = \frac{\text{Electrical energy consumed}}{\text{Time}}$

$= \frac{11\text{kWh}}{5\text{ h}}$ = 2.2kW or 2200 W

b. $I = \frac{P}{V}$

$= \frac{2200}{220} = 10\text{ A}$

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

$\frac{(220)^2}{2200} = 22\Omega$

36. i. When connected in series R_S = 3 + 3 + 3 = 9 ohm

ii. When connected in parallel, $\frac{1}{R_p} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{1+1+1}{3} = \frac{3}{3} = 1$ or R_p = 1 ohm

iii. Two are connected in parallel and third in series with combination.

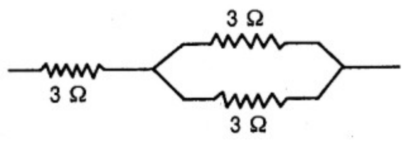
Combined resistance of two resistances of 3 ohm in parallel is

$\frac{1}{R_p} = \frac{1}{3} + \frac{1}{3} = \frac{1+1}{3} = \frac{2}{3}$

or $R_p = \frac{3}{2}$ = 1.5 Ω

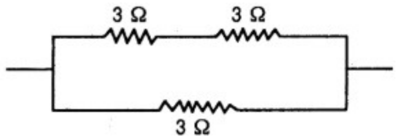
This resistance of 1.5Ω is in series with resistance of 3Ω is

R_{total} = 1.5 + 3 = 4.5Ω



Hence, connected two in parallel and third in series with the combination to get 4.5Ω

Another possible combination is two resistors in series and third in parallel to the combination is in fig.



Two resistors of 3 Ω in series becomes 3 + 3 = 6Ω

This resistor of 6 Ω in parallel with a resistor of 3Ω.

The total resistance in this case is

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

or R' total= 2Ω

Thus two resistors of 3Ω each in series connected to a third resistor of 3Ω in parallel to combination gives 2Ω resistance.

37. i. We know that

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

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

Resistance of 1st lamp,

$R_1 = \frac{V^2}{P} = \frac{220\times220}{100}$

$=484\Omega$

Resistance of 2nd lamp,

$R_2 = \frac{220\times220}{10}$

= 4840 Ω

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

$\frac{1}{R} = \frac{1}{R_1+}\frac{1}{R_2} = \frac{1}{484} + \frac{3}{4840}$

R = 440 Ω

By Ohm's Law,current drawn from the mains:

V = IR

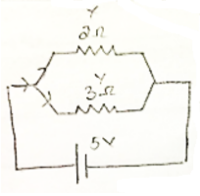
220 = I $\times$ 440

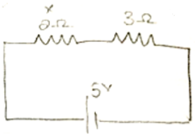
$I = \frac{220}{440}$

= 0.5 A

∴ The current drawn from the mains is 0.5 A

ii. a.





b. Voltage across the 3Ω resistor.

According to ohm's law, V ∝ I

V = IR

I = $\frac{V}{R}$ = $\frac{3}{5}$ A

V = IR

= $\frac{3}{5} \times 5$ = 3 V

38. i. a. A fuse is a safety device used in domestic electric circuits to prevent damages from short circuiting or overloading.

b. An alloy / metal of appropriate (lower) melting point / aluminium / copper / iron / lead etc.

c. In series

ii. 1A, 2A, 3A, 5A, 10A

iii. a. To protect the circuits and appliances by stopping the flow of unduly high electric current.

b. If current larger than the specified / rated value flows through the circuit, the temperature of the fuse wire increases, this melts the fuse wire and breaks the circuit.

iv. Power = 1 kW; V = 220 V; I = ?

Formula used

P = VI

⇒ I = $\frac{P}{V}$ = $\frac{1,000}{220}$ = 4.54 A

Rating of fuse will be 5A and above.

39. a. Power is the rate of doing work. S.I. unit of power = watt.

1 watt = Commercial unit of power kWh.

1 kWh = 3.6×10^6 Joules.

b. Power consumed by :

2 bulbs = 2×50 = 100W

Total power consumed per day = 6×100W = 600W = 0.6KWhr

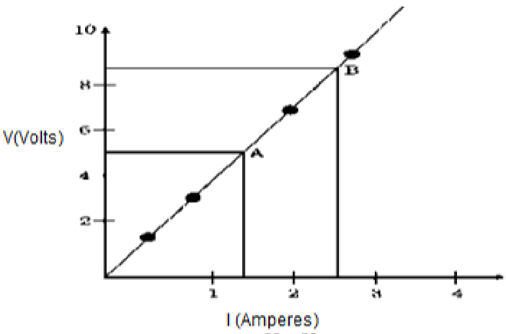
Power of geyser = 1KW

Total power consumed per day = 1×1 = 1kwhr

Total power consumed in 30 days = 1 + 0.6×30 = 48 kwhr

Cost of electricity = $P \times t$ = 48×8 = ₹ 384

40. i.



ii. Resistance of resistor $= \frac{V_2 - V_1}{I_2 - I_1} = \frac{8\cdot3 - 5\cdot2}{2\cdot5 - 1\cdot5} = 3\cdot1\Omega$

iii. The given resistor obeys Ohm’s law./Resistance remains constant.

iv. Because when the value of V = 0, the current I = 0.