10[TH] CBSE ELECTRICITY PROBLEMS QA

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

Answer : Given, charge, q = 1 C, potential, V = 6 V, W=?
As we know, W = q V = 1 × 6 = 6J
6J is given to each coulomb of charge passing through a 6V battery.

- An electric lamp of 100 Ω, a toaster of 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 the three appliances, and what is the current through it?

Answer : Let resistance of lamp, R_1 = 100 Ω
Resistance of toaster, R_2 = 50 Ω
Resistance of filter, R_3 = 500 Ω
Net resistance,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

[∵ R_2, R_2 and R_3 are connected in parallel]

$$\frac{1}{R} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500} = \frac{16}{500} \text{ or } R = \frac{500}{16} = 31.25\Omega$$

So, resistance of iron to take same current as much Current drawn by all the appliances should be 31.25 Ω . Current through circuit,

$$I = \frac{V}{R} = \frac{220}{31.25} = 7.04A$$

Thus, current through iron is 7.04 A.

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

Answer : (i) If 3 Ω and 6 Ω are connected in parallel, thus equivalent resistance of parallel combination

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

If this combination is connected in series with 2 Ω resistance, then total equivalent resistance
= 2Ω + 2Ω = 4 Ω
The resistor connections are as shown below:
(ii) Since, equivalent resistance is less than the least value of resistance (i.e. 2 Ω), it means that all three resistors are connected in parallel.

Equivalent resistance $= \frac{1}{\frac{1}{2}+\frac{1}{3}+\frac{1}{6}} = 1\Omega$

- What is (a) the highest, (b) the lowest total resistence. Which can be secured by combinations of four coils of resistance 4Ω, 8Ω, 12Ω, 24Ω ?

Answer : (a) Resistance is maximum when resistors are connected in series.
R_{max} = 4 + 8 + 12 + 24 = 48 Ω
(i) Resistance is minimum when resistors are connected in parallel.
$R_{min} = 1/\left[\frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}\right] = \frac{24}{12}\Omega = 2\Omega$

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

Answer : Given, Charge, q = 96000 C, Time, t = 1 h= 3600 s
Potential difference, V = 50 V
We know that,
Heat generated, H = VIt= $\frac{Vqt}{t}$ $\left[\because I = \frac{q}{t}\right]$
=Vq = 50 × 96000 = 4800000 J = 4800 kJ
4800 kJ is generated while transferring 96000 C of charge.

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

Answer : Given, Resistance, R = 20 Ω,
Current, I = 5 A, Time, t = 30 s
We know that,
Heat developed, H = I^2Rt
=$(5)^2$ × 20 ×30 = 5 ×5 × 20 × 30 = 15000 J = 15 kJ
15 kJ heat is developed in 30 s.

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

Answer : Given, I = 5 A, V = 220 V, t = 2h
∴ Power of motor,
P = VI = 220 ×5 = 1100 W = 1.1 kW
∴ Energy consumed = P t = 1.1 ×2 = 2.2 kWh
Thus, the power of the motor is 1.1 kW and energy consumed is 2.2 kWh.

- A battery of 9 V is connected in series with resistors of 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5Ω and 12 Ω, respectively. How much current would flow through the 12Ω resistors?

Answer : The circuit diagram for the given system of resistors can be drawn as below

∴ Total resistance, $R = R_1 + R_2 + R_3 + R_4 + R_5$

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

$= 13.4\ \Omega$

Current through all resistors in series is the same.

∴ Current through 12 Ω resistor = $\frac{V}{R}$

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

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

Answer : Given, V = 220 V, I = 5A

∴ Resistance of the wire, $R' = \frac{V}{I} = \frac{220}{5} = 44\Omega$

The net resistance 44 Ω is less than the individual resistance 176 Ω, so individual resistances are to be connected in parallel order.

In parallel connection, equivalent resistance

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

$$\therefore 44\Omega = \frac{176\Omega}{n} \quad or \quad n = \frac{176}{44} = 4 \quad resistors$$

- A copper wire has diameter 0.5 mm and resistivity of ρ = 1.6 x $10^{-8}\ \Omega m$. What will be the length of this wire to make its resistance 10 Ω? How much does the resistance change if diameter is doubled?

Answer : Given, radius of wire = diameter/ 2

$= \frac{0.5}{2} = 0.25 \text{ mm} = 0.25 \times 10^{-3} \text{ m.}$

$\rho = 1.6 \times 10^{-8}\ \Omega$-m and R = 10 Ω

(i) We know that, resistance,

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} \quad [\because A = \pi r^2]$$

$$or \quad l = \frac{R\pi r^2}{\rho} = \frac{10\times3.14\times0.25\times0.25\times10^{-6}}{1.6\times10^{-8}}$$

= 122.66 m

(ii) Resistance, $R \infty \frac{1}{d^2}$

If diameter is doubled, then resistance becomes one-fourth of its original value.

- 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.

Answer : Given, V = 12 V, I = 2.5 mA = 2.5×10^{-3} A, R = ?

$\therefore Resistance, R = \frac{V}{I}$ [by Ohm's law]

$\Rightarrow R = \frac{12}{2.5\times10^{-3}} = 4.8 \times 10^3 \Omega$

- Several electric bulbs designed to be used on a 220 V electric supply line are rated at 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?

Answer : Given, Potential difference, V = 220 V

Power, P = 10 W; Current, I = 5 A

∴ Resistance of bulb,

$R' = \frac{V^2}{P} = \frac{220\times220}{10} = 4840\Omega$

Since, bulbs are connected in parallel,

Equivalent resistance (R)

$= \frac{Individual \quad resistance(R')}{Number \quad of \quad bulbs \quad (n)}$

$\Rightarrow R = \frac{4840}{n}\Omega, V = IR$

$\Rightarrow 220 = \frac{5\times4840}{n}$

$\Rightarrow n = \frac{5\times4840}{220} = 110 \quad bulbs$

- 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?

Answer : Given, V = 220 V, $R_A = R_B = 24\ \Omega$

(i) Current in plates when used separately,

$I = \frac{V}{R_A} = \frac{V}{R_B} = \frac{220}{24} = 9.16A$

(i) Current in plates when connected in series. Equivalent resistance in series,

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

∴ Current flowing, $I = \frac{V}{R} = \frac{220}{48} = 4.58A$

(iii) Current in plates when connected in parallel. Equivalent resistance in parallel,

$R = \frac{R_A R_B}{R_A+R_B} = \frac{24\times24}{48} = 12 \quad \Omega$

∴ Current flowing, $I = \frac{V}{R} = \frac{220}{12} = 18.32$ = 18.32 A

- Compare the power used in the 2 Ω resistors in each of the followings 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.

Answer : (i) The circuit shown right has resistance connected in series combination:
Current in the circuit,
$I = \frac{V}{R_1+R_2} = \frac{6}{3} = 2A$
∴ Power used = $I^2R = 2^2 \times 2$
= 2 ×2 ×2 = 8W
(ii) The circuit is shown as right:
In parallel combination, potential across each resistor is same and equal to the potential applied to the circuit.
Potential across 2 Ω resistor,
V = 4 V
Power used, $\frac{V^2}{R} = \frac{4\times4}{2} = 8 \quad W$
Power used in both the cases is same.

- Two lamps, one rated at 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?

Answer : Given, potential, V = 220 V
Power, P_1 =100 W
Power, P_2 =60 W
$\therefore Current, I_1 = \frac{P_1}{V}$
$= \frac{100}{220} = 0.45A$
Current, $I_2 = \frac{P_2}{V} = \frac{60}{220} = 0.27A$
∴ Total current drawn,
$I = I_1 + I_2$
= 0.45 + 0.27
= 0.72 A

- Which uses more energy, a 250 W TV set in 1 h or a 1200 W toaster in 10 min?

Answer : Given, P_1 = 250 W, P_2 = 1200 W,
t_1 = 1h = 3600 s, t_2 = 10 min = 600 s
∴ Energy
$Q_1 = P_1t_1$ = 250 ×3600 = 900000 J = 900 kJ
and $Q_2 = P_2t_2$ = 1200 × 600 = 720000 J = 720 kJ
Thus, TV set uses more energy.

- 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.

Answer : Given, Resistance, R = 8 Ω , Current, J = 15 A
Time, t = 2 h = 7200 s
∴ Heat developed. $H = J^2Rr$
=15 ×15 × 8 × 7200 J
∴ Rate of heat developed.
$$P = \frac{H}{t} = \frac{15 \times 15 \times 8 \times 7200}{7200}$$
= 1800 W or 1800J/s
Thus, the rate at which heat is developed in the heater is 1800 joule per second.

- A current of 0.5 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.

Answer : We are given, I = 0.5 A; t = 10 min = 600 s.
From Eq we have
Q = It
= 0.5 A × 600 s
= 300 C

- How much work is done in moving a charge of 2 C across two points having a potential difference 12 V?

Answer : The amount of charge Q, that flows between two points at potential difference V (= 12 V) is 2 C. Thus, the amount of work W, done in moving the charge [from Eq. (V = W/Q)] is
W = VQ
= 12 V × 2 C
= 24 J

- (a) How much current will an electric bulb draw from a 220 V source, if the resistance of the bulb filament is 1200 Ω?
(b) How much current will an electric heater coil draw from a 220 V source, if the resistance of the heater coil is 100 Ω?

Answer : (a) We are given V = 220 V; R = 1200 Ω. From Eq , we have the current I = 220 V/1200 Ω = 0.18 A.
(b) We are given, V = 220 V, R = 100 Ω. From Eq. (R = V/I), we have the current I = 220 V/100 Ω = 2.2 A. Note the difference of current drawn by an electric bulb and electric heater from the same 220 V source!

- An electric bulb is connected to a 220 V generator. The current is 0.50 A. What is the power of the bulb?

  Answer : P = VI
  = 220V × 0.50 A
  = 110 J/s
  = 110 W

- An electric refrigerator rated 400 W operates 8 hour/day. What is the cost of the energy to operate it for 30 days at Rs 3.00 per kW h?

  Answer : The total energy consumed by the refrigerator in 30 days would be 400 W × 8.0 hour/day × 30 days = 96000 W h = 96 kW h
  Thus the cost of energy to operate the refrigerator for 30 days is 96 kW h × Rs 3.00 per kW h = Rs 288.00

- Out of 60 W and 40 W lamps, which one has a higher electrical resistance when in use?

Electric power, p = $\frac{V^2}{R}$, where R
V = Potential difference across the circuit
For 40 W bulb, 40 = $\frac{V^2}{R_{40}}$, where
R_{40} = Resistance offered by the 40 W bulb
For 60 W bulb, 60 = $\frac{V^2}{R_{60}}$, where
R_{40} = Resistance offered by the 60 W bulb
Therefore, R_{10} = $\frac{V^2}{40}$ and R_{60} = $\frac{V^2}{60}$ (as the voltage difference remains the same)
Therefore, $R_{40} > R_{60}$
So, the 40 W bulb has a higher electrical resistance when in use.

- An electric heater is used on 220 V supply and takes a current of 3.4 A. Calculate (i) its power and (ii) its power and (ii) its resistance when it is in use.

  Answer : (i) Power = Voltage Current
  = 220×3.4
  = 748 Watt
  (ii) Power = Voltage / Resistance
  P = V^2 / R
  R = V^2 / P=220^2 / 748 = 64.71 Ω

- An electric lamp is marked 100 W, 220 V. It i used for 5 hours daily. Calculate.
  (i) its reistance while glowing
  (ii) energy consumed in kWh per day

Answer : (i) Resistance of a glowing lamp is related to its power and voltage as

Power= $\frac{(voltage)^2}{Resistance}$

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

Therefore, R= $\frac{V^2}{P} = \frac{220^2}{100} = 484\Omega$

Therefore, the resistance of the bulb when glowing is 484Ω

(ii) Power=100 W=0.1 kW

Energy= Power x time

=0.1 kW x 5h

=0.5 kWh

0.5 kWh is the amount of energy is consumed by the bulb per day.

- A bulb is rated at 5.0 volt, 100 mA. Calculate its
  (i) power and
  (ii) resistance

Answer : Voltage (V) = 5.0 V

Current (I) = 100 mA = 0.1 A

(i) Power = VI = 5×0.1= 0.5W

(ii) Resistance = $\frac{V}{I} = \frac{5}{0.1} = 50\Omega$

- An electric iron has a rating of 750 W, 220 V. Calculate
  (i) current passing through it, and
  (ii) its resistance, when in use

Answer : (i) Electric power is related to voltage and electric current as:

Power= Voltage x Current

It is given that the rating of the electric iron is 750W, 220V.

Let the current passing through the bulb be I.

Therefore,

750=220 x I

I= $\frac{750}{220}$ =3.41A

Therefore, 3.41A current passes through the electric iron.

It is given that the rating of the electric bulb is 750W,220 V

Therefore, P= $\frac{V^2}{P} = \frac{220^2}{750}$ =64.53Ω when in use.

(ii) Electric power is related to voltage and resistance as:

$$\frac{(Voltage)^2}{Resistance}$$

That is,

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

$=64.53\Omega$

- Calculate the electric energy consumed by 120 W toaster in 20 minutes.

Answer : P = 120 W

t = 20 minutes E = P× t

E = ? = 120 × 20 × 60 = 120 × 1200

$E = 144 \times 10^3$ J

- A wire of resistance 10 ohm is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of the circle?

As the wire is bent in the form of a closed circle, it will be have like two resistors of 5Ω each, connected in parallel. Therefore, the equivalent resistance can be calculated as:

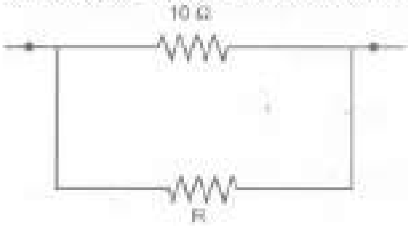
$$\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}$$

$$\frac{1}{R_{eq}}=\frac{1}{5}+\frac{1}{5}=\frac{1}{R_{eq}}=\frac{2}{5}$$

$$\frac{1}{R_{eq}}=\frac{5}{2}=2.5\Omega$$

The effective resistance between the two points at the ends of an diameter of the circle is 2.5 Ω.

- The combined resistance in the given circuit is 5Ω . What is the value of R?



In parallel

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

hence

$$\frac{1}{5} = \frac{1}{10} + \frac{1}{R_2}$$

$$\frac{1}{R_2} = \frac{1}{5} - \frac{1}{10}$$

$$\therefore R_2 = 10\,\Omega$$

- A wire of resistance 4 Ω is bent in the form of a closed circle. What is the resistance between the two points at the ends of any diameter of the circle?

Between two points A and B, the resistance is divided into two semicircular parts each having resistance 2 Ω Being in parallel connection, total resistance will be

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

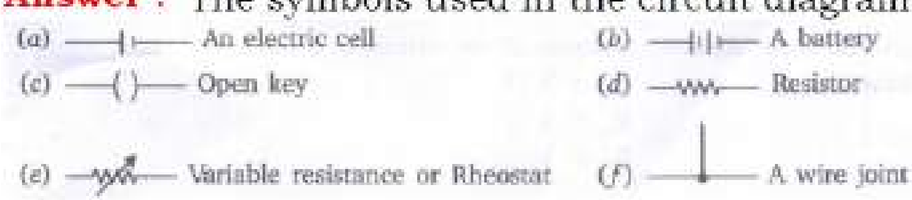
$$\frac{1}{R_P} = \frac{1}{2} + \frac{1}{2}$$

$$\frac{1}{R_p} = \frac{2}{2} \quad R_{p=1\Omega}$$

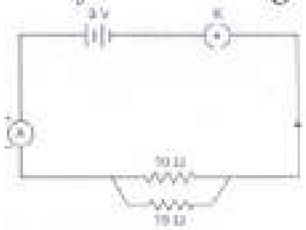
- What do the following symbols represent in the electric circuit?

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{5} + \frac{1}{10} + \frac{1}{30} = \frac{1}{3}$$

Answer : The symbols used in the circuit diagram are named as:



- Study the following circuit and answer the questions that follows:



(a) State the type of combination of the two resistors in the circuit.
(b) How much current is flowing through
(i) 10Ω and
(ii) 15 Ω resistor?
(c) What is the ammeter reading?

Answer : (i) 10 Ω $\rightarrow$ I = $\frac{V}{R} = \frac{3}{10}$ = 0.3A
(ii) 15Ω $\rightarrow$ I $\frac{V}{R} = \frac{3}{15}$ = 0.2A
(c) Ammeter reading = Total current flowing through the circuit = 0.5 A.

- Calculate resistance of an electric bulb which allows a 10 A current when connected to 220 V power source.

Answer : I = 10 A,
V = 220 V $\therefore V = IR$
R = ? $R = \frac{V}{I} = \frac{220}{10} = 22\Omega$

- A lamp rated 100 W at 220 V is connected to the mains electric supply. What current is drawn from the supply line if the voltage is 220 V?

Answer : P = 100 W
V = 220 V P=VI
I =? $\therefore I = \frac{P}{V} = \frac{100}{220} = \frac{5}{11} A$

- Define 1 volt. Express it in terms of SI unit of work and charge. Calculate the amount of energy consumed in carrying a charge of 1 coulomb through a battery of 3V

Answer : When 1 joule of work is done in carrying 1 coulomb of charge, from infinity to a point in the electric field, then potential at that point is called 1 volt. Potential difference between two points is
$V = \frac{W}{Q}$; W= Q x V = 1 x 3 = 3J

- The potential difference between the terminals of an electric heater is 60 V when it draws a current of 4 A from the source. What current will the heater draw if the potential difference is increased to 120 V?

Answer : We are given, potential difference V = 60 V, current I = 4 A.
According to Ohm's law, R = V/I = 60 V/4 A = 15 Ω .
When the potential difference is increased to 120 V the current is given by
current = V/R = 120 V/15Ω = 8 A
The current through the heater becomes 8 A.

- The potential difference between the terminals of an electric heater is 60 V when it draws a current of 4 A from the source. What current will the heater draw if the potential difference is increased to 120 V?

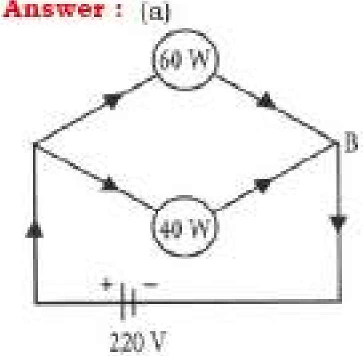
Answer : We are given, potential difference V = 60 V, current I = 4 A.
According to Ohm's law, $R = \frac{V}{I} = \frac{60\ V}{4\ A} = 15\Omega$.
When the potential difference is increased to 120 V the current is given by current
$= \frac{V}{R} = \frac{120\ V}{15\Omega} = 8\ A$
The current through the heater becomes 8 A .

- A wire of given material having length l and area of cross-section A has a resistance of 4 Ω. What would be the resistance of another wire of the same material having length l/2 and area of cross-section 2A?

Answer : For first wire $R_1 = \rho\, l/A = 4\Omega$
Now for second wire
$R_2 = \rho \frac{l/2}{2A} = 1/4\ \rho\, l/A$
$R_2 = 1/4\ R_1$
$R_2 = 1\Omega$
The resistance of the new wire is 1Ω.

- Two lamps, one related 60W at 220 W at 220V and the other 40 W at 220 V, are connected in parallel to the electric supply at 220V.
(a) Draw a circuit diagram to show the connections.
(b) Calculate the current drawn from the electric supply.
(c) Calculate the total energy consumed by the two lamps together when they operate for one hour.

Answer : (a)



(b) Electric current flowing through a bulb = $\frac{Power \quad of \quad the \quad bulb}{Voltage \quad across \quad the \quad bulb}$

$i.e., \quad I = \frac{P}{V}$

Therefore, $I_{60} = \frac{60W}{220V} = \frac{3}{11}A \quad and \quad I_{40} = \frac{40W}{220V} = \frac{2}{11}A$

Therefore, total current flowing through the circuit $= I_{60} + I_{40} = \frac{3}{11} + \frac{2}{11} = \frac{5}{11}A = 0.45A$

(c) Total energy consumed = Power × Time

That is, E = P × T

= (40W+60W)× 1h

= 100 Wh

= 0.1 kWh

- (i) Draw a schematic diagram of a circuit consisting of a battery of five 2 V cells, a 5 Ohm resistor, a 10 Ohm resistor and a 15 Ohm resistor, and a plug key, all connected in series.
(ii) Calculate the electric current passing through the above circuit when the key is closed.

Answer : (i)

(ii) When the key is closed, total voltage applied across the circuit will be = 2 × 5V = 10 V

Total resistance (R) applied across the circuit in Ohms = 5+10+15= 30Ω

By Ohm's Law,

Current (I) = $\frac{V}{R}$

$I = \frac{10}{30} = 0.33A$

- A touch bulb is rated 2.5 V and 750 mA. Calculate (i) its power, (ii) its resistance and (iii) the energy consumed if this bulb is lighted for four hours.

Answer : It is given that: Voltage (V) = 2.50 V

Current (I) = 750 mA = 0.75 A

The bulb is lighted for 4 hours.

Thus,

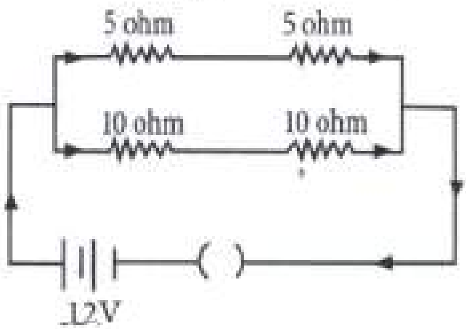
(i) Power generated (P) = VI = 2.50× 0.75 = 1.87 W

(ii) Resistance (R) = $\frac{V}{I} = \frac{2.5}{0.75} = 3.33\Omega$

(iii) Energy consumed in 4 hours = Power×Time = P×t =1.87×4 = 7.48 Wh

If a 12 V battery is connected to the arrangement of resistances given below, calculate
(i) the total effective resistance of the arrangement and
(ii) the total current flowing in the circuit

Answer :



(i) The 5 Ω resistors are connected in series. Therefore, their effective resistance = (5 + 5) = 10 Ω
The 10 Ω resistors are connected in series. Therefore, their effective resistance = (10 + 10) = 20 Ω
Now these 10 Ω equivalent and 20 Ω equivalent are connected in parallel. Therefore, the equivalent resistance (R_{eq}) will be:

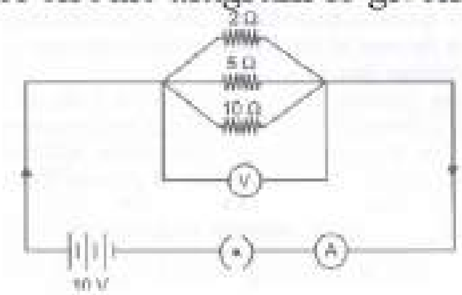
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{20}$$
$$\frac{1}{R_{eq}} = \frac{2+1}{20}$$
$$\frac{1}{R_{eq}} = \frac{20}{3} = 6.76\Omega$$

(ii) Total Current = Total voltage / Total equivalent resistor
=12 / 6.67
= 1.8 A.

How much work is done in moving a charge of 4 C across two points having potential difference of 12 V? Calculate the number of electrons flowing in it.

Answer : Q = 4 C
V = 12 V
W =?
∴ W = VQ = 12 V x 4 C
W = 48J
1 C = 6.25×10^{18} electrons.
∴ 4 C = $6.25 \times 10^{18} \times 4 = 25.00 \text{ X } 10^{18}$
= 2.5×10^{19} electrons

- A circuit diagram is given below



calculate

(a) Current through each resistor.
(b) The total current in the circuit.
(c) the total effective resistance of the circuit.

Solution:

R1 = 2 Ω V = 10V
R2 = 5 Ω
R3 = 10 Ω

Answer : (a) Current through each resistor

$$I_1 = \frac{V}{R_1} = \frac{10}{2} = 5A$$

$$I_2 = \frac{V}{R_2} = \frac{10}{5} = 2A$$

$$I_3 = \frac{V}{R_3} = \frac{10}{10} = 1A$$

(b) Total current I = $I_1 + I_2 + I_3$ =5 + 2 + 1 = 8A

(c) Total resistance

As resistance is in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10} = \frac{5+2+11}{10} = \frac{8}{10}$$

$$R_P = \frac{10}{8} = 1.25\ ohm$$

- A battery of 10 V is connected in a circuit with 3 0, 4 0, 6 0 resistors connected in series. How much current will flow through 6 0 resistor?

Answer : Total resistance in series $R_S = R_1 + R_2 + R_3 = 3 + 4 + 6$

$R_S = 13\Omega$

V = 10 V

I = ?

∴ I = $\frac{V}{R} = \frac{10}{13}$

I = 0.77A

The current flowing through 6Ω resistor is i.e. 0.77 A.

In series connection same current flows through each resistor.

- Two electric bulbs are rated 60 W, 220 V and 20 W, 220 V, are connected in parallel to a 220 V supply. Calculate the total electric current in the circuit.

Answer :

Given:

Bulb 1 : P = 60
V = 220 V
I =?
P = VI
$\therefore I = \frac{P}{V} = \frac{60}{220} = 0.27A$

Bulb 2 : P = 20 W
V = 220 V
I =?
P = VI
$\therefore I = \frac{P}{V} = \frac{20}{220} = 0.09$

Total current $I = I_1 + I_2 = 0.27 + 0.09$
I = 0.36 Ampere

- An electric lamp draws a current of 0.3 ampere and is used for 6 hours every day for a month (30 days). Calculate the amount of charge that flows through the circuit every day and for a month.

Answer : I = 0.3 A
t = 6 hours = 6 x 60 x 60 sec.
$\therefore$ charge, Q = It
per day = 0.3 x 6 x 60 x 60 = 6480 C
Charge flowing for a month = 6480 x 30 = 194400 C

- A wire is 1.0 m long, 0.2 mm in diameter and has a resistance of 10 Ω. Calculate the resistivity of its material

Answer : l = 1.0 m
d = 0.2 mm
$\therefore r = \frac{0.2mm}{2} = \frac{0.2m}{2000}$ (1mm $=10^{-3}$)
$R = 10\Omega$
$\rho = ?$
$R = \rho \frac{l}{A} \quad \therefore \quad \rho = \frac{RA}{l} = \frac{10 \times \pi r^2}{1.0\,m}$
$\rho = 10 \times \frac{22}{7} \times \frac{0.2}{2000} \times \frac{0.2}{2000} \times \frac{1}{1}$
$= \frac{22}{7} \times 10^{-7}\Omega m.$
$\therefore Resistivity\ is\ \frac{22}{7} \times 10^{-7}\Omega m$

- Calculate the area of cross section of a wire of length 1.0 m, its resistance is 23 Ω and the resistivity of the material of the wire is 1.84 x 10^{-6} Ωm.

Answer : R = 23 Ω
l = 1.0 m $\therefore R = \rho \frac{l}{A}$
ρ = 1.84 x 10^{-6} m
A = ?
$\therefore A = \frac{1.84 \times 10^{-6} \times 1}{23}$ = 0.08 x 10^{-6} m^2

- How much current will an electric bulb draw from 220 V source if the resistance of the bulb is 1200 Ω? If in place of bulb, a heater of resistance 100 Ω is connected to the sources, calculate the current drawn by it.

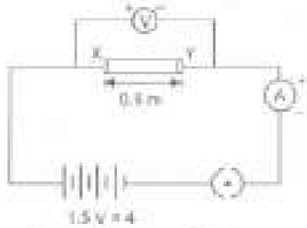
Answer : Given: V = 220 V,R_1 1200 Ω, I_1 = ?, R_2 = 100Ω , I_2 =?
Using Ohm's law, V = I_1R_1
$I_1 = \frac{V}{R_1} = \frac{220}{1200}$ =0.18 A
$I_2 = \frac{V}{R_2} = \frac{220}{100}$ = 2.2 A

- An electric bulb is rated at 60 W, 240 V. Calculate its resistance. If the voltage drops to 192 V, calculate the power consumed and the current drawn by the bulb. (Assume that the resistance of the bulb remain unchanged.)

Answer : Given: P_1 = 60 W, V_1 = 240 V, R = ?, P_2 = ?, V_2 = 192 V, I_1 = ?
Using, $P = \frac{V^2}{R}$
We get $R = \frac{V_1^2}{P_1} = \frac{(240)^2}{60} = 960\Omega$
Again $P_2 = \frac{V_1^2}{R} = \frac{192 \times 192}{960} = 38.4W$
Current drawn by bulb at 192 V is
$I = \frac{V}{R} = \frac{192}{960}$ = 0.2A

- (i) Draw a closed circuit diagram consisting of a 0.5 m long nichrome wire XY; an ammeter, a voltmeter, four cells of 1.5 V each and a plug key.
(ii) Following graph was plotted between V and I values: What would be the values of V/1 ratios when the potential difference is 0.8 V, 1.2 V and 1.6 V respectively? What conclusion do you draw from these values?

Answer : (i)



(ii) From the graph, when p.d. is 1.6 volt and 0.6 A current.

$\frac{V}{I} = \frac{1.6}{0.6} = 2.67\Omega$

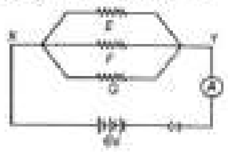
Therefore, value of $\frac{V}{I}$ ratio for all potential differences of 0.8 V, 1.2 V and 1.6 volt will be equal to 2.67Ω .

We conclude that at the given temperature, the resistance of wire is constant and is equal to 2.67 Ω.

(i) What is the meaning of electric power of an electrical device? Write its SI unit.
(ii) An electric kettle of 2 kW is used for 2 h . Calculate the energy consumed in
(a) kilowatt hour and
(b) joules

Answer : (i) Electric power of an electrical device is defined as its rate of consumption of electrical energy.
i.e., P=E/t
The SI unit of electrical power is watt (W)
(ii) Given, electric power $P = 2$ kW Time, $t = 2$ h
We know that,
(a) Electric energy, $W = Pt = 2 \times 2 = 4\text{kWh}$
(b) But $1\text{kWh} = 3.6 \times 10^6$ J
$\therefore \quad W = 4 \times 3.6 \times 10^6$ J
$= 14.4 \times 10^6 \text{ J} = 1.44 \times 10^{-} \text{ J}$

Three resistors in a circuit are attached as shown below. The resistance of F and G are 10Ω and 5Ω, respectively. The resistance of E Is unknown. These resistors are connected to a battery with potential difference 6 V .



(i) What is the term used to describe such an arrangement of resistors?
(ii) What is the resistance of E if 0.3 A current flows through it?
(iii) What is the total current flowing in the circuit?

Answer : (i) The term used to describe such an arrangement of resistors is parallel combination of resistors.

(ii) To find the resistance, we use the following equation.

$$V_E = I_E R_E$$

$$6 = 0.3 \times R$$

$$R_E = \frac{6}{0.3} = 20\Omega$$

(iii) The total current flowing in the circuit,

$$I = I_E + I_F + I_G$$

$$I = \frac{V}{R_E} + \frac{V}{R_F} + \frac{V}{R_G}$$

$$I = \frac{6}{20} + \frac{6}{10} + \frac{6}{5} = 2.1 \text{ A}$$

An electric lamp, whose resistance is 20 Ω, and a conductor of 4 Ω resistance are connected to a 6 V battery (Fig). Calculate (a) the total resistance of the circuit, (b) the current through the circuit, and (c) the potential difference across the electric lamp and conductor.

Answer : The resistance of electric lamp, R_1 = 20 Ω,

The resistance of the conductor connected in series, R_2 = 4 Ω.

Then the total resistance in the circuit

$R = R_1 + R_2$

R_s = 20 Ω + 4 Ω = 24 Ω.

The total potential difference across the two terminals of the battery

V = 6 V.

Now by Ohm's law, the current through the circuit is given by

$I = V/R_s$

= 6 V/24 Ω

= 0.25 A

Applying Ohm's law to the electric lamp and conductor separately,

we get potential difference across the electric lamp,

V_1 = 20 Ω × 0.25 A = 5 V;

and, that across the conductor, V_2 = 4 Ω × 0.25 A = 1 V.

Suppose that we like to replace the series combination of electric lamp and conductor by a single and equivalent resistor. Its resistance must be such that a potential difference of 6 V across the battery terminals will cause a current of 0.25 A in the circuit. The resistance R of this equivalent resistor would be

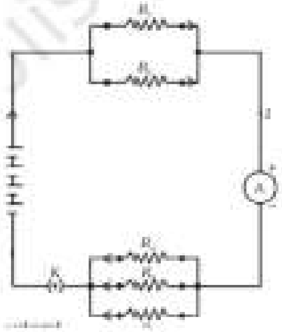
R = V/I

= 6 V/ 0.25 A

= 24 Ω.

This is the total resistance of the series circuit; it is equal to the sum of the two resistances.

If in Fig, R_1 = 10 Ω, R_2 = 40 Ω, R_3 = 30 Ω, R_4 = 20 Ω, R_5 = 60 Ω, and a 12 V battery is connected to the arrangement. Calculate (a) the total resistance in the circuit, and (b) the total current flowing in the circuit.



Answer : Suppose we replace the parallel resistors R_1 and R_2 by an equivalent resistor of resistance, R'. Similarly we replace the parallel resistors R_3 , R_4 and R_5 by an equivalent single resistor of resistance R''. Then using Eq., we have
1/ R' = 1/10 + 1/40 = 5/40; that is R' = 8 Ω.
Similarly, 1/ R'' = 1/30 + 1/20 + 1/60 = 6/60; that is, R'' = 10 Ω.
Thus, the total resistance, R = R' + R'' = 18 Ω.
To calculate the current, we use Ohm's law, and get I = V/R = 12 V/18 Ω = 0.67 A.

An electric iron consumes energy at a rate of 840 W when heating is at the maximum rate and 360 W when the heating is at the minimum. The voltage is 220 V. What are the current and the resistance in each case?

Answer : From Eq. (11.19), we know that the power input is P = V I
Thus the current I = P/V
(a) When heating is at the maximum rate,
I = 840 W/220 V = 3.82 A; and the resistance of the electric iron is R = V/I = 220 V/3.82 A = 57.60 Ω.
(b) When heating is at the minimum rate, I = 360 W/220 V = 1.64 A; and the resistance of the electric iron is R = V/I = 220 V/1.64 A = 134.15 Ω

100 J of heat is produced each second in a 4 Ω resistance. Find the potential difference across the resistor.

Answer : H = 100 J, R = 4 Ω, t = 1 s, V = ?
From Eq. we have the current through the resistor as
I = √(H/Rt)
= √[100 J/(4 Ω × 1 s)] = 5 A
Thus the potential difference across the resistor, V [from Eq.] is V = IR = 5 A × 4 Ω = 20 V.

(a) A torch bulb is rated 2.5 V and 750 mA.
Calculate-
(i) its power,
(ii) its resistance,
(iii) the energy consumed if in this bulb is lighted for 4 hours.
(b) Two identical resistors, each of resistance 2 Ohm, are connected in torch
(i) in series and
(ii) in parallel, to a battery of 12 volts. Calculate the ratio of power consumed in two cases.

Answer : (a) V = 2.5 P = ? Energy E = ?
I = 750 mA = 0.75 A. R = ? t = 4 hours
(i) P = VI . ∴ P = 2.5 x 0.75 = 1.875 W
(ii) R = $\frac{V}{I}$ $R = \frac{2.5}{0.75} = 3.33\Omega$
(iii) E =Pt ∴ E = 1.8 W x 4 = 7.2 Wh
(b) $R_1 = R_2 = 2\ \Omega$ P_1 = ? $\frac{P_1}{P_2} = ?$
V = 12 V P_2 = ?

Series
(i) R = $R_1 + R_2$ = 2 + 2 = 4 Ω
I = $\frac{V}{R} = \frac{12}{4} = 3A$
∴ P_1 = VI = 12 x 3 = 36 W

Parallel
$\frac{I}{R} = \frac{1}{R_1} + \frac{I}{R_2} = \frac{1}{2} + \frac{1}{2} = 1\Omega$
I = $\frac{V}{R} = \frac{12}{1} = 12A$ ∴ P_2 = VI = 12 x 12 = 144 W
Hence, $\frac{P_1}{P_2} + \frac{36}{144} = \frac{1}{4}$ = 1:4

Find the current drawn from the battery by the network of four resistors shown in the figure

Answer : Equivalent resistance of the given network is
$\frac{1}{R} = \frac{V}{R_4} + \frac{1}{R_1+R_1+R_3} = \frac{1}{10} + \frac{1}{10+10+10}$
$\frac{1}{10} + \frac{1}{30} = \frac{3+1}{30} = \frac{4}{30}$
∴ R = $\frac{V}{R} = \frac{3}{7.5} = 7.5\Omega$
Current drawn from the battery
I = $\frac{V}{R} = \frac{3}{7.5} = \frac{30}{75} = \frac{2}{5}$
I = 0.4 A

For the circuit shown in the diagram given below: Calculate:
(a) the value of current through each resistor.
(b) the total current in the circuit.
(c) the total effective resistance of the circuit

Answer : ,Data R_1, = 5 Ω V = 6V
R_2 = 10 Ω I_2 = ? (through each resistor)
R_3 = 30 Ω I_3 = ? (total)
R Total = ?

$$\text{(a) } I_{5\Omega} = \frac{V}{R_1} = \frac{6}{5} = 1.2\ A$$

$$I_{10\Omega} = \frac{V}{R_2} = \frac{6}{10} = 0.6\ A$$

$$I_{30\Omega} = \frac{V}{R_3} = \frac{6}{30} = 0.2\ A$$

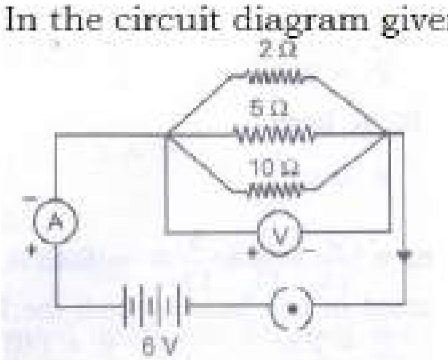
(b) 'Total current
$I = I_5\ \Omega + I_{10}\ \Omega + I_{30}\ \Omega$
I = 1.2 + 0.6 + 0.2 = 2.0 A

(c) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (parallel)

$$\frac{1}{R_P} = \frac{1}{5} + \frac{1}{10} + \frac{1}{30} = \frac{6+3+1}{30} = \frac{10}{30} = \frac{1}{3}$$

∴ $R_P = 3\Omega$

In the circuit diagram given below:



Calculate:
(a) the current through each resistor.
(b) the total current in the circuit.
(c) the total effective resistance of the circuit.

Answer :

$$Current\ through\ 2\ \Omega\ resistor\ I_1 = \frac{V}{R} = \frac{6}{2} = 3\ A$$

$$Current\ through\ 5\ \Omega\ resistor\ I_2 = \frac{V}{R} = \frac{6}{5} = 1.2\ A$$

$$Current\ through\ 10\ \Omega\ resistor\ I_3 = \frac{V}{R} = \frac{6}{10} = 0.6A.$$

(b) Total current in the circuit = 3 + 1.2 + 0.6 = 4.8 A

(c) Total resistance in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10} = \frac{5+2+1}{10} = \frac{8}{10}$$

$$\therefore\ R_P = \frac{10}{8} = 1.25\Omega$$

Two resistors with resistance 5 Ω and 10 Ω respectively are to be connected to a battery of emf 6 V so as to obtain:

(i) minimum current flowing, (ii) maximum current flowing:

(a) How will you connect the resistance in each case?

(b) Calculate the strength of the total current in the circuit in the two cases

Answer : (a) (i) To get minimum current-Resistance will be connected in series

(ii) To get maximum current the resistance should be connected in parallel.

(b) Strength of current in series

$R = R_1 + R_2 = 5 + 10 = 15\ \Omega$

$V = 6V \quad \therefore I = \frac{V}{R} \quad \frac{6}{15} = 0.4A$

Strength of current in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{5} + \frac{1}{10} = \frac{2+1}{10} = \frac{3}{10}$$

$$\therefore R_P = \frac{10}{3} \quad V = 6V$$

$$\therefore I = \frac{V}{R} = \frac{6}{10/3} = \frac{18}{10} = 1.8\ A$$

(a) Define the term 'Volt'.

(b) State the relation between work, charge and potential difference for an electric circuit.
Calculate the potential difference between the two terminals of a battery if 100 joules of work is required to transfer 20 coulombs of charge from one terminal of the battery of the other.

Answer : (a) Volt is defined as the work done in Joules, in carrying a coulomb of charge from one point to another.

(b) Work = W (J)

Charge = Q (C) $V = \frac{W}{Q}$

Potential difference = V $1\ V = \frac{1J}{1C}$

W = 100 J; Q = 20 C; V = ?

$\therefore V = \frac{W}{Q} = \frac{100}{20} = 5$ volt.

∴ Potential difference = 5V

(a) Though same current flows through the electric line wires and the filament of bulb, yet only the filament glows. Why?

(b) The temperature of the filament of bulb is 2700°C when it glows. Why does it not get burnt up at such high temperature?

(c) The filament of an electric lamp, which draws a current of 0.25 A is used for four hours. Calculate the amount of charge flowing through the circuit.

(d) An electric iron is rated 2 kW at 220 V. Calculate the capacity of the fuse that should be used for the electric iron.

Answer : (a) Electric line wires offer extremely low resistance to the flow of current, so they do not glow because negligible heat is produced in it. The filament of bulb glows because it becomes red hot due to large amount of heat produced, as it offers high resistance to the flow of current through it.

(b) The filament of bulb when it glows at 2700 °C does not get burnt because the tungsten metal of filament has

(i) a very high melting point (of 3380°C) and

(ii) a high resistivity.

(c) Given: I = 0.25 A, t = 4 h = 4 x 60 x 60 sec.

So, amount of charge flowing the filament of electric lamp

q = It = 0.25 x 4 x 60 x 60 = 3600 C

(d) Given: P = 2 kW = 2000 W, V = 220 V

Using, P = VI

2000= 220 x I

$$I = \frac{2000}{220} = 9.09A$$

(c) I = 0.25 A, t = 4h = 4 x 60 x 60 sec.

Amount of charge flowing the filament of electric lamp the capacity of the fuse that should be used for the electric iron is of the order or 10A.

(a) Calculate the resistance of 1 km long copper wire of radius 1 mm. Resistivity of the copper is 1.72×10^{-8} Ωm.

(b) Draw a schematic diagram of a circuit consisting of a battery of 4 cells of 2V each connected to a key, an ammeter and two resistors of 2 Ω and 3 Ω respectively in series and a voltmeter to measure potential difference across 3 Ω.

Answer : (a) L = 1 km = 1000 m

R = 1 mm = 1×10^{-3} m

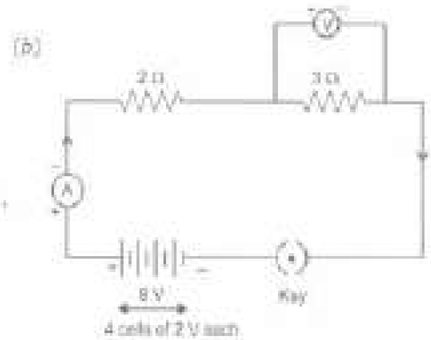
A = $\pi r^2 = 3.14 \times (1 \times 10^{-3})^2$

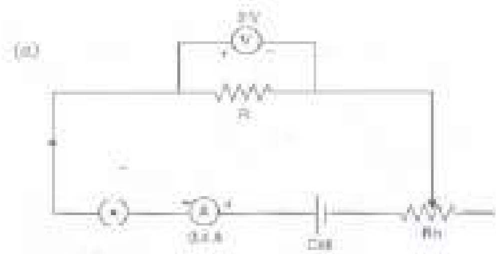
P = 1.72×10^{-8} Ωm

Resistance of the wire R = $\rho \frac{l}{A}$

R = $1.72 \times 10^{-8} \times \frac{1000}{3.14 \times (10^{-3})^2}$

R = 5.5 Ω





(OR)

(b) Resistance of resistor is R = $\frac{V}{I} = \frac{2}{0.4} = \frac{20}{4} = 5\Omega$

(c) Ohm's law: When the physical conditions such as temperature remain same, the current flowing through the conductor is directly proportional to the potential difference applied across the ends of the conductor. The graph between the V and I would be linear i.e: straight line.

(a) Define electric power. Express it in terms of potential difference V and resistance R.
(b) An electrical fuse is rated at 2 A. What is meant by this statement?
(c) An electric iron of 1 kW is operated at 220 V. Find which of the following fuses that respectively rated at 1 A, 3 A and 5 A can be used in it.

Answer : (a) Electric power: It is the rate of doing work by an energy source or the rate at which the electrical energy is dissipated or consumed per unit time in the electric circuit is called electric power.

So, Power P = $\frac{Work\ done(W)}{Time(t)} = \frac{electrical\ energy\ dissipated}{Time(t)}$

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

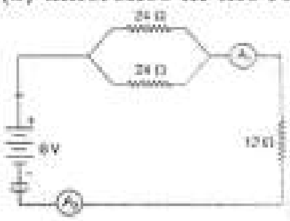
(b) It means, the maximum current will flow through it is only 2 A. Fuse wire will melt if the current exceeds 2 A value

(c) Given: P = 1 kW = 1000 W, V = 220 V

Current drawn, $I = \frac{P}{V} = \frac{1000}{220} = \frac{50}{10} = 454A$

To run electric iron of 1 kW, rated fuse of 5 A should be used.

(i) How will you infer with the help of an experiment that the same current flows through every part of the circuit containing three resistors R_1, R_2 and R_3 in series connected to a battery of V volts?
(ii) Study the following circuit and find out the (a) current in 12Ω resistor.
(b) difference in the reading of A_1 and A_2 if any



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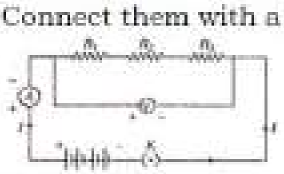
Answer : (i) The experimental set up comprise three resistors R_1, R_2 and R_3 of three different values such as 1 Ω, 2 Ω and 3 Ω which are connected in series.

Connect them with a battery of 6 V , an ammeter and plug key, as shown in figure



The key K is closed and the ammeter reading is recorded. Now, the position of ammeter is changed to anywhere in between the resistors again, the ammeter reading is recorded each time. It's observed that there was identical reading each time, which shows that same current flows through every part of the circuit containing three resistances in series connected to a battery.

(ii) (a) Equivalent resistance of given circuit is R, then

$R = (24||24) + 12 = \frac{24 \times 24}{24+24} + 12$ =12+12=24 Ω

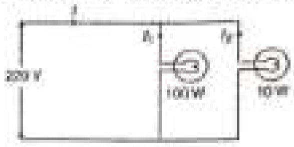
Therefore Current through S12 Ω resistor,

$I = \frac{V}{R} = \frac{6}{24} = 0.25$ A

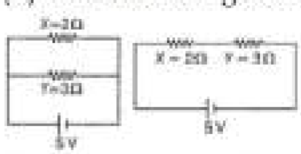
(b) Difference in reading of A_1 and A_2 = $(0.25 - 0.25)A = 0$ A

(i) Two lamps rated 100W, 220 V and 10 W , 220 V are connected in parallel to 220 V supply. Calculate the total current through the circuit.
(ii) Two resistors X and Y of resistances 2Ω and 3Ω respectively are first joined in parallel and then in series. In each case, the supplied voltage is 5 V .
(a) Draw circuit diagrams to show the combination of resistors in each case.
(b) Calculate the voltage across the 3Ω resistor in the series combination of resistors.

Answer : (i) Given, rating of two lamps, $P_1 = 100$ W,
$V_1 = 220$ V, $P_2 = 10$ W and $V_2 = 220$ V
The circuit is shown below



Current in first lamp, $I = \frac{P}{V}$ [$\because$ power = current × voltage]
$\Rightarrow \quad I_1 = \frac{100}{220} = 0.45$ A
Current in second lamp,$\Rightarrow \quad I_2 = \frac{P_2}{V_2} = \frac{10}{220} = 0.045$ A
As, net current from source, $I = I_1 + I_2 = 0.45 + 0.045 = 0.49$ A
(ii) Given, $X = 2\Omega, Y = 3\Omega$ and $V = 5$ V
(a) Circuits are given below



(b) Current in series combination circuit,
$I = \frac{V}{R} = \frac{V}{X+Y} = \frac{5}{2+3} = 1$ A
Since, current in series circuit is same through all resistors, so potential drop across 3Ω resistance,
$V_Y = IY = 1 \times 3 = 3$ V

2 A current of 1A flows through an electric bulb for 5 min . What is the amount of electric charge that flows through the bulb? Show your calculation.

Answer : Given, Electric current $(I) = 1$ A
time $(t) = 5$ min $= 300$ s
$\Rightarrow Q = I \times t$
$\Rightarrow Q = 1 \times 300$ s $= 300$ s]
$\Rightarrow Q = 300$C