Chapter 12
Electricity

Intext Questions Page No. 200

Question 1. What does an electric circuit mean?

Answer: A continuous and closed path of an electric current is called an electric circuit.

Question 2. Define the unit of current.

Answer: The SI unit of electric current is ampere (A).

When I coulomb of electric charge flows through any cross. Section of a conductor in I second, the electric current flowing through it is said to be 1 ampere.

∵ 1 ampere = 1C/1s

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

Answer: The SI unit of electric charge is column, which is equivalent to the charge contained in nearly 6 × 1018 electrons.

Intext Questions Page No. 202

Question 1. Name a device that helps to maintain a potential difference across a conductor.
Answer: A source of electricity such as battery, cell, power supply etc. can maintain a potential difference.

Question 2. What is meant by saying that the potential difference between two points is 1 V?
Answer: One Volt is the potential difference between two points in a current-carrying conductor when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

$$\text{Therefore 1 Volt} = \frac{1 \text{ joule}}{1 \text{ columb}}$$

1 V = 1 Jc-1

Question 3. How much energy is given to each coulomb of charge passing through a 6 V battery?
Answer:
W = VQ
= 6 × 1 = 6 joules
Hence 6 joules of energy is given to each coulomb of charge passing through a 6 V battery.

Intext Questions Page No. 209

Question 1. On what factors does the resistance of a conductor depend?

Answer: The resistance of a conductor depends upon main four factors which are given below:

1. Length of the conductor.
2. Cross-sectional area of the conductor.
3. Natural of material of the conductor.
4. Temperature of the conductor.

Question 2. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?

Answer: Thicker the wire, lower is the resistance of the wire. Hence, current flows more easily through a thick wire. It is because the resistance of a conductor is inversely proportional to its area of cross-section.

Question 3.
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?
Answer:
As per ohm's law, V = IR
I=V/R —– (i)
Potential difference is half

$$V^1 = \frac{V}{2}.$$

$$\therefore I^1 = \frac{V^1}{R}$$

$$\frac{\left(\frac{V}{2}\right)}{R} = \left(\frac{1}{2}\right)\left(\frac{V}{2}\right) = \frac{1}{2}(I) = \frac{1}{2}$$

∴ Current flowing is also half of ts former value.

Question 4. Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?
Answer:
a) Resistivity of iron = 10.0 × 10-8
Resistivity of Mercury = 94.0 × 10-8
Resistivity of an alloy is greater than iron. By this we conclude that, Iron is good conductor of heat comparing to Mercury.
b) Resistivity of silver is less, hence it is a good conductor of heat.

Question 5.

Use the data in Table 12.1 to answer the following:
Electrical resistivity of some substances at 20°C

Material	Resistivity (Ωm)	
Conductor	Silver	1.60 x 10-8
	Copper	1.62 x 10-8
	Aluminium	2.63 x 10-8
	Tungsten	5.20 x 10-8
	Nickel	6.84 x 10-8
	Iron	10.0 x 10-8
	Chromium	12.9 x 10-8
	Mercury	94.0 x 10-8
Manganese	**1.84 x 10-6**	
Alloys	Constantan	49 x 10-6
	Manganin	44 x 10-6
	Nichrome	100 x 10-6
Insulators	Glass	1010 – 1014
	Hard rubber	1013 – 1016
	Ebonite	1015 – 1017
	Diamond	1012 – 1013
	Paper (dry)	1012

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

Answer:

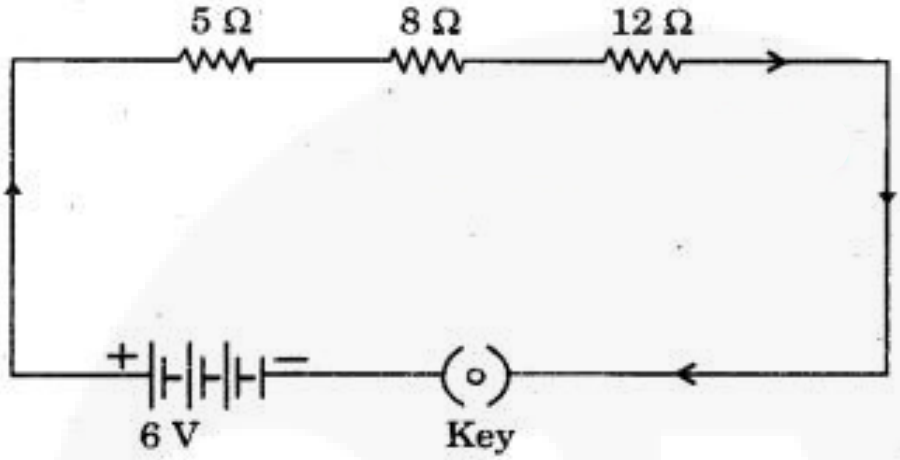
(a) Resistivity of iron = 10.0 × 10-8 Ωm
Resistivity of mercury = 94.0 × 10-8 Ωm
Hence, resistivity of mercury is more than that of iron. This implies that iron is a better conductor than mercury.
(b) It can be observed from table that the resistivity of silver is the lowest among the listed materials. Hence, it is the best conductor.

Intext Questions Page No. 213

Question 1. 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 12 Ω resistor, and a plug key, all connected in series.

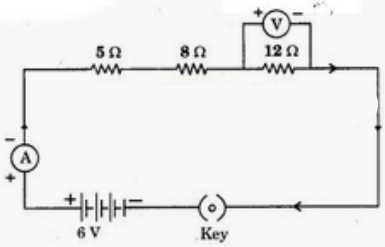
Answer:

Schematic diagram of a circuit:



Question 2. Redraw the circuit of question 1, putting in an ammeter 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?

Answer:



Given, $R_1 = 5\ \Omega, R_2 = 8\ \Omega, R_3 = 12\ \Omega$

$V = 6V$

$I = ?$

Equivalent resistance R_s in series $= R_1 + R_2 + R_3$

$= 5 + 8 + 12 = 25\ \Omega$

Hence $I = \frac{V}{R_s} = \frac{6V}{25\ \Omega}$

$= 0.24\ A$

Here, $R = 12\ \Omega$

$\therefore V = IR$

$= 0.24 \times 12$

$= 2.88\ V$

Hence, reading in the ammeter would be 0.24 A and reading in voltmeter would be 2.88 V.

Intext Questions Page No. 216

Question 1. Judge the equivalent resistance when the following are connected in parallel:

(a) 1Ω, and 106 Ω

(b) 1 Ω, and 103 Ω and 106 Ω

Answer:

(a) 1 ohm and 106 times ohm

R1 = 1 ohm

R2 = 106 times = 1000000 ohm

Total resistance (parallel)

1/R = 1/R1 + 1/R2

= 1/1 + 1/1000000

= 1000000 + 1 /1000000

= 1000000/ 1000000

1/R = 1/1 ohm (approx.)

∴ Resistance = 1 ohm (approx.)

(b) Given R1 = 1 ohm

R2 = 103 ohm

R3 = 106 ohm

So, total resistance $\frac{1}{R} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$

$= \frac{1}{1}+\frac{1}{1000}+\frac{1}{1000000} = \frac{1000000+1000+1}{1000000}$

$= \frac{1001001}{1000000} = 0.999\Omega$

Question 2.

An electric lamp of 100Ω, a toaster of resistance 50Ω and a water filter of resistance 500Ω 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?

Answer:

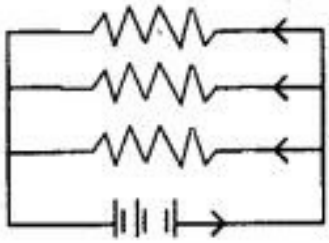
Resistance of Electric 1 amp R1 = 100Ω

Resistance of Tosser, R2 = 50Ω

Resistance of water filter, R3 = 50Ω

Potential difference, V = 220V

When these are connected in parallel,



$$V = 220\ V$$

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

7.04A of electricity is obtained by three appliances

Resistance of an electric iron connected to the same source that takes as much current as all three appliances

$$220\ V = 7.04\ A$$

As per ohm's law

$$V = IR^1$$

$$\therefore\ R^1 = \frac{V}{I}$$

$$= \frac{220}{7.04} \qquad = 31.25\ \Omega.$$

∴ Resistance of iron box = 31.25Ω

Electricity flowing through this = 7.04A.

Question 3. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?

Answer:

(i) In parallel circuit, if one electrical appliance stops working due to some defect, then all other appliances keep working normally. In series circuit, if one electrical appliance stops working due to some defect, then all other appliances also stop working.

(ii) In parallel circuits, each electrical appliance gets the same voltage as that of the power supply line. In series circuit, appliances do not get the same voltage, as that of the power supply line.

(iii) In the parallel connection of electrical appliances, the overall resistance of the household circuit is reduced due to which the current from the power supply is high. In the series connection, the overall resistance of the circuit increases too much due to which the current from the power supply is low.

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

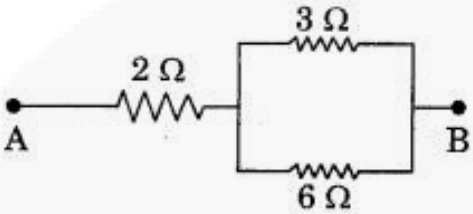
Answer: Given,

R1 = 2 Ω

R2 = 3 Ω

R3 = 6 Ω

(a) When R2 and R3 are connected in parallel with R1 in series we receive



$$1/R = 1/R_2 + 1/R_3$$
$$= 1/3 + 1/6$$
$$= 1/2$$

So, $R = 2\ \Omega$

Now, Resistance in series $= R + R_1$
$= 2 + 2$
$= 4\ \Omega$

(b) When R1, R2, R3 are connected in parallel we receive

$$220\ V = 7.04\ A$$

As per ohm's law

$$V = IR^1$$

$$\therefore R^1 = \frac{V}{I}$$

$$= \frac{220}{7.04} = 31.25\ \Omega.$$

Question 5.

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, 24 Ω?

Answer:

(a) For highest resistance according to question resistances must be connected in series:

4 Ω, 8 Ω, 12 Ω, 24 Ω

R1 = 4 Ω

R2 = 8 Ω

R3 = 12 Ω

R4 = 24 Ω

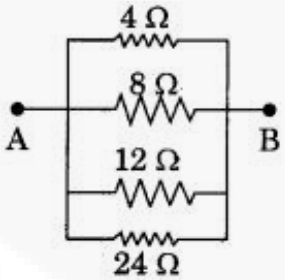
Total resistance in series = R1 + R2 + R3 + R4

= 4 + 8 + 12 + 24

= 48 Ω

Now, resistance is maximum when connected in series.

(b) For lowest resistance, resistances must be connected in parallel.



So, Total resistance in parallel $= 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$

$1/R = 1/4 + 1/8 + 1/12 + 1/24$

$= 12/24$

$1/R = 1/2\ \Omega, R = 2\ \Omega.$

Resistance is lowest when connected in parallel.

Intext Questions Page No. 218

Question 1. Why does the cord of an electric heater not glow while the heating element does?
Answer: In cord of an electric heater, as current flows these become hot arid glows but in case of electric heater this will not happen.

Question 2. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.
Answer: Given, Charge = 96000 coulomb
Time = 1 hour = 3600 seconds
Potential difference = 50 V Ω
As we know, I = Q/T
I = 96000/36000 = 80/3 amp.
V = I × R
50 = 80/3 × R
So, R = 15/8 Ω
Now, Heat = I2RT
= (80/3)2 × 15/8 × 3600
800 × 6000
= 4800000 joules or 4.8 × 106 J

Question 3. An electric iron of resistance 20Ω takes a current of 5 A. Calculate the heat developed in 30 s.
Answer: As per Joule's law
H = VIt
H = IR = 5A × 20Ω = 100V
I = 5A, t = 30 sec.
∴ H = 100 × 5 × 30 J
= 15000 J = 1.5 × 104 J.

Intext Questions Page No. 220

Question 1. What determines the rate at which energy is delivered by a current?

Answer: The rate at which electric energy is dissipated or consumed in an electric circuit is termed as electric power.

P = VI.

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

Answer:

P = VI

V = 220V, and I = 5A.

Power P = 220 × 5 = 1100 W

Power of the motor = P × t

P = 1100 W.

t = 2 Hr 2 × 60 × 60 W

= 7200 S

∴ Energy consumed, E = 1100 × 7200 J

= 7920000

= 7.92×10^6J.

NCERT Textbook Exercises

Question 1.

A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R′, then the ratio R/R′ is –

(a) 1/25 (b) 1/5 (c) 5 (d) 25

Answer: (d) 25

Question 2. Which of the following terms does not represent electrical power in a circuit?

(a) I^2R

(b) IR^2

(c) VI

(d) $\frac{V^2}{R}$

Answer:

(b) IR^2

Question 3.

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

Answer: (d) 25 W

Question 4. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be-
(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1
Answer: (c) 1 : 4

Question 5. How is a voltmeter connected in the circuit to measure the potential difference between two points?
Answer: Voltmeter is connected in parallel in the circuit to measure the potential difference between two points.

Question 6. A copper wire has diameter 0.5 mm and resistivity of 1.6 × 10-8 Ω m. What will be the length of this wire to make its resistance 10 Ω? How much does the resistance change if the diameter is doubled?
Answer: Given, Diameter = 0.5 mm = 0.0005 m

Radius, $r = \frac{0.0005}{2} = 0.00025 \text{ m or } 25 \times 10^{-3} \text{ m}^3$

Resistivity $\rho = 1.6 \times 10^{-8} \Omega \text{ m}$

Resistance $R = 10 \Omega$

Length $l = ?$

As we know, $R = \rho \frac{l}{A}$ or $l = \frac{RA}{\rho}$

$$l = \frac{10 \times 3.14 \times (25 \times 10^{-3})^2}{1.6 \times 10^{-8}}$$

$$= 122.7 \text{ m}$$

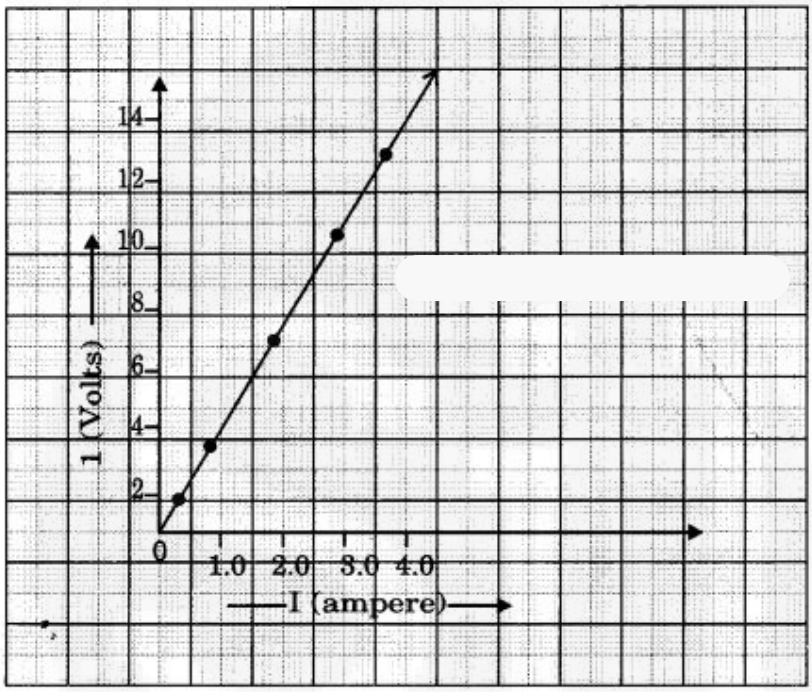
So, the resistance is one-fourth if the diameter is doubled.

Question 7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistors 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 are given below:

Answer:



S.No	I (amperes)	V (volts)	$R = \frac{V}{I}$ (Ω)
(*i*)	0.5	1.6	3.2
(*ii*)	1.0	3.4	3.4
(*iii*)	2.0	6.7	3.35
(iv)	3.0	10.2	3.4
(v)	4.0	13.2	3.3

$$\text{Resistance of resistor, R (mean)} = \frac{3.2 + 3.4 + 3.35 + 3.4 + 3.3}{5} = 3.33\,\Omega$$

Or

$$\text{Resistance} = \text{slope of graph} = \frac{\text{Y - intercept}}{\text{X - intercept}}$$

$$\frac{(10.2 - 0)\text{V}}{(3.0 - 0)\text{A}} = 3.4\Omega$$

Question 8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

Answer:

Given, V = 12v

$I = 2.5\ mA = 2.5 \times 10^{-3}\ A$

As we know, $R = \frac{V}{1}$

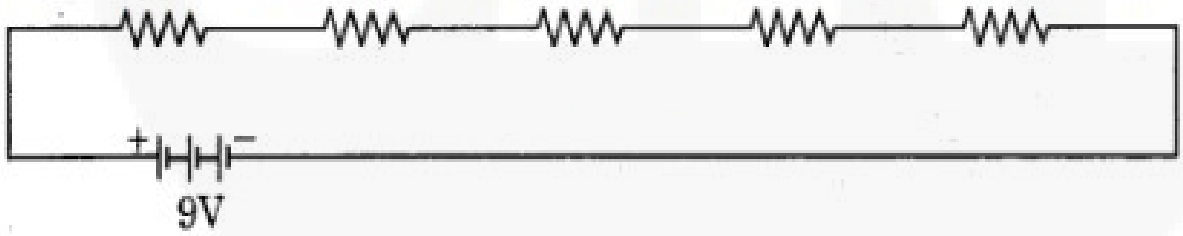
$R = \frac{12V}{2.5 \times 10^{-3} A} = 48000\ \Omega$

So, R = 4.8 kΩ

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

Answer:

$R_1 = 0.2\ \Omega\ R_2 = 0.3\ \Omega\ R_3 = 0.4\ \Omega\ R_4 = 0.5\ \Omega\ R_5 = 12\ \Omega$



Given, V = 9 V

R5 = 0.2 Ω + 0.3 Ω + 0.4 Ω + 0.5 Ω + 12 Ω

= 13.4 Ω

According to formula $I = \frac{V}{R}$

$= \frac{}{13.4\Omega}$

= 0.67 A

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

Answer: Given

I = 5 A V = 220 V

Now, Let the number of 176 Ω resistors be n.

$$\frac{1}{R_p} = \frac{1}{176} + \frac{1}{176} \ldots\ldots + n$$

$$\frac{1}{R_p} = \frac{n}{176} \text{ or } R_p = \frac{176}{n}$$

According to formula:

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

$$\frac{176}{n} = \frac{220}{5}$$

$$n = \frac{176 \times 5}{220}$$

$$n = 4$$

So, four resistors of 176 Ω are required to carry 5 A on a 220 V line.

Question 11. Show how you would connect three resistors, each of resistance 6Ω, so that the combination has a resistance of (i) 9Ω, (ii) 4Ω.

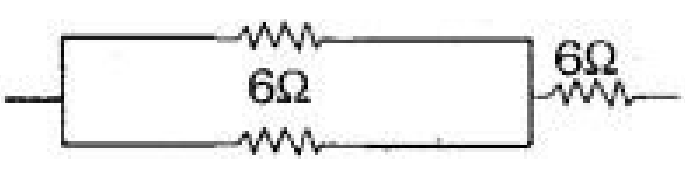
Answer: If resistors are connected in series 6Ω + 6Ω + 6Ω =18Ω

This ia not correct

When they are connected in parallel

1/6+1/6+1/6=3 This is also wrong,

i) When they are connected in parallel



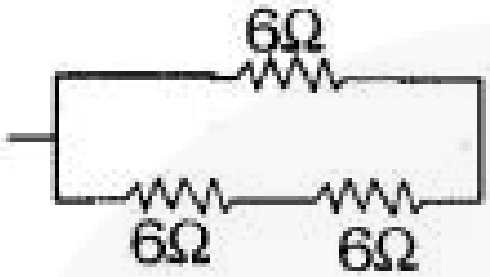
Two 6Ω resistors are connected in parallel

$$\text{Resistance} = \frac{1}{\frac{1}{6}+\frac{1}{6}}$$

$$= \frac{6\times 6}{6+6} = 3\Omega$$

If 3rd resistor of 6Ω and 3Ω are connected in series, it becomes 6Ω + 3Ω = 9Ω.

ii) When they are connected in series



Resistance = 6Ω + 6Ω

= 12Ω

If 3rd resistor 6Ω is connected to 12Ω in parallel

$$= \frac{1}{\frac{1}{2}+\frac{1}{6}} \qquad = \frac{12\times 6}{12+6} = 4W$$

Total resistance = 4Ω.

Question 12. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

Answer: Here V = 220V

I - 5A

$$P = 10W \text{ because } R = \frac{V^2}{P}$$

$$R_1 = \frac{(220)^2}{10} = 4840\Omega$$

As per ohm's law

$$V = IR$$

Let the number of bulbs be 'x'

$$R = \frac{V}{I} = \frac{220}{5} = 44\Omega$$

Resistance of one electric bulb

$$R_1 = 4840 \text{ W}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots\cdots x \text{ times}$$

$$\frac{1}{R} = \frac{1}{R_1} \times x$$

$$\frac{R_1}{R} = \frac{4840}{44} = 110$$

∴ 110 lamps can be connected in parallel with each other across the two wires.

Question 13. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

Answer: (i) If coils are connected separately V = 220 V

Resistance R1 = 240

As per ohm's law, V = IR

$$I = \frac{V}{R_1} = \frac{220}{24} = 9.166A$$

∴ If coils are connected separately 9.16A electricity flows in the coil.

(ii) If coils are connected in series

Resistance R2 = 24Ω + 24Ω = 48Ω

As per ohm's law V = IR

$$\therefore I_2 = \frac{V}{R_2} = \frac{220}{48} = 4.58A$$

∴ If coils are connected in series 4.58A electricity flows.

Question 14. Compare the power used in the 20 resistors in each of the following circuits:
(i) a 6 V battery in series with 1Ω and 2Ω resistors, and
(ii) a 4 V battery in parallel with 12Ω and 2Ω resistors.
Answer:
(i) Potential Difference V = 6V
If 1Ω and 2Ω resistors are connected in series, then Resistance

Answer:
(i) Potential Difference V = 6V
If 1Ω and 2Ω resistors are connected in series, then
Resistance
R = 1 + 2 = 3W.
As per ohm's law
$I = \frac{6}{3} = 2A$
$P(I^2)R = (2)^2 \times 2 = 8W.$
(ii) Potential difference V = 4V
If 12Ω and 2Ω resistors are connected in parallel,
voltage is equal
Voltage of resistance 2 W is 4 volts

$$\text{Now } P = \frac{V^2}{R} = \frac{4^2}{2} = 8W$$

∴ Power of 2Ω is 8 W.

Question 15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?
Answer: Both lamps are connected in parallel potential difference = 220 V
Power = V × I.

$$I = \frac{100}{220} + \frac{60}{220} = 0.727 \text{ A.}$$

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

Answer: 250W TV set in used in 1 Hr, then its energy

$= 250 \times 3600 = 9 \times 10^5$

energy of Toaster $= 1200 \times 600$

If it is used in 10 minutes, then its power $= 1200 \times 600 \times 7.2 \times 10^5$ J

∴ Energy of 250 W TV set is used in 1 Hr is greater than 1200 W toaster used in 10 minutes.

Question 17. An electric heater of resistance 8Ω draws 15 A from the service mains 2 hours.

Calculate the rate at which heat is developed in the heater.

Answer:

$P = I^2R$

$R = 8\Omega, I = 15A$

$P = (15)^2 \times 8 = 1800$ J/s.

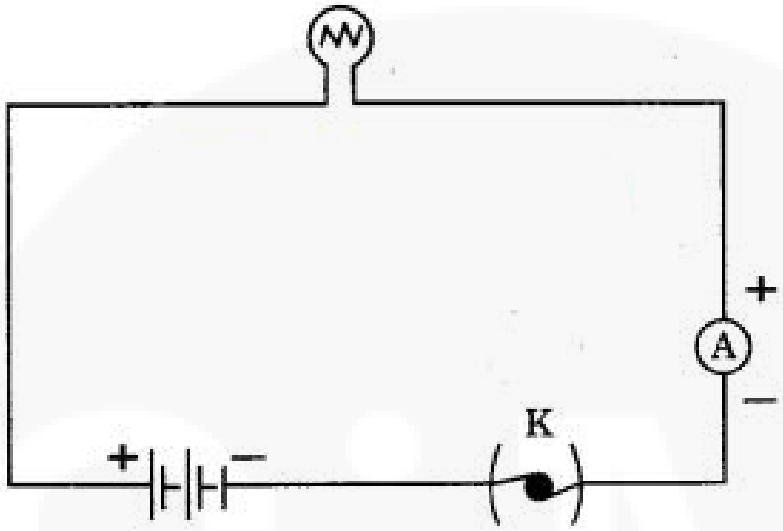
∴ Rate at which heat is developed in the heater $= 1800$ J/s.

Additional Important Questions

Very Short Answer Type Questions

Question 1. What kind of circuit is required for flow of current ?
Answer: Closed.

Question 2. Draw a schematic diagram of a simple electric with battery, bulb, ammeter and key.
Answer:



Question 3. Express in formula form:
1. net charge of a circuit
2. time taken for production of a unit amount of current.

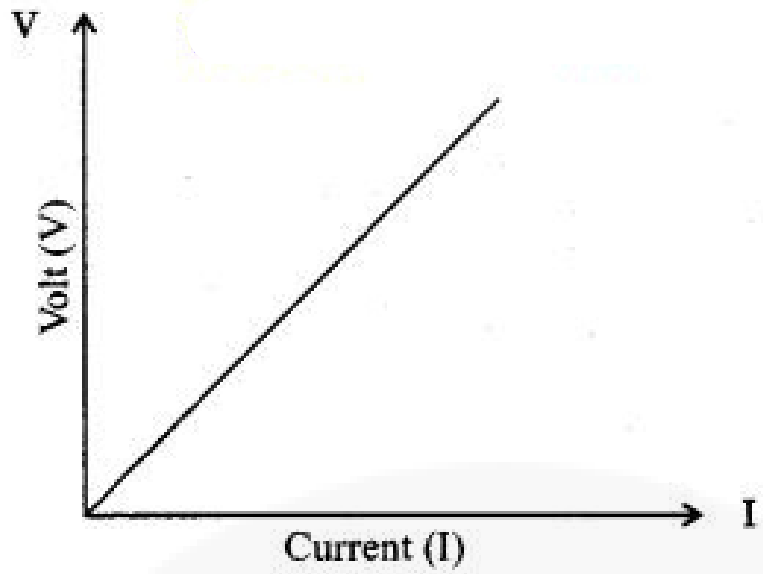
Answer:
1. Q = It.
2. t = Q/I.

Question 4. What is the value of an electric charge for an electron?
Answer:
-1.6×10^{-19}C.

Question 5. Formulate relationship between potential difference and current.
Answer: V = IR.

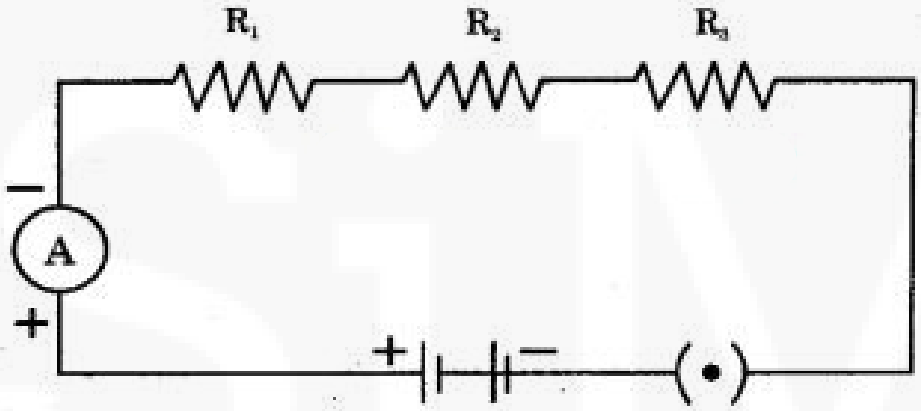
Question 6. Draw the graph verifying ohm's law.

Answer:



Question 7. Draw circuit with three resistor in series combination.

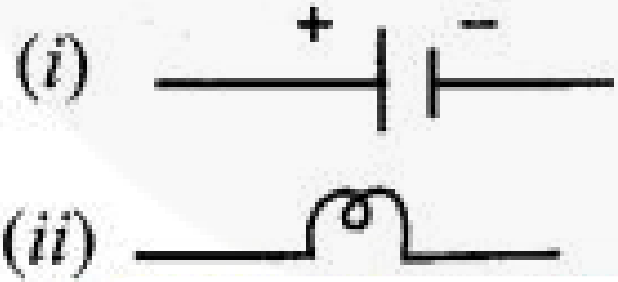
Answer:



Question 8. Represent with diagram:

(i) A cell (ii) A bulb.

Answer:

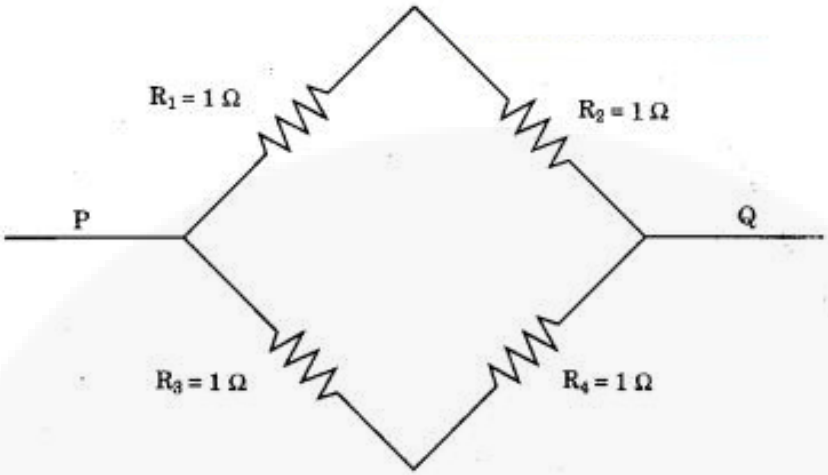


Question 9. Which material has highest conductivity and least resistance?

Answer: Super conductors.

Question 10. Which quality of electrical energy is inversely proportional to electrical power?
Answer: Resistance.

Question 11. Calculate resistance between terminal P & Q of following diagram.
Answer:



First R_1 and R_2 are in series.
So, $R' = R_1 + R_2 = 1\ \Omega + 1\ \Omega = 2\ \Omega$.
then, R_3 and R_4 are in series
$R'' = R_3 + R_4 = 1\ \Omega + 1\ \Omega = 2\ \Omega$
Now both R' and R'' are in parallel.

$$\frac{1}{R} = \frac{1}{R'} + \frac{1}{R''} + \frac{1}{2} + \frac{1}{2} = 1$$

So, $R = 1\ \Omega$

Question 12. If a circuit has open key will current flow from it?
Answer: No.

Question 13. If ammeter is not placed in circuit will current flow?
Answer: Yes.

Question 14. Which gas is filled in electric bulb?
Answer: Argon.

Question 15.
Write the formula representing relationship between heat produced and current flowing in a circuit.
Answer: H = I2RT.

Question 16. Write the formula to calculate power generated by a circuit a with current M
Answer: Since, P = VI
Putting value of I, P = VM (I = m, Given)

Question 17.
Convert 5 kWh in joule.
Answer:

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ Joule}$$
$$5 \text{ kWh} = 5 \times 3.6 \times 10^6 \text{ J.}$$
$$= 16 \times 10^6 \text{ J}$$
$$\text{or } 1.6 \times 10^7 \text{ J}$$

Question 18
One volt ampere is equal to how many watt power?
Answer:
1 Watt Power.

Short Answer Type Questions

Question 1. What is electric current?
Answer: Total charge which pass through a particular area in unit time is called electric current of that particular conductor.

Question 2. What is potential difference?
Answer: Movement of electron need a pressure difference among conductors. Hence, battery or current flow suppliers are added to circuit. This difference in potential is called potential difference.

Question 3. Define Ohm's law.
Answer: Ohm's law states that current flowing in a circuit is directly proportional to its potential difference. It is represented by formula,
$V \alpha I$
or $V = RI$
or $V = IR$
Here, R is a constant known as resistance.

Question 4. Why resistance is applied to a circuit?
Answer: To control the current flow in desired way resistance is applied. Example- Regulator of fan give desired speed of wind flow by controlling flow of current which is being converted to physical energy by fan.

Question 5. Write down the factors at which the resistance of the conductor depends.

Answer:

1. Length of wire: Resistance is directly proportional to length $R \propto L$.
2. Area cross section: Resistance is inversely proportional to area cross section of a wire $R \propto 1/A$.
3. Nature of material.
4. Temperature of the conductor.

Question 6. Arrange the resistivity in decreasing order of following material,

Iron, Silver, Tungsten, Manganin and Glass

Answer: Glass > Manganin > Iron > Tungsten > Silver.

Question 7. Give reason for the following:

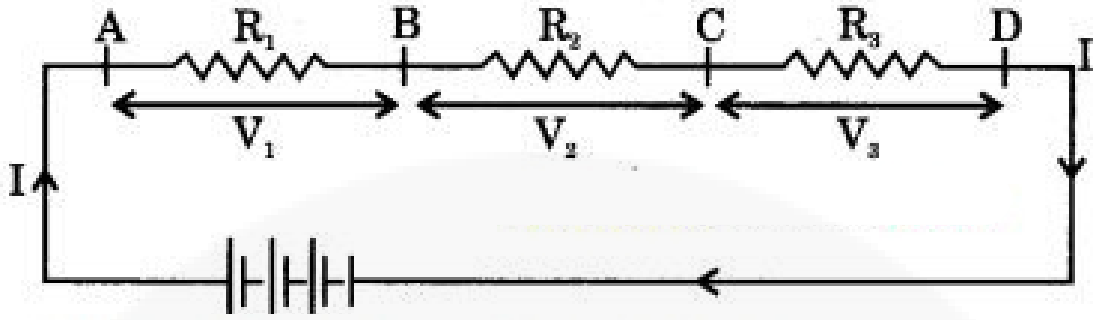
1. Electric bulbs are usually filled with chemically inactive gases like nitrogen and argon.
2. Copper and aluminium wires are usually employed for electricity transmission.
3. Fuse wire is placed in series with the device.

Answer:

1. Electric bulbs are usually filled with chemically inactive gases like nitrogen and argon because these gases do not react with the hot tungsten filament and hence, prolong the life of filament of the electric bulb.
2. Copper and aluminium wires are usually employed for electricity transmission because copper and aluminium have low resistivity and thus, they are very good conductors of electricity.
3. Fuse wire is placed in series with the device because when large current passes through the circuit the fuse wire gets heated up and melts and whole circuit breaks and the device is protected from the damage.

Question 8. If R1 = 10 Ω, R2 = 20 Ω and R3 = 30 Ω, calculate the effective resistance when they are connected in series to a battery of 6 V. Also find the current flowing in the circuit.

(a) Current flows through different resistances, when these are joined in series, as shown in the below figure:



(b) $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$

Effective resistance, $R = R_1 + R_2 + R_3$

R 10 + 20 + 30 = 60 Ω

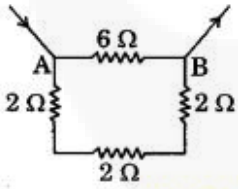
Potential difference, V = 6V,

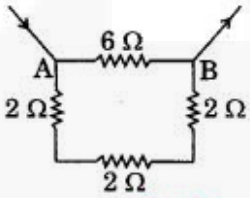
Current, I = ?

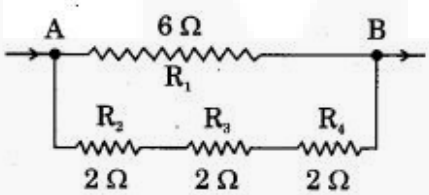
According to Ohm's law

V = IR

Question 9. Find the resistance between points A and B in the circuit diagram given below







$R_1 = 6\ \Omega$

Ans. R_2, R_3, R_4 are in series and have resultant resistance R

$R' = R_2 + R_3 + R_4$

$= 2 + 2 + 2 = 6\ \Omega$

R' is in parallel combination with R_1

∴ Resultant resistance of the circuit (R')

$\Rightarrow \frac{1}{R} = \frac{1}{R'} + \frac{1}{R_1} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$

∴ Resistance, R = 3 Ω.

Long Answer Type Questions

Question 1. An electric iron consumes energy at a rate of 840 W when heating is at the maximum and 360 W when the heating is at the minimum. The voltage at which it is running is 220 V. What are the current and resistance in each case?

Solution: At maximum heating:

The consumption of energy (electric) is given at the rate of 840 W at voltage 220 V.

P = 840 Ω, V = 220 V

Then current, I1 = ?

∴ P = V × I1

$$\therefore \quad I_1 = \frac{}{} = \frac{\frac{42}{\cancel{840}}}{\frac{\cancel{220}}{11}} = 3.81\text{A}$$

∴ Resistance, $R_1 = ?$

$$\therefore \quad V = I_1 R_1$$

$$\Rightarrow \quad R_1 \frac{V}{I_1} = \frac{220}{\frac{42}{11}}$$

$$R_1 = \frac{V}{I_1} = \frac{\cancel{220}^{110}}{\cancel{42}_{21}} \times 11 = \frac{1210}{21} = 57.6$$

At minimum temperature: $R_1 = 57.6\ \Omega$

$V = 220$ Volts

$P = 360$ W

Then current, $I_2 = ?$

$$\therefore \quad P = V \times I_2 = ?$$

$$I_2 = \frac{V}{I_2} = \frac{18}{\frac{360}{\frac{220}{11}}} \times \frac{18}{11} = 1.6\text{A}$$

Resistance, $R_2 = ?$

$$\therefore \quad V = I_2 R_2$$

$$R_2 = \frac{V}{I_2} = \frac{220}{\frac{18}{11}}$$

$$R_2 = \frac{220}{18} \times 11 = \frac{1210}{9} = 134.4\ \Omega$$

Question 2. Three resistors of 5 Ω,10 Ω and 15 Ω are connected in series and the combination is connected to battery of 30 V. Ammeter and Voltmeter are connected in the circuit. Draw a circuit diagram to connect devices all the in correct order. What is the current flowing and potential difference across 10 Ω resistance?

Answer: Current flowing I = ?

V2 = ?

Total resistance, R = R1 + R2 + R3

= 5 + 10 + 15 = 30 Ω

Total potential difference, V = 30 volts

According to Ohm's law V = IR

$$\Rightarrow \quad I = \frac{V}{R} = \frac{30}{30} = 1 \text{ amp}$$

Current remains constant in series

$$\therefore \quad I_1 = I_2 = I_3 = 1$$

$$I_2 = 1 \text{ amp}$$

$$R_2 = 10\ \Omega$$

$$V_2 = ?$$

As $V_2 = I_2 R_2 = 1 \times 10 = 10$ volts

Potential difference across 10 Ω is 10 volts.

Question 3. Nichrome wire of length 'l' and radius 'r' has resistance of 10 Ω. How would the resistance of the wire change when:

(a) (i) Only length of the wire is doubled?

(ii) Only diameter of the wire is doubled? Justify your answer.

(b) Why element of electrical heating devices are made up of alloys?

Solution: (a) Resistance, R ∝ 1

$$R \propto \frac{1}{A} \quad \Rightarrow \quad R \propto \frac{l}{A}$$

or $R = 10\ \Omega$ $\quad R = p\frac{l}{A}$

(i) Resistance is directly proportional to the length of the conductor. If length of nichrome wire (l) is doubled its resistance also gets doubled.
∴ R′ new resistance = 20 Ω

(ii) The resistance of the wire is inversely proportional to the square of its diameter. If the diameter of the wire is doubled, its resistance becomes one-fourth.
∴ R′, new resistance = 10/4 Ω = 2.5 Ω.

(b) The heating elements of electrical heating appliances are made up of nichrome alloy because,

- Nichrome has very high resistivity due to which it produces a lot of heat on passing current.
- Nichrome does not undergo oxidation easily even at high temperature, it can be kept red hot without burning.

Question 4. The resistance of a wire of 0.01 cm radius is 10 Ω. If the resistivity of the material of the wire is 50 × 10-8 ohm meter, find the length of the wire.
Answer:

Resistance of a wire, R = 10 Ω Radius, r = 0.01×10^{-2} m
Resistivity, p = 50×10^{-8} ohm meter Length of the wire, l = ?
Area of cross section, A = $\pi r^2 = 3.14 \times (0.01 \times 1o\text{-}2)^2$ m^2
$= 3.14 \times 0.01 \times 0.01 \times 10^{-4}\ m^2$
$= 3.14 \times 10^{-8}\ m^2$

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

$$l = \frac{R \times A}{\rho} = \frac{10 \times 3.14 \times 10^{-8}}{50 \times 10^{-8}} = \frac{3.14}{5} = \frac{314}{500}\ m$$

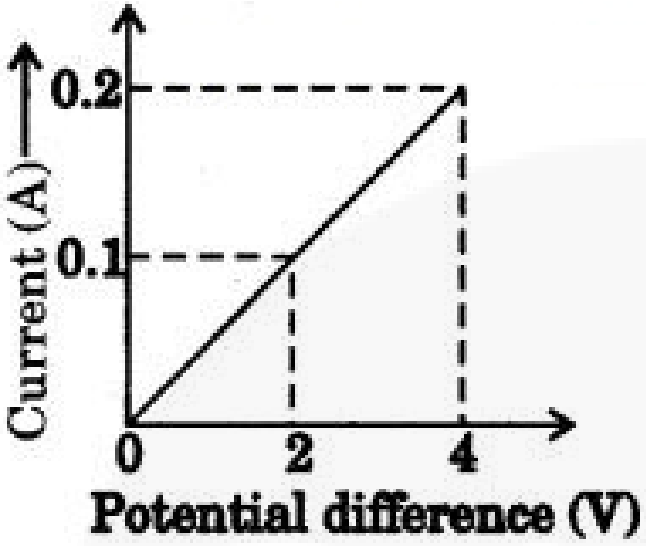
$$= 0.628\ m$$

Question 5.

(a) Calculate the resistance of the wire using the graph.

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

(c) Define electric power. Derive relation between power, potential difference and resistance.



Answer:

(a) Resistance of wire = Slope of the graph

According to Ohm's law,

V = IR or R = V/I

$$\therefore \quad R = \frac{V_2 - V_1}{I_2 - I_1} = \frac{4-2}{0.2-0.1} = \frac{2\times 10}{1} = 20\ \Omega$$

(b) Resistance, R^1 = 176 Ω, No. of resistors = n,

Current, I = 5A

Potential difference, V = 220 volts, Resultant resistance = R According to Ohm s law,

V = IR, $R = \frac{V}{1} = \frac{220}{5} = 44\ \Omega$

$$\frac{1}{R} = \left(\frac{1}{R'} + \frac{1}{R'} + \ldots\ldots n \text{ times}\right) = \frac{1+1+1,\ldots n \text{ Times}}{R'}$$

$$\frac{1}{R} = \frac{n}{R'} \Rightarrow n = \frac{R'}{R} = \frac{176}{44} = 4.$$

Thus, 4 resistors of 176 Ω in parallel combination are required to carry 5 A on a 220 V line.

(c) Electric power is defined as the electrical work done per unit-time.

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}} \qquad P = \frac{W}{t}$$

The work done, W by current, I when it flows for time t under potential difference V is given by

$$W = V \times I \times t \text{ joules}$$

$\because$ $$P = \frac{W}{t}$$

$$P = \frac{W}{t}$$

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

$\therefore$ $$P = V \times I$$

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

So $$P = \frac{V \times V}{R} \qquad P = \frac{V^2}{R}$$

$$\text{Electric power} = \frac{(\text{Potential difference})^2}{\text{Resistance}}.$$