EXERCISE (8 A)

Question 1:
Define the term current and state its S.I unit.

Solution 1:
Current is defined as the rate of flow of charge.

$I = Q/t$

Its S.I. unit is Ampere.

Question 2:
Define the term electric potential. State its S.I. unit.

Solution 2:
Electric potential at a point is defined as the amount of work done in bringing a unit positive charge from infinity to that point. Its unit is the volt.

Question 3:
How is the electric potential difference between the two points defined? State its S.I. unit.

Solution 3:
The potential difference between two points is equal to the work done in moving a unit positive charge from one point to the other.

It's S.I. unit is Volt.

Question 4:
Explain the statement 'the potential difference between two points is 1 volt'.

Solution 4:
One volt is the potential difference between two points in an electric circuit when 1 joule of work is done to move charge of 1 coulomb from one point to other.

Question 5:
Explain the analogy between the flow of charge (or current) in a conductor under a potential difference with the free fall of a body under gravity.

Solution 5:
If a body is free to fall, on releasing it from a height, it falls downwards towards the earth's surface. For, this one end has to be at higher level and other at lower level, so that gravity could effect on this difference and body could freely fall. Same way to make flow of the charge through a conductor, the gravity of course has no role of play; there should be difference of electric potential. This difference gives the flow of charge in a conductor.

Question 6:
Define the term resistance. State its S.I. unit.

Solution 6:
It is the property of a conductor to resist the flow of charges through it. It's S.I. unit is Ohm.

Question 7:
Name the particles which are responsible for the flow of current in a metal. Explain the flow of current in a metal on the basis of movement of the particles name by you.

Solution 7:
In a metal, the charges responsible for the flow of current are the free electrons. The direction of flow of current is conventionally taken opposite to the direction of motion of electrons.

Question 8:
How does the resistance of a wire depend on its radius? Explain your answer.

Solution 8:
Resistance of a wire is inversely proportional to the area of cross-section of the wire.

$R \propto \frac{1}{A}$

$R \propto \frac{1}{\pi r^2}$

This means if a wire of same length, but of double radius is taken, its resistance is found to be one-fourth.

Question 9:
How does the resistance of a wire depend on its length? Give a reason for your answer with reason.

Solution 9:
Resistance of a wire is directly proportional to the length of the wire.

$R \propto I$

The resistance of a conductor depends on the number of collisions which the electrons suffer with the fixed positive ions while moving from one end to the other end of the conductor. Obviously the number of collisions will be more in a longer conductor as compared to a shorter conductor. Therefore, a longer conductor offers more resistance.

Question 10:
How does the resistance of a metallic wire depend on its temperature? Explain with reason.

Solution 10:
With the increase in temperature of conductor, both the random motion of electrons and the amplitude of vibration of fixed positive ions increase. As a result, the number of collisions increases. Hence, the resistance of a conductor increases with the increase in its temperature. The resistance of filament of a bulb is more when it is glowing (i.e., when it is at a high temperature) as compared to when it is not glowing (i.e., when it is cold).

Question 11:
Two wires one of copper and other of iron, are of the same length and same radius. Which will have more resistance? Give reason.

Solution 11:
Iron wire will have more resistance than copper wire of the same length and same radius because resistivity of iron is more than that of copper.

Question 12:
Name three factors on which resistance of a given wire depends and state how is it affected by the factors stated by you.

Solution 12:
(i) Resistance of a wire is directly proportional to the length of the wire means with the increase in length resistance also increases.

R ∝ I

(ii) Resistance of a wire is inversely proportional to the area of cross-section of the wire. If area of cross-section of the wire is more, then resistance will be less and vice versa.

R ∝ $\frac{1}{A}$

(iii) Resistance increases with the increase in temperature since with increase in temperature the number of collisions increases.

(iv) Resistance depends on the nature of conductor because different substances have different concentration of free electrons. Substances such as silver, copper etc. offer less resistance and are called good conductors; but substances such as rubber, glass etc. offer very high resistance and are called insulators.

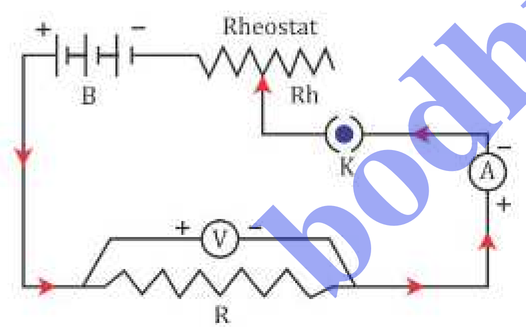
Question 13:

State Ohm's law and draw a neat labelled circuit diagram containing a battery, a key, a voltmeter, an ammeter, a rheostat and an unknown resistance to verify it.

Solution 13:

It states that electric current flowing through a metallic wire is directly proportional to the potential difference V across its ends provided its temperature remains the same. This is called Ohm's law.

V = IR



Question 14:

What is the necessary condition for a conductor to obey Ohm's law?

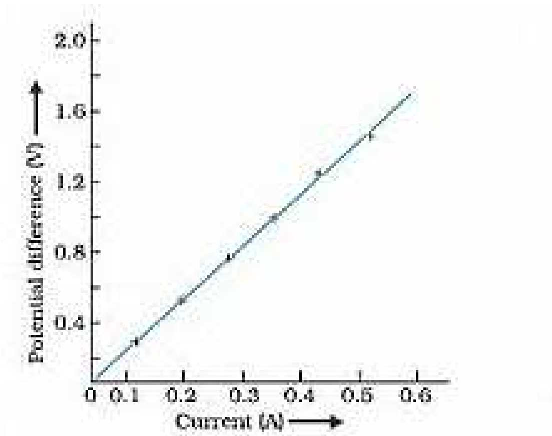
Solution 14:

Ohm's law is obeyed only when the physical conditions and the temperature of the conductor remain constant.

Question 15:

(a) draw a V-I graph for a conductor obeying Ohm's law. (b) what does the slope of V–I graph for a conductor represent?

Solution 15:

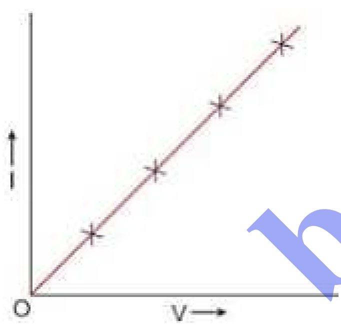


Slope of V-I graph represents the Resistance.

Question 16:

Draw a I – V graph for a linear resistor. What does its slope represent?

Solution 16:



The slope of I-V graph $\left(=\frac{\Delta I}{\Delta v}\right)$ is equal to the reciprocal of the resistance of the conductor, i.e.

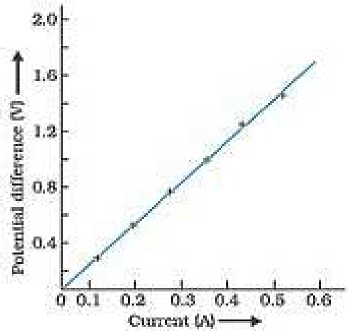
$$\text{Slope} = \frac{\Delta I}{\Delta v} = \frac{1}{\text{Resistance of conductor}} = \text{Conductance}$$

Question 17:

What is an ohmic resistor? Give one example of an ohmic resistor. Draw a graph to show its current voltage relationship. How is the resistance of the resistor determined from this graph.

Solution 17:

Ohmic Resistor: An ohmic resistor is a resistor that obeys Ohm's law. For example: all metallic conductors (such as silver, aluminium, copper, iron etc.)



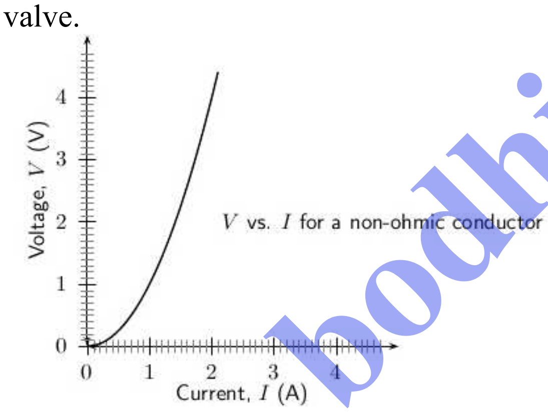
From above graph resistance is determined in the form of slope.

Question 18:

What are non-ohmic reistors? Give one example and draw a graph to show its current-voltage relationship.

Solution 18:

The conductors which do not obey Ohm's Law are called non-ohmic resistors. Example: diode valve.



Question 19:

Give two difference between an ohmic and non-ohmic resistor.

Solution 19:

(1) Ohmic resistor obeys ohm's law i.e., V/I is constant for all values of V or I; whereas Non-ohmic resistor does not obey ohm's law i.e., V/I is not same for all values of V or I.

(2) In Ohmic resistor, V-I graph is linear in nature whereas in non-ohmic resistor, V-I graph is non-linear in nature.

Question 20:

Fig 8.13 below shows the I-V characteristic curves for four resistors. Identify the ohmic and non-ohmic resistors. Give a reason for your answer.

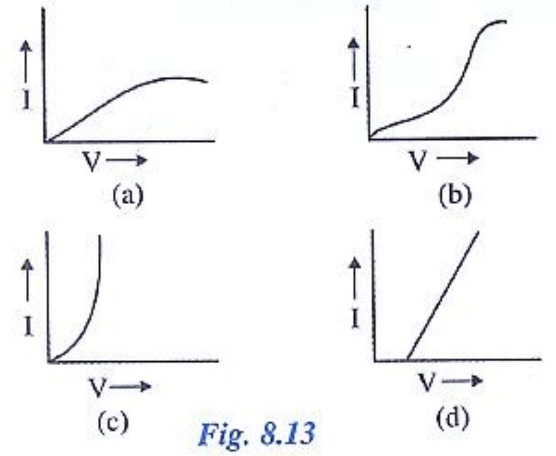


Fig. 8.13

Solution 20:

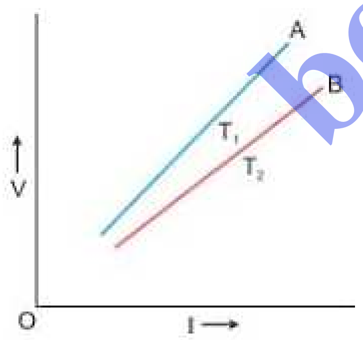
Ohmic: (d), Non-Ohmic: (a), (b) and (c)

Only for (d) the I-V graph is a straight line or linear while for (a), (b) and (c), the graph is a curve.

Question 21:

Draw a V-I graph for a conductor at two different temperature. What conclusion do you draw from your graph for the variation of resistance of conductor with temperature?

Solution 21:



In the above graph, $T_1 > T_2$. The straight line A is steeper than the line B, which leads us to conclude that the resistance of conductor is more at high temperature T_1 than at low temperature T_2. Thus, we can say that resistance of a conductor increases with the increase in temperature.

Question 22:
Define the term resistivity and state its S.I unit.
Solution 22:
The resistivity of a material is the resistance of a wire of that material of unit length and unit area of cross-section.
Its S.I. unit is ohm metre.

Question 23:
Write an expression connecting the resistance and resistivity. State the meaning of symbols used.
Solution 23:
Expression :

$$R = p\frac{I}{A}$$

p – resistivity
R – resistance
l – length of conductor
A – area of cross-csection

Question 24:
State the order of resistivity of (i) a metal, (ii) a semiconductor and (iii) an insulator.
Solution 24:
Metal < Semiconductor < Insulator

Question 25:
Name a substance of which the resistance remains almost unchanged by the increase in temperature.
Solution 25:
Manganin

Question 26:
Name the material used for making the connection wires. Give a reason for your answer. Why should a connection wire be thick?

Solution 26:
'Copper or Aluminium' is used as a material for making connection wires because the resistivity of these materials is very small, and thus, wires made of these materials possess negligible resistance.

The connection wires are made thick so that their resistance can be considered as negligible.

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

Therefore, greater the area of cross-section, lesser shall be the resistance.

Question 27:
Name a material which is used for making the standard resistor. Give a reason for your answer.

Solution 27:
Manganin is used for making the standard resistor because its resistivity is quite large and the effect of change in temperature on their resistance is negligible.

Question 28:
Name the material used for making a fuse wire. Give a reason.

Solution 28:
Generally fuse wire is made of an alloy of lead and tin because its resistivity is high and melting point is low.

Question 29:
Name the material used for (i) filament of an electric bulb, (ii) heating element of a room heater.

Solution 29:
(i) A wire made of tungsten is used for filament of electric bulb because it has a high melting point and high resistivity.

(ii) A nichrome wire is used as a heating element for a room heater because the resistivity of nichrome is high and increase in its value with increase in temperature is high.

Question 30:
What is a superconductor? Give one example of it.

Solution 30:
A superconductor is a substance of zero resistance at a very low temperature. Example: Mercury at 4.2 K.

Question 31:
A substance has zero resistance below 1 k. what is such a substance called?

Solution 31:
Superconductor

MULTIPLE CHOICE TYPE:

Question 1:
Which of the following is an ohmic resistance?

(a) diode valve (b) junction diode

(c) filament of a bulb (d) nichrome

Solution 1:
Nichrome is an ohmic resistance.

Hint: Substances that obey Ohm's law are called Ohmic resistors.

Question 2:
For which of the following substance, resistance decreases with increase in temperature?

(a) copper (b) mercury

(c) carbon (d) platinum

Solution 2:
For carbon, resistance decreases with increase in temperature.

Hint: For semiconductors such as carbon and silicon, the resistance and resistivity decreases with the increase in temperature.

NUMERICALS:

Question 1:

In a conductor 6.25×10^{16} electrons flow from its end A to B in 2 s. Find the current flowing through the conductor ($e = 1.6 \times 10^{19}$ C)

Solution 1:

Number of electrons flowing through the conductor,

$N = 6.25 \times 10^{16}$ electrons

Time taken, t = 2 s

Given, $e = 1.6 \times 10^{-19}$c

Let I be the current flowing through the conductor.

Then, $I = \frac{ne}{t}$

$$\therefore\ I = \frac{\left(6.25\times10^{16}\right)\left(1.6\times10^{-19}\right)}{2} = 5\times10^{-J}\,A$$

Or, I = 5 mA

Thus, 5 Ma current flows from B to A.

Question 2:

A current of 1.6 mA flows through a conductor. If charge on an electron is -1.6×10^{-19} coulomb, find the number of electrons that will pass each second through the cross section of that conductor.

Solution 2:

Current , I = 1.6 mA = 1.6×10^{-3} A

Charge, Q = -1.6×10^{-19} coulomb

t = 1 sec

I = Q/t

Q = I x t

$Q = 1.6 \times 10^{-3} \times 1$

No. of electrons = $1.6 \times 10^{-3}/1.6 \times 10^{-19}$

$= 10^{16}$

Question 3:

Find the potential difference required to pass a current of 0.2 A in a wire of resistance 20Ω

Solution 3:

Current (I) = 0.2 A

Resistance (R) = 20 ohm
Potential Difference (V) = ?
According to Ohm's Law :
V = IR
V = 0.2 × 20 = 4 V

Question 4:

An electric bulb draws 1.2 A current at 6.0 V. Find the resistance of filament of bulb while glowing.

Solution 4:

Current (I) = 1.2 A
Potential Difference/Voltage (V) = 6.0 V
Resistance (R) = ?
According to Ohm's Law :
V=IR
Then R = V/I
R = 6 / 1.2
R = 5 Ohm

Question 5:

A car bulb connected to a 12 volt battery draws 2 A current when glowing. What is the resistance of the filament of the bulb? Will the resistance be more same or less when the bulb is not glowing?

Solution 5:

Potential Difference/Voltage (V) = 12 V
Current (I) = 2 A
Resistance (R) = ?
According to Ohm's Law :
V=IR
Then R = V/I
R = 12 / 2
R = 6 Ohm
Resistance will be less when the bulb is not glowing.

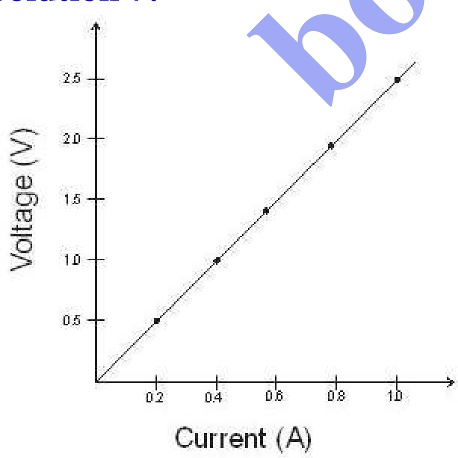
Question 6:
Calculate the current flowing through a wire of resistance 5 Ω connected to a battery of potential difference 3 V.

Solution 6:
Potential Difference/Voltage (V) = 3 V
Resistance (R) = 5 ohm
Current (I) = ?
According to Ohm's Law :
V=IR
Then I = V/R
I = 3/5 = 0.6 A

Question 7:
In an experiment of verification of Ohm's law following observations are obtained.

Potential difference V (in volt)	0.5	1.0	1.5	2.0	2.5
Current *I* (in ampere)	0.2	0.4	0.6	0.8	1.0

Draw a characteristic V –I graph and use this graph to find:
(a) potential difference V when the current I is 0.5 A,
(b) current I when the potential difference V is 0.75 V,
(c) resistance in circuit.

Solution 7:


(a) 1.25 V
(b) 0.3 A

(c) The graph is linear so resistance can be found from any value of the given table. For instance:
When V = 2.5 Volt
Current is I = 1.0 amp
According to ohm's law :
R = V/I
R = 2.5/1.0 = 2.5 ohm

Question 8:

Two wires of the same material and same length have radii r_1 and r_2 respectively compare: (i) their resistances, (ii) their resistivities.

Solution 8:

(i) For wire of radius

$$R_1 = \rho \frac{1}{A_1}$$

$$R_1 = \rho \frac{1}{\pi r_1^2}$$

(ii) For wire of radius r_2 :

$$R_2 = \rho \frac{1}{A_2}$$

$$R_2 = \rho \frac{1}{\pi r_2^2}$$

$$R_2 : R_2 \text{ will be } \rho \frac{1}{\pi r_1^2} : \rho \frac{1}{\pi r_2^2}$$

$$= r_2^2 : r_1^2$$

(ii) Since the material of the two wires is same, so their resistivities will also be same i.e., $\rho_1 : \rho_2 = 1:1$

Question 9:

A given wire of resistance 1 Ω is stretched to double its length. What will be its new resistance?

Solution 9:

Let 'I' be the length and 'a' be the area of cross – section
of the resistor with resistance, R = 1Ω

when the wire is stretched to double its length,
the new length I' = 2I and the new area of cross section,
a' = a/2

$\therefore$ Resistance $(R^{'}) = \rho\frac{I^{'}}{a^{'}} = \rho\frac{2I}{a/2}$

$\therefore R^{'} = 4p\frac{I}{a} = 4R$

$\therefore R^{'} = 4\times 1 = 4\Omega$

Question 10:

A wire 3 ohm resistance and 10 cm length is stretched to 30 cm length. Assuming that it has a uniform cross section, what will be its new resistance?

Solution 10:

Resistance (R) = 3 ohm
Length l = 10 cm
New Length (l') = 30 cm = 3 × l

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

New Resistance :
With stretching length will increase and area of cross-section will decrease in the same order

$R^{'} = \rho\frac{3}{A/3}$

Therefore,

$R^{'} = 9\rho\frac{l}{A} = 9R$

$R^{'} = 9\times 3 = 27\Omega$

Question 11:

A wire of 9 ohm resistance having 30 cm length is tripled on itself. What is its new resistance?

Solution 11:

Resistance (R) = 9 ohm
Length l = 30 cm
New Length (l) = 30 cm = 3/l = 10 cm

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

New Resistance :
With change in length, there will be change in area of cross-section also in the same order.

$$R' = \rho \frac{I/3}{3A}$$

$$R' = \frac{1}{9} \rho \frac{I}{A}$$

$$R' = \frac{1}{9} R$$

$$R' = 1 \text{ohm}$$

Question 12:

What length of copper wire of resistivity 1.7×10^{-8} **Ω** m and radius 1 mm is required so that its resistance is 1**Ω**?

Solution 12:

Resistance (R) = 1 ohm
Resistivity (ρ) = 1.7 x 10^{-8} ohm metre
Radius (r) = 1 mm = 10^{-3} m
Length (l) = ?

$$R = \rho \frac{1}{A}$$

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

$$= \frac{R\pi r^2}{\rho}$$

$$= \frac{1 \times \pi \times 10^{-6}}{1.7 \times 10^{-8}}$$

$$= 184.7 \text{m}$$

EXERCISE. (8 B)

Question 1:

Explain the meaning of the terms e.m.f.., terminal voltage and internal resistance of a cell.

Solution 1:

e.m.f.: When no current is drawn from a cell, the potential difference between the terminals of the cell is called its electro-motive force (or e.m.f.).

Terminal voltage: When current is drawn from a cell, the potential difference between the electrodes of the cell is called its terminal voltage.

Internal Resistance: The resistance offered by the electrolyte inside the cell to the flow of electric current through it is called the internal resistance of the cell.

Question 2:

State two differences between the e.m.f and terminal voltage of a cell.

Solution 2:

e.m.f. of cell	Terminal voltage of cell
1.It is measured by the amount of work done in moving a unit positive charge in the complete circuit inside and outside the cell.	1. It is measured by the amount of work done in moving a unit positive charge in the circuit outside the cell.
2.It is the characteristic of the cell i.e., it does not depend on the amount of current drawn from the cell	2. It depends on the amount of current drawn from the cell. More the current is drawn from the cell, less is the terminal voltage.
3.It is equal to the terminal voltage when cell is not in use, while greater than the terminal voltage when cell is in use.	3. It is equal to the emf of cell when cell is not in use, while less than the emf when cell is in use.

Question 3:

Name two factors on which the internal resistance of a cell depends and state how does it depend on the factors stated by you.

Solution 3:

Internal resistance of a cell depends upon the following factors:

(i) The surface area of the electrodes: Larger the surface area of the electrodes, less is the internal resistance.
(ii) The distance between the electrodes: More the distance between the electrodes, greater is the internal resistance.

Question 4:

A cell of e.m.f ε and internal resistance r is used to send current to an external resistance R. write expresssions for (a) the total resistance of circuit, (b) the current drawn from the cell. (c) the p.d across the cell. And (d) voltage drop inside the cell.

Solution 4:

(a) Total resistance = R + r
(b) Current drawn from the circuit:
As we know that,
ε = V+v
= IR + Ir
= I(R+r)
I = e / (R + r)
(c) p.d. across the cell : $\frac{\varepsilon}{(R+r)} \times R$
(d) voltage drop inside the cell: $\frac{\in}{R+r} \times r$

Question 5:

A cell is used to send current to an external circuit. (a) How does the voltage across its terminals compare with its e.m.f? (b) under what condition is the e.m.f of a cell equal to its terminal voltage?

Solution 5:

(a) Terminal voltage is less than the emf : Terminal Voltage < e.m.f.
(b) e.m.f. is equal to the terminal voltage when no current is drawn.

Question 6:

Explain why the p.d across the terminals of a cell is more in an open circuit and reduced in a closed circuit.

Solution 6:

When the electric cell is in a closed circuit the current flows through the circuit. There is a fall of potential across the internal resistance of the cell. So, the p.d. across the terminals in a closed circuit is less than the p.d. across the terminals in an open circuit by an amount equal to the potential drop across the internal resistance of the cell.

Question 7:

Write the expressions for the equivalent resistance R of three resistors R_1, R_2 and R_3 joined in (a) parallel (b) series

Solution 7:

(a) Total Resistance in series:

$$R = R_1 + R_2 + R_3$$

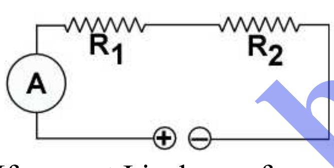
(b) Total Resistance in parallel:

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

Question 8:

How would you connect two resistors in series? Draw a diagram. Calculate the total equivalent resistance.

Solution 8:



If current I is drawn from the battery, the current through eac resistor will also be I.

On applying Ohm's law to the two resistors separately, we further have

$V_1 = I R_1$

$V_2 = I R_2$

$V = V_1 + V_2$

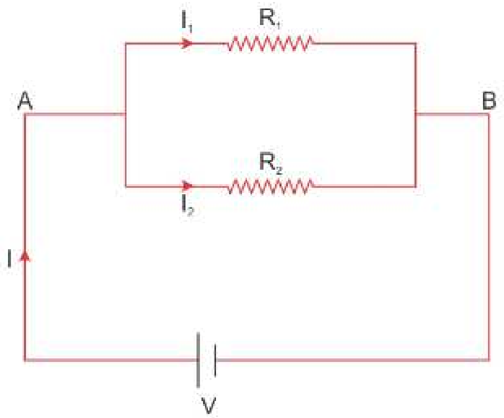
$IR = I R_1 + I R_2$

$R = R_1 + R_2$

Total Resistance in series R

$$R = R_1 + R_2 + R_3$$

Question 9:
Show by a diagram how two resistors R_1 and R_2 are joined in parallel. Obtain an expression for the total resistance of combination.

Solution 9:


On applying Ohm's law to the two resistors separately, we further Have

$I_1 = V / R_1$

$I_2 = V / R_2$

$I = I_1 + I_2$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$$

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

Question 10:
State how are the two resistors joined with a battery in each of the following cases when:
(a) same current flows in each resistor
(b) potential difference is same across each resistor
(c) equivalent resistance is less than either of the two resistances
(d) equivalent resistance is more than either of the two resistances.

Solution 10:
(a) series
(b) parallel
(c) parallel
(d) series

Question 11:
The V-I graph for a series combination and for a parallel combination of two resistors is shown in Fig – 8.38. Which of the two, A or B, represents the parallel combination? Give a reason for your answer.

Solution 11:
For the same change in I, change in V is less for the straight line A than for the straight line B (i.e., the straight line A is less steeper than B), so the straight line A represents small resistance, while the straight line B represents more resistance. In parallel combination, the resistance decreases while in series combination, the resistance increases. So A represents the parallel combination.

MULTIPLE CHOICE TYPE:

Question 1:
In series combination of resistances:
(a) p.d is same across each resistance
(b) total resistance is reduced
(c) current is same in each resistance
(d) all above are true

Solution 1:
In series combination of resistances, current is same in each resistance.
Hint: In a series combination, the current has a single path for its flow. Hence, the same current passes through each resistor.

Question 2:
In parallel combination of resistances:
(a) p.d is same across each resistance
(b) total resistance is increased
(c) current is same in each resistance
(d) all above are true

Solution 2:
In parallel combination of resistances, P.D. is same across each resistance.
Hint: In parallel combination, the ends of each resistor are connected to the ends of the same source of potential. Thus, the potential difference across each resistance is same and is equal to the potential difference across the terminals of the source (or battery).

Question 3:

Which of the following combinations have the same equivalent resistance between X and Y?

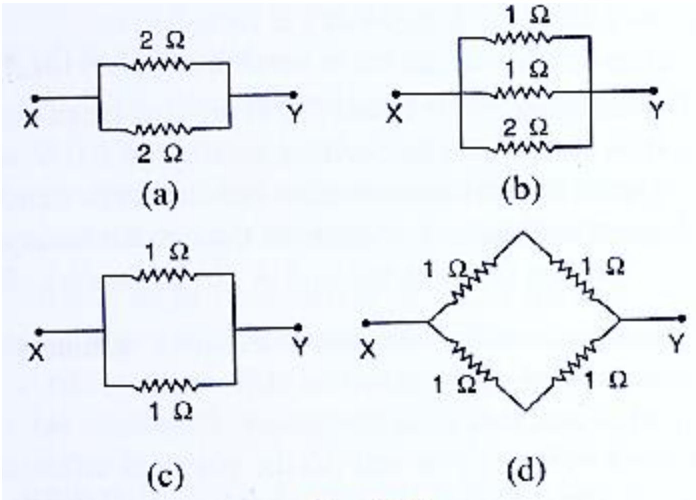


Fig. 8.39

Solution 3:

(a) and (d)

<u>Solution:</u>

In fig (a), the resistors are connected in parallel

Between X and Y.

Let $R^{'}$ be their equivalent resistance.

Then , $\frac{1}{R^{'}} = \frac{1}{2} + \frac{1}{2} = \frac{2}{2}\Omega$

Or, $R^{I} = 1\ \Omega$ .... (i)

In fig (d) a series combination of two $1\,\Omega$ resistors

Is in parallel with another series combination of two

$1\,\Omega$ resistors

Series resistance of two 1 Ohm resistors,

$R = (1 + 1)\,\Omega = 2\ \Omega$

Thus, we can say that across X and Y, two $2\,\Omega$ resistors

are connected in parallel

Let $R^{'}$ be the net resistance across X and Y.

Then, $\frac{1}{R^{'}} = \frac{1}{2} + \frac{1}{2} = \frac{2}{2}\Omega$

Or, $R^{'} = 1\,\Omega$ ....(ii)

From (i) and (ii), it is clear that (a) and (d) have

The same equivalent resistance between X and Y.

NUMERICALS:

Question 1:

The diagram below in Fig. 8.40 shows a cell of e.m.f. ε = 2 volt and internal resistance r = 1 ohm to an external resistance R = 4 ohm. The ammeter A measures the current in the circuit and the voltmeter V measures the terminal voltage across the cell. What will be the readings of the ammeter and voltmeter when (i) the key K is open, (ii) the key K is closed.

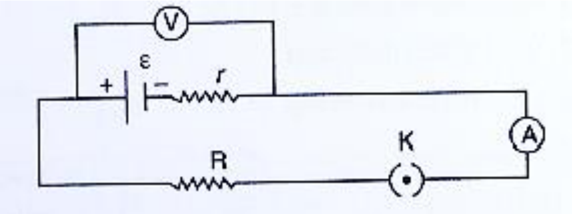


Fig. 8.40

Solution 1:

(i) Ammeter reading = 0 because of no current

Voltage V = ϵ − Ir

V = 2 − 0 × 1 = 2 volt

(ii) Ammeter reading :

$I = \varepsilon/(R+r)$

I=2 / (4+1) = 2 / 5 = 0.4 amp

Voltage reading :

Voltage V = ϵ - Ir

V=2 - 0.4 x 1 = 2 - 0.4 = 1.6 V

Question 2:

A battery of e.m.f 3.0 V supplies current through a circuit in which the resistance can be changed. A high resistance voltmeter is connected across the battery. When the current is 1.5 A, the voltmeter reads 2.7 V. Find the internal resistance of the battery.

Solution 2:

ε = 3 volt

I = 1.5 A

V = 2.7 V

V = ε − Ir

r = (e-V) / I

= (3 – 2.7) / 1.5 = 0.2 ohm

Question 3:

A cell of e.m.f. 1.8V and internal resistance 2Ω is connected in series with an ammeter of resistance 0.7Ω and a resistor of 4.5Ω as shown in Fig. 8.41

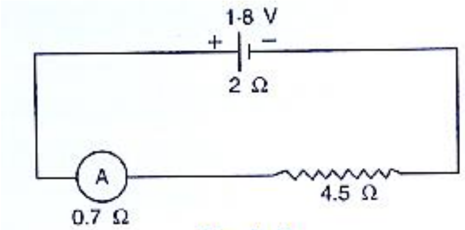


Fig. 8.41

(a) what would be the reading of the ammeter?

(b) what is the potential difference across the terminals of the cell?

Solution 3:

(a) ε = 1.8 V

Total Resistance = 2 + 4.5 + 0.7 = 7.2 W

I = ?

I = ε / R (total resistance)

I = 1.8 / 7.2 = 0.25 A

(b) Current (calculated in (a) part) I = 0.25 A

Now, total resistance excluding internal resistance = 4.5 + 0.7 = 5.2 ohm

V = IR = 0.25 x 5.2 = 1.3 V

Question 4:

A battery of e.m.f. 15 V and internal resistance 3 ohm is connected to two resistors of resistances 3 ohm and 6 ohm is series Find:

(a) the current through the battery

(b) the p.d. between the terminals of the battery.

Solution 4:

(a) ε = 15 V

R = 6 + 3 = 9 ohm

r = 3 ohm

I = ?

I = ε / (R + r)

I = 15 / (9 + 3) = 15/12 = 1.25 A

(b) Current (calculated in (a) part) I = 1.25 A

External Resistance R = 6 + 3 = 9 ohm

V = IR = 1.25 × 9 = 11.25 V

Question 5:

A cell of e.m.f. ε and internal resistance r sends current 1.0 A when it is connected to an external resistance 1.9Ω. But it sends current 0.5 A when it is connected to an external resistance 3.9 Ω. Calculate the values of ε and r.

Solution 5:

In first case

I = 1 A, R = 1.9 ohm

ε = I(R + r) = 1(1.9+r)

ε = 1.9 + r------------(1)

In second case

I = 0.5 A, R = 3.9 ohm

ε = I(R + r) = 0.5 (3.9 + r)

ε = 1.95 + 0.5r ----------------(2)

From eq. (1) and (2),

1.9 + r = 1.95 + 0.5r

r = 0.05/0.5 = 0.1 ohm

Substituting value of r

ε = 1.9 + r = 1.9 + 0.1 = 2 V

Question 6:

Two resistors having resistance 4**Ω** and 6**Ω** are connected in parallel. Find their equivalent resistance.

Solution 6:

Let R' be their equivalent resistance of the 4Ω and 6Ω resistors connected in parallel.

Then, $\frac{1}{R'} = \frac{1}{4} + \frac{1}{6} = \frac{3+2}{12} = \frac{5}{12}\Omega$

$\text{Or}, R' = \frac{12}{5} = 2.4\Omega$

Question 7:

Four resistors each of resistance 2Ω are connected in parallel. What is the effective resistance?

Solution 7:

R_1 = 2 ohm

R_2 = 2 ohm

R_3 = 2 ohm

$R_4 = 2$ ohm

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

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

R = 0.5 oh m

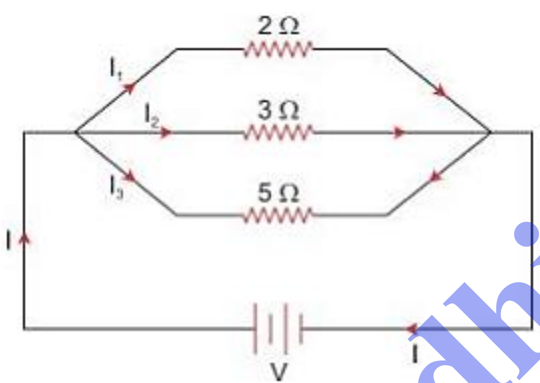
Question 8:

You have three resistors of values 2Ω, 3Ω and 5Ω. How will you join them so that the total resistance is less than 1Ω? Draw diagram and find the total resistance.

Solution 8:

The three resistors should be connected in parallel

To get a total resistance less than 1Ω



Let R' be the total resistance.

Then,

$$\frac{1}{R'} = \frac{1}{2} + \frac{1}{3} + \frac{1}{5} = \frac{15+10+16}{30} = \frac{31}{30}\Omega$$

$$\text{Or}, R' = \frac{30}{31} = 0.97\Omega$$

Question 9:

Three resistors each of 2Ω are connected together so that their total resistance is 3Ω. Draw a diagram to show this arrangement and check it by calculation.

Solution 9:

A parallel combination of two resistors, in series with one resistor.

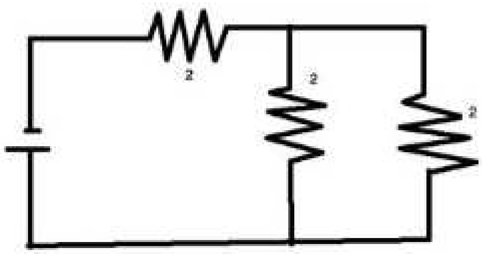
$R_1 = 2$ ohm
$R_2 = 2$ ohm
$R_3 = 2$ ohm

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

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

$$R' = 1ohm$$

$$R = R' + R_3 = 1 + 2 = 3ohm$$



Question 10:

Calculate the equivalent resistance of the following combination of resistors r_1, r_2, r_3 and r_4 if $r_1 = r_2 = r_3 = r_4 = 2.0\Omega$, between the points A and B in Fig. 8.42

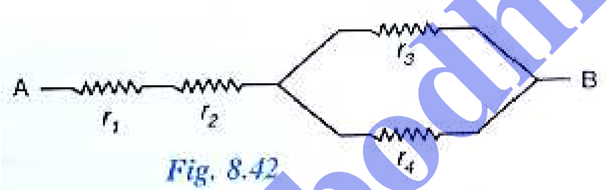


Fig. 8.42

Solution 10:

$$r_1 = r_2 = r_3 = r_4 = 2.0\,ohm$$

$$r' = r_1 + r_2 = 2 + 2 = 4 \text{ ohm}$$

$$\frac{1}{r''} = \frac{1}{r_3} + \frac{1}{r_4} = \frac{1}{2} + \frac{1}{2} = 1$$

$$r'' = 1ohm$$

$$r = r' + r'' = 4 + 1 = 5ohm$$

Question 11:

A combination consists of three resistors in series. Four similar sets are connected in parallel. If the resistance of each resistor is 2 ohm, find the resistance of the combination.

Solution 11:

Resistance of each set:

$r_1 = 2 + 2 + 2 = 6$ ohm

$r_2 = 2 + 2 + 2 = 6$ ohm

$r_3 = 2 + 2 + 2 = 6$ ohm

$r_4 = 2 + 2 + 2 = 6$ ohm

Now these resistances are arranged in parallel :

$$\frac{1}{r} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4}$$

$$\frac{1}{r} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$$

$$r = \frac{6}{4} = 1.5\text{ohm}$$

Question 12:

In the circuit shown below in Fid 8.43, calculate the value of x if the equivalent resistance between A and B is 4Ω.

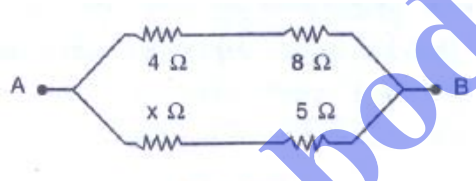


Fig. 8.43

Solution 12:

$r_1 = 4$ ohm

$r_2 = 8$ ohm

$r_3 = x$ ohm

$r_4 = 5$ ohm

$r = 4$ ohm

$$r' = r_1 + r_2 = 4 + 8 = 12\text{ohm}$$

$$r'' = r_3 + r_4 = (x + 5)\text{ohm}$$

$$\frac{1}{r} = \frac{1}{r'} + \frac{1}{r''}$$

$$\frac{1}{4} = \frac{1}{12} + \frac{1}{5+x}$$
$$\frac{1}{6} = \frac{1}{5+x}$$
$$x = 1\,ohm$$

Question 13:

Calculate the effective resistance between the points A and B in the circuit shown in Fig 8.44.

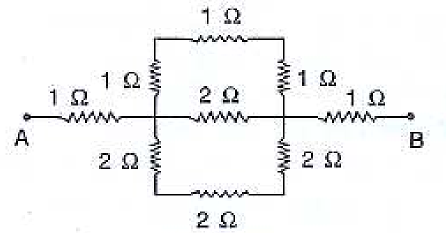
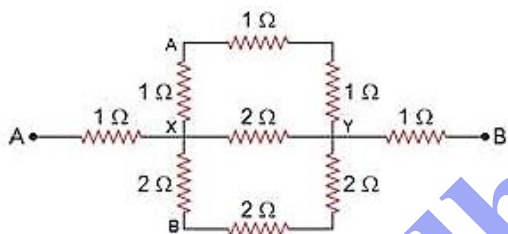


Fig. 8.44

Solution 13:



In the figure above,

Resistance between XAY = (1 + 1 + 1) = 3Ω

Resistance between XY = 2Ω

Resistance between XBY = 6Ω

Let R' be the net resistance between points X and Y

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

Or, $R^{I} = 1\Omega$

Thus, we can say that between points A and B,

Three 1 Ω resistors are connected in series.

Let R_{AB} be the net resistance between points A and B.

Then, $R_{AB} = (1 + 1 + 1)\Omega = 3\Omega$

Question 14:
A wire of uniform thickness with a resistance of 27Ω is cut into three equal pieces and they are joined in parallel. Find the equivalent resistance of the parallel combination.

Solution 14:
Wire cut into three pieces means new resistance = 27/3 = 9

Now three resistance connected in parallel :

$$\frac{1}{r}=\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}=\frac{1}{9}+\frac{1}{9}+\frac{1}{9}$$

r = 9/3 = 3 oh m

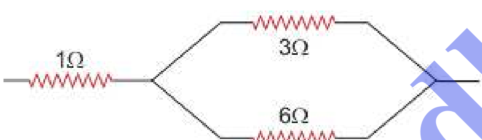
Question 15:
A circuit consists of a 1 ohm resistor in series with a parallel arrangement of 6 ohm and 3 ohm resistors. Calculate the total resistance if the circuit. Draw a diagram.

Solution 15:

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

R = 2 oh m

R = 2 + 1 = 3 oh m



Question 16:
Calculate the effective resistance between the points A and B in the network shown below in Fig 8.45

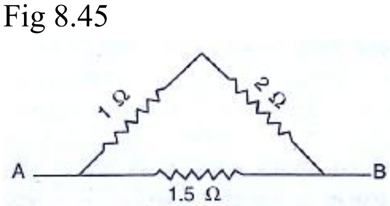


Fig. 8.45

Solution 16:
R_1=1+2 = 3 ohm

R_2=1.5 ohm

R_1 and R_2 are connected in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3} + \frac{1}{1.5} = 1$$

R = 1 oh m

Question 17:

Calculate the equivalent resistance between A and B in the adjacent diagram in Fig 8.46.

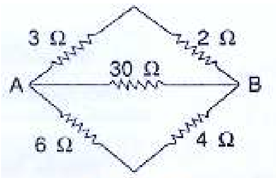


Fig. 8.46

Solution 17:

$R_1 = 3 + 2 = 5$ ohm

$R_2 = 30$ W

$R_3 = 6 + 4 = 10$ ohm

R_1, R_2 and R_3 are connected in parallel

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

R = 3 oh m

Question 18:

In the network shown in adjacent Fig. 8.47, calculate the equivalent resistance between the points.

(a) A and B

(b) A and C

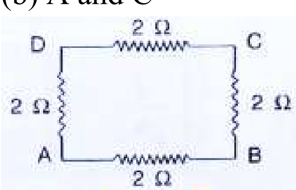


Fig. 8.47

Solution 18:

(a) $R_1 = 2 + 2 + 2 = 6$ohm

$R_2 = 2$ohm

R_1 and R_2 are connected in parallel

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

R = 6/ 4 = 1.5 oh m

(b) R_1=2+2 = 4 ohm

R_2=2+2=4 W

R_1 and R_2 are connected in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$

R = 2 oh m

Question 19:

Five resistors, each 3 Ω, are connected as shown in Fig 8.48. Calculate the resistance (a) between the points P and Q. (b) between the points X and Y.

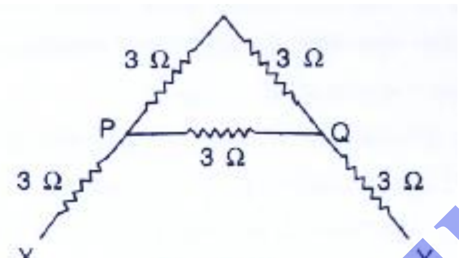


Fig. 8.48

Solution 19:

(a) R_1=3+3=6 W

R_2=3 W

R_1 and R_2 are connected in parallel

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

(b) As calculated above R=2 ohm

R_3 = 3 ohm

R_4 = 3 ohm

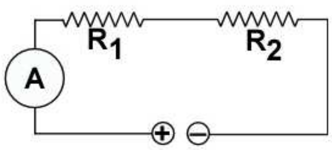
R' = R + R_3 + R_4 = 2 + 3 + 3 = 8 ohm

Question 20:

Two resistors of 2.0Ω and 3.0Ω are connected (a) in series (b) in parallel, with a battery of 6.0 V and negligible internal resistance. For each case draw a circuit diagram and calculate the current through the battery.

Solution 20:

(a)



R_1=2 ohm

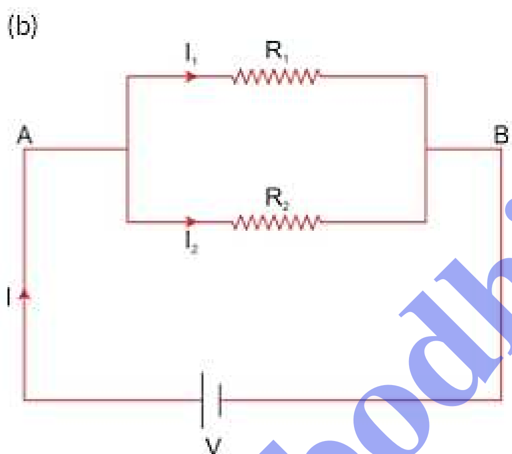
R_2=3 ohm

$R = R_1 + R_2 = 2 + 3 = 5$ ohm

V=6 V

$$I = \frac{V}{R} = \frac{6}{5} = 1.2 \text{ oh m}$$

(b)



R_1 and R_2 are connected in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}$$

R = 1.2 oh m

V = 6 V

$$I = \frac{V}{R} = \frac{6}{1.2} = 5A$$

Question 21:
A resistor of 6Ω is connected in series with another resistor of 4 Ω. A potential difference of 20 V is applied across the combination. Calculate (a) the current in the circuit and (b) the potential difference across the 6Ω resistor.

Solution 21:
(a) R_1 = 6 ohm

R_2 = 4 ohm

R = R_1 + R_2 = 6 + 4 = 10 ohm

V = 20 V

I = V/R = 20/10 = 2 A

(b) R = 6 W

I = 2 A

V = ?

V = IR = 6 × 2 = 12 V

Question 22:
In fig 8.50, calculate:

(a) the total resistance of the circuit

(b) the value if R, and

(c) the current flowing in R.

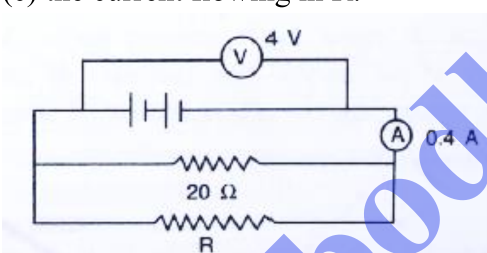


Fig. 8.50

Solution 22:
For resistor A:

R = 1 ohm

V = 2 V

I = V/R = 2/1 = 2A

For resistor B:

R = 2 ohm

V = 2 V

I = V/R = 2/2 = 1A

Question 23:
A wire of length 5 m has a resistance of 2.0 Ω calculate:
(a) the resistance of wire of length 1 m
(b) the equivalent resistance if two such wires each of length 2 m are joined in parallel.
(c) the resistance of 1 m length of wire of same material but of half diameter.

Solution 23:
(a)
V = 4 V
I = 0.4 A
Total Resistance R'=?
R' = V/I = 0.4/4 = 10 ohm

(b)
R_1= 20 ohm

R' = 10 ohm

$$\frac{1}{R'} = \frac{1}{R} + \frac{1}{R_1}$$

$$\frac{1}{10} = \frac{1}{R} + \frac{1}{20}$$

$$\frac{1}{R} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$$

$$R = 20\Omega$$

(c)
R = 20 ohm
V = 4 V
I = V/R = 4/20 = 0.2 A

Question 24:
A particular resistance wire has a resistance of 3.0 ohm per meter. Find:
(a) The total resistance of three lengths of this wire each 1.5 m long, joined in parallel.
(b) The potential difference of the battery which gives a current od 2.0 A in each of the 1.5 m length when connected in parallel to the battery (assume that the resistance of battery is negligible)
(c) the resistance of 5 m length of a wire of the same material, but with twice the area of cross section.

Solution 24:

(a)

Resistance of 1m of wire = 3 ohm

Resistance of 1.5 m of wire = 3 × 1.5 = 4.5 W

$$\frac{1}{R} = \frac{1}{4.5} + \frac{1}{4.5} + \frac{1}{4.5} = \frac{3}{4.5}$$

R = 1.5 oh m

(b)

I=2 A

V=IR = 2 × 4.5 = 9 V

(c)

R = 3 ohm for 1 m

For 5 m: R = 3 × 5 = 15 ohm

But Area A is double i.e. 2A and Resistance is inversely proportional to area so Resistance will be half.

R = 15/2 = 7.5 ohm

Question 25:

A cell supplies a current of 1.2 A through two 2 Ω resistors connected in parallel. When the resistors are connected in series, it supplies a current of 0.4 A. Calculate: (i) the internal resistance and (ii) e.m.f. of the cell.

Solution 25:

In parallel R = ½ + ½ = 1 ohm

I = 1.2 A

ε = I(R + r) = 1.2(1 + r) = 1.2 + 1.2 r

In series R = 2+2 = 4 ohm

I = 0.4 A

ε = I(R + r) = 0.4(4 + r) = 1.6 + 0.4 r

It means :

1.2 + 1.2 r = 1.6 + 0.4 r

0.8 r = 0.4

r = 0.4 / 0.8 = ½ = 0.5 ohm

(i) Internal resistance r = 0.5 ohm

(ii) ε = I(R+r) = 1.2(1+0.5) = 1.8 V

Question 26:

A battery of e.m.f 15 V and internal resistance 3 Ω is connected to two resistors 3Ω and 6Ω connected in parallel. Find: (a) the current through the battery. (b) p.d. between the terminals of the battery, (c) the current in 3 Ω resistors, (d) the current in 6 Ω resistor.

Solution 26:

(a)In parallel 1/R = 1/3 + 1/6 = 1/2

So R = 2 ohm

r = 3 W

ε = 15 V

ε = I(R + r)

15 = I(2 + 3)

I = 15/5 = 3 A

(b) V = ?

R = 2 ohm

V = IR = 3 × 2 = 6 V

(c)V = 6 V

R = 3 ohm

I = V/R = 6/3 = 2 A

(d) R = 6 ohm

V = 6 V

I = V/R = 6/6 = 1 A

Question 27:

The following circuit diagram (Fig . 8.51) shows three resistors 2Ω, 4Ω and RΩ connected to a battery of e.m.f 2 V and internal resistance 3Ω. A main current of 0.25A flows through the circuit.

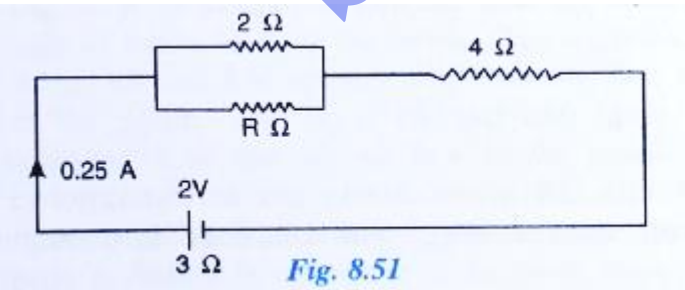


Fig. 8.51

(a) What is the p.d. across the 4Ω resistor?

(b) Calculate the p.d. across the internal resistance of the cell.

(c) What is the p.d. across the RΩ or 2Ω resistor?

(d) calculate the value of R.

Solution 27:

(a) $R = 4\ \Omega$

$I = 0.25$ A

$V = IR = 0.25 \times 4 = 1$ V

(b) Internal Resistance r=3 ohm

$I = 0.25$ A

$V = IR = 0.25 \times 3 = 0.75$ V

(c) Effective resistance of parallel combination of two 2 ohm resistances = 1 ohm

$V = I/R = 0.25/1 = 0.25$ V

(d) $I = 0.25$ A

$\varepsilon = 2V$, $r = 3$ ohm

$\varepsilon = I(R' + r)$

$2 = 0.25(R' + 3)$

$R' = 5$ W

$$\frac{2R}{2+R} + 4 = 5$$

$R = 2$ oh m

Question 28:

Three resistors of 6.0 **Ω**, 2.0**Ω** and 4.0**Ω** are joined to an ammeter A and a cell of e.m.f. 6.0 V as shown in fig 8.52 Calculate:

(a) the effective resistance of the circuit and

(b) the reading of ammeter.

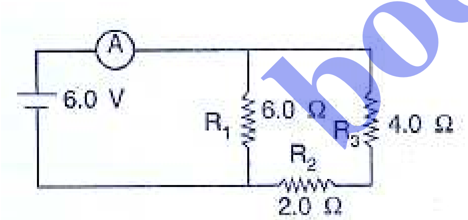


Fig. 8.52

Solution 28:

(a) $R_1 = 6$ W

$R' = R_2 + R_3 = 2 + 4 = 6$ W

R_1 and R' in parallel :

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

$R = 3$ oh m

(b) R = 3 ohm
V = 6 V
I = ?
I = V/R = 6/3 = 2 A

Question 29:

The diagram below in Fig. 8.53 shows the arrangement of five different resistances connected to a battery of e.m.f. 1.8V Calculate:
(a) the total resistance of the circuit, and
(b) the reading of ammeter A.

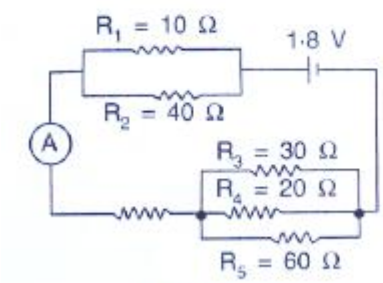
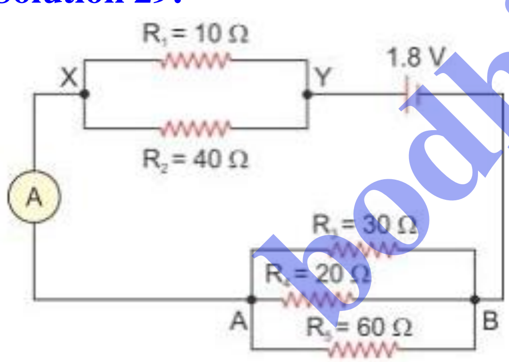


Fig. 8.53

Solution 29:



(a) In the figure above,
Let resistance between X and Y be R_{xy}

Then, $\frac{1}{R_{xy}} = \frac{1}{10} + \frac{1}{40} = \frac{4+1}{40} = \frac{5}{40}\Omega$

Or, $R_{xy} = 8\Omega$

Let R_{AB} be the net resistance between points A and B.

Then, $\frac{1}{R_{AB}} = \frac{1}{30} + \frac{1}{20} + \frac{1}{60} = \frac{2+3+1}{60} = \frac{6}{60}\Omega$

Or, $R_{AB} = 10\Omega$

∴ Total resistance of the circuit = 8Ω + 10Ω = 18Ω

(b) Current, $I = \frac{\text{Voltage}}{\text{Total resistance}} = \frac{1.8}{18}\text{A}$

Or, I = 0.1 A

Thus, 0.1 A shall be the reading of the am meter