EXERCISE 8(A)

Solution:
The rate of flow of charge is known as current. The S.I. unit of current is Ampere.

Solution:
The amount of work done per unit charge in bringing a positive test charge from infinity to that point is known as electric potential at a point. The S.I. unit of electric potential is volt.

Solution:
The potential difference between two points can be defined as 'the potential difference between two points is equal to the work done per unit charge in moving a positive test charge from one point to the other. It's S.I. unit is volt.

The potential difference between two points is said to be 1 volt when 1 joule of work is done in bringing 1 coulomb charge from infinity to that point.

Solution:
(a) Current is a scalar quantity. The direction of current conveys that the electrons flow opposite to the direction of flow of current.
(b) Potential is a scalar quantity. The positive sign of potential states that work has to be done on the positive test charge against the repulsive force due to the positive charge in bringing it from infinity. Negative sign of potential states that the work done on the negative test charge is due to the attractive force.

Question: 6
Define the term resistance. State its S.I. unit.
Solution:
The obstruction offered to the flow of current by the conductor is known as its resistance. The S.I. unit of resistance is Ohm.

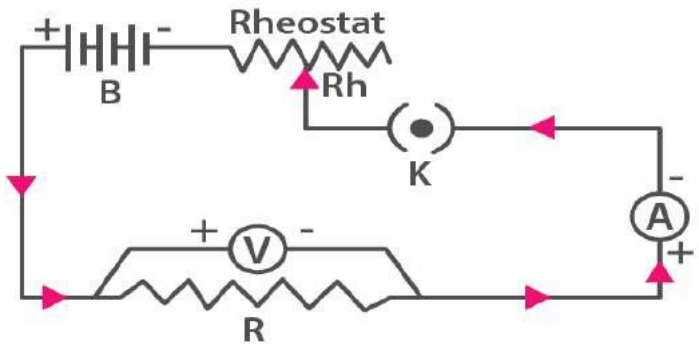
Question: 7
(a) Name the particles which are responsible for the flow of current in a metallic wire.
(b) Explain the flow of current in a metallic wire on the basis of movement of the particles named by you above in part (a).
(c) What is the cause of resistance offered by the metallic wire in the flow of current through it?
Solution:
(a) Free electrons are the particles which are responsible for the flow of current in a metallic wire
(b) Free electrons are the moving charges that result in the conduction of electricity in metals. In time 't' if 'n' electrons pass through the metallic conductor, then the total charge that has flown is given by

$$Q \text{ (charge)} = n \times e \text{ (charge on an electron)}$$

(c) A metal contain free electrons and fixed positive ions.
When electrons move through a conductor such as a metal wire then an electric current flows. In the metal, the moving electrons can collide with the ions. Thus this makes it more difficult for the current to flow and therefore causes resistance.

Question: 8
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.
Solutions:
According to Ohm's law, the current flowing in a conductor is directly proportional to the potential difference applied across its ends provided that the physical conditions and the temperature of the conductor remain constant. This is known as Ohm's law

$$V = IR$$



Question: 9

(a) Name and state the law which relates the potential difference and current in a conductor.

(b) What is the necessary condition for a conductor to obey the law named above in part (a)?

Solution:

(a) The law is known as Ohm's law. This law states that the current flowing through the conductor is directly proportional to the potential difference across its ends provided that the physical conditions and the temperature of the conductor remain constant.

(b) The necessary condition for a conductor to obey Ohm's law is that the temperature should remain constant.

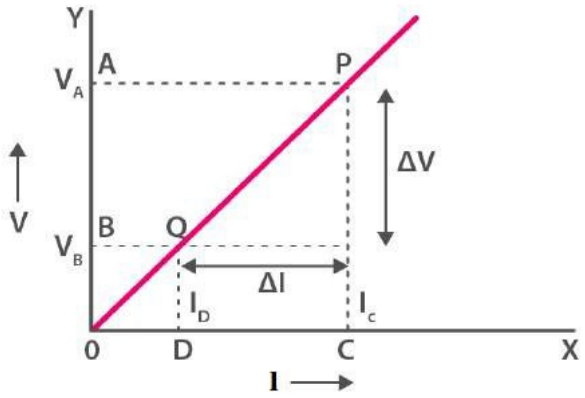
Question: 10

(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?

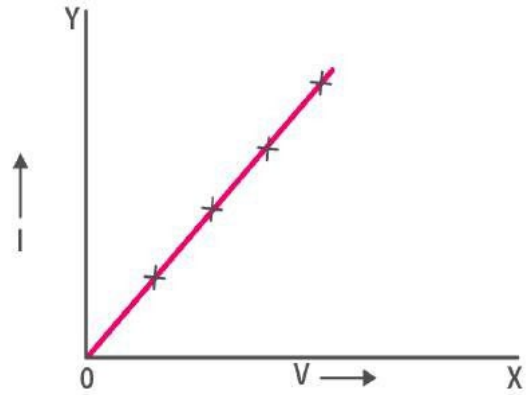
Solution:

(a) V-I graph for a conductor obeying Ohm's law is given below



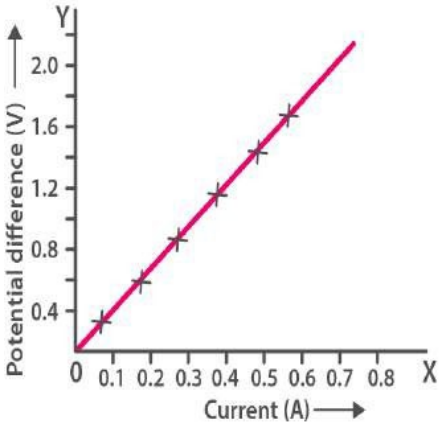
(b) Slope of V-I graph for a conductor represents resistance.

Question: 11
Draw a I-V graph for a linear resistor. What does its slope represent?
Solution:



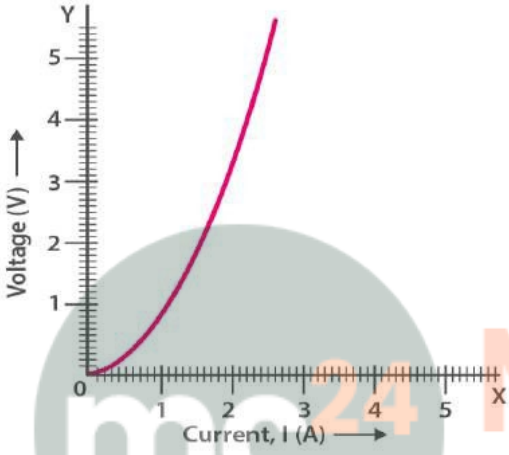
I-V graph for a linear resistor
Slope of I-V graph: The slope of I-V graph is $\Delta I / \Delta V$
$\Delta I / \Delta V$ is the reciprocal resistance of the conductor i.e.
Slope = $\Delta I / \Delta V$
= 1 / resistance of the conductor

Question: 12
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:
The conductors which obey the Ohm's law are known as the ohmic resistors or linear resistances.
Examples: All metallic conductors such as silver, aluminium, copper, iron etc.



Resistance is determined in the form of slope from the above graph

Question: 13
What are non-ohmic resistors? Give one example and draw a graph to show its current-voltage relationship.
Solution:
The conductors which do not obey the Ohm's law are known as the non-ohmic resistors or non-linear resistances).
Examples: LED, solar cell, junction diode, etc.

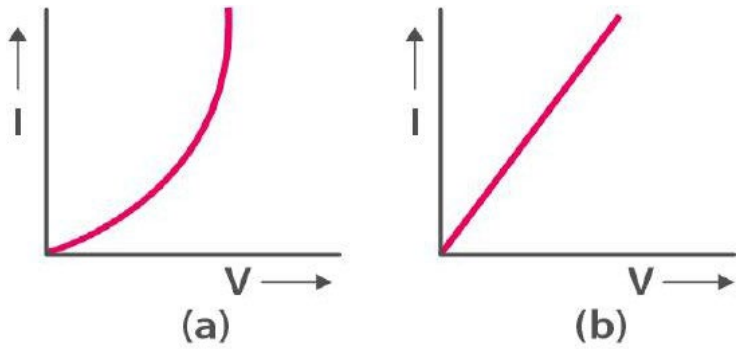


V vs I for non-ohmic conductors

Question: 14
Give two differences between an ohmic and non-ohmic resistor
Solution:

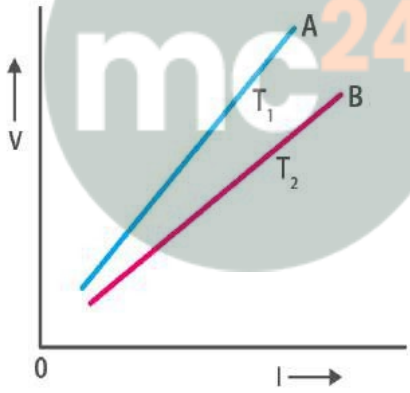
Ohmic resistor	Non-ohmic resistor
It obeys the Ohm's law i.e., V / I is constant for all values of V or I.	It does not obey the Ohm's law i.e., V / I is not same for all values of V or I.
The slope of V-I graph is same at all values of V or I at a given temperature	The slope of V-I graph is different at different values of V or I even at a given temperature

Question: 15
Fig. below shows the I-V characteristic curves for two resistors. Identify the ohmic and non-ohmic resistors. Give a reason for your answer.



Solution:
Graph (a) is non-ohmic resistor and Graph (b) is ohmic resistor
The I-V graph for (b) is a straight line or linear while the I-V graph for (a) is a curve

Question: 16
Draw a V - I graph for a conductor at two different temperatures. What conclusion do you draw from your graph for the variation of resistance of conductor with temperature?
Solution:



In the given graph above $T_1 > T_2$. The straight line A is more steeper than the line B because the resistance of conductor is more at high temperature T_1 than at low temperature T_2. Hence we can conclude that resistance of a conductor increases with the increase in temperature.

Question: 17
(a) How does the resistance of a wire depend on its radius? Explain your answer.
(b) Two copper wires are of same length, but one is thicker than the other. Which will have more resistance?
Solution:

Resistance of a wire varies inversely as the area of cross section of the wire i.e.,

$R \propto 1 / a$

$R \propto 1 / \pi^2$

Resistance of a wire is directly proportional to its length, i.e., $R \propto l$ and varies inversely as the area of cross section of the wire i.e., $R \propto 1 / a$ or $R \propto 1 / \pi r^2$

Since the resistance is inversely proportional to area of cross section, hence thin wire will have more resistance.

Question: 18

How does the resistance of a wire depend on its length? Give a reason of your answer.

Solution:

Resistance of a wire is directly proportional to the length of the wire.

$R \propto l$

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

Question: 19

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

Solution:

With the increase in temperature of a conductor, the random motion of electrons increases. This makes the number of collisions of electrons with the positive ions to increase. Hence, the resistance of a conductor increases with an increase in its temperature.

The resistance of filament of a bulb is more when it is glowing that is when it is at a high temperature as compared to when it is not glowing that is when it is cold.

Question: 20

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:

Iron has more resistivity as compared to copper which has less resistivity. So, greater the resistivity, the more the resistance is and the smaller the resistivity, the lesser the resistance. Hence, iron wire has more resistance than copper wire of the same length and same radius.

Question: 21
Name three factors on which the resistance of a wire depends and state how it is affected by the factors stated by you?
Solution:
The three factors on which the resistance of wire depends are as follows
(i) Resistance of a wire is directly proportional to its length that is

$R \propto l$

(ii) Resistance of a wire varies inversely as the area of cross section of the wire. The resistance will be less when the area of cross section of the wire is more and vice versa

$R \propto 1 / a$

(iii) Resistance of a conductor increases with an increase in its temperature. As a result the number of collisions increases.
(iv) Resistance depends on the nature of conductor since different substances have different concentration of free electrons. Substances which have a large concentration of electrons, offer less resistance and hence called good conductors and substances which have negligible concentration of free electrons offer very high resistance and are called insulators.

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

Question: 23
Write an expression connecting the resistance of a wire and specific resistance of its material. State the meaning of symbols used.
Solution:
The expression is
$R = \rho l / a$ where
ρ = specific resistance of the material of conductor
R = resistance of conductor
l = length of conductor
A = area of cross section of conductor

Question: 24
State the order of specific resistance of (i) a metal, (ii) a semiconductor and (iii) an insulator.
Solution:

(i) The specific resistance for metals is low, since it allows most of current to pass through it.
(ii) The specific resistance for semiconductor is more than metals
(iii) The specific resistance for insulators is very high, since the current won't pass through it

Question: 25
(a) Name two factors on which the specific resistance of a wire depends?
(b) Two wires A and B are made of copper. The wire A is long and thin while the wire B is Short and thick. Which will have more specific resistance?
Solution:
(a) Two factors on which the specific resistance of a wire depends are
(i) Material of the substance and
(ii) Temperature of the substance
(b) Both the wires will have the same specific resistance because the specific resistance depends on the material of the wire and not its dimensions.

Question: 26
Name a substance of which the specific resistance remains almost unchanged by the increase in temperature.
Solution:
The substance of which the specific resistance remains almost unchanged by the increase in temperature is manganin.

Question: 27
How does specific resistance of a semi-conductor change with the increase in temperature?
Solution:
With the increase in temperature, specific resistance of a semi-conductor decreases.

Question: 28
How does (a) resistance, and (b) specific resistance of a wire depend on its (i) length, and (ii) radius?
Solution:
(a) Resistance is directly proportional to length of the wire and inversely proportional to the square of radius of the wire
(b) Specific resistance of a wire do not depend on length and radius of the conductor that is independent of its length and radius.

Question: 29
(a) Name the material used for making the connection wires. Give reason for your answer.
(b) Why should a connection wire be thick?
Solution:
(a) Copper or aluminium are the materials used for making connection wires because they have small specific resistance and hence the wires of these materials possess negligible resistance
(b) The connection wires are made thick to consider their resistance as negligible to the flow of current through the circuit.

Question: 30
Name the material used for making a fuse wire. Give a reason.
Solution:
Alloy of lead and tin is used for making a fuse wire because it has high resistivity and low melting point.

MULTIPLE CHOICE TYPE
Question: 1
Which of the following is an ohmic resistance?
(a) LED
(b) Junction diode
(c) Filament of a bulb
(d) Nichrome wire
Solution:
An ohmic resistance is nichrome wire

Question: 2
For which of the following substances, resistance decreases with increase in temperature?
(a) Copper
(b) Mercury
(c) Carbon
(d) Platinum
Solution:
Resistance decreases with increase in temperature for carbon

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:

Given

Number of electrons flowing through the conductor,

$n = 6.25 \times 10^{16}$ electrons.

Time taken to flow from A to B = 2 s and $e = 1.6 \times 10^{-19}$ C

Let I be the current flowing through the conductor

Now, $I = ne / t$

Therefore $I = [(6.25 \times 10^{16}) (1.6 \times 10^{-19})] / 2$

$I = 5 \times 10^{-3}$ A or

I = 5 m A

Hence, 5 mA current flows from B to A

Question: 2

A current of 1.6 mA flows through a conductor. If charge of 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:

Given

Current, I = 1.6 m A or

$I = 1.6 \times 10^{-3}$ A

Charge, $Q = -1.6 \times 10^{-19}$ coulomb

t = 1 s

$I = Q / t$

$Q = I \times t$

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

Number of electrons $= 1.6 \times 10^{-3} / 1.6 \times 10^{-19}$

∴ Number of electrons $= 10^{16}$

Question: 3

Find the potential difference required to flow a current of 200 mA in a wire of resistance 20 ohm.

Solution:

Given

Current I = 200 mA

I = 0.2 A

Resistance R = 20 ohm
Potential difference V =?
Using Ohm's law
V = IR
V = 0.2 × 20
V = 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:

Given
Current I = 1.2 A
Potential difference or Voltage V = 6.0 V
Resistance R =?
From Ohm's law
V = IR
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:

Given
Potential difference or Voltage V = 12 V
Current I = 2 A
Resistance =?
According to Ohm's law
V = IR
R = V / I
R = 12 / 2
R = 6 Ohm
Hence, when bulb is not glowing, resistance will be less

Question: 6

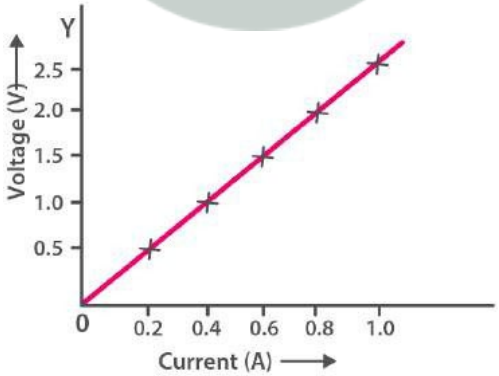
Calculate the current flowing through a wire of resistance 5 Ohm connected to a battery of potential difference 3 V.

Solution:
Given
Potential difference or Voltage V = 3 V
Resistance R = 5 Ohm
Current =?
From Ohm's law
V = IR
I = V / R
I = 3 / 5
I = 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 amp)	**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:



(a) Potential difference is 1.25 V when the current is 0.5 A
(b) Current is 0.3 A when the potential difference is 0.75 V
(c) The graph is linear and thus resistance can be found from any value of the given table.
If V = 2.5 Volt then
Current I = 1.0 amp
Using Ohm's law

$R = V / I$
$R = 2.5 / 1.0$
$R = 2.5$ Ohm

Question: 8
Two wires of the same material and same length have radii 1 mm and 2 mm respectively. Compare (i) their resistances (ii) their specific resistance.
Solution:
(i) For wire of radius r_1

$R_1 = \rho (l / A_1)$
$R_1 = \rho (l / \pi r_1^2)$

(ii) For wire of radius r_2

$R_2 = \rho (l / A_2)$
$R_2 = \rho (l / \pi r_2^2)$

$\therefore R_1 : R_2$ will be
$\rho (l / \pi r_1^2) : \rho (l / \pi r_2^2)$
$= r_2^2 : r_1^2$
(ii) The resistivities of the two wires will be same because the material of the two wires is same. That is
$\rho_1 : \rho_2 = 1 : 1$

Question: 9
A given wire of resistance 1 Ohm is stretched to double its length. What will be its new resistance?
Solution:
Let 'I' be the length and 'a' be the area of cross section of the resistor with resistance, R = 1 Ohm
A given wire is stretched to double its length,
Therefore length l' = 2l and area of cross section a' = a / 2
Now Resistance (R') = ρ l'/ a'
$R' = \rho\ 2l / a / 2$
$R' = 4\ \rho (1 / a)$
$R' = 4R$
$R' = 4 \times 1$
$R' = 4$ Ohm

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

Solution:
Given
Resistance R = 3 Ohm
Length l = 10 cm
The new length l' = 30 cm = 3 × l
R = ρ (l / A)
New resistance
Stretching length will increase and area of cross section will decrease in same order
R' = ρ (3l / A / 3)
Hence,
R' = 9 ρ (l / A)
R' = 9R
R' = 9 × 3
R' = 27 Ohm

Question: 11
A wire of resistance 9 Ohm having length 30 cm is tripled on itself. What is its new resistance?
Solution:
Given
Resistance R = 9 Ohm
Length l = 30 cm
New length l' = 3 × l
New resistance R'=?
Area of cross section will also change in same order with change in length
R' = ρ (l / 3 / 3A)
R' = 1 / 9 (ρ l / A)
R' = 1 / 9 R
R' = 1 Ohm

Question: 12
What length of copper wire of specific resistance 1.7 x 10^{-8} ohm m and radius 1 mm is required so that its resistance is 1 ohm.
Solution:
Given
Resistance R = 1 ohm
Specific resistance = 1.7 × 10^{-8} ohm m
Radius r = 1 mm that is 10^{-3} m
Length l =?

$R = \rho\, 1 / A$
$l = RA / \rho$
$l = R\pi r^2 / \rho$
$l = (1 \times \pi \times 10^{-6}) / (1.7 \times 10^{-8})$
$l = (1 \times 3.14 \times 10^{-6}) / (1.7 \times 10^{-8})$
$l = 1.847 \times 10^2$ m
$l = 184.7$ m

Question: 13
The filament of a bulb takes a current 100 mA when potential difference across it is 0.2 V. When the potential difference across it becomes 1.0 V, the current becomes 400 mA. Calculate the resistance of filament in each case and account for the difference.
Solution:
From Ohm's law
$V = IR$
$R = V / I$
$R_1 = V_1 / I_1$
$R_1 = 0.2 / 0.1$
$R_1 = 2$ ohm
Similarly
$R_2 = V_2 / I_2$
$R_2 = 1 / 0.4$
$R_2 = 2.5$ ohm
∴ With increase in temperature resistance of the wire increases. Thus resistance of filament increases with the increase in temperature.