Chapter–8 Electricity

Q.1. Define the term "Electricity".

Ans. The term electricity means the phenomenon associated with electric charges such as electrons either stationary or in motion.

Q.2. What is the function of a switch?

Ans. A switch provides a conducting link for the electric current between the cell and the bulb.

Q.3. What is an electric circuit?

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

Q.4. Why is a cell or battery always connected to an electric circuit?

Ans. A cell or a battery is connected to an electric circuit because it provides potential difference to set electrons in motion and produces or flows electric current in the circuit.

Q.5. What is an electric current? Give its SI unit.

Ans. The quantity of charge flowing through a conductor per unit time is called electric current.

OR

The rate of flow of charge through a conductor is called electric current. Its SI unit is Ampere (A).

Expression of electric current

If a net charge Q flows through a conductor in a time t, then current I flowing through the conductor is given as:

$$I = \frac{Q}{t}$$

$$Q = It$$

Q.6. Define 1 Ampere of current.

Ans. The current flowing through a conductor is said to be 1 Ampere if 1 coulomb of charge flows through it during 1 second, i.e.

$$I = \frac{Q}{t}, \quad 1\,A = \frac{1\,C}{1\,\text{sec}}$$

Note:

(i) An electron carries a negative charge of 1.6×10^{-19} C.

(ii) 1 C of charge contains 6×10^{18} electrons.

(iii) Quantization of charge: $Q = ne$, where

$$n = 1, 2, 3, \ldots$$

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

(iv) SI unit of electric charge (Q) is coulomb (C).

Ammeter: An instrument which is used to measure an electric current in a circuit is called an Ammeter. It is always connected in series in a circuit.

Q.7. What is the conventional direction of electric current?
Ans. The conventional direction of electric current is from the positive terminal of a cell or battery to the negative terminal through the outer circuit.

Q.8. What is the actual direction of electric current?
Ans. The actual direction of electric current is from the negative terminal to the positive terminal of a cell or battery.

Definition of Electric potential:
The electric potential energy per unit charge is called electric potential.

$$i.e.\text{ Electric potential} = \frac{\text{Electric potential energy}}{\text{Charge}}$$

Definition of Electric potential difference:
The electric potential difference between two points or ends of a conductor carrying current is defined as the amount of work done to move a unit charge from one point to the other.

Expression of electric potential difference:
If W is the work done to move a charge Q from one end to the other end of a conductor, then the potential difference is given as:

$$V = \frac{W}{Q}$$

$$\Rightarrow W = VQ$$

SI unit of potential difference (V) is volt (V).

Q9. Define 1 volt of potential difference.
Ans. The potential difference between two ends of a conductor carrying current is said to be 1 volt if 1 joule of work is done to move a charge of 1 coulomb across its ends.

$$V = \frac{W}{Q}$$

$$1\,V = \frac{1\,J}{1\,C} = 1\,J\,C^{-1}$$

Voltmeter: The instrument that is used to measure potential difference between two ends of a conductor is called a voltmeter. It is always connected in parallel across the ends of the conductor.

Electric Symbols: The symbols which are used to represent the different electrical components present in an electrical circuit are called electrical symbols.
For symbols refer to page no. 148, Art No. 83.

Q. State Ohm's law and from it define the resistance of a conductor.

Ans. Ohm's law states that at constant temperature, the current flowing through a conductor is directly proportional to the potential difference across its ends.

$$i.e. I \propto v \quad \text{(at constant temperature)}$$

$$i.e. v \propto I$$

$$i.e. v = RI$$

where, R is a constant called resistance.

$$i.e. R = \frac{v}{I}$$

Definition of resistance:

The resistance of a conductor is the ratio of the potential difference across its ends to the current flowing through it.

Q. Define 1 ohm of resistance.

Ans. The resistance of a conductor is said to be 1 ohm if 1 ampere of current flows through the conductor having a potential difference of 1 volt.

$$i.e. R = \frac{v}{I}$$

$$i.e. 1\,\Omega = \frac{1\,v}{1\,A} = 1vA^{-1}$$

Resistance of a conductor: The property of a conductor due to which it opposes the flow of electric current through it is called resistance of the conductor.

SI unit of resistance (R) is ohm (Ω).

Q. What are the factors on which the resistance of a metallic conductor depends? Derive an expression of the resistance based on these factors.

Ans. The resistance of a conductor depends on the following factors:

(i) The nature of the material of the conductor

(ii) Cross-sectional area of the conductor

(iii) Length of the conductor

(iv) Temperature of the conductor

Derivation: It is clear that:

Resistance of the conductor is directly proportional to the length of the conductor,

$$R \propto l \quad ------(1)$$

Resistance of the conductor is inversely proportional to the cross-sectional area of the conductor,

$$R \propto \frac{1}{A} \quad -------- (2)$$

Combining equations (1) and (2),

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

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

where ρ (rho) is a constant of proportionality called resistivity.

Rheostat: A device which is used to regulate the quantity of current in the circuit without changing the voltage of a source (battery) is called a rheostat.

Q. State two functions of a rheostat.
Ans. The two functions of a rheostat are:

(i) It regulates the quantity of current in the circuit without changing the voltage of a source.

(ii) It is also used to change the resistance in the circuit.

Q. Find the resistivity of a conductor.
Ans. Resistance of a conductor is directly proportional to the length of the conductor,

$$i.e. R \propto l \quad ------(1)$$

Resistance of a conductor is also inversely proportional to the cross-sectional area of the conductor,

$$i.e. R \propto \frac{1}{A} \quad ------(2)$$

Combining equations (1) and (2),

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

$$i.e. R = \rho \frac{l}{A}$$

where ρ (rho) = a constant of proportionality called resistivity of a conductor.

$$i.e. \qquad \rho = \frac{RA}{l} \qquad ------(3)$$

This is the required expression of resistivity.

Note:

(a) SI unit of resistivity (ρ) is ohm-metre (Ωm).

(b) Resistivity is defined as the resistance of a conductor of unit length having a cross-sectional area of $1\,m^2$.

Q. When are resistors said to be connected in series? Obtain the expression of equivalent resistance of three resistors connected in series.

Ans. A number of resistors are said to be connected in series if they are joined end to end and the same current flows through each one of them when a potential difference is applied across the combination.

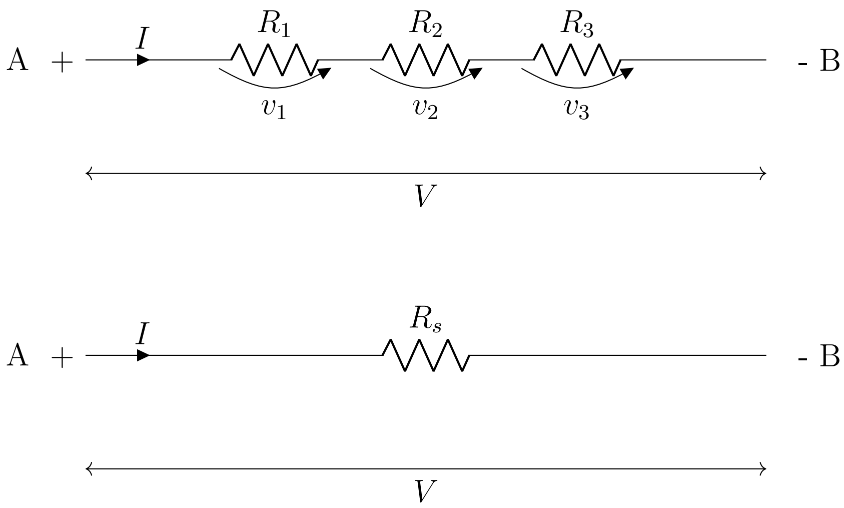

fig.

Derivation:

Let R_1, R_2, R_3 be three resistors connected in series.
Let v be the potential difference across the terminals A and B.
Let v_1, v_2, v_3 be the potential differences across R_1, R_2, and R_3 respectively.
Let I be the current flowing through the combination.

$$v = v_1 + v_2 + v_3 \quad ------(1)$$

By Ohm's law:

$$v_1 = IR_1, \quad v_2 = IR_2, \quad v_3 = IR_3 \quad ------(2)$$

Let R_s be the equivalent resistance of the series combination.

$$V = IR_s \quad (3)$$

Substituting (2) and (3) in (1), we get:

$$IR_s = IR_1 + IR_2 + IR_3$$

$$\Rightarrow R_s = R_1 + R_2 + R_3$$

This is the required expression.

Q. When are resistors said to be connected in parallel?

Ans. A number of resistors are said to be connected in parallel if one end of each resistor is connected to one point and the other end is connected to another point so that the potential difference across each resistor is the same and equal to the applied potential difference between the two points.

Q. Find the equivalent or resultant resistance of three resistors connected in parallel.

Ans.

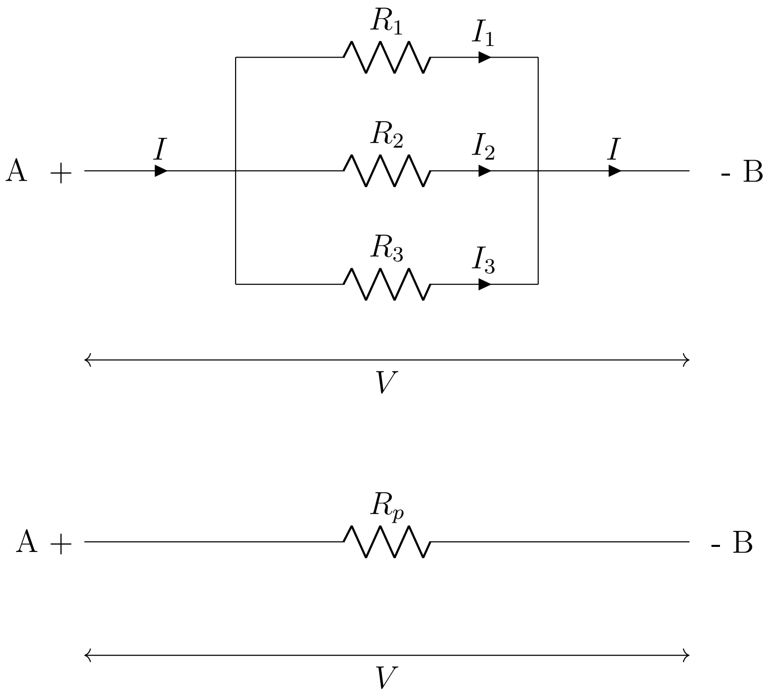

fig.

From the fig.

Let R_1, R_2, R_3 be three resistors connected in parallel.
v = pd across the points A and B
I_1, I_2, I_3 = currents flowing through R_1, R_2, and R_3 respectively.
I = total current flowing through the points A and B.

It is clear that,

$$I = I_1 + I_2 + I_3 \tag{1}$$

By Ohm's law,

$$I_1 = \frac{v}{R_1}, \quad I_2 = \frac{v}{R_2}, \quad I_3 = \frac{v}{R_3} \tag{2}$$

Let R_p be the equivalent or resultant resistance of three resistors connected in parallel. Then, by Ohm's law,

$$I = \frac{v}{R_p} \tag{3}$$

Using eqn. (2) and (3) in eqn. (1), we get

$$\frac{v}{R_p} = \frac{v}{R_1} + \frac{v}{R_2} + \frac{v}{R_3} \tag{1}$$

$$\Rightarrow \frac{v}{R_p} = v\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \tag{2}$$

$$\Rightarrow \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \tag{4}$$

Note:

(a) In series combination, the equivalent resistance is greater than the greatest resistance in the combination.

(b) Equivalent resistance, $R_s = nR$, where n = number of resistors connected in series and R = resistance of each resistor joined in series.

(c) In parallel combination, the equivalent resistance is lesser than the least of all the resistances.

(d) $R_p = \frac{R}{n}$, where n = number of resistors joined in parallel and R = resistance of each resistor joined in parallel.

(e) If two resistances R_1 and R_2 are connected in parallel, then equivalent resistance R_p is given by:

$$R_p = \frac{R_1 R_2}{R_1 + R_2} \tag{3}$$

Q. State the laws of combination of resistances in series.
Ans. The laws of series combination are:
(i) The combined resistance or equivalent resistance of any number of resistors connected in series is equal to the sum of individual resistances.
(ii) The same current flows through all resistors irrespective of the value of resistance.
(iii) The pd across each individual resistor is directly proportional to the resistance.

Q. State the laws of combination of resistances in parallel.
Ans. The laws of parallel combination are:
(i) The reciprocal of the equivalent resistance of any number of resistors connected in parallel is equal to the sum of the reciprocals of all the resistances.
(ii) The pd across each individual resistor remains same, irrespective of the values of the resistance.
(iii) The current flowing through each of the resistors is inversely proportional to the value of resistance.

Q. State three disadvantages of series combination.
Ans. The three disadvantages of series combination are:
(i) The total resistance in a series circuit is increased with the increasing number of resistors.
(ii) A smaller current will be drawn through the series arrangement.
(iii) In series combination, when one of the components gets fused, none of the components will work.

Q. State three advantages of parallel combination.
Ans. The three advantages of parallel combination are:
(i) The total resistance in a parallel circuit is decreased with the increasing number of resistors or components.
(ii) In parallel combination, a larger current will be drawn from the source (main supply).

(iii) In parallel combination, when one of the components gets fused, other components will remain working.

Q. What do you mean by heating effect of electric current or Joule heating?
Ans. The phenomenon of producing heat by the flow of electric current through a circuit is called heating effect of electric current.

Q. State Joule's Law of heating effect of electric current.
Ans. Joule's Law of heating effect of current states that heat produced in a resistor is directly proportional to:
(a) the square of the current for a given resistance, i.e., $H \propto I^2$ when R is constant.
(b) the resistance for a given current, i.e., $H \propto R$ when I is constant.
(c) the time for passing current through the resistor, i.e., $H \propto t$ when R and I remain constant.

Q. What are the applications of heating effect of electric current?
Ans. The applications of heating effect of electric current are:
(i) Heating effect of electric current or Joule's heating is used to work some electrical appliances such as electric iron, electric heater, electric cooker, electric kettle, etc.
(ii) Heating effect of current is also utilised in electric bulbs for producing light.
(iii) It is also used in electric fuse of an electric circuit.

Q. A current I amp is allowed to pass through a resistor of resistance R ohms for t seconds. Calculate the amount of heat generated in the resistor in Joules.
Ans. If w be the amount of work done to carry a charge q from one end to another end of the resistor, then
work done, $w =$ charge $(q) \times$ pd (v)
$\Rightarrow w = qv$
$\Rightarrow w = (It)v \quad [since\ q = It]$
$\Rightarrow w = vIt$
$\Rightarrow w = (IR)It \quad [since\ v = IR]$
$\Rightarrow w = I^2Rt$ —— (1)
This work done is equal to the heat generated in the resistor.
Then $w = H$, hence eqn. (1) becomes

$$H = I^2Rt \quad \text{(in joule)}$$

Q. 24. Name the inactive gases that present in an electric bulbs. Why is an electric bulb filled with these gases?
Ans. The inactive gases are Nitrogen and Argon. An electric bulb is filled with these gases in order to increase the life of the tungsten filament of the bulb.

Electric power (p): The rate at which electrical energy is consumed or dissipated in an electric circuit is called electric power.

Electric power (p) is given by:

$$p = vI \tag{1}$$
$$or,\ p = (IR)I \quad [v = IR] \tag{4}$$
$$or,\ p = I^2R \tag{2}$$
$$or,\ p = \frac{v^2}{R} \quad [I = \frac{v}{R}] \tag{5}$$
$$or,\ p = \frac{v^2}{R} \tag{3}$$

(*) SI unit of power (p) is watt (W)

Q. Define 1 watt of power.
Ans. Electric power is said to be 1 watt if 1 ampere of current flows through a circuit having a pd of 1 volt.
i.e., $p = vI$
i.e., 1 watt = 1 volt × 1 amp = 1 vA

Note:

(i) 1 kilowatt (kW) = 1000 W

(ii) 1 horse power (h.p.) = 746 W

(iii) Electrical energy consumed, E = power × time ⇒ $E = pt$

(iv) Commercial unit of electrical energy is kilowatt hour (kWh)

(v) 1 unit = 1 kWh

(vi) Unit of electrical energy is watt-hour (Wh)

(vii) $p = I^2R$, when I is constant

And $p = \frac{v^2}{R}$ when v is constant.

Q. Define 1 kWh. Find the relation between kWh and Joule.
Ans. A kilowatt hour (1 kWh) is the amount of electrical energy consumed by an electric appliance of power 1 kW when it operates for 1 hour.

$$1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ hr}$$
$$= 1000 \text{ watt} \times 60 \times 60 \text{ sec}$$
$$= 36 \times 10^5 \text{ watt-sec}$$

i.e., 1 kWh = 3.6×10^6 Joule