UNIT - IV: EFFECTS OF CURRENT

CHAPTER-11
ELECTRICITY

Topic-1 Electric Current, Ohm's Law

Concepts Covered • **Electric current and Electric potential,** • **Electric circuit and symbols of some commonly used component in circuit,** • **Ohm's law,** • **Resistance and resistivity**

Revision Notes

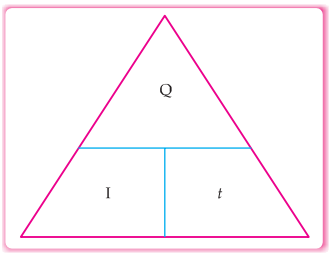
- **Charge** is a fundamental particle of matter. It may be positive and negative.
  - S.I. unit of charge is Coulomb (C).
- **Static and Current Electricity:** Static electricity deals with the electric charges at rest while the current electricity deals with the electric charges in motion.
- **Electric Current:** The electric current is defined as the rate of flow of electric charge through any cross section of a conductor.

$$\text{Electric current} = \frac{\text{Charge}}{\text{Time}} \quad \text{or} \quad I = \frac{Q}{t}$$

  - Electric current is a scalar quantity.

Mnemonics

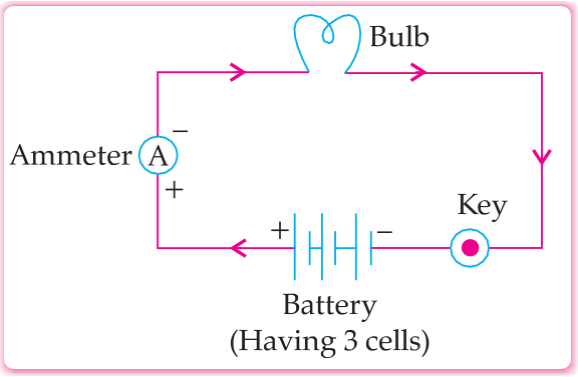
Concept: Current Formula



Interpretation:
I=Q/t
Q=I x t
t=Q /I

- **Ampere:** It is the SI unit of current. If one Coulomb of charge flows through any cross-section of a conductor in one second, then current through it is said to be one ampere.

- **Electric circuit:** The closed path along which an electric current flows is called an 'electric circuit'.
  - The schematic diagram of a typical electric circuit is



S.No.	Components	Symbol
(i)	An electric or Electronic cell	
(ii)	A battery or a combination of cells	
(iii)	Plug key of switch (open)	
(iv)	Plug key or switch (closed)	
(v)	A wire joint	
(vi)	Wire crossing without joining	
(vii)	Electric bulb	
(viii)	A resistor of resistance *R*	
(ix)	Variable resistance or rheostat	or
(x)	Ammeter	A
(xi)	Voltmeter	V

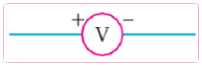
- **Conventional direction of current:** Conventionally, the direction of motion of positive charges through the conductor is taken as the direction of current. The direction of conventional current is opposite to that of the negatively charged electrons.
- **Electrochemical or voltaic cell:** It is a device which converts chemical energy into electrical energy.
- **Galvanometer:** It is a device to detect current in an electric circuit.
- **Ammeter:** It is a device to measure current in a circuit. It is a low resistance galvanometer and is always connected in series in a circuit.
- **Electric potential** is the amount of electric potential energy at a point while **Potential difference** is the difference in the amount of electric potential energy between two points in an electric circuit.
  - It is known as voltage, which is equal to the work done to move a unit charge from one point to another against static field.

$$\text{Voltage (V)} = \frac{\text{Work done (W)}}{\text{Charge (Q)}}$$

- S.I unit of potential difference is Volt (V).
- **1 Volt :** When 1 Joule of work is done in carrying one Coulomb charge then potential difference is called 1 Volt.

$$1\ V = 1\ JC^{-1}$$

Voltmeter: It is a device to measure the potential difference. It is a high resistance galvanometer and is always connected in parallel to the component across which the potential difference is to be measured. Symbol is,



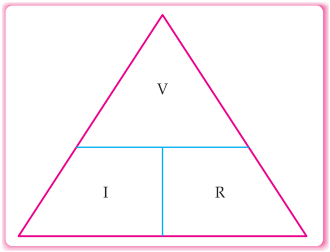
Mnemonics

Concept: Connection of ammeter and voltmeter
Mnemonics: I **A**m **S**leeping **V**ery **P**atiently
Interpretation:
Ammeter is connected in **S**eries **V**oltmeter is connected in **P**arallel

Ohm's Law: It states that "the current through a conductor between two points is directly proportional to the voltage across the two points provided external conditions remain constant".

Mnemonics

Concept: Ohm's Law



Interpretation:
To find **V**=Multiply I and R
To find **I**=Divide V and R
To find **R**=Divide V and I

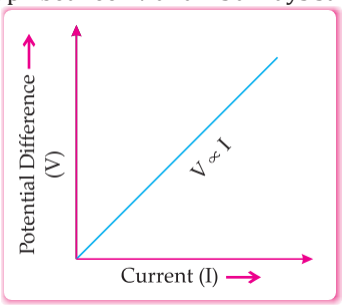
(i) Mathematical expression for Ohm's law:

$I \propto V$

$V = IR$

(where, R = Resistance)

***(ii)* *V-I* graph for Ohm's law :** The graph between *V* and *I* is always straight line with slope equals to *R*



Resistance (*R*): It is the property of a conductor to resist the flow of charges through it.

(i) S.I. unit of resistance is Ohm (Ω).

(ii) $1\ \text{Ohm} = \frac{1\ \text{Volt}}{1\ \text{Ampere}}$

- When potential difference is 1 V and current through the circuit is 1 A, then resistance will be 1 ohm.

- **Rheostat:** Rheostat is a variable **resistor** used to regulate current without changing the source of voltage.

Key Word

Resistor is a conductor which has some appreciable resistance.

- **Factors on which the Resistance of a Conductor depends:** Resistance of a uniform metallic conductor is,
  - **(i)** Directly proportional to the length of the conductor.
  - **(ii)** Inversely proportional to the area of cross-section.
  - **(iii)** Directly proportional to the temperature.
  - **(iv)** Depends on nature of the material.

- **Resistivity (ρ):** The resistance offered by a wire of unit length and unit cross-sectional area is called resistivity.
  - Its S.I. unit is Ohm-metre (Ωm).
  - Resistivity does not change with change in length or area of cross-section but it changes with change in temperature.
  - Range of resistivity of metals and alloys is 10^{-8} to 10^{-6} Ωm.
  - Range of resistivity of insulators is 10^{12} to 10^{17} Ωm.
  - Resistivity of alloy is generally higher than that of its constituent metals.
  - Alloys do not oxidize (burn) readily at high temperature, so they are commonly used in electrical heating devices.
  - Copper and aluminium are used for electrical transmission lines as they have low resistivity.

Topic-2

Resistance in Series and Parallel Combination, Electric Power and Heating Effect

Concepts Covered • **Resistance in series and in parallel combinations • Electric Power • Heating effect of electric current (Joule's law) • Applications of heating effect of electric current**

Revision Notes

- **Resistances in series:** When two or more resistances are connected end to end so that same current flows through each one of them in turn, they are said to be connected in series. Here, the total resistance is equal to the sum of the individual resistances.

$$R_S = R_1 + R_2 + R_3 + ...$$

- **Resistances in parallel:** When two or more resistances are connected across two points so that each one of them provides a separate path for current, they are said to be connected in parallel. Here, the reciprocal of their combined resistance is equal to the sum of the reciprocals of the individual resistances.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

- **Heating effect of current** : When an electric current is passed through a conductor, heat is produced in it. This is known as heating effect of current.
- **Joule's law of heating:** It states that the heat produced in a conductor is directly proportional to **(i)** the square of the current I through it, **(ii)** its resistance R and **(iii)** the time t, for which current is passed. Mathematically, it can be expressed as :

$$H = I^2 Rt \text{ Joule} = \frac{I^2 Rt}{4.18} \text{cal}$$

Or

$$H = VIt \text{ Joule} = \frac{VIt}{4.18} \text{ cal}$$

- **Practical application of the heating effect of electric current:** It is utilised in the electrical heating appliances such as electric iron, room heaters, water heaters etc. The electric heating is also used to produce light as in an electric-bulb.

Key Fact

Tungsten filament is used for making bulb. The bulbs are filled with inert nitrogen and argon gas.

- **Electric energy:** It is the total work done in maintaining an electric current in an electric circuit for a given time.
  Electric energy, $W = VIt = I^2Rt$ Joule

- **Electric Fuse:** It is a safety device that protects our electrical appliances in case of short circuit or overloading.
  (i) Fuse is made up of pure tin or alloy of copper and tin.
  (ii) Fuse is always connected in series with live wire.
  (iii) Fuse has low melting point.
  (iv) Current capacity of fuse is slightly higher than that of the appliance.
- **Electric Power:** The rate at which electric energy is consumed or dissipated in an electric circuit :

$$P = VI$$

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

Mnemonics

Concept: Formula of power
Mnemonics: 2 Iron men have Super Power.
Interpretation:
2 represents square of I.
IRon - I and R

- S.I. unit of power = Watt (W)
  1 Watt = 1 Volt × 1 ampere
- **Commercial unit of electric energy** = kilo Watt-hour (*KWh*)
  1 *kWh* = 3.6×10^6 J
  1 *kWh* = 1 unit of electric energy
- **Electrical power:** Electrical power is the rate at which electric energy is consumed by an appliance.
- **Watt:** It is the SI unit of power. The power of an appliance is 1 Watt if one Ampere of current flows through it on applying a potential difference of 1 Volt across its ends.

$$1 \text{ Watt} = \frac{1 \text{ Joule}}{1 \text{ Second}} = 1 \text{ Volt} \times 1 \text{ Ampere}$$

or $1 \text{ W} = 1 \text{Js}^{-1} = 1 \text{VA}$

1 kilowatt = 1000 W.

- **Kilowatt hour:** It is the commercial unit of electrical energy. One kilowatt hour is the electrical energy consumed by an appliance of 1000 watts when used for one hour.
  1 kilowatt hour (kWh) = $3{\cdot}6 \times 10^6$ J
- **Power rating:** The power rating of an appliance is the electric energy consumed per second by the appliance when connected across the marked voltage of the mains.
- **Efficiency of an electrical device:** It is the ratio of the output power to the input power.

$$\text{Efficiency, } \eta = \frac{\text{Output power}}{\text{Input power}}$$