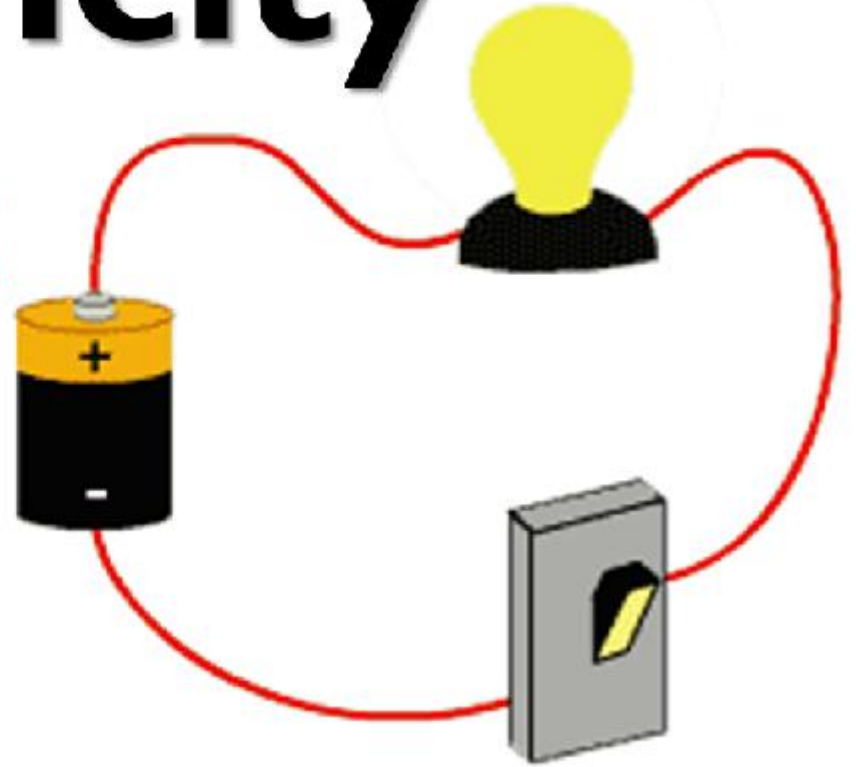# Electricity

## Chapter 12

## Class – X

**04.08.20 to 14.08.20**

# Ammeter

- An **ammeter** is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name.

- An ammeter should have a very low resistance so that it may not change the value of current flowing in the circuit.

# Voltmeter

- A **voltmeter** is an instrument used for measuring electrical potential difference between two points in an electric circuit.

- Voltmeter has a high resistance so that it takes negligible current.

# 1) **Electric current** :-

**Electric current** :- is the flow of electrons through a conductor.
The device which causes the flow of electrons through a conductor is called a cell.
Electrons flow from the negative terminal to the positive terminal.
Electric current flows from the positive terminal to the negative terminal.
This is called conventional current.

**<u>Electric current is expressed as :-</u>** The rate of flow of charges through a conductor or the quantity of charges flowing through a conductor in unit time.

**I=Q/t**

I = current

Q - quantity of charge ,          t - time

The SI unit of electric charge is **coulomb (C).** It is the charge contained in $6 \times 10^{18}$ electrons.

The SI unit of current is called **ampere (A).**

One ampere is the current flowing through a conductor if I coulomb of charge flows through it in 1 second.
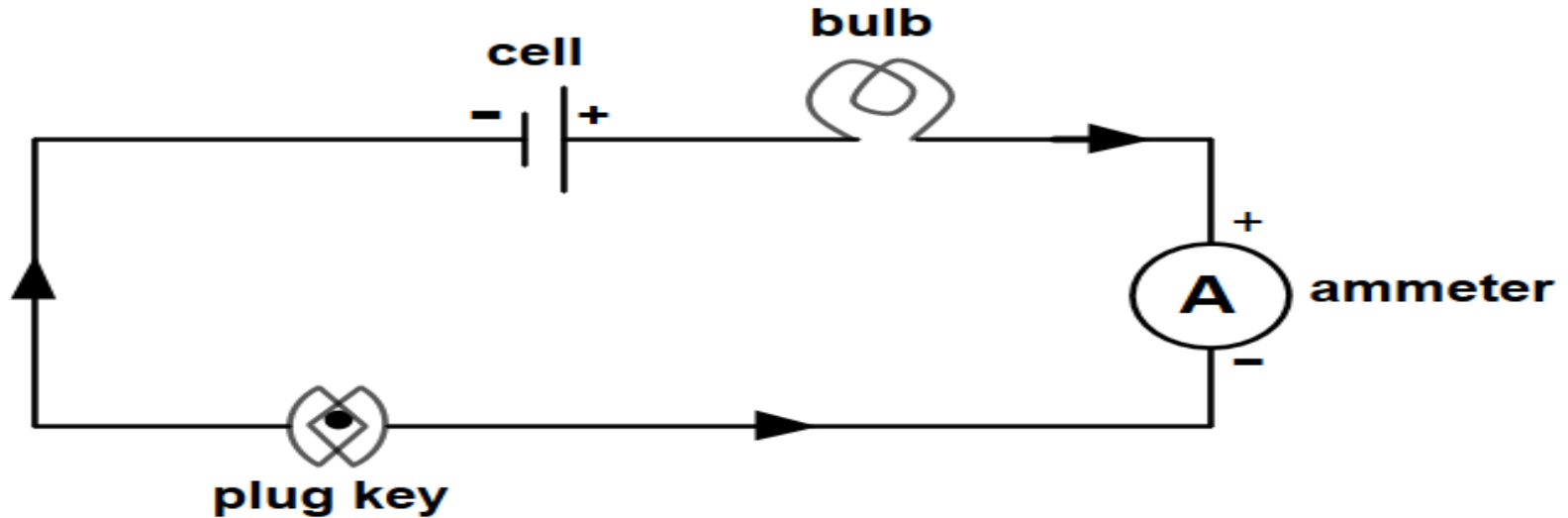
$$1 ampere = \frac{1 coulomb}{1\ second}$$

Electric Current is measured by an **ammeter.** It is always connected in series in a circuit.

# 3a) Electric circuit :-

**Electric circuit** :- is a continuous and closed path of an electric current.

A schematic diagram of an electric circuit comprising of a cell, electric bulb, ammeter and plug key.

## 2) Electric potential and Potential difference :-

Electric current will flow through a conductor only if there is a difference in the electric potential between the two ends of the conductor. This difference in electric potential between the two ends of a conductor is called **potential difference.**

The potential difference in a circuit is provided by a cell or battery. The chemical reaction in the cell produces a potential difference between the two
terminals and sets the electrons in motion and produces electric current.

# Potential difference :-

**Potential difference :-** between two points A and B of a conductor is the amount of work done to move a unit charge from A to B.

Potential difference = or $V = \dfrac{\text{Work done W}}{\text{Charge Q}}$

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

One volt is the potential difference when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

$1 \text{ volt} = \dfrac{1 \text{ joule}}{1 \text{ coulomb}}$  or  $1 \text{ V} = \dfrac{1J}{1C}$

Potential difference is measured by a voltmeter. It is always connected in parallel across the two point between which the potential difference is to be measured.

| Sl. No. | Components | Symbols |
|---|---|---|
| 1 | An electric cell | |
| 2 | A battery or a combination of cells | |
| 3 | Plug key or switch (open) | |
| 4 | Plug key or switch (closed) | |
| 5 | A wire joint | |
| 6 | Wires crossing without joining | |
| 7 | Electric bulb | or |
| 8 | A resistor of resistance $R$ | |
| 9 | Variable resistance or rheostat | or |
| 10 | Ammeter | |
| 11 | Voltmeter | |

# 4) Ohm's law :-

Ohms law is a relationship between the potential difference across a conductor and the current flowing through it.
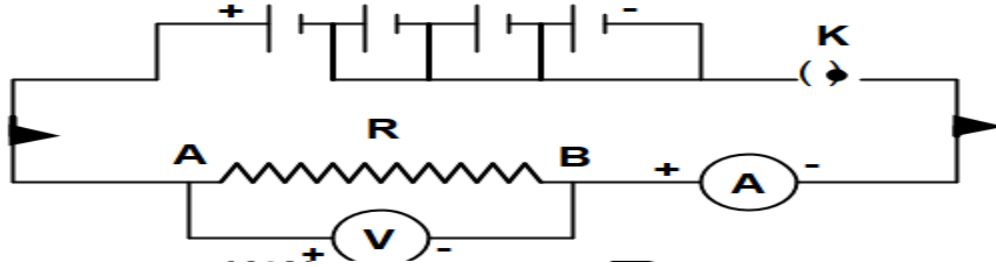
## Ohm's law states that :-

'The current flowing through a conductor is directly proportional to the potential difference between its ends provided its temperature remains constant.'

I α V or V α I or V=I*R

Where R is a constant called resistance for a given metallic wire at a given temperature.

Verification of Ohm's law :-

# Verification of Ohm's law :-



Set up the circuit as shown in the circuit diagram. First use one cell and note the current (I) in the ammeter and the potential difference (V) in the voltmeter across the nichrome wire AB. Repeat by using two cells, three cells and four cells and note the readings in the ammeter and voltmeter. Then plot a graph between the current (I) and potential difference (V). The graph will be a straight line.
This shows that the current flowing through a conductor is directly proportional to the potential difference across its ends.

I α V or V α I or V=I*R

where R is a constant called resistance of the conductor.
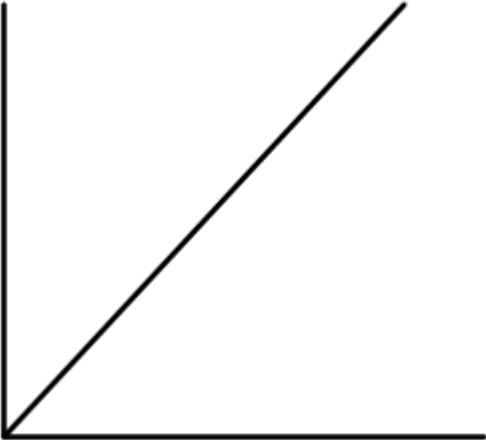
# 5a) Resistance :-

Resistance is the property of a conductor to resist the flow of current through it.

According to Ohm's law   $R = \dfrac{V}{I}$

The SI unit of resistance is **ohm (Ω).**
If the potential difference across the two ends of a wire is 1 V and the current flowing through it is 1 A then the resistance R of the conductor is 1 ohm (1 Ω ).

Since    $I = \dfrac{V}{R}$

The current flowing through a resistor is inversely proportional to the resistance.
So if the resistance is doubled, then the current gets halved.

# Resistivity

- It has been found by experiments that :
- The resistivity of a given of a given conductor is directly proportional to its length.
- The resistivity of a given conductor is inversely proportionWhere $p$(rho) is a constant known as resistivity of the material.
- The resistivity of a substance is numerically equal to the resistance of a rod of that substance which is 1 meter long and 1 square meter in cross section.

- Resistivity, $p = \dfrac{R \times A}{l}$.
- The unit of resistance R is ohm.

## b) Factors on which the resistance of a conductor depends:-

The resistance of a conductor depends upon its:-
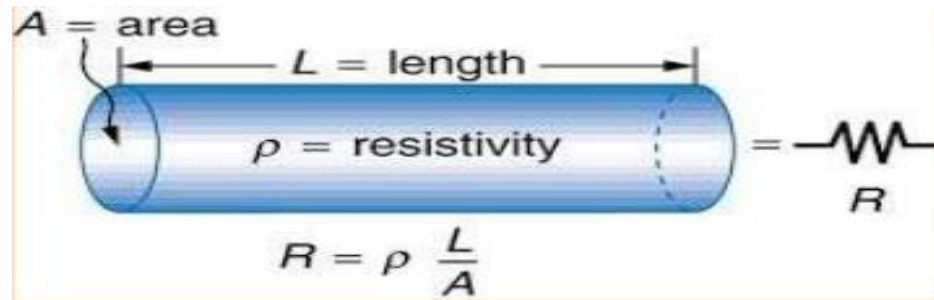
i) Length

ii) Area of cross section

iii) Material of the conductor.

Resistance is directly proportional to the length of the conductor and inversely proportional to the area of cross section of the conductor.

$R \propto L$ ,   $R \propto 1/A$

$R \propto L /A$

or $R = \rho \dfrac{L}{A}$



$A = \text{area}$

$L = \text{length}$

$\rho = \text{resistivity}$

$R = \rho \dfrac{L}{A}$

$R$

Where $\rho$ (rho) is a constant of proportionality called Resistivity of the material of the conductor.

The SI unit of resistivity is **ohm meter ( Ωm).**

Conductors like metals and alloys have low resistivity $10^{-8}$ Ωm to $10^{-6}$ Ωm.

Insulators like rubber, glass etc. have high resistivity $10^{12}$ Ω

# 6a) <u>Resistors in series</u> :-

When three resistors $R_1$, $R_2$ and $R_3$ are connected in series
i) The current in all the resistors is the same.
ii) The total voltage (PD) across the resistors is equal to the sum of the voltage across each resistor.
$V = V_1 + V_2 + V_3$
iii) The equivalent resistance is the sum of the resistances of each resistor.
$R_S = R_1 + R_2 + R_3$

# b) Resistors in parallel :-

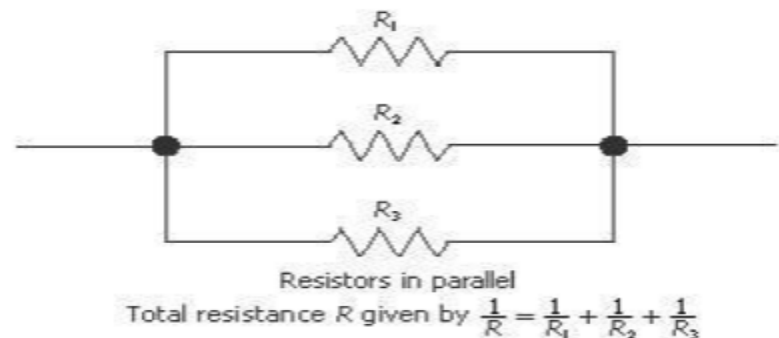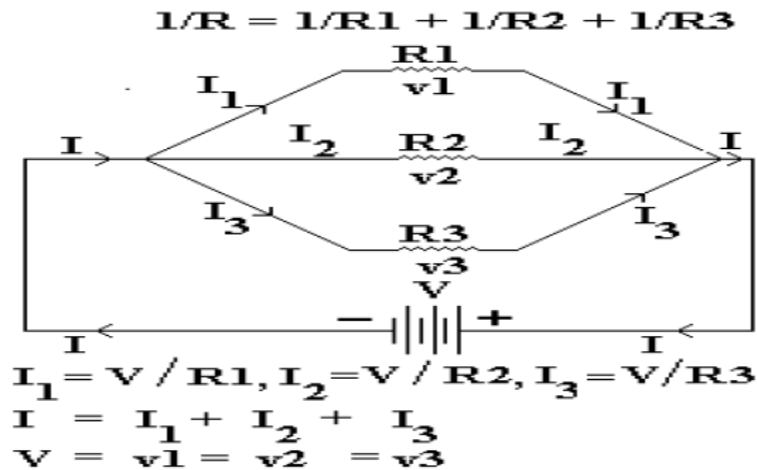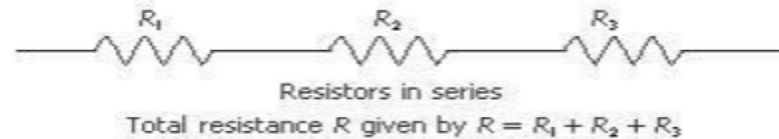When three resistors R1, R2 and R3 are connected in parallel across AB,
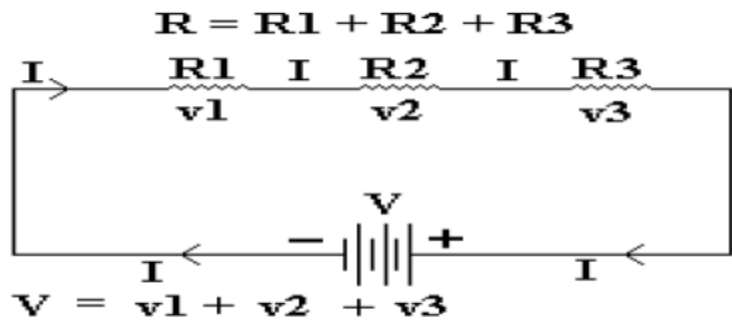i) The voltage (PD) in all the resistors is the same.
ii) The total current in all the resistors is the sum of the current in each resistor. I = I1 + I2 + I3
iii) The reciprocal of the equivalent resistance is the sum of the reciprocals of each resistance.

$$\frac{1}{Rp} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

# Resistors in series and in parallel :-

$$R = R1 + R2 + R3$$

$$V = v1 + v2 + v3$$

Resistors in series

Total resistance $R$ given by $R = R_1 + R_2 + R_3$

$$1/R = 1/R1 + 1/R2 + 1/R3$$

$$I_1 = V / R1, I_2 = V / R2, I_3 = V/R3$$

$$I = I_1 + I_2 + I_3$$

$$V = v1 = v2 = v3$$

Resistors in parallel

Total resistance $R$ given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

| Parallel connection | Series connection |
|---|---|
| ▸ If one electric appliance stops working due to some defect, then all other appliances keep working normally.<br><br>▸ In parallel circuits, each electric appliance has its own switch due to which it can be turned on or off independently.<br><br>▸ Each appliance gets same voltage as that of power source. | ▸ If one electric appliance stop working due to some defect, then all other appliances stop working.<br>▸ All the electric appliances have only one switch due to which they cannot be turned on or off separately.<br>▸ In series circuit, the appliances do not get same voltage (220 V) as that of the power supply line.<br>▸ In series circuit the overall resistance of the circuit increases due to which the current from the power source is low. |

# Heating effect of electric current

- When electricity passes through a high resistance wire like a nichrome wire, the resistance wire becomes very hot and produces heat. This is called the heating effect of current.

# 7) Heating effect of electric current :-

If a current I flows through a resistor of resistance R and t be the time for which a charge Q flows through it, then the work done to move the charge through potential difference V

W = Q X V
P = W/t = Q X V/t                   as Q = I x t
P= I X t X V/t     or
P = V X I
or
Heat energy supplied = P X t = V X I X t
According to Ohm's law    V = IR
Heat produced **H = I$^2$Rt**

# 8) Electrical energy and Electric power :-

**i) Electrical energy :-** is the work done to maintain the flow of current in a conductor.

$W = Q \times V$  $\qquad (I = Q / t \implies Q = I \times t)$

$W = I \times t \times V$  $\qquad (V = IR)$

$\mathbf{W = I^2Rt}$

The unit of electrical energy is joule (J).

**ii) Electric power :-** is the rate at which electric current is used.

Power = Work done/time $\implies P = W/t$  $\qquad$ as $W = I^2Rt$  $\qquad P = I^2Rt/t$

Power = $I^2R$  $\qquad$ as $R = V/I$ $\implies P = I^2 \times V/I \implies \mathbf{P = I \times V}$

The SI unit of power is **watt (W).**

One watt is the power when 1A of current flows across a potential difference of 1V.

1000 W = 1kW  $\qquad$ 1kWh = 1000 watt x 3600 seconds = $3.6 \times 10^6$ joules

THANKS