JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

Electricity - I

New york

- **In 1882**, when it was sun set in the west that miracle happened in New york city.
- When Thomas Alva Edison gently pushed the switch on 14,000 bulbs in 9,000 houses suddenly got lighted up.

Thomas Alva Edison (February 11, 1847 – October 18, 1931) was an American inventor. He invented more than 1000 useful inventions and most of them are electrical appliances used in homes. He is remembered for the invention of electric bulb.


Thomas Alva Edison

India

- **Seventeen years after** the New York, in **1899** electricity first came to India.
- **The Calcutta Electric Supply Corporation Limited** commissioned the first thermal power plant in India on 17 April 1899

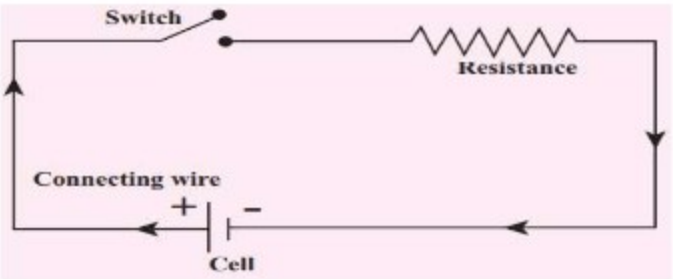
Madras

Around **1900s,** a thermal power station was set up at **Basin Bridge in Madras city**

Electric circuit diagram

The four main components of any circuits namely,

(i) cell, (ii) connecting wire, (iii) switch and (iv) resistor or load

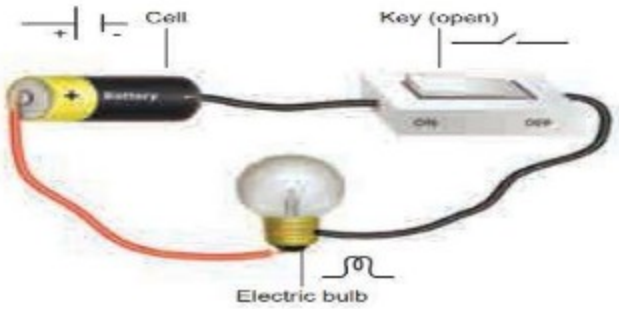


Electric Circuits

The path through which electrons flow from one terminal to another terminal of the source, is called electric circuit.

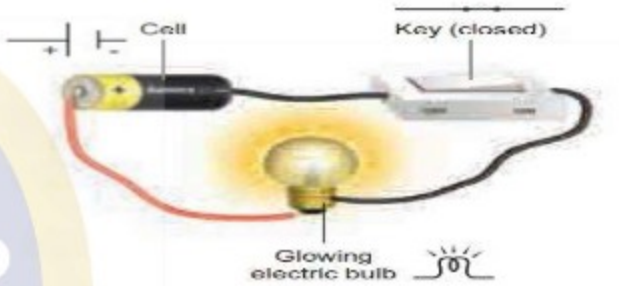
a.Open Circuit

- In a circuit if the **key is in open (off) condition**, then electricity will not flow and the circuit
- **The bulb will not glow** in this circuit.



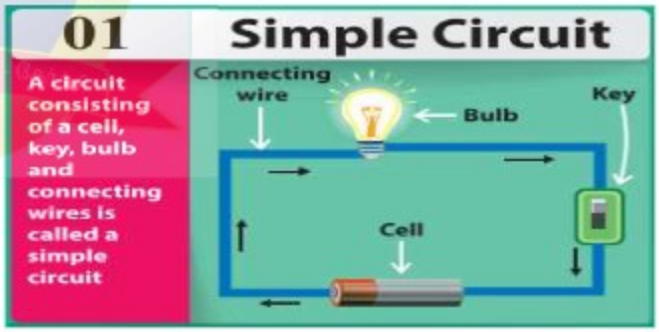
b. Closed Circuit

- In a circuit if the **key is in closed (on) condition**, then electricity will flow and the circuit
- The **bulb will glow** in this circuit.

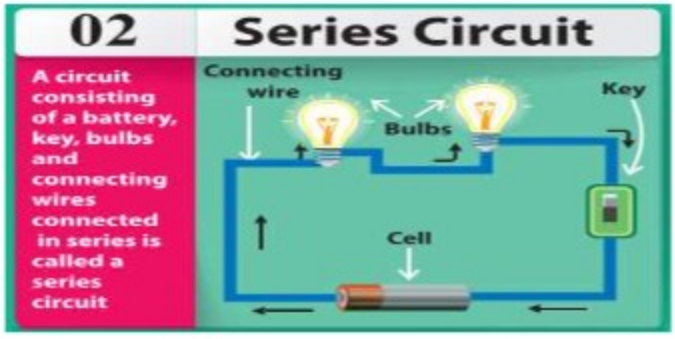


Types of Circuits

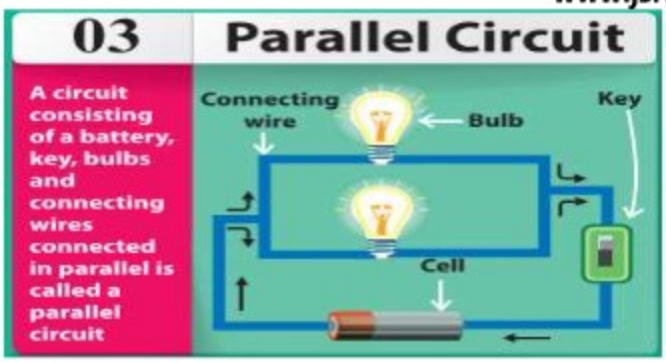
1. Simple Circuit

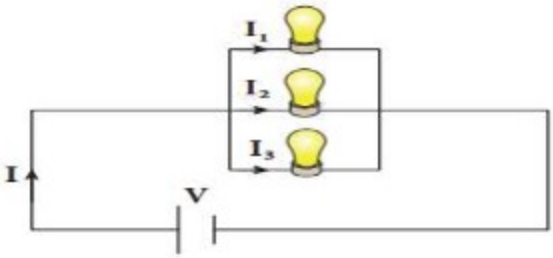


2. Series Circuit



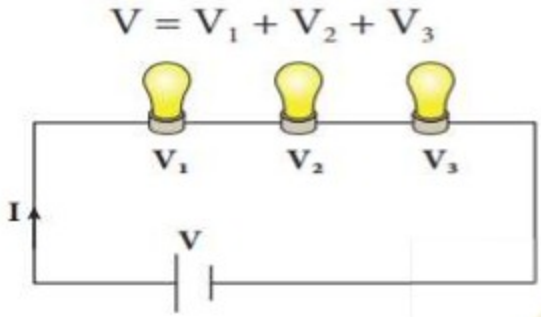
3. Parallel Circuits





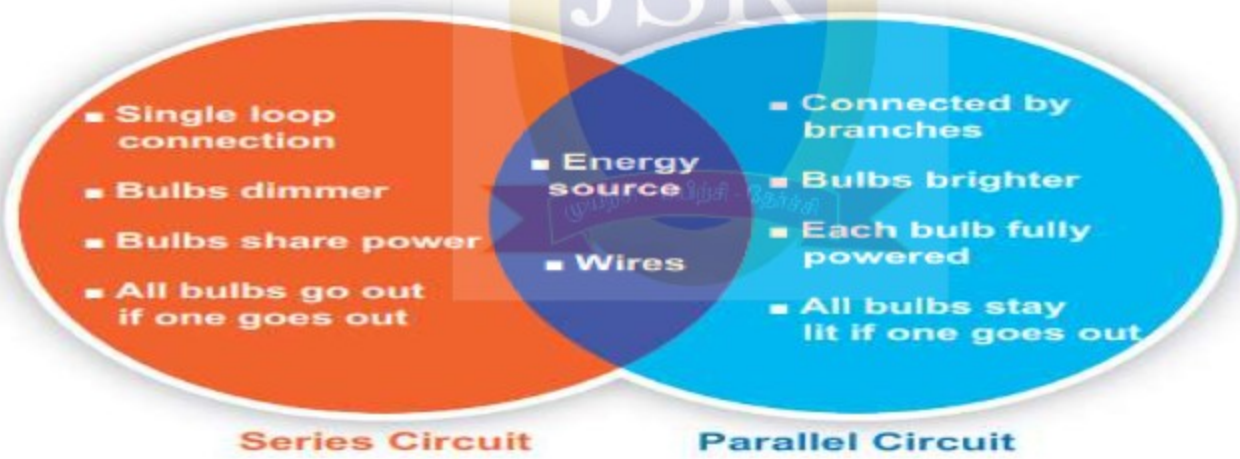
$I = I_1 + I_2 + I_3$

Series Circuit



Series circuit	Parallel circuit
Same amount of current flows through all the components.	The current flowing through each component combines to form the current flow.
Voltage is different across different components.	Sum of the voltage through each component will be the voltage drawn from the source.
Components are arranged in a line.	Components are arranged parallel to each other.
If one component breaks down, the whole circuit will burn out.	Other components will function even if one component breaks down.

Parallel Circuit



S. No.	CRITERIA	SERIES	PARALLEL
1	Equivalent resistance	More than the highest resistance.	Less than the lowest resistance.
2	Amount of current	Current is less as effective resistance is more.	Current is more as effective resistance is less.
3	Switching ON/OFF	If one appliance is disconnected, others also do not work.	If one appliance is disconnected, others will work independently.

DO YOU KNOW?

Short circuit

You might have observed the spark in the electric pole located nearby your house. Do you know the cause of this electric spark? This is due to the short circuiting of electricity along its path.A short circuit is simply a low resistance connection between the two conductors supplying electrical power to any circuit.

Arc welding is a common example of the practical application of the heating due to a short circuit.

Conductors

- The materials which **allow electric charges to pass through** them are called conductors.
- Examples: **Copper, iron, aluminum, impure water, earth etc.,**

Insulators (Non-Conductors)

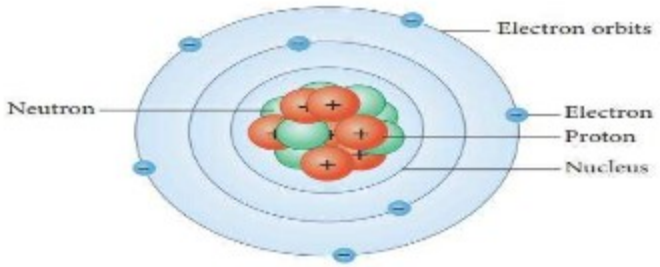
- The materials which **do not allow electric charges to pass through them** are called insulators or nonconductors.
- Examples: **plastic, glass, wood, rubber, china clay, ebonite etc.,**

Insulators

- Those materials which don't have enough 'free electrons' are not good at conducting electricity or we can say that they would be 'poor conductors' of electricity and they are called insulators.

Atom

- The centre of the atom is called the nucleus.
- The **nucleus consists of protons and neurtrons**.
- Protons are positively charged. Neutrons have no charge.
- Negatively charged electrons revolve around the nucleus in circular orbits.
- In an atom, **the number of protons and the number of electrons will be equal.**
- There is a force of attraction between the protons in the nucleus and the electrons in the orbits.
- Electrons in the inner orbits are strongly attracted by the protons and they cannot be removed from the atom easily.
- But, the electrons in the outermost orbits are loosely bound and they can be easily removed from the atom.
- Electricity is a form of energy that is associated with electric charges that exists inside the atom



Electric charge

- Electric charge is measured in **coulomb (C).**
- One unit of coulomb is charge of approximately **6.242×10^{18}** protons or electrons.
- The **charge of an electron is numerically a very tiny value**.
- The charge of an electron **(represented as e)** is the fundamental unit with a charge equal to **$e=1.6\times10^{-19}$ C.**
- This indicates that any charge **(q)** has to be an integral multiple **(n)** of this fundamental unit of electron charge **(e).**
- Electrical charges are generally denoted by the letter **`q`**
- **q = ne**. Here, n is a whole number.
-
- Since protons and electrons are equal in number, an atom is electrically neutral.

How many electrons will be there in one coulomb of charge?

Solution:

Charge on 1 electron, $e = 1.6 \times 10^{-19}$ C

$q=ne$ or $n=q/e$

$\therefore$ number of electrons in 1 coulomb

$$= \frac{1}{1.6\times10^{-19}} = 6.25\times10^{18} \text{ electrons}$$

a system has **two charges +5C and –2C.** Then the **total or net charge** on the system is, **(+5C) + (–2C) = +3C.**

DO YOU KNOW? Electrostatic forces between two point charges obey Newton's third law. The force on one charge is the action and on the other is reaction and vice versa.

Flow of Charges

- electrons flow from lower potential to higher potential. This is known electric current (flow of electrons).
- Flow of positive charge is called conventional current.
- Conventional current flows from higher potential to lower potential.

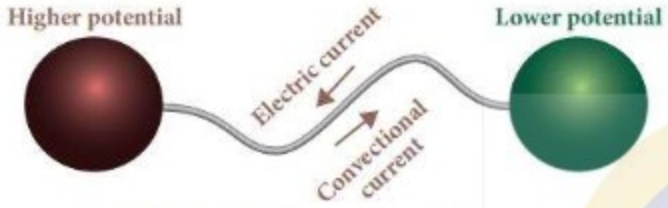


Figure 2.6 Transfer of charges

Conventional current is in the direction opposite to electron flow.

Free charge

- Many of these particles are fixed to the atoms but in conductors (such as all metals) there are **lots of particles that are not held to any particular atom but are free to wander around randomly in the metal**.

Electric Current

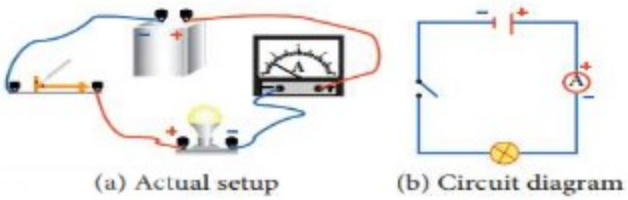
- The **flow of electric charges** constitute an electric current.
- An electric current is measured by the amount of electric charge moving per unit time at any point in the circuit.
- The conventional symbol for current is **'I'.**
- The SI unit for measuring an electric current is the **ampere,**
- Current of 1 ampere means that there is one coulomb (1C) of charge passing through a cross section of a wire every one second (1 s).
- **1 ampere = 1 coulomb / 1 second**
- **(or)**
- **1 A = 1 C / 1 s = 1Cs-1**

$I = q / t$

- $I \Rightarrow$ current (in Ampere - A)
- $q \Rightarrow$ charge (in coulomb - c)
- $t \Rightarrow$ time taken (in seconds - s)

Measurement of electric current

- **Ammeter** is an instrument **used to measure the strength of the electric current in an electric circuit.**
- **The ammeter is connected in series in a circuit** where the current is to be found. .
- The current flows through the positive (+) red terminal of ammeter and leaves from the negative (–) black terminal.



(a) Actual setup (b) Circuit diagram

Figure 4.6 Ammeter in a circuit

The current flowing through a lamp is 0.2A. If the lamp is switched on for one hour, what is the total electric charge that passes through the lamp?

Solution:

$I = q / t; q = I \times t$

$1hr = 1 \times 60 \times 60\ s = 3600\ s$

$q = I \times t = 0.2\ A \times 3600\ s = 720\ C$

A charge of 12 coulomb flows through a bulb in 5 second. What is the current through the bulb?

Solution:

Charge Q = 12 C, Time t = 5 s. Therefore,

$$\text{current } I = \frac{Q}{t} = \frac{12}{5} = 2.4\ A$$

If 30 coulomb of electric charge flows through a wire in two minutes, calculate the current in the wire?

Solution

Given :

Charge (q) = 30 coulomb

Time (t) = 2 min x 60s

= 120 s

Current I = q/t = 30C/120s = 0.25 A

Types of current

1. Direct current (dc)
2. Alternating current (ac).

Direct current

- Electrons move from negative terminal of the battery to positive of the battery.
- Battery is one of the sources for dc current.
- The dc is due to the unidirectional flow of electric charges.
- Some other sources of dc are solar cells,thermocouples etc.

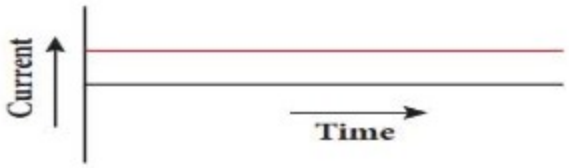
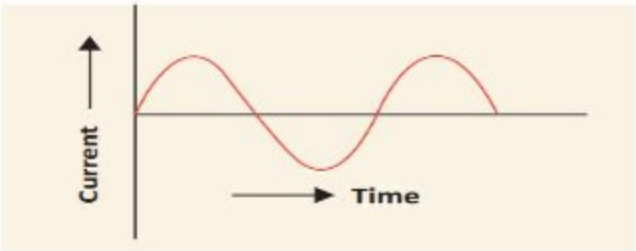


Figure 4.13 Wave form of dc

Alternating current

If the direction of the current in a resistor or in any other element changes its direction alternately, the current is called an alternating current.

- The alternating current varies sinusoidally with time.
- This variation is characterised by a term called as frequency.
- Frequency is the number of complete cycle of variation, gone through by the ac in one second.
- In ac, the electrons do not flow in one direction because the potential of the terminals vary between high and low alternately.
- Thus, the electrons move to and fro in the wire carrying alternating current.



- The device used to convert ac to dc is called **rectifier.**
- Colloquially it is called with several names **like battery eliminator, dc adaptor** and so on.
- The device used to convert dc into ac is called **inverter.**

Advantages of ac over dc

- The voltage of ac can be varied easily using a device called transformer.
- The ac can be carried over long distances using step up transformers.
- The loss of energy while distributing current in the form of ac is negligible. Direct current cannot be transmitted as such.
- The ac can be easily converted into dc and generating ac is easier than dc.
- The ac can produce electromagnetic induction which is useful in several ways.

Advantage of dc

- Electroplating, electro refining and electrotyping can be done only using dc.
- Electricity can be stored only in the form of dc.