ELECTRIC CHARGE AND FIELD

CHARGING BY INDUCTION

Charging of a body

A body can be charged by means of

(a) Friction,

(b) Conduction,

(c) Induction,

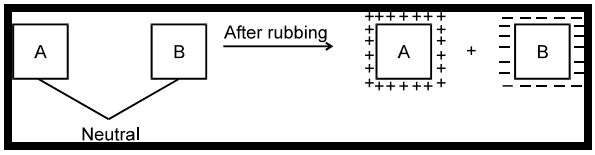
(d) Thermionic ionization or thermionic emission

(e) Photoelectric effect

(f) Field emission.

Charging by Friction:

When a neutral body is rubbed against other neutral body then some electrons are transferred from one body to other. The body which can hold electrons tightly, draws some Electrons and the body which cannot hold electrons tightly, looses some electrons. The body which draws electrons becomes negatively charged and the body which looses electrons become positively charged.



For example:

Suppose a glass rod is rubbed with a silk cloth. As the silk can hold electrons more tightly and a glass rod can hold electrons less tightly (due to their chemical properties), some electrons will leave the glass rod and gets transferred to the silk. So in the glass rod their will be deficiency of electrons, therefore it will become positively charged. And in the silk there will be some extra electrons, so it will become negatively charged

Charging by conduction (flow):

There are three types of material in nature

(i) Conductor:

Conductors are the material in which the outer most electrons are very loosely bounded, so they are free to move (flow). So in a conductors, there are large number of free electrons.

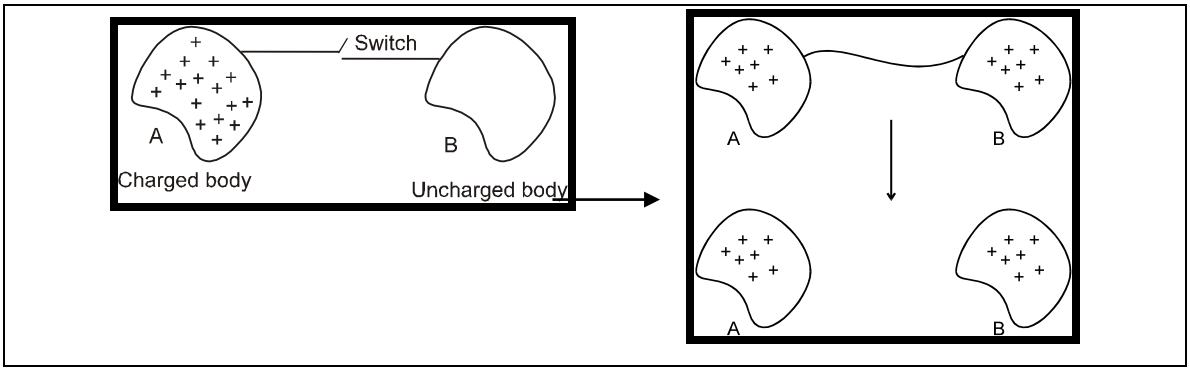
Ex. Metals like Cu, Ag, Fe, Al.....

(ii) Insulator or Dielectric or Nonconductor:

Non-conductors are the materials in which outer most electrons are very tightly Bounded, so they cannot move (flow). Hence in a non-conductor there is no free Electrons. Ex. plastic, rubber, wood etc.

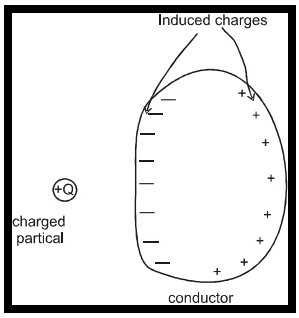
(iii) Semiconductor:

Semiconductor are the materials which have free electrons but very less number. Now Let's see how the charging is done by conduction. In this method we Take a charged conductor 'A' and an uncharged conductor 'B'. When both are Connected some charge will flow from the charged body to the uncharged body. If both The conductors are identical & kept at large distance, if connected to each other, then Charge will be divided equally in both the conductors otherwise they will flow till their Electric potential becomes same. Its detailed study will be done in last section of this chapter.



Charging by Induction:

To understand this, let's have introduction to induction



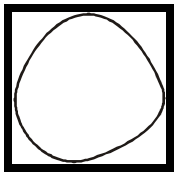
We have studied that there are lot of free electrons in the conductors. When a charge particle +Q is brought near a neutral conductor. Due to attraction of +Q charge, many electrons (–ve charges) come closer and accumulate on the closer surface.

On the other hand a positive charge (deficiency of electrons) appears on the other surface. The flow of charge continues till there is resultant force on free electrons of the conductor becomes zero. This phenomena is called induction, and charges produced are called induced charges.

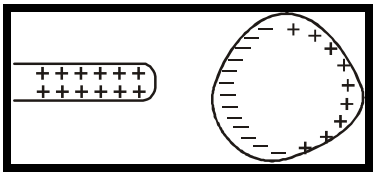
A body can be charged by induction in the following two ways :

Method I :

Step 1. Take an isolated neutral conductor.

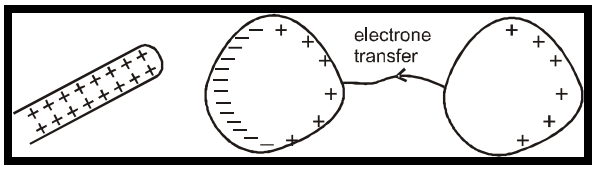


Step 2. Bring a charged rod near to it. Due to the charged rod, charges will induce on the conductor.

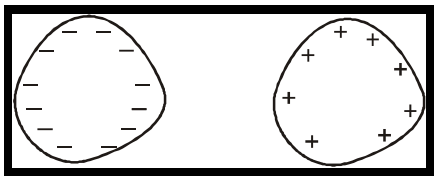


Step 3. Connect another neutral conductor with it. Due to attraction of the rod, some free electrons will move from the right conductor to the left conductor and due to

deficiency of electrons positive charges will appear on right conductor and on the left conductor there will be excess of electrons due to transfer from right conductor



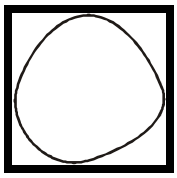
Step 4. Now disconnect the connecting wire and remove the rod.



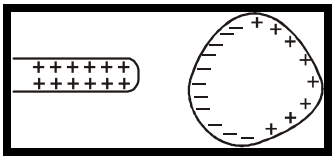
The first conductor will be negatively charged and the second conductor will be positively charged

Method II

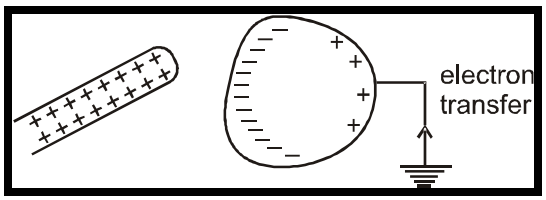
Step 1. Take an isolated neutral conductor



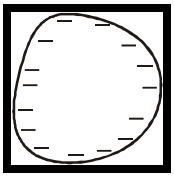
Step 2. Bring a charged rod near to it. Due to the charged rod, charges will induce on the conductor.



Step 3. Connect the conductor to the earth (this process is called grounding or earthling). Due to attraction of the rod, some free electrons will move from earth to the conductor, so in the conductor there will be excess of electrons due to transfer from the earth, so net charge on conductor will be negative.

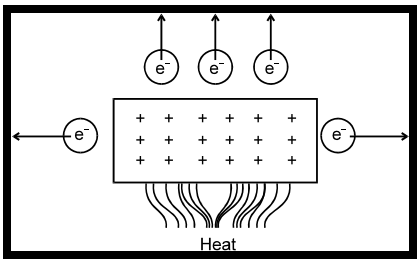


Step 4. Now disconnect the connecting wire. Conductor becomes negatively charge.



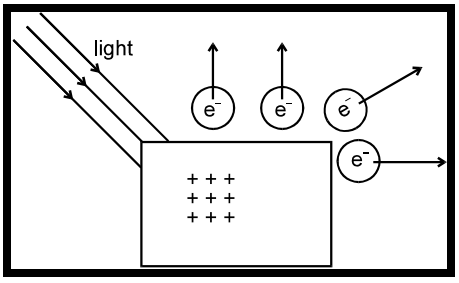
(d) Thermionic emission:

When the metal is heated at a high temperature then some electrons of metals are Ejected and the metal becomes positively charged.



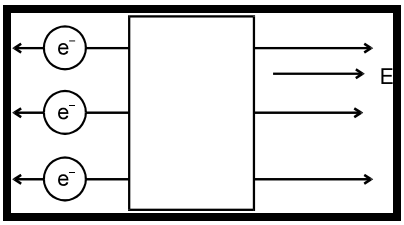
(e) Photoelectric effect:

When light of sufficiently high frequency is incident on metal surface then some Electrons gains energy from light and come out of the metal surface remaining Metal becomes positively charged



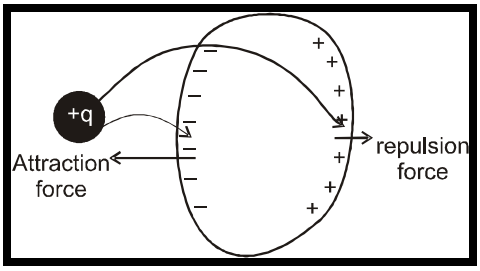
(f) Field emission:

When electric field of large magnitude is applied near the metal surface then some electrons come out from the metal surface hence the metal gets positively charged.



Example 1 If a charged body is placed near a neutral conductor, will it attract the conductor or repel it?

Solution.



If a charged body (+ve) is placed leftside near a neutral conductor, (–ve) charge will induce at left surface and (+ve) charge will induce at right surface. Due to positively charged body –ve induced charge will feel attraction and the +ve induced charge will feel repulsion. But as the –ve induced charge is nearer, so the attractive force will be greater than the repulsive force. So the net force on the conductor due to positively charged body will be attractive. Similarly we can prove for negatively charged body also. From the above example we can conclude that. "A charged body can attract a neutral body."If there is attraction between two bodies then one of them may be neutral. But if there is repulsion between two bodies, both must be charged (similarly charged). So **"repulsion is the sure test of electrification".**

Example A positively charged body 'A' attracts a body 'B' then charge on body 'B' may be:

(A) positive (B) negative (C) zero (D) can't say

Answer. B, C

Example Five styrofoam balls A, B, C, D and E are used in an experiment. Several experiments are performed on the balls and the following observations are made

(i) Ball A repels C and attracts B.

(ii) Ball D attracts B and has no effect on E.

(iii) A negatively charged rod attracts both A and E.

For your information , an electrically neutral styrofoam ball is very sensitive to charge induction, and gets attracted considerably, if placed nearby a charged body. What are the charges, if any, on each ball ?

	A	B	C	D	E
(A)	+	–	+	0	+
(B)	+	–	+	+	0
(C)	+	–	+	0	0
(D)	–	+	–	0	0

Answer. C

Solution. From (i), As A repels C, so both A and C must be charged similarly. Either both are +ve or both are –ve. As A also attract B, so charge on B should be opposite of A or B may be uncharged conductor.

From (ii) As D has no effect on E, so both D and E should be uncharged, and as B attracts uncharged D, so B must be charged and D must be on uncharged conductor.

From (iii) a –ve charged rod attract the charged ball A, so A must be +ve, and from exp. (i) C must also be +ve and B must be –ve.

Example . Charge conservation is always valid. Is it also true for mass?

Solution. No, mass conservation is not always. In some nuclear reactions, some mass is lost and it is converted into energy.

Example 5. What are the differences between charging by induction and charging by conduction?

Solution. Major differences between two methods of charging are as follows :

(i) In induction, two bodies are close to each other but do not touch each other while in conduction they touch each other. (or they are connected by a metallic wire)

(ii) In induction, total charge of a body remains unchanged while in conduction it changes.

(iii) In induction, induced charge is always opposite in nature to that of source charge while in conduction charge on two bodies finally is of same nature.