Electric Charges & Fields.

In our daily life we may observe crackling sound when we are taking dried synthetic clothes from the wire and when we sit or getting up from the chair we may feel some electric shock.

What is the reasons for all these examples, here we will learn.

Electric charge

* Amber rubbed with wool or silk cloth, attracts light objects.
* Cut out along thin strips of white paper and lightly iron them. Take them near TV screen or a monitor, you may observe that these white papers are attracted and stick to the screen for a while

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* It was observed that if two glass rods rubbed with wool or silk cloth are brought close to each other, they repel each other. glass rod and wool will attract each other.

* Similarly two plastic rods rubbed with cat's fur repelled with each other, but attracted the fur.

On the other hand plastic rod attracts glass rod and repel each other, but attracted the fur.

* From all these examples we can say that like charges repel each other and unlike charges attract each other.

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*. Charges acquired after rubbing are lost when the charged bodies are brought in contact.

- If an object possesses an electric charge it is said to be electrified or charged
- When it has no charge it is said to be neutral.

CONDUCTORS AND INSULATORS

Conductor: The materials which allow electricity to pass through them easily are called as conductors

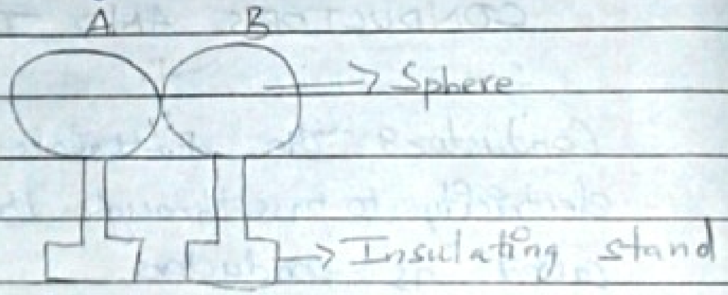
Example: All the metals

Insulators: The materials which do not allow electricity to pass through them are called as insulators

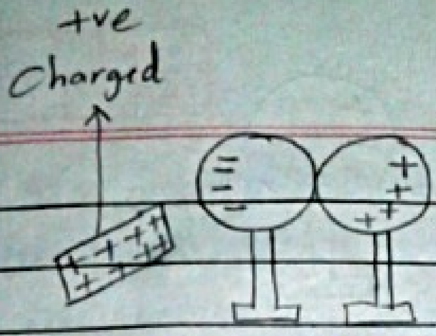
Example: paper, plastic, wood.. etc

CHARGING BY INDUCTION.

(1) Bring two metal spheres A and B supported on insulating stands in contact.

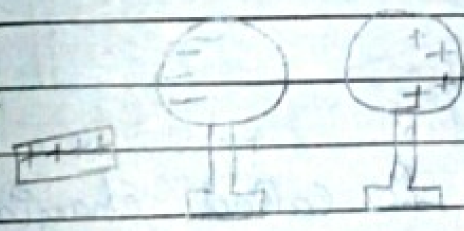


(2) Bring positively charged rod near by sphere A and we can observe the charge distribution in the both spheres A and B.

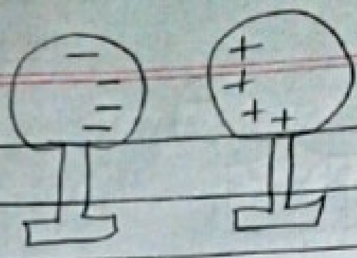


Now they will reach equilibrium of charge that is neutral.

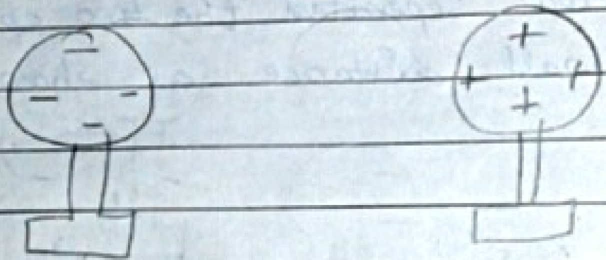
(3) Now seperated the two spheres by a small distance as shown in figure



(4) Remove the rod, the changes on spheres rearrage themselves as shown in fig.



(5) Now seperate the spheres by a long distance and observe the charge distribution on spheres



This process is called charging by induction.

So this process explains why electrified rod attracts with ball, when they brought near by them. When pith balls brought near by them, they

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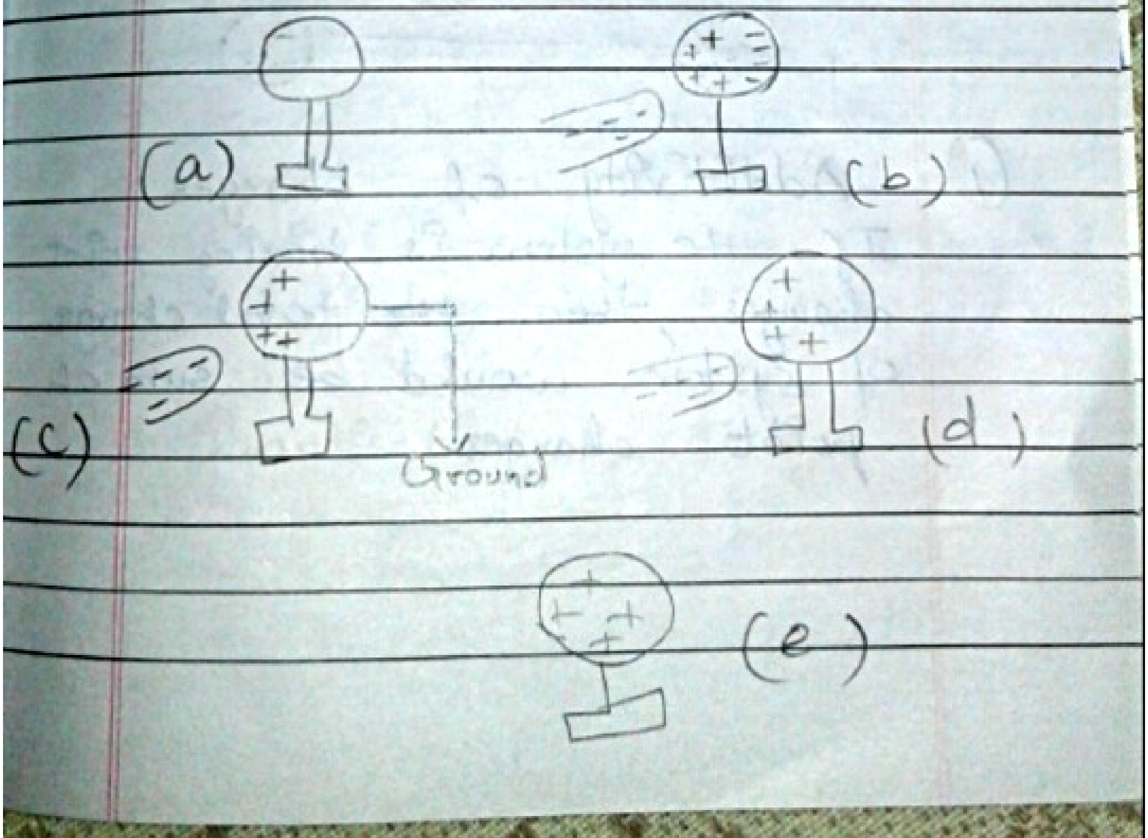
are oppositely charged with respect to electrified rod so they will attract each other.

Example 1.1

How you can charge a metal sphere positively without toathing it

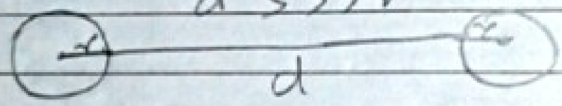


BASIC PROPERTIES OF ELECTRIC CHARGE

Point charges

Size of the body is very small compared with distance b/w them.

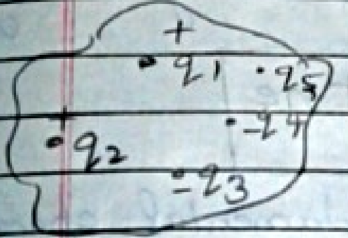
$$d >>> r$$



① Additivity of charges

If the system is having point charges, then the total charge of system would be sum of point charges

Ex. Take a system A



Net charge(q) = $q_1 + q_2 + -(q_3) + (-q_4) + q_5$

(2) Charge is conserved.
It is not possible to destroy or create net charge carried by any isolated system although the charge carrying particles may be created or destroyed in a process

(3) Quantisation of charge.

The charge of body (q) is always denoted or given by

$$q = \pm ne$$

'e' is the fundamental charge

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

Q In one coulumb how many $e^{\ominus}$ are there?

$1e = 1.6 \times 10^{-19} C$

$\frac{1}{1.6 \times 10^{-19}} e = \frac{1.6 \times 10^{-19} C}{1.6 \times 10^{-19}}$

$\frac{1}{1.6} \times 10^{19} e = 1C$

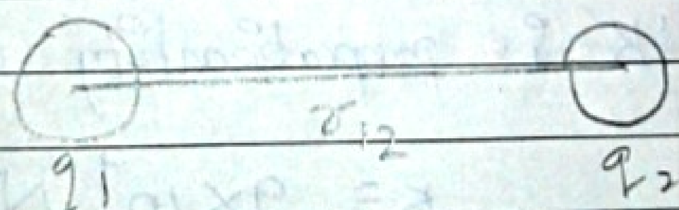
$\{ 1C = 6.25 \times 10^{18} e \}$

1C is a largest unit of charge

COULUMB'S LAW.

The force of attraction or repulsion between two point charges is directly proportional to product of the charges and is inversely proportional to the square of the distance between them, and acts along the line joining them.

Let us consider two point charges q_1 and q_2 seperated by distance $\vec{r}_{12}$ as shown



Let F be force between two charges, then.

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r_{12}^2}$$

$$F \propto \frac{q_1 q_2}{r_{12}^2}$$

$$\boxed{F = K \frac{q_1 q_2}{r_{12}^2}}$$

'K' is proportionality constant

$$K = 9 \times 10^9 \frac{Nm^2}{C^2}$$

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and K can be written as

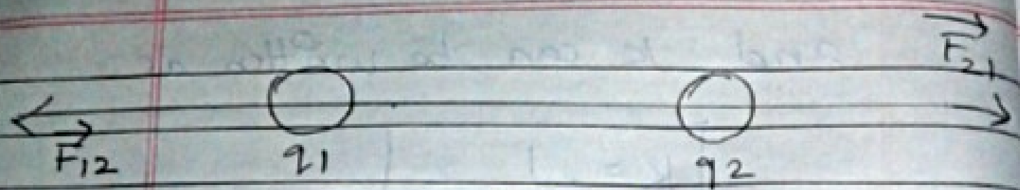
$$K = \frac{1}{4\pi\epsilon_0}$$

'ϵ_0' is the permittivity of free space

$$\left\{ \epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N m^2} \right\}$$

$$\left\{ \therefore \quad \vec{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}^2} \right\}$$

Force between charges depends on the medium of seperation between them.



$$\boxed{F_{12} = -F_{21}}$$

Action = − Reaction

Forces between multiple charges

The principle of superposition says that in a system of charge $q_1, q_2, q_3 \cdots q_n$ the force on q_1 due to q_2 is the same as coulumb's law, ie it is unaffected by the presence of the other charges $q_3, q_4 \cdots q_n$

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The total force F_1 on q_1 due to all other charges, is then given by the vector sum of the forces $F_{12}, F_{13} \cdots F_{1n}$

$$\vec{F_1} = F_{12} + F_{13} + \cdots + F_{1n}$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + \frac{q_1 q_3}{r_{13}}\hat{r}_{13} \cdots\right]$$

$$\boxed{\vec{F_1} = \frac{q_1}{4\pi\epsilon_0}\sum_{i=2}^{n}\frac{q_i}{r_{1i}^2}\hat{r}_{1i}}$$