STATIC ELECTRICITY

Static electricity is the imbalance of electric charge on the surface of a material. Static means stationary, therefore it is used in contrast to dynamic (moving) electricity in the form of electric current.

Electric charge is a fundamental physical property that causes objects to feel an attractive or repulsive force. It is measured in coulomb (C)

The existence of static charges

Rub a plastic pen or comb on your sleeve and then hold it near some tiny pieces of paper. The papers are attracted to the pen or comb because of friction with your sleeve, the plastic object has been charged with stationary or static electricity.

Static charge

An object can store electric charges that cannot flow. These charges are called **static charges** (**Static electricity**).

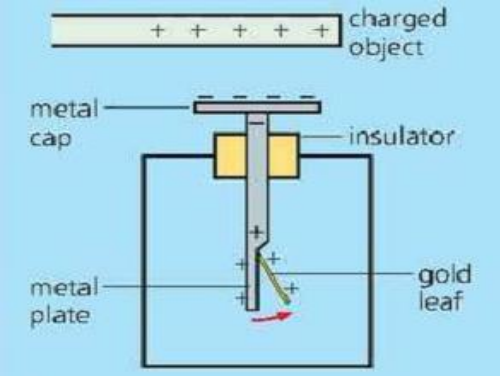
For example, when you wear or take off a sweater in very cold and dry season, you can get small amount of electric shock. It is caused as a result of the sweater being charged. When two different substances are rubbed, they are charged.

The atoms of all substances consist of protons, electrons and neutrons. Usually, the atoms have the same numbers of protons and electrons, therefore are electrically neutral. When one object is rubbed with another object, some electrons escape from one object and move on to the other object. One object decreases in electrons. It is positively charged. Otherwise, the other object increases in electrons. It is negatively charged.

There are positive and negative charges and these charges obey the law of electric charge which states that like charges repel while unlike charges repel.

Detect the electric charges

Charges can be detected by an instrument called Gold leaf electroscope. The electroscope also measures the electric charge on an object.



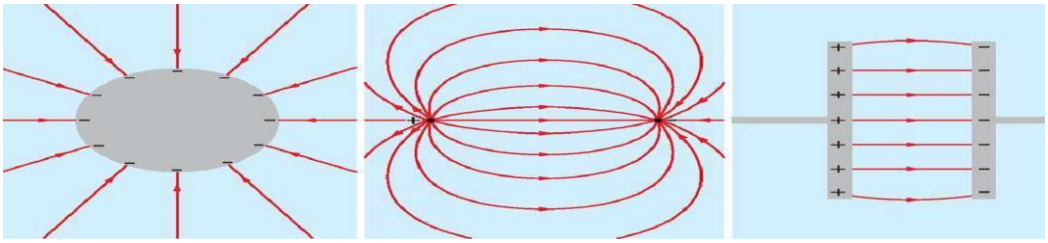
Electrostatic charge can be detected using a leaf electroscope as above. If a charged object is placed near the cap, charges are induced in the electroscope. Those in the goldleaf and metal plate repel. so the leaf rises.

The round cap on top of the electroscope is connected to a narrow copper plate that is on the inside. The very thin and flexible strip of gold foil is attached to a metal plate. The metal rod passes through a plug of insulating material and is mounted in a metal case which has glass windows. The metal case protects the leaf from air currents (draughts) while the glass window enables the leaf to be seen. When the metal cap receives a charge, the charge is redistributed by induction and is conducted through the metal plate and rod down to the leaf. The metal plate and the leaf receive the same charge and consequently repel each other. The gold leaf moves away from the metal plate when the charged object is taken permanent.

On the other hand, the electroscope can be charged by contact as the charged rod is scraped on the edge of the metal cap. In this case, the gold leaf should diverge and stay up even when the bar is taken away. The reason for the permanent charge is that some of the electrons were actually transferred by conduction to the metal plate and the leaf when the polythene rod touched the metal cap. The electroscope can be discharged by touching the cap to the metal case.
If a like charge is brought closer to a permanently charged electroscope, the gold leaf diverges more as the amount of repulsion between them increases. If an unlike charge is brought close to the electroscope there is a decrease in the amount of repulsion. In this way the electroscope can be used to determine the charge of any object brought close to it.

Properties Of Static Charges

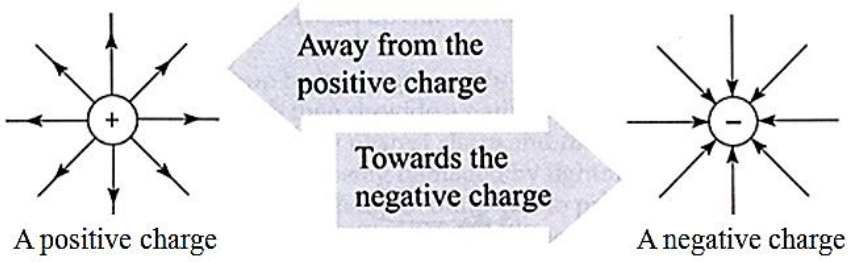
I. Static charges obey the law of electrostatics which states that: Like charges repel, unlike charges attract.

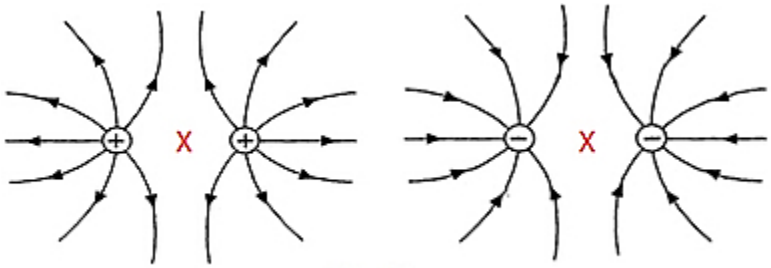


Electric field close to a negatively charged sphere

Electric field between two opposite point charges

Electric field between two parallel plates with opposite charges on them.





Like Charges

Note that X is the neutral point where the electric fields from both charges cancel out each other. There is no electric effect at X.

II. Conservation of charge: charge can neither be destroyed nor created, but it can only be transferred from one material to another.

III. Sparks: The force of attraction between two oppositely-charged objects may be so great, that it may cause some electrons to jump from one object to the other, without the objects touching. Each electron heats the air around it as it jumps, and with enough heat, the air heats up to the point where it glows. This happens very quickly, so all we see is a very brief spark.

USES

1) Reducing air pollution: electrostatic smoke and dust precipitators are used in chimneys to attract tiny particles of smoke and dust to metal plates with opposite charges, unable to escape into the air, thereby reducing the amount of air pollution.

2) In photocopying machines: photocopiers use static electricity to form an image of a document on a charged drum. The powdered ink (toner) is attracted to a light-sensitive plate that has an image of the document projected onto it by electrostatics. Wherever the document has dark areas, the plate keeps its charge so that it can attract the toner. When a piece of paper is pressed against the plate, the toner is transferred to the paper. The same idea is used in inkjet printer, except that in the printer, ink is used instead of powder. It uses electrostatics to position the tiny droplets of ink on the paper.

3) Paint spraying: bicycles and cars are painted using an electrostatic spray. The nozzle is given a charge and this makes a better spray - the droplets of paint all have the same charge and repel each other so that the paint spreads out to form a large even cloud. Less paint is needed because the charged droplets are all attracted to the object because it has an opposite charge. The same idea is used to make crop-spraying more efficient for farmers.

4) Finger printing: the paper is placed near a charged wire and a fine black powder is used. The powder sticks to the fingerprint but not to the clean paper.

5) Preventing fires: A liquid flowing in a pipe can become charged and this can be dangerous if it causes a spark and the liquid is inflammable. For this reason, whenever an aero plane is being re-fueled by a tanker lorry they are always connected together by a copper wire. For the same reason, spare petrol for cars should always be carried in metal cans, never plastic.

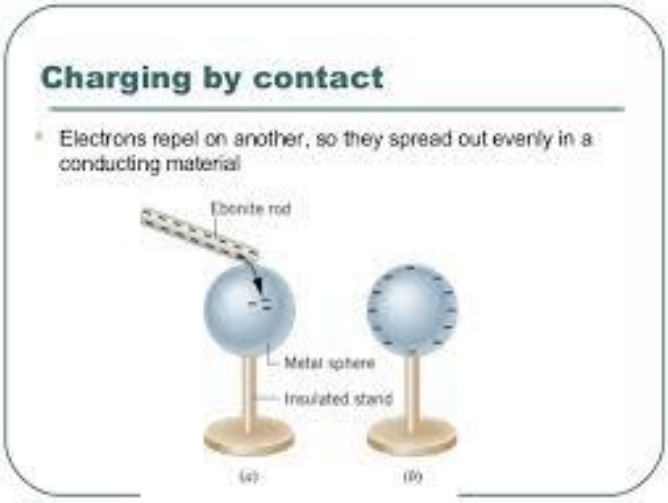
Electric charging and discharging of objects?

1) Charging by friction

Electric charging can be done by friction; when a glass or Perspex rod is rubbed against with fur or cotton wool, it acquires positive charges as electrons flows from the surface of the rod to the cloth so that the cloth would have had the net negative charge. On the other hand, a polythene rod when rub to the woolen cloth ,it gains electrons from the cloth and it will have a net negative charge while the cloth will have a net positive charge by losing electrons.

Charging by contact :

An electroscope can be charged by touching the cap with a charged object. Similarly, a neutral object such as polystyrene ball can be charged by touching it with a charged object. When two charged objects touch each other, the total charge of the system is conserved. If they each have same amount of opposite charges, they will both become neutral after touching.



2) Charging by Induction:

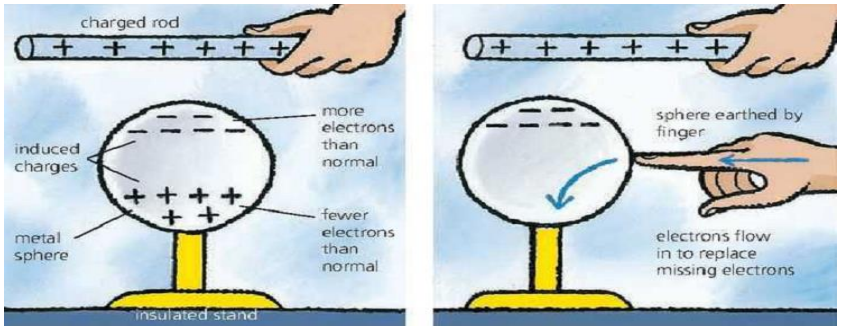
❖ A charged object can transfer or induce a charge in a neutral object simply by coming close to that object. When a negatively charged rod is brought near the metal cap of an electroscope electrons are repelled down to the metal strip and the leaf, this causes the leaf to diverge by electrostatic induction.

❖ When you rub a balloon on your clothes and then put it on the wall or ceiling, it stays there because the negative charge on the rubbed balloon repels some of the electrons in the ceiling away from the surface. This leaves the surface positively charged and so the negative balloon is attracted to the ceiling. The separated charges in the ceiling are called induced charges.

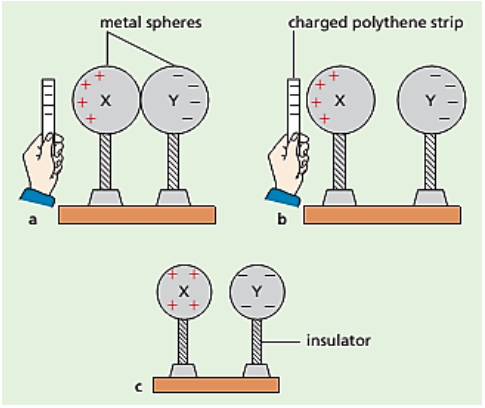
❖ To demonstrate the effects of charging by induction

I. Using a single metal sphere and a charged rod: a negatively charged polythene rod is brought near uncharged metal sphere held by insulator stand, the negative charges are repelled to the left hand side of the metal sphere. While the rod is still there touch the side farthest from the charged rod with your finger, electrons are conducted right through your body to the earth (earthling effect) and remove your finger away from the sphere. The electrons can no longer return to the sphere and this will leave it with a permanent deficiency of electrons, resulting into a positively charged metal sphere.

II. Similarly, when a charge Perspex rod (positively) is brought near the uncharged metal sphere and earthed, the end result will be a negatively charged sphere as electrons flow to the sphere from the earth.



III. Two metal spheres touching each other but held by separate insulating stands: bring a charged polythene rod near the first metal sphere A, like charges, negative charges will be repelled to the other metal sphere B, While the charged rod is still there, separate the two spheres using their insulating stands. Metal sphere A, becomes positively charged and B, becomes negatively charged.



Discharging of objects by static electricity.

Any imbalance of charge can be corrected by earthling the object. This means the object is connected to the earth by some conducting material. Any statically charged object can be earthed by touching the object with your hand, provided your body is touching the ground.so, your body acts as the conductor, and the excess charge flows through you and into the ground, or enough electrons flow from the ground through you and into the object to cancel out the net positive charge. Therefore,

(i) Objects can be discharged by touching the metal cap with the finger. The electrons flow to the earth if the electroscope is negatively charged or electrons flow from the earth if the electroscope is positively charged.
(ii) Bringing the cap of the charged electroscope near a water tap.
(iii) Putting a bare flame of a candle close to the cap

Relationship between current and static electricity

The relationship between current and static electricity in terms of effects as static electricity produces same effects as current electricity. The effects include lighting.

-Both involve the movement of electrons, but differ in the following ways:

STATIC ELECTRICITY	CURRENT ELECTRICITY
-builds up on the surface of insulating materials such as rubber and plastic	-moves through conducting materials such as copper and silver
-cannot travel inside wires	-can travel inside wires
-is generated by friction, contact and induction methods	-is generated by batteries and power plants
-moves by transferring electrons from one surface to another(through air) in an uncontrolled and sudden manner	-moves by transferring electrons from one atom to another in a controlled manner.

Investigate effects of static charges on the environment

a) STATIC SHOCKS

-the effect of static electricity is greater when the humidity in the air is lower

-in buildings where air –conditioners or heaters are used, the natural moisture content in the air is reduced. So, people are most likely to experience static shocks under these conditions,

- for the same reason passengers sliding off a car seat on to the ground sometimes gets a shock,
-in dry weather, people walking on nylon carpets may get a shock if they touch a radiator or a metal door knob

b) DUSTY ENVIROMENT

-A mirror or window polished by a dry cloth on a dry day soon becomes dusty

- Cassette-cases, records, T.V screens and objects soon become dusty.

c) STATIC ELECTRIC FIRES

When refueling an aircraft, charge can build up in fuel pipes. A single spark caused by static build-up is enough to ignite the fuel vapor surrounding the fuel pipes and tanks.

Large ships have been known to explode because their tanks were being cleaned out by a high speed water-jet which become charged and caused a spark

-some anesthetics used in operating theatre can explode because of lack of conducting floor tiles.

d) LIGHTNING

- This is the most destructive form of static electricity. It is the best known example of a natural spark.
- A very large charge jumps across an air gap and releases an explosive burst of energy, which can destroy houses, can cause wild fires and can kill people or animals.
-on the other hand, lightning can be beneficial to us as it helps to add nitrogen in the atmosphere.