

Electricity 1st Year - Semester 2

ELECTROSTATICS

ELECTRIC CHARGE

The earliest experiments in electrostatics showed that there are two types of charge - positive and negative. It was found by experimentation that a positively charged object will repel another positively charged object and attract an object with a negative charge. Similarly an object with a negative charge will repel another with a negative charge, but will attract a positively charged object.

"Like charges repel each other, unlike charges attract each other."

Although charge is an intrinsic feature of every atom, and although we know how charges interact, the nature of charge is still a mystery and there is still no theory to explain the nature of charge.

The net charge of a body is the algebraic sum of the individual charges - when a body has an equal number of positive and negative charges then the net charge is zero and the body is said to be neutral.

SI unit of charge is the COULOMB (C)

Definition: The coulomb is defined in terms of the ampere. If 1 ampere of charge current flows in 1 second, then the total charge moved is 1 coulomb.

Magnitude of charge q or $e = 1.602 \times 10^{-19} \text{ C}$

Charge in matter

In an atom, it is the electric forces which exist between the electrons and protons which hold the atom together.

All electrons have the same charge and therefore in bodies the net charge is the integral multiple of this charge - charge is therefore said to be *quantised*.

In a closed system the total charge is always conserved. Individual charges can be created or destroyed so long as the net change in charge is zero - *conservation of charge*.

- Q.1 When a gamma ray (a photon) passes near a nucleus, the photon disappears and 2 particles emerge. One is an electron, what can be said about the electrical properties of the other.
- A.1 It has a charge of $+1.602 \times 10^{-19} \text{ C}$ due to the conservation of charge (the electron has a charge of $-1.602 \times 10^{-19} \text{ C}$).

It is possible to charge objects like plastic and glass by rubbing. When this happens it is a transfer of charge that occurs, not a creation of charge. If, for example, a plastic rod is rubbed with fur, it is found that the plastic becomes negatively charged. This happens because the plastic rod Acquires extra electrons, which are negatively charged. these electrons are taken from the fur, which as a result becomes positively charged. By rubbing a glass rod on a piece of silk, the glass becomes positively charged and the silk negatively charged.

Q.2 Why, after walking across a nylon carpet, does an electric charge discharge from our bodies to earth. What atmospheric conditions must prevail for this to occur.

A.2 As we walk across the carpet a positive charge is built up on the body. When we approach an object which is earthed the charge is neutralised by flow of electrons from the earth. The atmosphere must be dry so that the charge does not leak away via polarised water molecules in the air.

Conductors and insulators

In general charge moves easily through a conductor and not through an insulator.

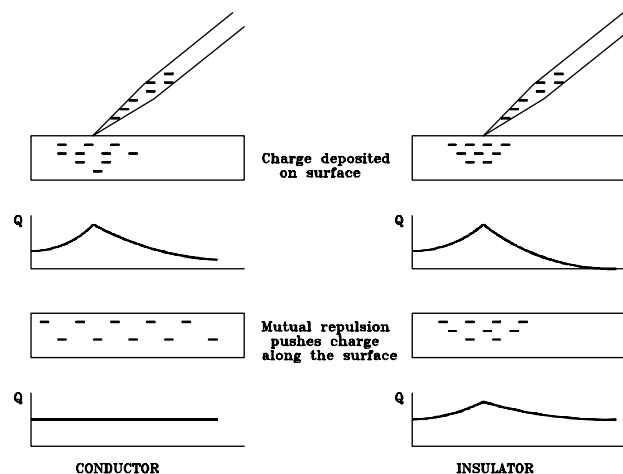
Conductors have valance electrons which are weakly bound to their parent atoms and therefore can move freely. (For reference look at the free electron theory).

Insulators are quite the opposite and the valance electrons are tightly bound the parent atoms and are therefore not free to move.

(One way to describe the conduction mechanisms in good conductors, semiconductors and insulators is the *band theory for solids*.)

When a charged surface is brought into contact with a good conductor, then the charge is quickly distributed throughout the conductor at a rate determined by the electrical conductivity of the material (the reciprocal of resistivity; units mho's).

When a charged surface is brought into contact with an insulator, then the charge is remains where it is placed and only slowly distributes.



Gold Leaf Electroscope

One of the first devices used to detect charge was the electroscope. A leaf electroscope has two thin foils of gold or aluminium attached to a metal rod. The rod is held in a transparent container with an insulating plug and has a metal pan at the exposed end.

If a positively charged glass rod is brought near an uncharged electroscope, the electrons in the metal pan are attracted to the rod. Their movement results in an unbalanced positive charge on the leaves, which causes them to repel each other. If the rod is moved away the leaves will simply move together again. If the rod touches the pan it will give it a positive charge. Since we do not know exactly how much charge has been transferred to the pan, the electroscope detects charge but does not measure it. The charged electroscope can be used to indicate the sign of the charged object. When a positively charged object is moved close to the pan the leaves move further apart. A negatively charged object would cause the deflection of the leaves to decrease.