Electrostatics

Static Electricity; Electric Charge and Its Conservation

The word electricity comes from the Greek work *elektron*, which means "amber." Amber is petrified tree resin, and the ancients knew that if you rub an amber rod with a piece of cloth, the amber attracts small pieces of leaves or dust.

We call this "amber effect" **static electricity**.

When an object becomes "charged" due to a rubbing process it is said to possess a net **electric charge**.

It is found experimentally that there are two, and only two, types of charges. Each type of charge repels the same type but attracts the opposite type. That is: unlike charges attract; like charges repel.
Benjamin Franklin named these charges *positive* and *negative* (the choice was arbitrary).

Franklin argued that whenever a certain amount of charge is produced on one body in a process, an equal amount of the opposite type of charge is produced on the other body.

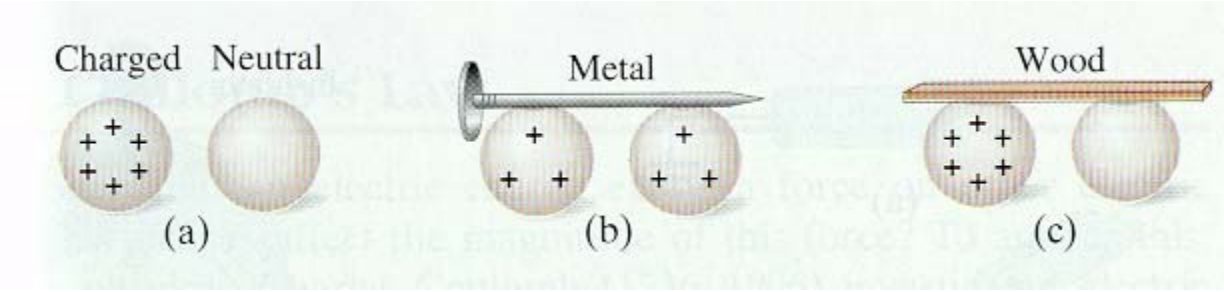
The positive and negative are to be treated algebraically, so that during any process, the net change in the amount of charge produced is zero.

This became the **law of conservation of electric charge**:

> The net amount of electric charge produced in any process is zero.

Insulators and Conductors

Suppose we have two metal spheres, one highly charged and the other electrically neutral (a). If we place an iron nail so that it touches both spheres (b), then the neutral sphere becomes charged. If we connect the two spheres with a piece of wood (c), nothing changes.



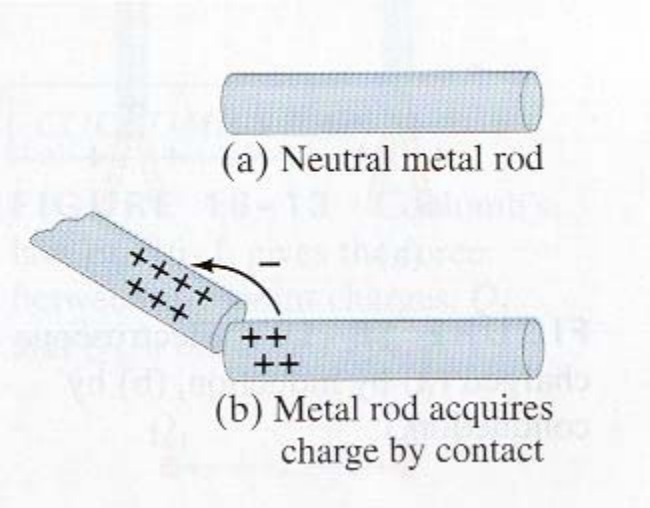
Materials like the nail are called conductors.
Materials like the wood are called insulators.

Conductors work because the electrons in the material can freely move throughout the material. In an insulator, the electrons are tightly bound to the atoms and cannot move.

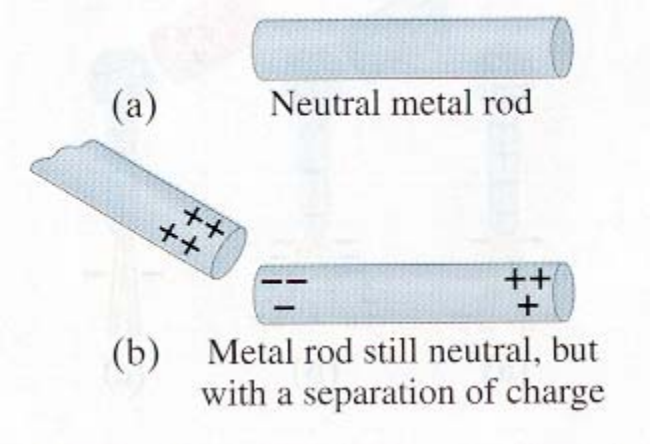
There are also a few materials (notably silicon, germanium, and carbon) that fall into an intermediate (but distinct) category known as semiconductors. In a semiconductor only some of the electrons can move freely.

Electrostatic Induction

Suppose a positively charged object touches a neutral metal rod, the free electrons in the neutral rod are attracted to the positively charged object and some will pass into it. This is known as charging by **conduction** (by contact).

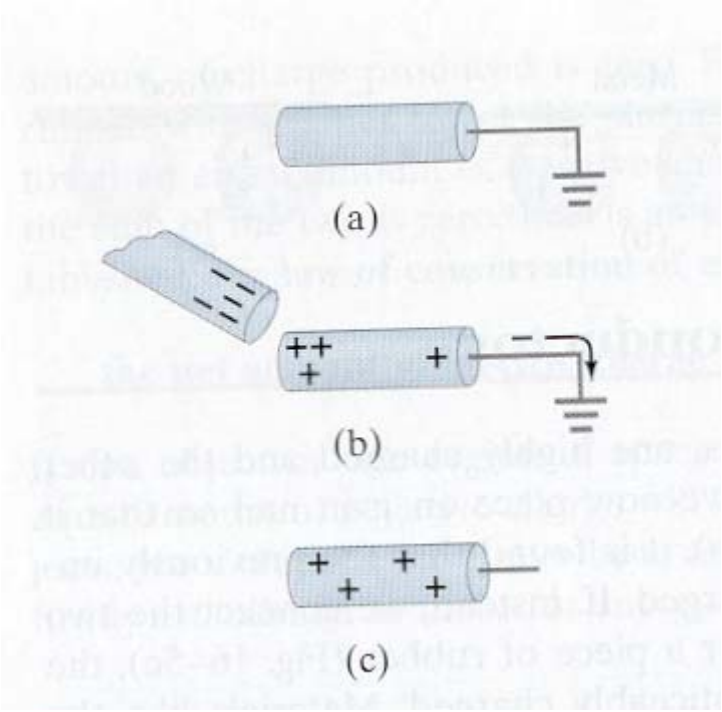


Now suppose a positively charged object is brought close to a metal rod, but does not touch it. The free electrons will still move towards the positively charged object (but do not leave the metal rod) leaving a positive charge at the other end. This charge is said to have been **induced**.



Although the net charge is still zero, if the metal were broken into two pieces, we could have two charged objects, one positive and one negative.

Another way to induce a net charge on a metal object is to connect it with a conducting wire to the ground. The object is said to be "grounded."



If a charged object (let's say negative this time) is brought near the grounded rod then electrons are repelled and leave the rod through the ground wire.

If the wire is cut before the charged object is removed then the metal rod will remain charged.

If the charged object had been removed before the ground wire was cut, then the electrons would have returned from the ground to give a net neutral charge.

An electroscope is a device that can be used for detecting charges. It usually has enclosed moveable gold leaves connected by a conductor to a metal ball on the outside.