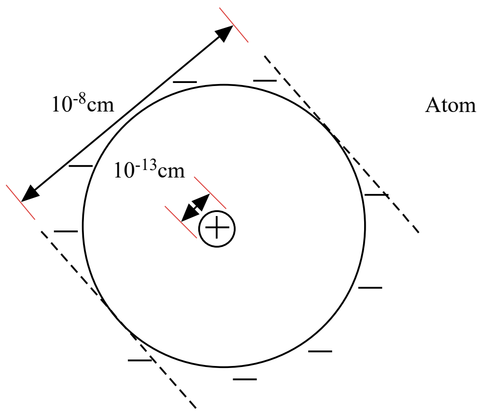
Electostatics

The origin of electric charge lies in the atom:

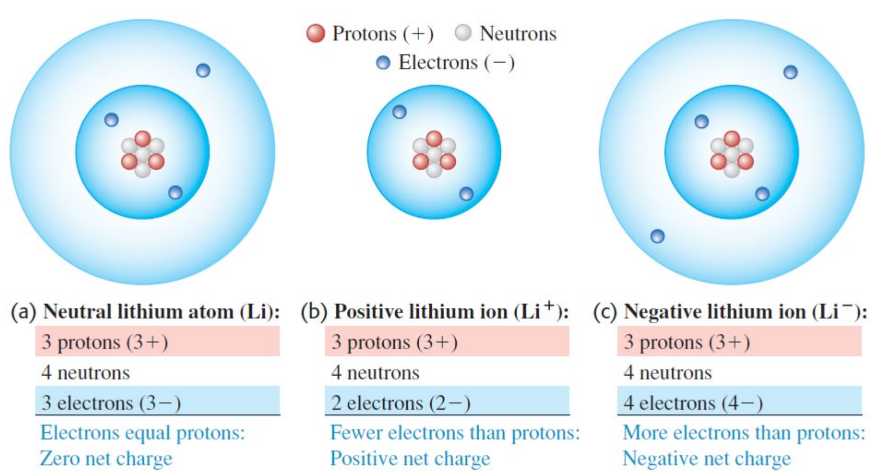
The atom consists of a very small nucleus that contains protons and neutrons. The protons have positive charge and the neutrons have NO charge. The number of protons is equal to the atomic number of the element. Moving around the nucleus are particles called electrons. The electrons have negative charge. The magnitude of the charge on the electron is equal to that of the proton. The atom is held by the electric force between the protons and the electrons.



$m_p = 1.67 \times 10^{-27}$kg $\approx m_n$

$m_e = (1/1800)\ m_p$

In a neutral atom, the number of electrons is equal to the number of protons. If they are different, we say that atom is ionized. In general, when we talk about the charge on an atom or any body, we mean the net charge. An atom gains a charge by gaining of losing electrons. It cannot gain or lose protons. The protons are very tightly bound to the nucleus.



Electric Charge

A neutral body acquires a net negative charge by gaining negative charges or losing positive charges. A neutral body acquires a net positive charge by gaining positive charges or losing negative charges.

In metals, the transfer of charge is due solely to the motion of the valence electrons in the atoms and not the protons in the nucleus. The protons are extremely tightly bound to the nucleus and cannot be added or removed from the nucleus.

Material are sometimes classified in terms of their ability to conduct electric charges.

Conductors and Insulators

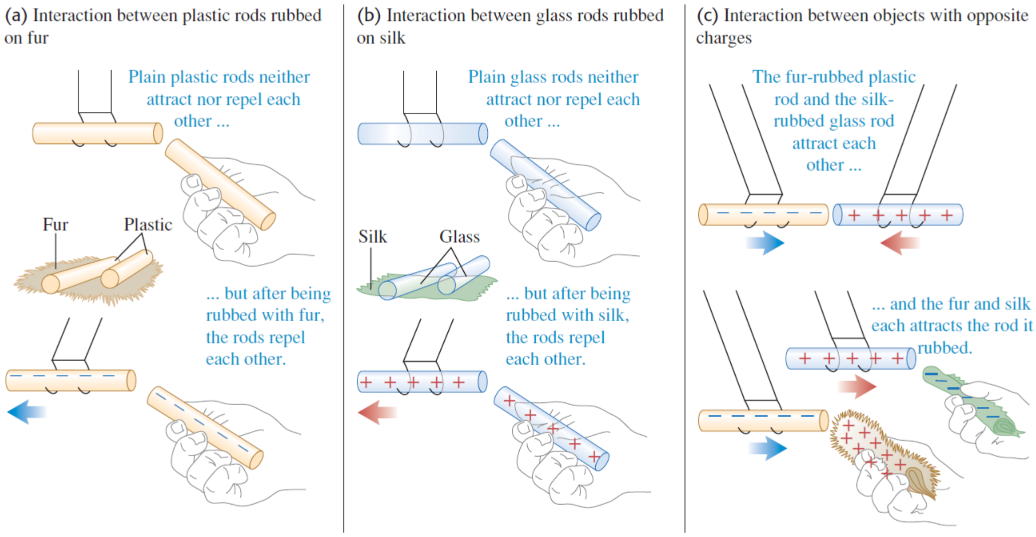
Conductors – materials in which electric charges move freely. Ex. Cu, Al, Ag

Insulators – materials in which electric charges cannot move freely. Ex. glass, rubber, wood

Semiconductors – materials that have electrical properties between those of conductors and insulators. Ex. Si, Ge

Experimental Proof of Electrical Charge

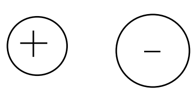
21.1 Experiments in electrostatics. (a) Negatively charged objects repel each other. (b) Positively charged objects repel each other. (c) Positvely charged objects and negatively charged objects attract each other.



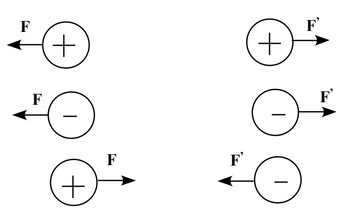
<u>According to the convention established by Benjamin Franklin (which we still use) a plastic rod rubbed with fur becomes negatively charged and a glass rod rubbed with silk becomes positively charged. Since we now know that rubbing a plastic rod with fur transfers electrons to the rod, then we say that electrons have negative charge.</u>

A. <u>Qualitative</u>

1. There are two types of charges: positive and negative

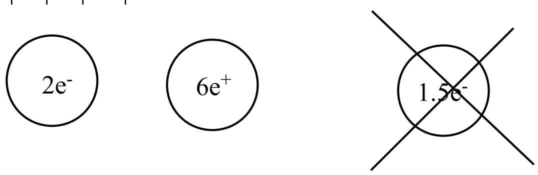


2. Unlike charges attract and like charges repel

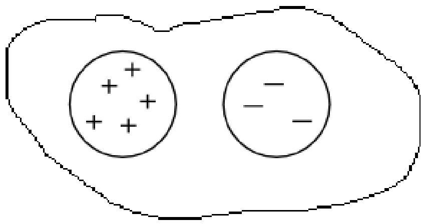


3. Charge is quantized. Electric charge always occurs as an integer multiple of some fundamental unit of charge. The fundamental unit of charge is the charge on the electron or proton.

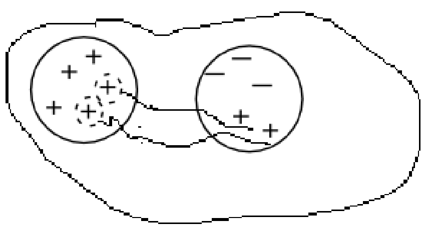
   $|e^-| = |p^+| = 1.6 \times 10^{-19} C$



4. Charge is conserved



net charge = +5 +(-3) = +2

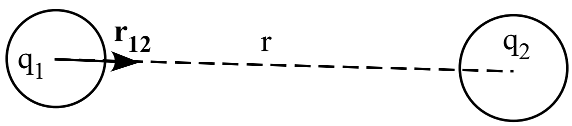


net charge = +3 +(-1) = +2

5. Neutral objects have same number of positive and negative charges.

B. <u>Quantitative</u>

1. Coulomb's Law



$$\boxed{\vec{F}_{12} = \frac{kq_1q_2}{r^2}\hat{r}_{12}}$$

$k = 9.0 \times 10^9$ = Coulombs constant

* note that this equation is sign sensitive

$[F] = Newton$
$[q] = Coulombs$ (C)
$[r] = meters$
$[k] = \frac{Nm^2}{C^2}$

The Coulomb constant is sometimes written in the following form:

$k = \frac{1}{4\pi\varepsilon_o}$, where $\varepsilon_o = 8.85\times10^{-12}\frac{C^2}{Nm^2}$

ε_o = permittivity of free space

1 C of charge is a very large quantity of charge. Typical value of charges are μC and nC.

When dealing with Coulomb's Law you must remember that force is a vector quantity and must be treated vectorially.

Superposition Principle – The net electric force on a charge is equal to the vector sum of all the electric forces due to all the surrounding charges.