Homework 21.

We started discussing the structure of atoms.

Electromagnetic forces, second strongest force in nature, play a crucial role in the world which surrounds us. As we know, the atoms exist due to electrical attraction between negatively charged electrons and positively charged protons in the atomic nuclei. The idea about small particles which are "the nature"s building blocks" for all the objects around us appeared very long time ago in ancient Greece and India. First subatomic particle, electron, was discovered by British physicist J.J.Thomson in 1897.

Joseph John Thomson (1856-1940).

Based on this discovery he suggested the "plum pudding model" of an atom. According to this model the electrons are like negatively charged particle –"plums" sitting in a positively charged substance – "pudding". In 1906 J.J.Thomson was awarded a Nobel Prize for his discoveries.
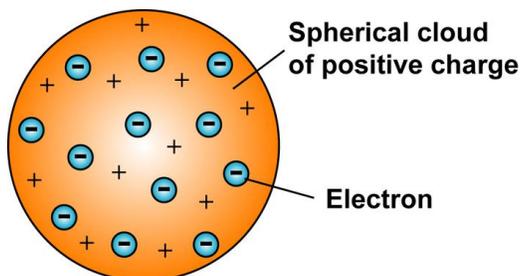
Plum pudding model (image from askeyphysics.org)

In 1909, another British physicist and chemist, former student of J. J. Thomson, Ernest Rutherford (He was awarded a Nobel Prize in Chemistry, 1908 for his work on the chemistry of radioactive substances), performing (together with Hans Geiger and Ernest Marsden) experiment on scattering of heavy and positively charged alpha particles by atoms of gold, found, to his great surprise, that some of the particles were reflected back. He said that "*It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you.*"
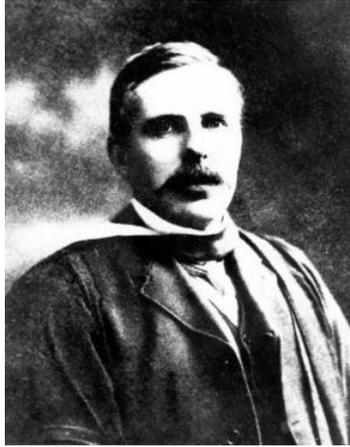
Ernest Rutherford (1871-1937).

This indicated that positive charge of an atom as well as most of the atom's mass was concentrated in a small volume, which did not agree with the plum pudding model.

As the explanation of the experiment results, Rutherford put forward another model which is called "planetary model" of atom. According to this model the electrons are revolving around a small positively charged nucleus similar to planets revolving around the Sun.
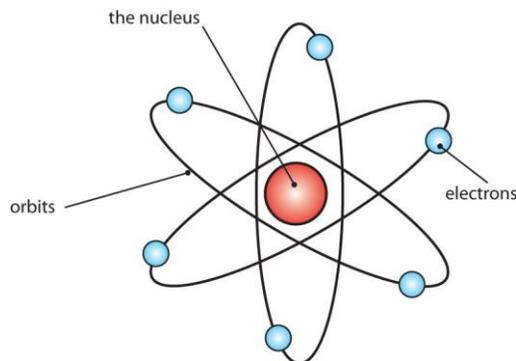
Planetary model of the atom.

Now we know that this model is not quite correct either. Later we will discuss it in more details.

The atomic nucleus consists of positively charged protons and neutral neutrons. Both proton and neutron have close masses: ~1,673 x 10^{-27}kg (proton) and ~1,675 x 10^{-27}kg (neutron). The electron's mass more than 1000 times smaller: 9.1 x 10^{-31}kg.

Problems:

1. In spite of the planetary model of atom is oversimplified, it can be used for some estimations. Use planetary model to estimate the energy, which is required to rip off the electron from a hydrogen atom. The size of the hydrogen atom is 1.1 x 10^{-10}m. The charge of electron is 1.6 x 10^{-19}C.

2. The alpha particle is a positively charged particle with the mass of ~ 6.64 x 10^{-27}kg the electric charge equal to 3.2 x 10^{-19}C. The alpha particle consists of 4 smaller particles. Estimate the electrical repulsion force between protons in an alpha particle. Take the size of the alpha particle as ~ 2 x 10^{-15}m.

3. Imagine that we suddenly "turned off" nuclear force which holds the protons in an alpha particle together. Calculate the velocities of the protons as they will be far away from each other.