Unit 10
Development of the Structure of the Atom

• Rutherford’s Gold Foil Experiment (3.4)
• Scattering simulation
Status in Early 1900’s (3.1)

- Atoms are not indivisible, but are made of smaller particles
- At this point, the electron was pretty well characterized and the existence of a positive counterpart was known
- A hanging question is: How are these particles arranged in the atom
- Ernest Rutherford devised an experiment that shed light on this arrangement of particles
Rutherford’s Scattering Experiment (3.4)

- Rutherford had coworkers Geiger and Marsden set up the apparatus below.
- Alpha particles are relatively massive positively charged particles.
- Alpha particles were fired into a thin piece of gold foil.
- Most went straight through the foil undeflected which is expected.
- However, some of the alpha particles rebounded nearly straight back.

Image from www.wiredchemist.com/
Simulation of Rutherford’s Scattering Experiment

• To see and work with a simulation of this experiment please do the following:
  • Go to: http://phet.colorado.edu/en/simulation/rutherford-scattering
  • Click on the Run Now button (or download if you would like)
  • Turn on the electron gun by clicking on the number in the red circle on the left
  • You can change the energy of the alpha particles coming out of the gun by using the slider on the right.
  • You can also change the size of the atoms in the chamber by using the appropriate slider on the right.

• The next slide offers a couple of questions related to the simulation (no, you don’t have to do the simulation stuff at all – I just thought it was interesting).
Questions from the Simulation

• A couple of questions:
  • Do the nuclei (plural of nucleus) affect the paths of the alpha particles more or less when the alpha particles are at higher energies?

  • Keep the number of neutrons fixed at some number and increase the number of protons (while keeping the alpha particle energy constant). As the number of protons increases, what can you say about the approach distance of the alpha particles to the nuclei – does it go up, down, or remain the same?

  • Keep the number of protons fixed at some number and increase the number of neutrons (while keeping the alpha particle energy constant). As the number of neutrons increases, what can you say about the approach distance of the alpha particles to the nuclei – does it go up, down, or remain the same?
Answers to Questions from the Simulation

• Answers:
  • Do the nuclei (plural of nucleus) affect the paths of the alpha particles more or less when the alpha particles are at higher energies?
  • The path of the alpha particles is affected less by when they are at higher energy. This is similar to trying to change the direction of a moving car – the more slowly it is moving, the easier it is to change.

  • Keep the number of neutrons fixed at some number and increase the number of protons (while keeping the alpha particle energy constant). As the number of protons increases, what can you say about the approach distance of the alpha particles to the nuclei – does it go up, down, or remain the same?
  • As the number of protons changes, the alpha particles (which are also positively charged) do not approach as closely. Like charges repel each other.

  • Keep the number of protons fixed at some number and increase the number of neutrons (while keeping the alpha particle energy constant). As the number of neutrons increases, what can you say about the approach distance of the alpha particles to the nuclei – does it go up, down, or remain the same?
  • As the number of neutrons changes, the alpha particle paths do not change much at all. Neutrons, as we will see shortly, carry no charge and thus have no electrical interaction with alpha particles.
Conclusions from Rutherford’s Scattering Experiment (3.4)

• Most of the atom is empty space – most of the alpha particles go straight through the foil

• There are concentrated regions of positive charge with high mass in the atom – some of the large positively charged alpha particles bounce nearly straight back.

• Rutherford proposed a nuclear theory of the atom where the protons are localized in a small core called the nucleus and the electrons are outside of the nucleus. See image to the right.