



1-3: Rutherford's Backscattering Experiment

A key experiment in understanding the nature of atomic structure was completed by Ernest Rutherford in 1911. He set up an experiment that directed a beam of alpha particles (helium nuclei) through a gold foil and then onto a detector screen. According to the “plum-pudding” atomic model, electrons float around inside a cloud of positive charge. Based on this model, Rutherford expected that almost all of the alpha particles should pass through the gold foil and not be deflected. A few of the alpha particles would experience a slight deflection due to the attraction to the negative electrons (alpha particles have a charge of +2). Imagine his surprise when a few alpha particles deflected at all angles, even nearly straight backwards.

According to the “plum-pudding” model there was nothing in the atom massive enough to deflect the alpha particles. Rutherford's reaction was that this 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.” He suggested that the experimental data could only be explained if the majority of the mass of an atom was concentrated in a small, positively charged central nucleus. This experiment provided the evidence needed to prove the nuclear model of the atom. In this experiment, you will make observations similar to those of Professor Rutherford.

1. Start *Virtual ChemLab*, select *Atomic Theory*, and then select *Rutherford's Backscattering Experiment* from the list of assignments. The lab will open in the Quantum laboratory.
2. The experiment will be set up on the lab table. The gray box on the left side of the table contains a sample of ^{241}Am .

What particles are emitted from this source? _____

What are alpha particles? _____

3. Mouse over the metal foil stand in the middle of the table.

What metal foil is used? If you want to see the metal foil, click and hold on the metal stand. _____

4. Point the cursor to the detector (on the right).

What detector is used in this experiment? _____

5. Turn on the detector by clicking on the red/green light switch.

What does the signal in the middle of the screen represent? _____

The phosphor screen detects charged particles (such as alpha particles) and it glows momentarily at the positions where the particles impact the screen.

What other signals do you see on the phosphor detection screen? _____



What do these signals represent? _____

Click the **Persist** button (the dotted arrow) on the phosphor detector screen.

According to the plum pudding model, what is causing the deflection of the alpha particles?

Make a general observation about the number of alpha particles that hit the phosphor detection screen in a minute's worth of time.

6. Now, you will make observations at different angles of deflection. Click on the main laboratory window to bring it to the front. Grab the phosphor detection screen by its base and move it to the spotlight in the top right corner. The **Persist** button should still be on.

Observe the number of hits in this position as compared with the first detector position. _____

7. Move the detector to the top center spotlight position at a 90° angle to the foil stand.

Observe the number of hits in this spotlight position as compared with the first detector position. ____

8. Move the detector to the top left spotlight position and observe the number of hits on the phosphor screen in one minute.

Observe the number of hits in this spotlight position as compared with the first detector position. ____

What causes the alpha particles to deflect backwards? _____

How do these results disprove the plum pudding model? Keep in mind that there are 1,000,000 alpha particles passing through the gold foil per second.

Are the gold atoms composed mostly of matter or empty space? _____

How does the Gold Foil Experiment show that almost all of the mass of an atom is concentrated in a small positively charged central atom?



Students often ask, “Why did Rutherford use gold foil?” The most common response is that gold is soft and malleable and can be made into very thin sheets of foil. There is another reason, which you can discover for yourself.

9. Turn off the phosphor detection screen. Click and drag the base of the metal foil holder to the stockroom counter. Click on the *Stockroom* to enter. Click on the metal sample box on the top shelf. Click on *Mg* to select magnesium. Click on the *Return to Lab* arrow.
10. Move the metal foil sample holder from the stockroom window back to the center of the table. Move the phosphor screen back to its original location on the right side of the table and turn it on. Click ***Persist***. Observe the number of hits with magnesium compared with the number of hits with a gold sample.

Why would Rutherford choose gold foil instead of magnesium foil? Explain. _____
