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Lab 9: Rutherford and the Nucleus

Purpose

To learn how Rutherford found evidence for the nucleus of the atom

Background

In your laboratory experiments, you have made observations and drawn conclusions from data. But imagine that you had to do your experiments in a dark room and couldn't see the materials you were working with. Imagine that the objects you were working with were so small that they couldn't be seen with a microscope. The early scientists who studied the atom had to work under similar conditions. They were trying to find out about a bit of matter so small that there was no hope of actually seeing it. Nevertheless, these atomic scientists were able to infer that the atom has a nucleus.

A key experiment in understanding atomic structure was completed by Ernest Rutherford in 1911. He directed a beam of positively charged particles (alpha particles) through a gold foil and then onto a detector screen. Before Rutherford performed his experiment, most scientists thought that electrons were distributed in a positively charge mass like raisins in a muffin. Based on this model, Rutherford expected that almost all the positively charged particles would pass through the gold foil along a straight path. A few particles might be slightly deflected because they were attracted by the negative electrons (alpha particles have a charge of +2). Imagine his surprise when some alpha particles veered off their straight line paths at large angles. Occasionally an alpha particle was deflected back towards the source.

According to the raisin muffin atomic model that Rutherford was testing, nothing in the atom was massive enough to strongly deflect an alpha particle. Rutherford said about his results 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!" He inferred from the experimental data that most of the mass of an atom was concentrated in a small, positively charged nucleus at its center. This nucleus was surrounded by mostly empty space. Electrons moved around the nucleus in that space. Now you can make observations similar to Rutherford's.

Skills Focus

Inferring, drawing conclusions

Procedure

1. Start *Virtual Physical Science* and select *Rutherford and the Nucleus* from the list of assignments. The lab will open in the Quantum laboratory.
2. The experiment will be set up on the lab table. Point the cursor at the gray box on the left side where you should see a popup describing what this device is. What particles are emitted from this source?

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3. Point the cursor at the metal sample holder in the center. What metal foil is used?

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4. Point the cursor at the detector on the right. What detector is used in this experiment?

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5. Turn on the detector by clicking on the red/green light switch. A window will pop up showing a close-up of the screen and the controls. The phosphor screen detects charged particles such as alpha particles. It glows momentarily at the positions where the particles impact the screen. The signal in the middle of the screen represents the alpha particles coming straight through the gold foil undeflected or only slightly deflected. What other signals do you see on the phosphor detection screen?

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Inferring What do these signals represent?

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Click the *Persist* button (the dotted arrow) on the phosphor detector screen. According to the raisin muffin model, what is causing the deflection of the alpha particles?

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What can you observe about the rate at which the positively charged particles (alpha particles) hit the screen?

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6. Now you will make observations at different angles of deflection. Click on the main window to bring it to the front. Click and drag the phosphor detection screen by its base and move it to the spotlight in the top right corner of the table. The *Persist* button should still be on. Observe the number of hits in this position as compared to the first detector position.

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7. Move the detector to the top center spotlight position at a 90-degree angle to the foil holder. Observe the number of hits in this spotlight position as compared to the first detector position.

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8. **Analyzing Cause and Effect** Move the detector to the top left spotlight position. Observe the number of hits in this spotlight position as compared to the first detector position. What could cause the alpha particles to deflect backwards?

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

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

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11. 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?

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