The Rutherford Experiment

Objectives: Content

- Examine Rutherford’s model of the structure of the atom.
- Examine how the results of Rutherford’s experiment relate to the structure of the atom.

Vocabulary Preview

- nucleus
- alpha particle

Activity Overview

In this activity, the student will:

- Be introduced to Rutherford’s experiment.
- Predict the results of the experiment if Thomson’s model is correct.
- Observe actual results and compare them with those expected from the Thomson model.
- Review Rutherford’s theory, explaining his results.

Teaching Strategies

Prior to the activity:

- Review Thomson's theory of the atom.
- Discuss the state of knowledge of science in general in the late 1800s, e.g., discoveries such as electric current and natural radioactivity. These encouraged new ideas about structure of matter.

At the end of the activity:

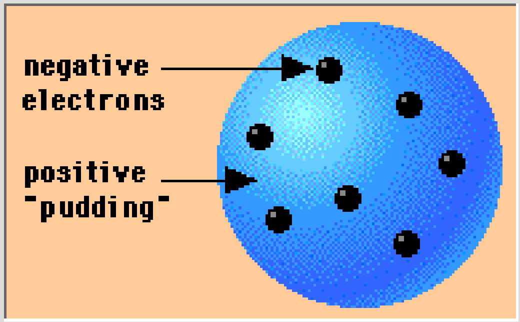
- Obtain some gold foil, and demonstrate how thin it is by showing that you can shine a light through it!
- Have students research the life of Rutherford.
- Have students research the lives of Geiger and Marsden, and find out how a Geiger counter works. (Geiger and Marsden were Rutherford's students who did many of the experiments.)

The Rutherford Experiment - Introduction

By the early 1900s, scientists knew that all atoms were made of a positively charged part and a negatively charged part, which they named an electron.

There were many different ideas about the structure of an atom. The most popular idea was expressed by Thomson's model. He said that the electrons with their negative charges are spread out in a positively charged "pudding."

Later, Ernest Rutherford performed experiments that changed the theory about atomic structure. In this activity, you will perform Rutherford's experiment to see how it explains a different view of atomic structure.

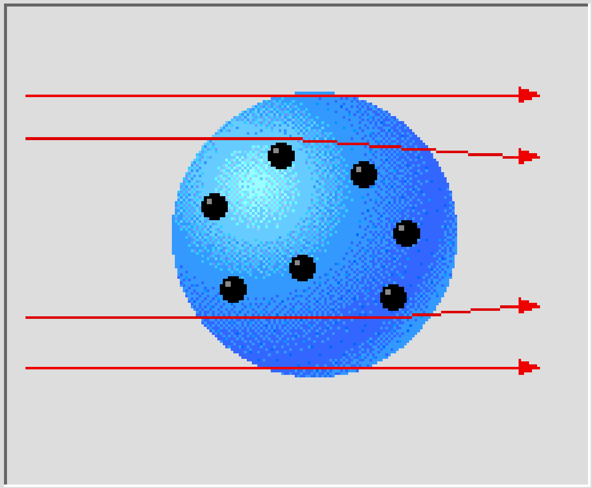


Objectives

To continue, click the Next Page arrow at the bottom of the screen.

The Rutherford Experiment - Background

Analysis of Thomson's model led Rutherford to expect that if atoms are bombarded with very small particles **(alpha particles),** most particles will pass through the atoms without any deflection. Only a few particles will be slightly deflected.



Why do you think alpha particles would deflect at all?

A few alpha particles, which are positively charged, will be slightly deflected as they pass through the positively charged "pudding."

Experimental Setup

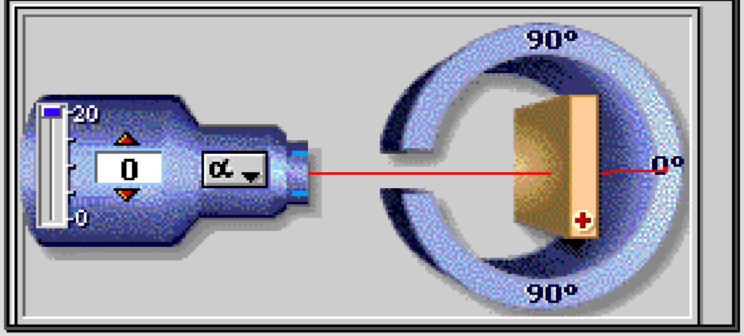
In an attempt to observe the phenomenon, Rutherford used a setup similar to what is shown in the Model Window to perform his experiment. A "gun" was used to fire alpha particles, at an extremely thin gold foil. Alpha particles are positively charged particles that are very small and that don't have much penetrating power. As the gun fires particles, they hit the foil at different places. A cylindrical screen that surrounds the metallic foil measures the direction of the alpha particles after they strike the foil.

Fire a number of alpha particles by clicking repeatedly on the blue underlined sentence. Observe their paths.

Throughout this activity, click each blue underlined sentence to make the described action happen in the Model Window.

Fire an alpha particle.

Model Window



Describe the paths that the alpha particles take.

Almost all of the particles show very slight deflections after passing throught the foil. Occasionally a particle shows a major deflection or bounces back.

The Rutherford Experiment

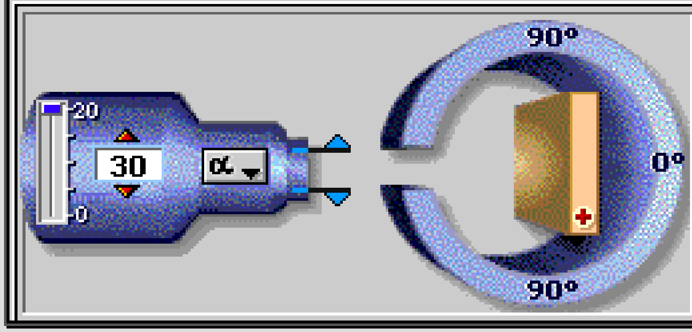
You will now perform an experiment that replicates Rutherford's experiment. You will fire 30 alpha particles in succession at the foil. The alpha particles are randomly fired at the gold foil. In his original experiment, Rutherford actually fired thousands of alpha particles.

After you complete the experiment, enter the number of particles with small and large deflections in the table.

Do Run 1.

	No. of Particles Small Deflection	No. of Particles Large Deflection
Run 1	28	2

Model Window



No. of Particles with Small Deflection	No. of Particles with Large Deflection
0	0

The Rutherford Experiment

If you run the experiment again, how do you think your new results will compare with your first run?

The results will not be exactly the same, but they will be very close.

You will check your prediction by performing a second run. Again you will fire 30 alpha particles in succession at the foil.

After you finish this run, complete the table.

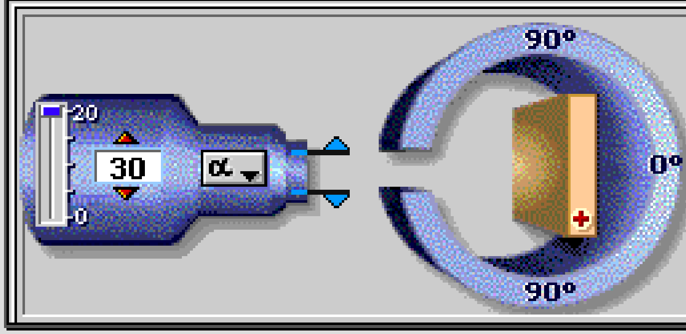
Do Run 2.

	No. of Particles Small Deflection	No. of Particles Large Deflection
Run 1	28	2
Run 2	27	3

If you did a third run with 30 alpha particles, about how many particles would you expect to show a small deflection?

about 27 (or 28) particles

Model Window



No. of Particles with Small Deflection	No. of Particles with Large Deflection
0	0

Write a brief summary of your results.

Almost all of the alpha particles pass through the foil with only small deflections. A few show large deflections.

Analyzing Your Results

Your results show that most alpha particles pass through the foil with very little deflection.

What do your results suggest about what happens to the alpha particles as they pass through the foil?

The results suggest that there is nothing in their way as they are passing through the foil.

What do your results suggest about the nature of the space that makes up most of the atom?

It is empty space.

	No. of Particles Small Deflection	No. of Particles Large Deflection
Run 1	28	2
Run 2	27	3

Analyzing Your Results

Your results show that a few alpha particles, which are positively charged, are deflected at much larger angles. Bearing in mind what you know about the behavior of objects having the same electrical charge, why do you think these few particles change direction?

	No. of Particles Small Deflection	No. of Particles Large Deflection
Run 1	28	2
Run 2	27	3

> The alpha particles with their positive charge are deflected by another positively charged part of the atom.

Knowing that only a few particles changed direction significantly, what do you predict is the size of the part of the atom that is causing these deflections?

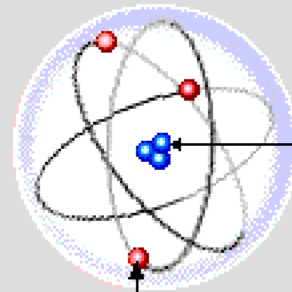
> The positively charged part of the atom is very small compared to the size of the entire atom.

Discussion

By examining the results of his experiment, Rutherford developed a new model of the atom. He proposed that the atom had a small central positive charge, called a **nucleus.** The positive alpha particles are highly deflected when they come close to the nucleus, because they feel a large force from the positive nucleus.

Rutherford's model differed from Thomson's model in that it could account for the small number of alpha particles that were highly deflected.

Rutherford also suggested that negatively charged electrons orbited around the nucleus, and the rest, (most of the atom) was empty space! This explains the data from your experiment that shows that most of the alpha particles were passing through empty space and, therefore, did not change their direction very much.



	No. of Particles Small Deflection	No. of Particles Large Deflection
Run 1	28	2
Run 2	27	3

Check Your Understanding

1. Suppose you found a way to aim 30 alpha particles precisely at the positively charged nucleus of an atom. How would you expect the alpha particles to behave as they hit the nucleus?

> All the alpha particles will be deflected at a sharp angle.

2. What behavior of alpha particles was accounted for by Rutherford's model and not by Thomson's?

> Rutherford's model accounted for the large deflection of some alpha particles. Thomson's model did not predict this behavior.

3. In Rutherford's model, when did alpha particles bounce at large angles?

> The alpha particles bounced at large angles when they were close to the nucleus.

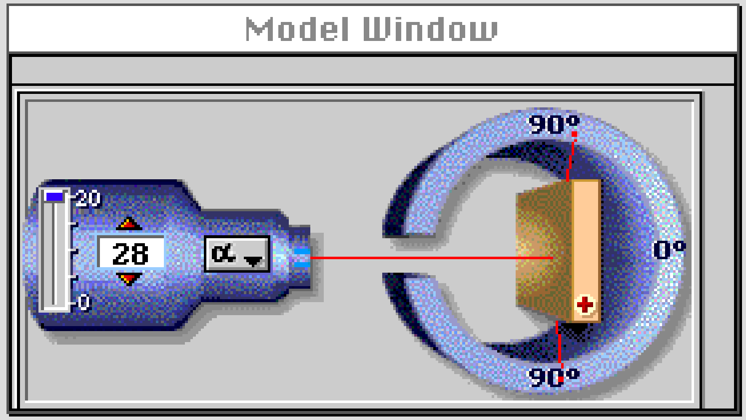
And the Answers Are...

1. All the alpha particles will be deflected at a sharp angle. To check:

Fire the alpha particles.

2. Rutherford's model accounted for the large deflection of some alpha particles. Thomson's model did not predict this behavior.

3. The alpha particles bounced at large angles when they were close to the nucleus.



No. of Particles with Small Deflection	No. of Particles with Large Deflection
0	2

If you gave different answers, you may wish to repeat this activity or discuss your answers with your teacher.

You have reached the end of this activity.
Click one of these icons at the bottom of the screen.

Restart - to repeat this activity

Home - to return to the Main Menu

Structure of the Atom Documentation Main Menu

This material helps you prepare your use of the *Structure of the Atom* activities in the classroom.

You can access information about the *Science Gateways* product or the *Structure of the Atom* title.

In addition, for each activity, there are overviews and pictures of the on-screen activities (including text, Model Window, displays, questions, and answers).

- **To print a file,** click the chapter or activity name.

  Then choose Print from the File menu.
- **To reaccess this list,** click the "Last Page" icon in the toolbar above.

The *Structure of the Atom* Activities