Activity 1: Atomic Discoveries

Objectives

Students will:

- Simulate Ernest Rutherford's Gold Foil Experiment.
- Explain how the Rutherford-Bohr Theory of Atomic Structure helps provide us with a basic understanding of atomic structure.

NOTE: This activity serves as an introduction to atomic structure and does not address radiation or radioactive elements.

Next Generation Science Standards

The concepts in this activity can be used to support the following science standard:

- PS1. Structure and Properties of Matter.

Materials and Resources

- *Evolution of a Radioactive Atom: Teacher Background Information.*
- *Vocabulary Materials.*
- *The Smallest Matter Worksheet* (one per student, pair or group) and *The Smallest Matter Teacher Answer Key*.
- Objects to simulate the gold foil experiment (enough for a class or group demonstrations).
  - Solid object to represent the detecting screen (e.g., thin metal sheet, cardboard or books).
  - Small solid objects to represent the protons within the nucleus of gold atoms (e.g., small gravels or rocks that have a flat bottom to keep them in place).
  - Marbles, ping pong balls or other small balls to represent alpha particles being shot through the gold foil.
  - Online video of the gold foil experiment (optional). Sources may include TeacherTube or other allowed Internet sources.

Time

45-60 minutes, not including optional activities or extensions.

Vocabulary

- Alpha particle
- Atom
- Electron
- Neutron
- Nucleus
- Proton

Directions

1. Start with a vocabulary activity if students are not familiar with radiation and the terms used in this activity, or provide students with the terms and definitions.

2. Ask students to explain or hypothesize:
   - How we know about the existence of atoms and their structure. **Ancient Greeks were the first to believe that all matter in the universe must be made of tiny building blocks — or atoms. Early scientists started forming theories about, and conducting experiments to confirm, the existence and structure of atoms.**
   - Whether we know everything about atoms. **Beginning with early science scholars throughout history and into this century, scientists strive to learn more about the atom and how to control it. For example, scientists are exploring how to use nuclear fusion — the joining of lighter nuclei to create a larger one — to generate power.**

3. Provide students with a copy of *The Smallest Matter Worksheet*. Explain that Ernest Rutherford and Niels Bohr were among those early scientists who wanted to know more about atoms. They formed their model after Rutherford conducted a gold foil experiment (described in the *Evolution of a Radioactive Atom: Teacher Background Information*).

4. Have students work in pairs or small groups to simulate Rutherford's gold foil experiment and to answer the questions on *The Smallest Matter Worksheet*. You can also search online and show students an image, simulation or video of Rutherford's gold foil experiment when conducting this activity. NOTE: You may want have students answer question 1 on *The Smallest Matter Worksheet* first.

5. Conclude by asking students how the Rutherford-Bohr Theory of Atomic Structure Model helps us understand atomic structure today. **The theory provides us with the understanding that an atom has a dense, positively-charged nucleus and that electrons orbit around the nucleus.**

6. Optional activity or extension: Direct students to:
   - Examine other historical atomic models, compare them with our current understanding of atomic structure and analyze how our understanding of atomic structure has evolved over time.
   - Explore or diagram the atomic structure of different elements.
   - Examine Rutherford and Bohr's other discoveries related to atomic theory and radioactivity.

The Smallest Matter Worksheet

Name: _____ Date: _____

During the early 20th century, New Zealand scientist Ernest Rutherford conducted an experiment. He shot electrically charged alpha particles at thin gold foil. This experiment helped Rutherford and Danish scientist Niels Bohr develop a way of thinking about the structure of an atom.

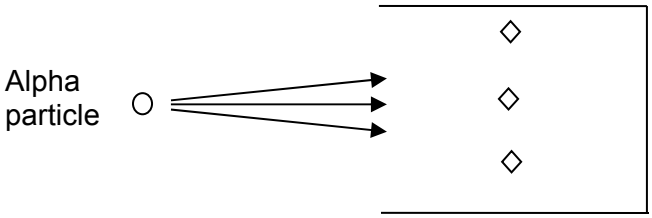
Follow the directions to simulate Rutherford's Gold Foil Experiment.

Equipment:

- Solid object to represent the detecting screen.
- Small solid objects to represent the protons in the nucleus of gold atoms.
- Round object to represent alpha particles (positively charged particles made up of two neutrons and two protons).

Directions:

Select a flat surface. Set up the detecting screen in a U or circular shape, leaving an opening for the alpha particle. Place the small objects that represent the protons of a gold atom in the center of the area within the detecting screen. The space between the protons represents neutrons.



Detecting screen, protons within the nucleus of gold atoms, and space between protons to represent neutrons of gold atoms

1. Observe the experiment setup and hypothesize what will happen when you roll alpha particles at the gold foil and why.

   _____

   _____

   _____

2. Roll the round object representing alpha particles toward the gold foil. Observe and record your observations for each roll.

   Roll 1: _____

   Roll 2: _____

   Roll 3: _____

   Roll 4: _____

   Roll 5: _____

   Roll 6: _____

   Roll 7: _____

   Roll 8: _____

   Roll 9: _____

   Roll 10: _____

3. Share your conclusions.

   a. What conclusions did you form about the structure of an atom based on the experiment and your observations?

   _____

   _____

   _____

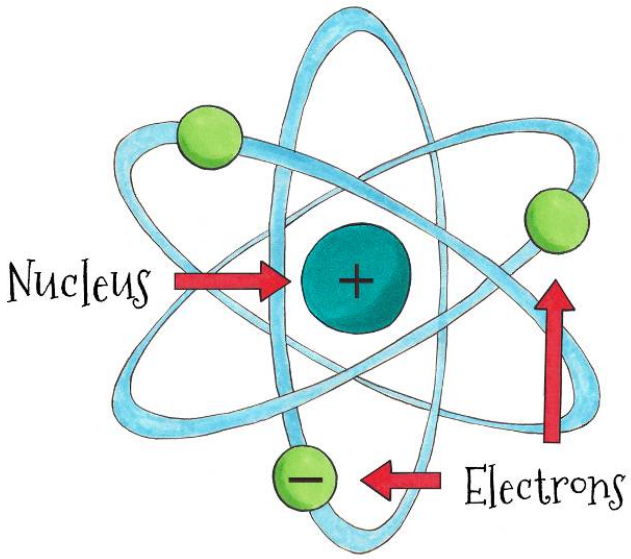
   b. From the gold foil experiment, Rutherford and Bohr concluded that each atom was mostly empty space, but also contained a central mass that the alpha particles could not pass through. Rutherford concluded that the central mass must have a positive charge. Why did he think that?

   _____

   _____

   _____

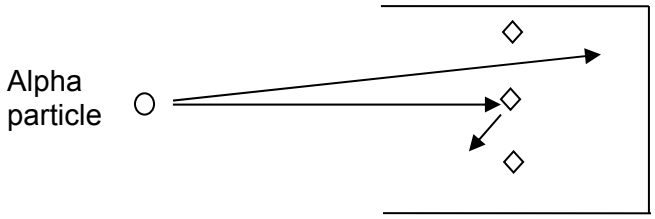
The Rutherford-Bohr Theory of Atomic Structure



The Smallest Matter Teacher Answer Key

1. Observe the experiment setup and hypothesize what will happen when you roll alpha particles at the gold foil and why.
   Answers will vary.

2. Roll the round object representing alpha particles toward the gold foil. Observe and record your observations for each roll.
   Answers will vary. Students should observe the alpha particles (marbles, ping pong balls, etc.) passing straight through at times and striking the protons and deflecting in different directions at times.



3. Share your conclusions.

   a. What conclusions did you form about the structure of an atom based on the experiment and your observations?
      Answers will vary.

   b. From the gold foil experiment, Rutherford and Bohr concluded that each atom was mostly empty space, but also contained a central mass that the alpha particles could not pass through. Rutherford concluded that the central mass must have a positive charge. Why did he think that?
      Because the positively charged alpha particles were deflected by the positively charged nucleus. This is based on the principles of electromagnetic force and the repulsion of like charges.