5 ATOMIC STRUCTURE: RUTHERFORD'S EXPERIMENT

Text Reference
Section 4.2

Time Required
30 minutes

Objectives
- Measure the shape of a hidden object by analyzing entry and rebound paths for a marble rolled at the object.

Advance Preparation
Plastic-foam shapes
Cut geometric shapes from a sheet of 1-inch plastic foam. Even simple shapes—such as a triangle, circle, half circle, rectangle, square, or L—are a challenge for students. More complicated shapes can be used in a second trial. Make the largest dimension of the shapes approximately 20 cm. Place a shape under a cover board at each lab station before the students come into the lab.

Cover boards
The cover boards must be sturdy enough not to bend when students write on them. Masonite or 1/4-inch plywood is adequate.

PURPOSE

To discover how the physical properties, such as size and shape, of an object can be measured by indirect means.

BACKGROUND

As you have done experiments, you have learned to make useful observations and to draw reasonable conclusions from data. But imagine how little you would be able to accomplish if the room in which you worked were so dark that you could not see the materials you were working with. Imagine how limited your observations would be if the object of your scrutiny were so small that it could not be seen, even with a microscope. When you think of how difficult experimentation would be under such adverse conditions, you will gain some appreciation for the enormous technical problems confronting early atomic scientists.

These scientists had as their target the atom—a bit of matter so small that there was no hope of seeing it directly. Nevertheless, these ingenious experimenters were able to infer that the atom had a nucleus.

It is impractical to reproduce the classic experiments that led to the discovery of the nucleus in a high school laboratory. You can get some idea of the challenge that these researchers faced, however, by playing the game described in this experiment. You will infer the size and shape of an object you cannot see or touch.

MATERIALS (PER PAIR)

safety goggles
sheet of heavy cardboard or thin plywood sheet, 60 cm × 60 cm
plastic-foam shape
marble
sheet construction paper
sheet notebook paper

SAFETY FIRST!

Caution: Wear your safety goggles. (All steps.)

Name _____ Date _____ Class _____

Review with students how to relate each marble's angle of reflection to its angle of incidence. Meter or yard sticks can be used to retrieve "lost" marbles without posing the associated hazard of revealing the mystery shape.

PROCEDURE

1. At your lab station, you will find a sheet of cardboard resting on top of a hidden object. *Do not look under the cardboard!* Roll a marble under the cardboard from various directions and observe where it comes out. (Have your teacher retrieve the marble if it stays under the board; no peeking!)
2. Place a sheet of construction paper on top of the board and trace the entry and exit path for each roll of the marble.
3. Continue rolling the marble and recording its path until you think you know the size and shape of the object. Draw a full-sized sketch of the object on a sheet of paper. Check your results with your teacher. Do not look under the board until your teacher confirms your results.
4. Ask your teacher for a second mystery object if you have time to repeat the game.

Name _____ Date _____ Class _____

ANALYSES AND CONCLUSIONS

1. How does this game simulate early efforts to determine the structure of the atom? In what ways is it different?

Like the students, Rutherford and other scientists were faced with the problem of identifying properties of an object not visible to the unaided eye. The game and Rutherford's efforts to solve the structure of the atom are similar because, in each instance, the angles of deflection of particles were used to infer the size and shape of the unseen object. Thus, Rutherford's experiment and this game used a similar indirect means to study the structure of an object. The two activities are also dissimilar. In the game, the board can be lifted to check the shape of the object. The atomic nucleus, however, is invisible because of its small size. The theory that the nucleus exists can only be supported by indirect evidence.

2. You eventually had the satisfaction of seeing the shape under the board. Did the early atomic scientists have this same opportunity? Do scientists today have this opportunity?

Student answers will vary. The scanning tunneling microscope makes it possible to view atoms and molecules on a solid surface.

GOING FURTHER

Develop a Hypothesis

On the basis of the results in this lab, develop a hypothesis about how the size, shape, or identity of other kinds of objects could be determined by indirect means.

The shadow of an object can be very dissimilar from the shape of the real object. By shining a light on the object from different angles, it is sometimes possible to identify the object. Players of games such as Twenty Questions (animal, vegetable, or mineral?) attempt to identify an object that, for purposes of the game, exists only in someone's mind.

Name _____ Date _____ Class _____

Design an Experiment

Propose an experiment to test your hypothesis. If resources are available and you have your teacher's permission, perform the experiment.