Lab: Investigating the Sizes of Atomic Particles

FOR THE TEACHER

Summary
In this lab, students will use yarn and peas to compare the sizes of the three subatomic particles and will see that most of an atom is empty space.

Grade Level
Middle and High School

Objectives
By the end of this lab, students should be able to
- Describe the structure of an atom
- Recognize the differences in size of the three subatomic particles
- Build a model to demonstrate aspects of atomic structure

Chemistry Topics
This lab supports students’ understanding of
- Atomic Structure
- Subatomic Particles
- Model of the Atom
- Atomic Theory

Time
Teacher Preparation: 30 minutes
Lesson: 30 minutes

Materials
For each pair of students
- Calculator
- Meter Stick
- Peas, dried
- Pencil
- Ruler, metric
- Scissors
- Yarn, 70 meters (There are approximately 120 meters per skein of yarn)

Safety
- Remind students to review all safety cautions and icons before beginning this lab. If you wish, you may restrict the use of scissors by cutting the yarn yourself.

Teacher Notes
- In this activity, students will build a scale model of a proton and an electron in a hydrogen atom. Provide students with information regarding the relative mass of the proton and the electron.
- The mass of a proton is about 1,800 times greater than the mass of an electron.
- Then, tell students that the distance of the electron from the proton is 50,000 times the diameter of the proton. Ensure students have enough room to build the scale model.
To have enough space, it may be necessary to use a hallway or even a playing field. Alert in advance instructors who might be affected by students working in the vicinity and take the steps needed to prevent distractions to other classes.

If outside space is unavailable, suggest that students use a smaller point that can be drawn, but still visualized, such as a dot of 0.1 millimeter (mm) to represent the proton. This will require the electron to be about 5 meters (m) away (rather than 50 m). Inform the students that if a calculator is unavailable, calculations can be done long-hand.

If peas are unavailable as a material, have students suggest an acceptable small substitute (any small, spherical object). Engage students by explaining that this lab demonstrates we’re primarily made of empty space.

Modification: Allow students to choose the size of the circle they wish to draw in Step 1 of the procedure, and then allow them to follow through on the remainder of the procedure with minimal direction. Students may make a circle that is so large that the length of yarn they need to model the distance to the electron exceeds the length of yarn they have available. Allow students to go back to Step 1 and begin again with a smaller circle, and repeat until they are able to make a viable model.

Potential answers to Conclusion questions:
1. Scientists discovered that the atom was primarily empty space, which meant the plum pudding model was inaccurate. The nucleus was not as large as first believed.
2. Student responses will vary.
3. Hydrogen does not contain any neutrons. We would have to use a different atom to add neutrons to the model.

FOR THE STUDENT

Lesson

Investigating the Size of Atomic Particles

Background
In this lab, you will build a scale model of a hydrogen atom. Your teacher will provide information regarding the relative size of the proton compared with the relative distance of an electron from a proton in a hydrogen atom.

Pre-lab Questions
Before beginning this lab, define the following terms:
1. Atom:
2. Proton:
3. Electron:
4. Neutron:
5. Nucleus:
6. Relative Distance:

Objective
Build a model to demonstrate aspects of atomic structure.

Materials
For each pair of students:
- Calculator
- Meter stick
- Peas, dried
- Pencil
- Ruler, metric
- Scissors
- Yarn, 70 meters

**Procedure**
1. Draw a small circle, about 1 millimeter (mm) (0.1 centimeter) in diameter on your data sheet.
2. Measure and record the diameter of the circle in the data table below.
3. Assuming the diameter of the circle represents a proton, calculate the relative distance of the electron from the proton in a hydrogen atom. Show your calculations in the section below.
4. Roll out a length of yarn to reflect the length you just calculated; this will illustrate the relative distance of the electron from the proton.
5. Record the length of yarn you used in the data table below.
6. Measure the diameter of a pea with the metric ruler and record this value in your data table.
7. Assuming the diameter of the pea represents a proton, calculate the relative distance of the electron from the proton in a hydrogen atom.

**Data**

<table>
<thead>
<tr>
<th>Diameter of your circle</th>
<th>Length of yarn</th>
<th>Diameter of pea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Calculations**
1. Calculated relative distance of the electron from the proton in a hydrogen atom (using the drawn circle diameter). Show all your work! Remember: the relative distance is not the actual distance of a proton from an electron. Atoms are too small to be seen by the human eye, so relative distances are used to help model what an atom looks like.

2. Calculated relative distance of the electron from the proton in a hydrogen atom (using pea diameter). Show all your work!

**Analysis**
1. What can you conclude when comparing the size of the proton with the distance of the electron from the proton?

2. What do you think lies between the proton and the electron in a hydrogen atom?

3. Is the electron always in one spot in a hydrogen atom, or does its position change?

**Conclusion**
1. After learning how the atomic model has changed over time, what new information was applied when scientists stopped using the “plum pudding” model and started using the Bohr model?
2. What are other ways you could model an atom and its subatomic particles?
3. Why did we not analyze the relative size of a neutron?