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Constructing Models of Atoms

Background Information

With an electron microscope, scientists can observe the arrangement of atoms on the surface of a material. But they cannot observe the arrangement of subatomic particles within an atom. Scientists use models to describe the structure of atoms.

Atomic models are revised as scientists learn more about atoms. Thomson revised Dalton's model of atoms as solid spheres when he discovered that atoms contained subatomic particles. To explain why most alpha particles could pass through a thin metal foil without being deflected, Rutherford proposed an atomic model with a dense, positively charged nucleus. The nucleus contains protons and neutrons. In the Bohr model of the atom, electrons move in fixed orbits around the nucleus, like planets around a sun. The currently accepted model of the atom assumes that the movement of electrons is less predictable. In the current model, an electron cloud is used to describe the likely locations for electrons in atoms.

Isotopes are atoms of a given element that contain different numbers of neutrons. Isotopes have the same atomic number, but different mass numbers. In this investigation, you will construct a model of an isotope. Then, you will evaluate your model and identify ways in which it can be improved.

Problem

How might the structure of an atom be modeled?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Classifying** How do isotopes of the same element differ?

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2. **Using Tables and Graphs** How can you use the information in Figure 1 to determine the number of protons, neutrons, and electrons in an isotope?

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3. **Using Models** What will you use the following items to represent: red pushpins, green pushpins, beads, pipe cleaners?

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4. **Using Models** How will you model different isotopes of the same element?

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5. **Drawing Conclusions** Which model of the atom does the model you will construct most resemble? Explain your answer.

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Materials *(per group)*

2 plastic-foam balls
pipe cleaners
red pushpins
green pushpins
beads
2 coat hangers
fishing line
scissors

Safety

Put on safety goggles. Be careful when handling sharp instruments. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

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Procedure

1. Construct a model of one of the isotopes assigned by your teacher. Use the information in Figure 1 to predict the number of protons, neutrons, and electrons in the isotope. In the data table, record this information and the name of the isotope.

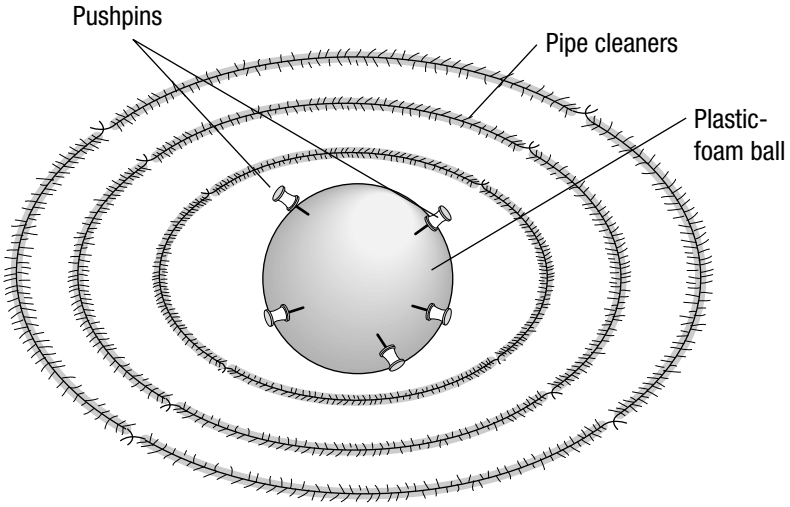
Figure 1

Element	Atomic Number	Stable Isotopes
Hydrogen	1	hydrogen-1, hydrogen 2
Helium	2	helium-3, helium-4
Lithium	3	lithium-6, lithium-7
Boron	5	boron-10, boron-11
Carbon	6	carbon-12, carbon-13
Nitrogen	7	nitrogen-14, nitrogen-15
Oxygen	8	oxygen-16, oxygen-17, oxygen-18
Neon	10	neon-20, neon-21, neon-22
Magnesium	12	magnesium-24, magnesium-25, magnesium-26
Silicon	14	silicon-28, silicon-29, silicon-30
Sulfur	16	sulfur-32, sulfur-33, sulfur-34, sulfur-36
Chlorine	17	chlorine-35, chlorine-37
Argon	18	argon-36, argon-38, argon-40

2. In your model, red pushpins will represent protons, green pushpins will represent neutrons, and beads will represent electrons. Collect the appropriate number of each item for your model.
3. The plastic-foam ball will represent the nucleus. Insert the appropriate number of red and green pushpins into the ball to represent the correct number of protons and neutrons.
4. Recall that the first energy level can hold 2 electrons, the second energy level can hold 8 electrons, and the third energy level can hold 18 electrons. Calculate the number of energy levels occupied by electrons when atoms of your isotope are in the ground state. Record this number in the data table.

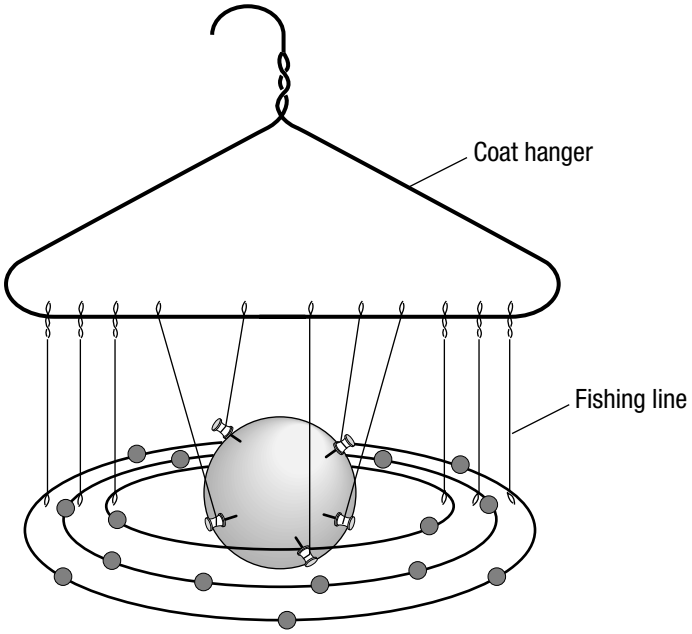
5. Use pipe cleaners to construct the appropriate number of energy levels for your isotope, as shown in Figure 2. Twist the ends of several pipe cleaners together to make the energy levels long enough to circle the nucleus, but do not close up the pipe-cleaner circles.

Figure 2



6. Place the appropriate number of beads on each pipe-cleaner circle to represent the electrons in each energy level. In the data table, record the number of electrons in each energy level.
7. Place the energy levels around the nucleus. If there is more than one occupied energy level, place the levels in the correct order.
8. Use fishing line to attach the nucleus and energy levels to a coat hanger, as shown in Figure 3. Your model is now complete.
9. Repeat Steps 1–8 to model the second isotope of your element.

Figure 3



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Observations

DATA TABLE

Isotope		
Atomic number		
Mass number		
Number of protons		
Number of neutrons		
Number of electrons		
Number of energy levels occupied by electrons		
Number of electrons in first energy level		
Number of electrons in second energy level		
Number of electrons in third energy level		

Analysis and Conclusions

1. **Using Models** Why were pushpins with the same mass used to represent protons and neutrons in your model?

2. **Using Models** Why were the objects used to represent electrons smaller than the objects used to represent protons and neutrons?

3. **Comparing and Contrasting** How were the two models that you constructed similar? How were they different?

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4. **Applying Concepts** Explain why a model of an atom must always contain the same number of protons and electrons.

5. **Evaluating** What are some inaccuracies in the way your models represent the nucleus?

6. **Evaluating and Revising** In what two ways does your model fail to accurately depict the electrons in an atom?

Go Further

Describe a physical model that could more closely represent the currently accepted model of an atom. Focus on how the model could best represent the behavior of electrons.