Unit Project

Half-Life

Most things around you are composed of atoms that are stable. However, the atoms that make up *radioactive* substances are unstable. They break down in a process known as *radioactive decay*. From their decay, they emit radiation. At high levels, radiation can be dangerous.

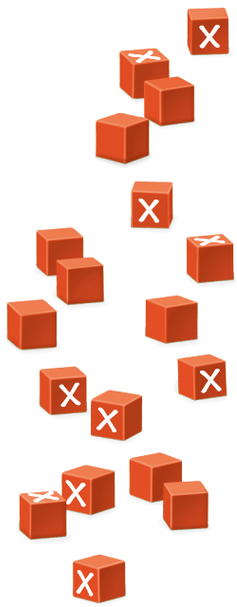
Rates of decay vary from substance to substance. The term *half-life* describes the time it takes for half of the atoms in a radioactive sample to change into other more stable atoms. For example, the half-life of carbon-11 is 20 minutes. This means that 2,000 carbon-11 atoms are reduced to 1,000 carbon-11 atoms and 1,000 boron-11 atoms in 20 minutes. After 40 minutes, the carbon-11 atoms are reduced to 500 carbon-11 atoms and 1,500 boron-11 atoms.

Half-lives vary from a fraction of a second to billions of years. For example, the half-life of polonium-214 is 0.00016 seconds. The half-life of rubidium-87 is 49 billion years.

In this experiment, you will model the decay of a radioactive substance known as iodine-124. About $\frac{1}{6}$ of the atoms in a sample of iodine-124 decay each day. This experiment will help you determine the half-life of this substance.

Follow these steps to conduct your experiment:

- Use 100 cubes to represent 100 iodine-124 atoms. Mark one face of each cube.
- For the first day, place all 100 cubes in a container, shake the container, and pour the cubes onto the table.
- The cubes for which the mark is facing up represent atoms that have decayed. Remove these cubes, and record the number of cubes that remain.
- For the next day, place the remaining cubes in the container, shake the container, and pour the cubes onto the table.
- Repeat the last two steps until one cube or no cubes remain.



When you complete your experiment, answer the following questions.

1. **a.** In your experiment, how many days did it take to reduce the 100 iodine-124 atoms to 50 atoms? In other words, how many times did you have to roll the cubes until about 50 cubes remained?

   b. How many days did it take to reduce 50 iodine-124 atoms to 25 atoms?

   c. Based on your answers to parts (a) and (b), what is the half-life of iodine-124?

2. **a.** In a sample of real iodine-124, $\frac{1}{6}$ of the atoms decay after 1 day. What fraction of the atoms remain after 1 day?

   b. Suppose a sample contains 100 iodine-124 atoms. Use your answer from part (a) to write an equation for the number of atoms n remaining in the sample after d days.

   c. Use your equation to find the half-life of iodine-124.

   d. How does the half-life you found based on your equation compare to the half-life you found from your experiment?

3. **a.** Make up a problem involving a radioactive substance with a different rate of decay that can be modeled by an experiment involving cubes or other common objects. Describe the situation and your experiment.

   b. Conduct your experiment and record your results.

   c. Use your results to predict the half-life of your substance.

   d. Use what you know about the rate of decay to write an equation that models the decay of your substance.

   e. Use your equation to find the half-life of your substance.

Write a report that summarizes your findings about decay rates and half-lives. Your report should include tables and graphs justifying your answers to the questions above.