Experiment 9-1

Understanding Half-life

In any sample of a radioactive isotope, the individual atoms are decaying in a random fashion. It is impossible to predict which atom is the next to decay, yet statistically you can predict how many atoms will decay in a certain period of time. Scientists measure how much time elapses while half of the atoms of a given radioactive sample decay. That time is called the *half-life*. For example, the half-life of the carbon-14 isotope is 5730 years. This means that if you were to start with 100 grams of carbon-14 today, in 5730 years you would have 50 grams of the carbon-14 left. You would have 25 grams left after 5730 more years had passed.

Half-lives of radioactive isotopes vary greatly, from much less than a second to billions of years. The half-life is a very important consideration when choosing a radioactive isotope for a specific application such as a medical tracer.

Objectives

1. ***Interpret*** a model of radioactivity and half-life.
2. ***Demonstrate*** the connection between half-life and a decay graph.
3. ***Relate*** half-life and geologic dating.

Materials

Apparatus

shoe box or equivalent
200 or more pennies

Prelab

1. Read the introduction and the procedure before you begin.
2. Answer prelab questions 1–6 on the Report Sheet.

Procedure

1. Place at least 200 pennies into a box and put the lid on the box. Shake the box for several seconds. Open the box and remove all the pennies that have the "heads" side up. *Carefully* count these pennies and record the number on Data Table 1. Do not put the pennies back in the box.
2. Shake the box again for several seconds. Open the box and again remove all the pennies with "heads" up. Count the pennies and record in Data Table 1.
3. Continue this process until either one penny remains or no pennies remain. Record the number each time.
4. Put all the materials away and begin the calculations and questions.

Experiment 9-1

Name _____

Class _____

Date _____

Report Sheet

Understanding Half-life

Prelab Questions

1. Explain what is meant by the term half-life.

_____

_____

2. What is the half-life of carbon-14? _____

3. How can carbon-14 help in determining the age of a fossil?

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4. Suppose you have a radioactive isotope with a half-life of two years and you start with 800 grams of this substance today.

   a. How much will you have two years from today?

   b. How much will you have eight years from today?

5. Is the quantity of a radioactive isotope ever equal to exactly zero? Explain your answer.

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6. In your own words, write the purpose of this experiment.

Data and Observations

Data Table 1

How many pennies did you begin with?	
Shake number	Number of pennies removed

Calculations

Using the data on Data Table 1, complete the table below.

1. In this exercise, what is the "half-life" of your "atomic pennies"?

_____

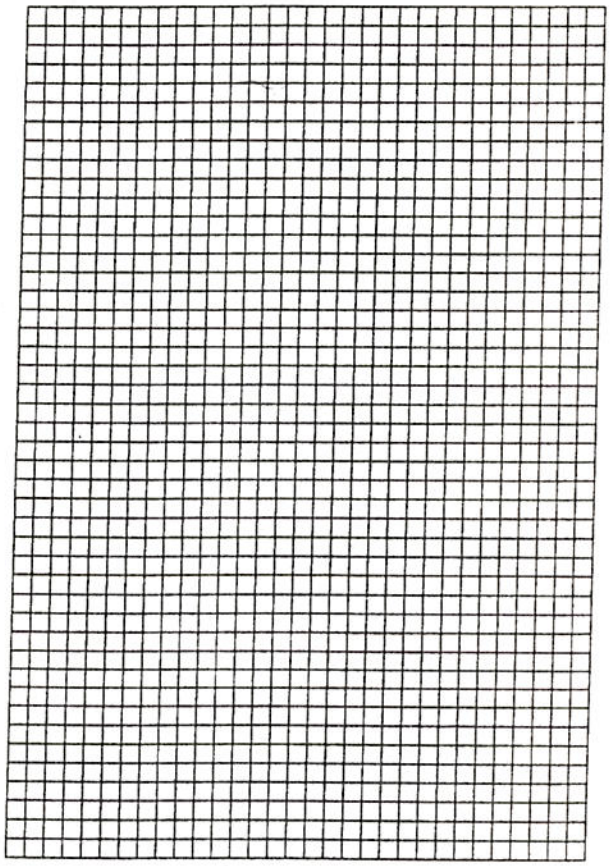
2. Use this value in Data Table 2 to calculate "Time passed."

Data Table 2

Time passed	Pennies remaining

Analysis and Conclusions

1. Make a graph of your results on the grid below. Decide what information should be displayed on the graph and how you should display the information.



2. How would you describe the shape of your graph?

3. Suppose you had started with 1000 pennies. Would the shape of the graph be different? Explain your answer.

4. Approximately what percent of the pennies were removed with each shake? _____

5. Is it possible to identify in advance which pennies will be "heads" up? _____

6. Is it possible to predict approximately how many pennies will be "heads" up for each shake? Explain your answer

_____

_____

_____

7. Check with at least two other groups in your class. Look at both the data you collected and the graphs you constructed.

   a. Was your data identical to other groups?

   b. Was your graph identical to other groups?

   c. Explain the similarities and differences.

Real World Connections

1. The half-life of iodine-125 is 60 days. The half-life of iodine-131 is 8.05 days. Often radioactive isotopes are used as tracers in diagnostic medical tests. Radioactive iodine is used to help identify diseases of the thyroid gland. Which of these two isotopes do you think would be the best to use in this application? Explain your answer.

_____

_____

One of the controversies surrounding the use of nuclear power is the storage of nuclear waste. Explain how the concept of half-life is an important consideration in this debate.

_____

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In a tree or other living organism, the amount of carbon-14 is quite low. In fact, the number of decays or disintegrations is only about 15.3 disintegrations per minute. This rate remains constant while the tree is alive because the carbon-14 is being replaced in the tree through respiration. When the tree dies, the rate slowly decreases according to the half-life of carbon-14. Suppose a piece of fossil tree is analyzed and found to be disintegrating at a rate of about 3.8 disintegrations per minute. About how old is this fossil?

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