

HALF-LIFE SIMULATION WITH PENNIES

LAB NR 6

INTRODUCTION

Half-life, $t_{1/2}$, is the time required for the number of radioactive nuclei in a sample to drop to one-half the initial value. For example, the half-life of phosphorus-32, a radioisotope used in leukemia therapy, is 14.28 days. If today you have 1.000 grams of phosphorus-32, 14.28 days from now only 0.500 grams of phosphorus-32 will be left because one-half of the sample will have decayed by beta emission, yielding 0.500 grams of sulfur-32. After another 14.28 days have passed, only 0.250 grams of phosphorus-32 will remain, and so on. Each passage of a half-life causes the decay of one-half of whatever sample remains.

The half-life of a radioisotope is a constant - no matter the size of the sample, the temperature or any other external conditions. There is no way to speed up or slow down this natural process. Half-lives range from fractions of a second to billions of years. Radioisotopes used internally in medical applications have fairly short half-lives so that they decay rapidly and cause no long term health hazards.

PURPOSE

The purpose of this experiment is to simulate the process of radioactive decay and determine the "half-life" for the process.

SAFETY

There are no safety hazards for this experiment.

MATERIALS

Approximately 250 pennies in a cup, can, or jar

PROCEDURE

Each penny will represent an atom of a radioisotope. The pennies are thoroughly mixed and poured out onto a flat surface. Those pennies that land as "heads" are still "radioactive". The others have "decayed" and should be removed. Count the numbers of "atoms" that remain, and record the value in the data table. Return those pennies that are still radioactive to the (cup, can or jar), mix thoroughly and pour out. Again, count the number of pennies with "heads" showing. Record and continue. When all of the "atoms" have "decayed", plot the data (atoms left vs. trial number) and draw a smooth curve through the points.

DATA SHEET

Name _____

Name _____

Period _____ Class _____

Date _____

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DATA TABLE

Original Number of Atoms _____

Trial	Atoms Decayed	Atoms Left
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

ANALYSIS

1. Write a balanced nuclear equation for beta emission from phosphorus-32.

2. Use your graph and the definition of half-life to determine the half-life of the "penny" radioisotope. Show your work on your graph.

3. The decay constant, k , for a radioisotope is related to its half-life:

$$k = 0.693 / t_{1/2}$$

Use this relationship to determine the decay constant for the pennies.

4. The equation in question 3 can be obtained from the integrated rate law

$$\ln (N/N_0) = -kt$$

where N_0 is the number of radioactive nuclei originally present in the sample and N is the number remaining at time t . Show how this is done.

5. How long (many turns) would it take to complete this simulation - until 1 penny remains - if you had started with \$100 worth of pennies? Show your work.

CONCLUSION (2-3 sentences)