Straw Half-Life

Nuclear Chemistry

Introduction

This creative simulation and excellent critical thinking exercise allows students to count and graph the results of the random "decay" of small, cut-off sections of straws in order to determine the half-life.

Concepts

- Radioactive decay
- Half-life

Materials

Clear plastic box, small
Forceps
Scissors
Straws

Safety Precautions

Although this activity is considered nonhazardous, please follow all normal classroom or laboratory safety guidelines.

Procedure

1. Cut straws into 40 sections, each approximately 7 cm in length.
2. Place all of the straw pieces "one edge" into the clear plastic box. (You should be looking at the curved cylinder edge, not directly at its end—you should not be able to see into the straw cylinder itself.)
3. Give the box a good shake for 1–2 seconds, and then open the box. Using forceps, remove those straw sections that flipped over on end (so that you are now looking down into the straw cylinder). The removed straws represent the number of atoms that have decayed at time "1."
4. Count and record the number of straws left in the box (still on edge so that you are looking at the curved cylinder edge). This number represents the number of atoms left undecayed at time "1."
5. Repeat steps 3 and 4 until all of the straws have "decayed."
6. Compile the data into a spreadsheet. Plot a graph of time (in years or some other arbitrary distinction for each shake) versus the number of straws remaining. Fit a curve to the graph and find the half-life for the "radioactive decay" of the 7-cm straws.
7. Repeat steps 1–5, this time using 40 straw sections that have been cut into 4-cm lengths.
8. Plot the data from the second trial onto the graph from step 6 and determine the half-life of the 4-cm straws.

Disposal

None required—save all materials for future use.

Tips

- Results of individual trials for this activity are typically not very reproducible—expect wide variation. Therefore, instead of having each individual student or group plot their data to determine the half-life of the straws, compile the class data together and plot a curve based on the class average for each time interval. This often produces much better and more reproducible results, even in different class sections. There is a fundamental principle illustrated here as well; that is the importance of large sample sizes when evaluating the probability of random events, such as nuclear decay (or rolling dice)!
- While it is not necessary to plot both sets of data on the same graph, it is helpful to compare the two sets of data. Typically, the 4-cm straw lengths will decay much faster than the 7-cm straw lengths, and thus have a much shorter half-life. The visual representation of the graph will help students to get a better idea of what is really meant by the

Publication No. 91669
061616

term "half-life" and how it can differ depending on the radioactive atom or isotope.

Discussion

Radioactive decay is a spontaneous and completely random process. There is no way to predict how long it will take a specific atom of a radioactive isotope to disintegrate and produce a new atom. The probability, however, that a specific atom will decay after a certain period of time can be simulated by studying other random processes, such as a coin toss, or a "roll of the dice."

Radioactive nuclei disintegrate via different processes and at different rates. The amount of time required for different radioactive nuclei to decompose varies widely, from seconds or minutes for very unstable nuclei to a billion years or more for long-lived radioactive nuclei. The relative rate of decay of different radioactive isotopes is most conveniently described by comparing their half-lives. The *half-life* ($t_{½}$) of a radioactive isotope (called a radioisotope) is the amount of time needed for one-half of the atoms in a sample to decay. Every radioisotope has a characteristic half-life that is independent of the total number of atoms in the sample. For example, the half-life of polonium-218 is about three minutes, while the half-life of uranium-238 is more than 4 billion years. Thus, regardless of the total number of atoms in a sample of polonium-218, one-half of the atoms will always disappear or decompose within three minutes.

The process of radioactive decay may be modeled by studying a random process like a coin toss. In this experiment, 40 small straw sections are placed on edge in a box to start, and the box is shaken. Those straw sections that land directly on end are discarded as they have "decayed." The process is repeated until all of the straws have decayed. The "half-life" of the straws can be determined by graphing the number of straws remaining after each shake in a "radioactive decay curve" (Figure 1).

Sample Individual Data Table *(results of one trial)*

	Nuclei remaining after…								
Years (shakes)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
7-cm straws	40	32	23	19	11	9	6	3	0
4-cm straws	40	11	3	1	0	—	—	—	—

Sample Class Data Table *(results averaged for many trials)*

	Nuclei remaining after…												
Years	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
7-cm straws	40	26	19	13	9	7	6	5	3	3	2	1	0
4-cm straws	40	21	9	2	0	—	—	—	—	—	—	—	—

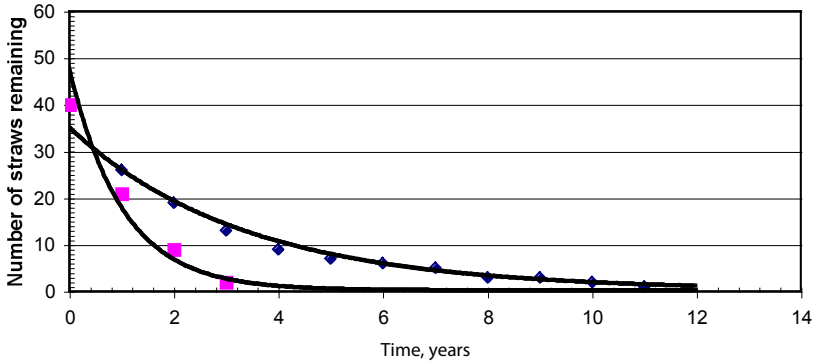

Figure 1. Radioactive decay of straws (class data). Diamonds represent the longer length; squares represent the shorter length.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure of atoms, structure and properties of matter
Content Standard F: Science in Personal and Social Perspectives, environmental quality, natural and human-induced hazards, science and technology in local, national, and global challenges

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Straw Half-Life* activity, presented by Bob Becker, is available in *Nuclear Chemistry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Straw Half-Life* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6025	Straws, Plastic, Wrapped
AB1018	Forceps, Polypropylene

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.