Activity 23 - Introduction to Radioactivity and Half-Life Experiment Kit

Introduction

Some substances contain radioactive nuclides (isotopes) which have a property called half-life. Half-life is the time it takes for half of the atoms of the radioactive nuclide to decay or change into another substance. The atoms do not decay in any set order. Some radioactive nuclides have a half-life of 5000 years. This means that after 5000 years, only half of the atoms in the sample will decay.

Geologists use half-life in radioactive dating of some rocks. They compare the amount of the radioactive nuclide in a rock to the amount that has decayed to form another substance. By knowing the half-life of the nuclide, the approximate age of the rock can be determined.

For example, uranium is radioactive. Through a series of steps it breaks down to lead (Pb) at a known rate. Its half-life is used to calculate the age of rock. The half-life of uranium (the amount of time it takes half of any amount of uranium to break down to lead) is very long, so if little lead is present relative to the amount of uranium, the rock is very young. In other words, the uranium has had no time to decay to lead.

By measuring the ratios between uranium and lead, we can estimate the ages of rocks that are millions of years old. The measurements are not perfect, but they have provided a time scale that is more accurate than any previous one. Similar calculations have been made using radioactive potassium and rubidium.

Carbon-14 is radioactive carbon formed from nitrogen in the atmosphere. It has been used to date (determine the age of) plant and animal remains. All living things used carbon in life processes, and a fraction of that carbon is carbon-14. After death, no additional carbon-14 is incorporated into the plant or animal tissue, so the existing carbon-14 gradually reverts to nitrogen. The rate of decay – its half-life – is approximately 5730 years. In 5730 years, half of the carbon-14 disappears and turns into nitrogen. In another 5730 years, half of that amount disappears, and so on until no carbon-14 remains.

Organic matter younger than 1000 years has lost too little radioactive carbon for the difference to be measured. Organic matter between 1000 to 50,000 years can be dated by the amount of carbon-14 it contains. This information is extremely useful to the geologist, anthropologist, and archeologist.

Using the simulats (simulated radioactive atoms), each having a white and black side to represent atoms of a radioactive nuclide, you will perform the following series of activities:

1. repeatedly shake and toss a given number of simulats on a flat surface;
2. remove the ones that land white side up and count the whites and blacks;
3. graph the results.

In addition, you will:

1. calculate the amount of carbon-14 found in an insect embedded in amber about 18,000 years ago;
2. calculate the amount of carbon-14 present in charcoal burned about 28,000 years ago; and
3. calculate the age of pollen from the amount of carbon-14 remaining in a sample of pollen.

Materials

1 Set plastic simulated radioactive atoms (simulates)
1 Shaker
1 Worksheet and Guide

Activity 23 - Radioactivity Simulation

Name____________________________

Section____________ **Date**_______

Procedure - Exercise A

Work independently or in teams as directed by your instructor. It is necessary for each student to complete a worksheet while possibly sharing materials.

1. Assemble the shaker if necessary.
2. Place an entire set (about 200) simulats (simulated radioactive atoms) in the shaker. Place a hand over the open end and shake the contents. Count the simulats and record in with "0 toss" row.
3. Carefully toss or spill the entire contents on a flat surface in front of you.
4. Move all of the simulats that landed white side up to one side. Assume these have decayed. Count the number of white simulats and record this number in Table 1 in the "removed" column. Count the number of black simulats and record this number in the column labeled "No. of simulats left".
5. Replace only the black simulats in the shaker and repeat the procedure until you have done 8 tosses. Record the number removed and the number left each time in Table 1.
6. Plot the number of simulats left against the number of tosses (the time unit) in Figure 1 on the next page. Use a ruler to accurately plot your points.

Table 1. Data from Simulation of Radioactive Decay

No. of tosses	No. of simulats removed ("decayed")	No. of simulats left
0	0	Starting total =
1		
2		
3		
4		
5		
6		
7		
8		

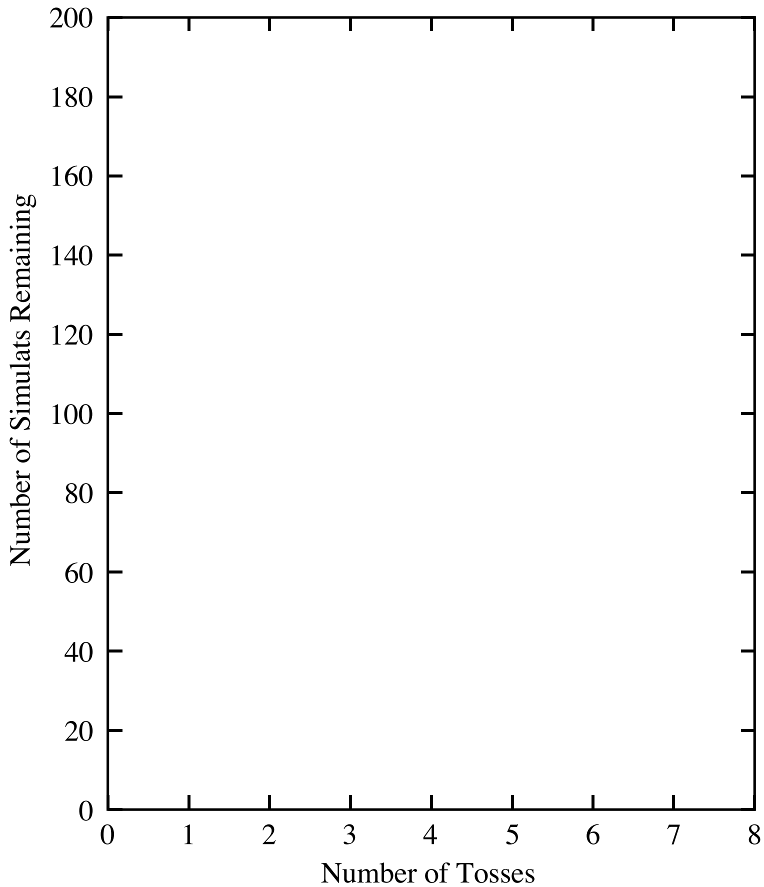

Figure 1. Graph of simulated decay results.

Procedure - Exercise B

Use the square to the right (Figure 2) to represent 100% of the carbon-14 (^{14}C) found in all living matter.

1. Divide the square in half with a vertical line to represent the amount of ^{14}C left after 5730 years (the half-life of ^{14}C).
2. Divide one of the halves again by drawing another line perpendicular to the first line. One of the resulting squares represents the amount of ^{14}C left after 11,460 years.
3. Continue to draw dividing lines to show the amount of ^{14}C left after 17,190 years, 22,920 years, and 28,650 years. Label each region accordingly.
4. On the graph in Figure 3 on the next page, plot time against the fraction of carbon-14 remaining in a once-living organic substance. This can be used to answer questions 5, 6 and 7.
5. What fraction of ^{14}C still remains in charcoal burned in a primitive man's campfire approximately 29,000 years ago? Use Fig. 2 or 3 to find the answer.

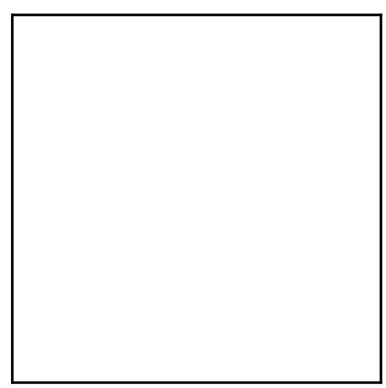

Figure 2. Depiction of sample size.

__________________remains

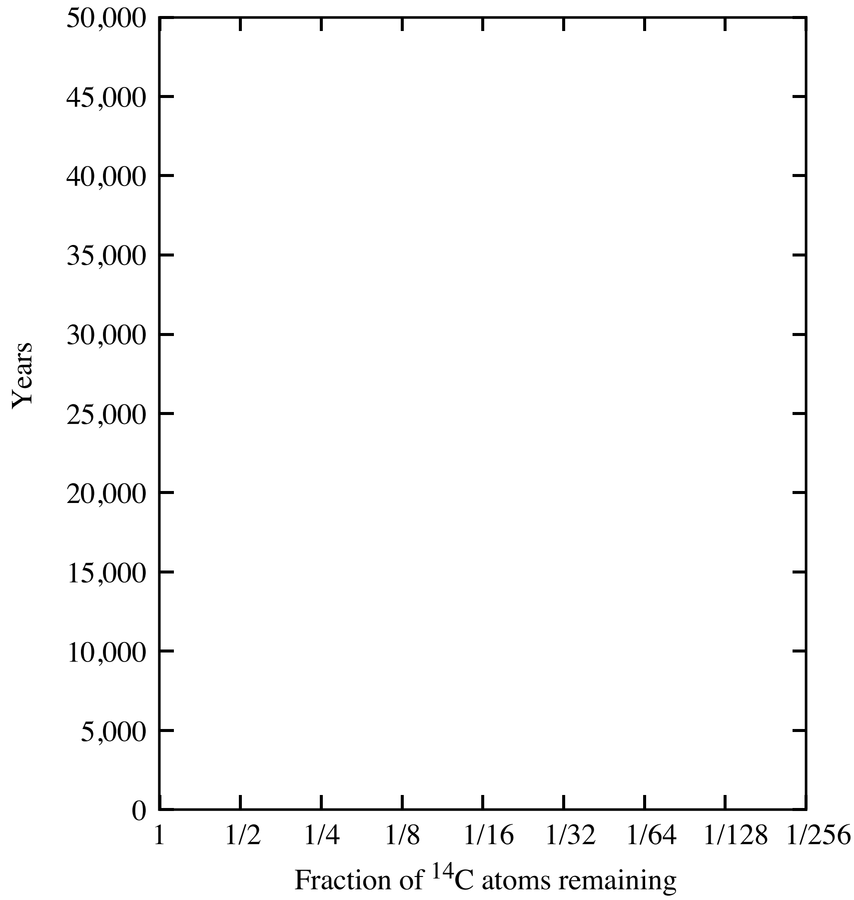

Figure 3. Relationship between half-life and sample remaining.

6. Using Figure 3, approximate the fraction of carbon-14 that still remains in an insect imbedded in amber 18,000 years ago. [Check your answer with the square in Figure 2]

_______________remains

7. Estimate the age of pollen found in peat swamps left by a glacier from your graph (Figure 3). Assume only 1/16 of the original carbon-14 was found in the pollen. [Check your answer with the square in Figure 2]

_______________years

Questions and Problems

1. How many simulats (atoms) changed or decayed by the end of Part 1?

2. Compared to the original number of simulats with which you started, approximately what fraction was left after each shake?

3. What does this indicate about the half-life? In other words, do atoms decay at about the same rate?

4. If each shake represented 500 years of time, what would be the half-life of the simulated radioactive nuclide?

5. What are some of the inaccuracies of this experiment in demonstrating half-life?

6. Will all of the carbon-14 in nature eventually disappear? Explain your answer

7. Precambrian time is older than 600,000,000 years. Can carbon-14 be used in dating organic substances from the era? Explain your answer.

8. Can carbon-14 be used for dating lava flows? Explain your answer.