Activity 5: Half-Life

Objectives

Students will:

- Learn about radioactive decay and decay chains.
- Demonstrate the concept of half-life.
- Calculate and chart the half-life of a given sample.
- Discuss the significance of knowing the half-life of radioactive elements.

Next Generation Science Standards

The concepts in this activity can be used to support the following science standard:

- PS1. Structure and Properties of Matter.

Materials and Resources

- Evolution of a Radioactive Atom: Teacher Background Information.
- Vocabulary Materials.
- Half-Life Data Worksheet (one per student, pair or group) and Half-Life Data Teacher Answer Key. NOTE: The Half-Life Data Worksheet is doublesided.
- 12 sheets of colored paper in two different colors – 6 sheets of each color.
- Student calculators (optional).

Time

45-60 minutes.

Vocabulary

- Atom
- Decay chain
- Half-life
- Ionizing radiation
- Radiation
- Radioactive atom
- Radioactive decay

Directions

1. Start with a vocabulary activity if students are not familiar with radiation and the terms used in this activity, or provide students with the terms and definitions.

2. Ask students:
   - Do radioactive materials always remain unstable (radioactive)? **No. They will eventually become stable.**
   - How long does it take for unstable (radioactive) atoms to give off energy (radiation) and become stable or do all radioactive atoms lose energy and decay at the same rate? **Radioactive elements decay at different rates from fractions of seconds to millions and billions of years.**

3. Provide students with the Half-Life Data Worksheet. Have them read the initial statement and form a hypothesis.

4. Demonstrate the concept of half-life with the class by choosing from the following options:
   - Select three volunteers. Have the volunteers stand at a distance from an easily identifiable location (e.g., a wall or the classroom door). Direct each volunteer to move at varying rates (fast, moderate and slow) to represent half-lives of different elements. For example, radon has a half-life of 3.8 days, radium has a half-life of 1600 years, and uranium has a half-life of 4.5 billion years. Direct each volunteer to walk halfway toward the identifiable location at their designated rate and stop before continuing to the next halfway point between them and the identifiable location. They will continue this process until they cannot go any farther. You can mark the halfway points with string or paper if students need guidance.
   - Ask for 12 volunteers. Have the student volunteers line up in the front of the room. Provide each volunteer with two different colored sheets of paper to represent radon and polonium. Have all of the volunteers hold the radon paper out, facing the students. Have half of the volunteers (any 6 of the 12) place the polonium colored paper facing out to represent the half of the atoms that transferred into polonium. Then have the next half (3 of the 6 volunteers showing radon) place the polonium paper out, facing the students. In the next half-life, have one volunteer place the polonium paper out front and have another volunteer show half radon and half polonium by folding one or both of the papers in half. The remaining volunteer should then place the polonium paper out front and the volunteer showing half radon and half polonium should fold one or both papers to represent three-fourths radon and one-fourth polonium.
   - Show an online video or demonstration of half-life. Sources may include TeacherTube, other allowed Internet sources, or Colorado University's online applet that demonstrates half-life and radioactive decay.

5. Direct students to complete the remainder of the Half-Life Data Worksheet. The use of calculators is optional.

6. Ask students to share their observations and conclusions from the activity. A Half-Life Data Teacher Answer Key is provided.

Half-Life Data Worksheet

Name: ____________________________________ Date: ____________________

Follow the directions and answer the questions.

The following image shows how uranium-238 (a radioactive element) decays and changes to a stable element (lead-206). The half-life of each element is shown in years and days.

1. Hypothesize what half-life is:

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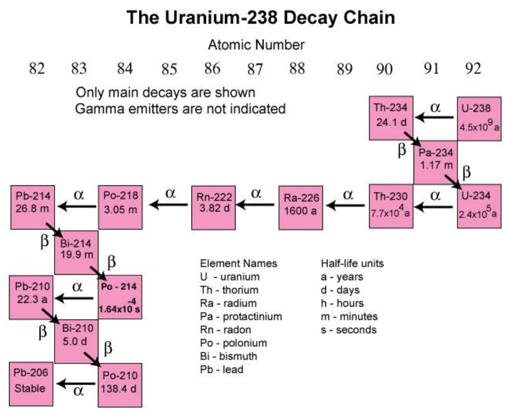
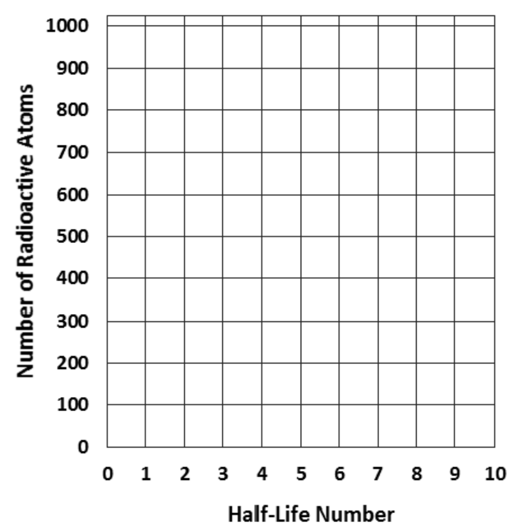


Observe the half-life demonstration as directed by your teacher.

2. Calculate the number of radioactive atoms remaining after each half-life. Write the number of atoms in the “Number of Radioactive Atoms” column. Plot the number of radioactive atoms on the graph provided. Note that the number of unstable (radioactive) atoms decreases as they are being transformed into stable atoms.

Half-Life Number	Number of Radioactive Atoms
0	1024
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	



Observations: ____
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Half-Life Data Worksheet

Questions:

3. If you had a sample of 4,000 radioactive atoms, how many atoms would remain after 5 half-lives?

Half-Life Number	Number of Radioactive Atoms
0	4000
1	
2	
3	
4	
5	

4. If you had a sample of 210 atoms, and you started with a sample of 3,360 atoms, how many half-lives have elapsed?

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5. If the half-life of the sample from question 2 is 30 minutes, how many hours did it take to decay from 3,360 atoms to 210 atoms?

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6. Can you determine the age of something (like a fossil) by examining its half-life? Explain.

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7. In what other ways might it be useful to know a sample's half-life?

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Half-Life Data: Teacher Answer Key

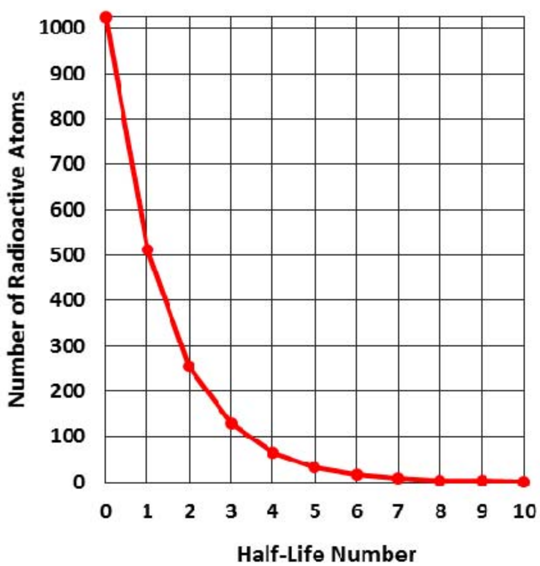
1. Hypothesize what half-life is:

Half-life is the amount of time it takes for approximately half of the radioactive atoms in a sample to decay into a more stable form. Every radioactive element has a different half-life.

2. Calculate the number of radioactive atoms remaining after each half-life. Write the number of atoms in the "Number of Radioactive Atoms" column. Plot the number of radioactive atoms on the graph provided. Note that the number of unstable (radioactive) atoms decreases as they are being transformed into stable atoms.

Observations: **Answers will vary, but students should recognize that the number of radioactive atoms decreases by half after each half-life.**

Half-Life Number	Number of Radioactive Atoms
0	1024
1	*512*
2	*256*
3	*128*
4	*64*
5	*32*
6	*16*
7	*8*
8	*4*
9	*2*
10	*1*



Questions:

3. If you had a sample of 4,000 radioactive atoms, how many atoms would remain after 5 half-lives? **125 radioactive atoms.**

Half-Life Number	Number of Radioactive Atoms
0	**4000**
1	**2000**
2	**1000**
3	**500**
4	**250**
5	**125**

4. If you had a sample of 210 atoms, and you started with a sample of 3,360 atoms, how many half-lives have elapsed? **4 half-lives.**

Half-Life Number	Number of Radioactive Atoms
0	**3360**
1	**1680**
2	**840**
3	**420**
4	**210**

5. If the half-life of the sample from question 2 is 30 minutes, how many hours did it take to decay from 3,360 atoms to 210 atoms? **2 hours.**

Half-Life Number	Number of Radioactive Atoms	Time that has passed (minutes)
0	**3360**	**0**
1	**1680**	**30**
2	**840**	**60**
3	**420**	**90**
4	**210**	**120**

6. Can you determine the age of something (like a fossil) by examining its half-life? Explain. **Yes, this process is called carbon dating. Basically, all living things are made of carbon that continuously cycles through the environment. A small portion of this carbon is in the form of carbon–14, an unstable (radioactive) element. Once an organism dies, the carbon–14 begins to disintegrate. Because it disintegrates at a steady known rate scientists can measure the amount of carbon–14 remaining and use a scientific formula to determine the age of the sample.**

7. In what other ways might it be useful to know a sample's half-life? **It helps in determining how long radioactive material must be safely stored, when radioactive material will be safe to handle, or how long a source will remain radioactive. For example, radioactive dye (called a tracer) and radioactive seeds are used in medical imaging and cancer treatment. Knowing the half-life helps doctors and patients know how long the radioactive material will be effective and when it will stop producing radiation.**