Name: _____   Date: _____

Student Exploration: Half-life

Vocabulary: daughter atom, decay, Geiger counter, half-life, isotope, neutron, radiation, radioactive, radiometric dating

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. Have you ever made microwave popcorn? If so, what do you hear while the popcorn is in

   the microwave? _____

   _____

2. If you turn the microwave on for two minutes, is the rate of popping always the same, or

   does it change? Explain. _____

   _____

Gizmo Warm-up

Like an unpopped kernel in the microwave, a **radioactive** atom can change at any time. Radioactive atoms change by emitting **radiation** in the form of tiny particles and/or energy. This process, called **decay**, causes the radioactive atom to change into a stable **daughter atom**.

The *Half-life* Gizmo allows you to observe and measure the decay of a radioactive substance. Be sure the sound is turned on and click **Play** (▶).
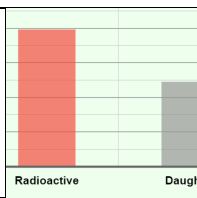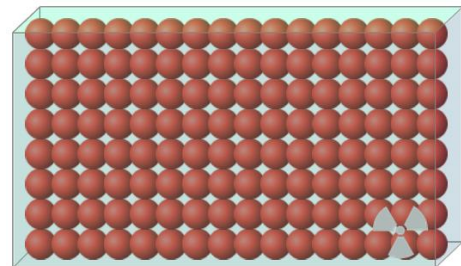

● Radioactive atom   ● Daughter atom

1. What do you see and hear? _____

   _____

   Note: The clicking sound you hear comes from a **Geiger counter**, an instrument that detects the particles and energy emitted by decaying radioactive atoms.

2. What remains at the end of the decay process? _____

3. Is the rate of decay fastest at the beginning, middle, or end of the process? _____

Activity A: **Decay curves**	<u>Get the Gizmo ready</u>: • Click **Reset** (↺). Be sure that **User chooses half-life** and **Random decay** are selected. • Check that the **Half-life** is 20 seconds and the **Number of atoms** is 128.	

Question: How do we measure the rate of radioactive decay?

1. <u>Observe</u>: Select the BAR CHART on the right side of the Gizmo and click **Play**.

    A. What happens to the numbers of radioactive and daughter atoms as the simulation

    proceeds? _____

    _____

    B. Do the numbers of radioactive and daughter atoms change at the same rate

    throughout the simulation? Explain. _____

    _____

2. <u>Experiment</u>: Click **Reset**, and select the GRAPH tab. Run a simulation with the **Half-life** set to 5 seconds and another simulation with the **Half-life** set to 35 seconds. Sketch each resulting decay curve graph in the spaces below.
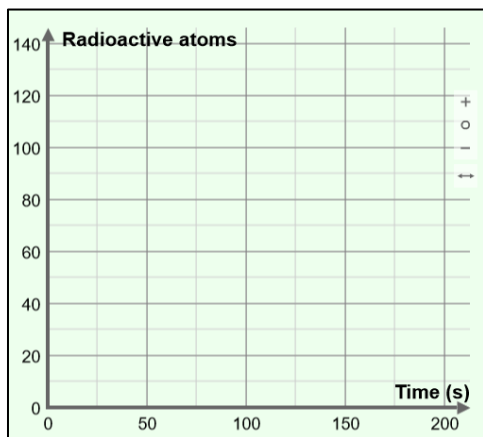
Half-life = 5 seconds
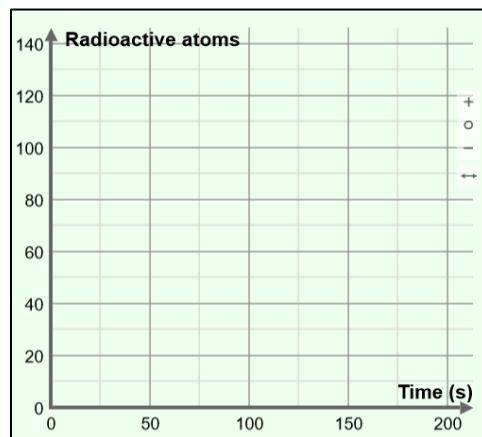
Half-life = 35 seconds

3. <u>Interpret</u>: How does the **Half-life** setting affect how quickly the simulated substance decays?

    _____

    _____

(Activity A continued on next page)

Activity A (continued from previous page)

4. <u>Collect data</u>: Click **Reset**. Change the **Half-life** to 10 seconds and click **Play**. Select the TABLE tab and record the number of radioactive atoms at each given time below.

    0 s: _____   10 s: _____   20 s: _____   30 s: _____   40 s: _____   50 s: _____

5. <u>Analyze</u>: What pattern, if any, do you see in your data? _____

    _____

6. <u>Revise and repeat</u>: Use your data from #4 above to fill in the first line of the data table below. Then repeat the experiment four more times. Calculate the average number of radioactive atoms for each time.

Trial	0 s	10 s	20 s	30 s	40 s	50 s
1						
2						
3						
4						
5						
Averages:						

7. <u>Analyze</u>: A **half-life** is defined as the amount of time it takes for half of the radioactive particles to decay. For the simulated substance, every 10 seconds represents one half-life.

    How does your data demonstrate the definition of a half-life? _____

    _____

    _____

8. <u>Revise and repeat</u>: Click **Reset**. Real radioactive samples will contain billions of radioactive atoms. To model the decay of a large sample, change from **Random decay** to **Theoretical decay** on the SIMULATION pane. Click **Play** and record the numbers of radioactive atoms:
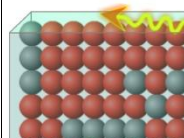
    0 s: _____   10 s: _____   20 s: _____   30 s: _____   40 s: _____   50 s: _____

    How does this data demonstrate the meaning of half-life? _____

    _____

    _____

| **Activity B:**

Measuring half-life | Get the Gizmo ready:

• Click **Reset**.
• Select **Isotope A** from the left drop-down menu.
• Check that **Theoretical decay** is selected. | |

Introduction: Different **isotopes** of the same element have the same number of protons but different numbers of **neutrons** in the nucleus. Some isotopes are radioactive.

Question: How do we find the half-life of a radioactive isotope?

1. <u>Observe</u>: Select the GRAPH tab, and click **Play**. Based on the graph, what is your estimate

   of the half-life of isotope A? _____

2. <u>Measure</u>: Turn on the **Half-life probe**. Use the probe to measure how long it takes for exactly one-half of the original radioactive atoms to decay.

   What is the exact half-life of isotope A? _____

3. <u>Collect data</u>: In the first row of the table below, write how many seconds represent one half-life, two half-lives, and so forth. On the next row, predict the number of radioactive atoms that will be present at each time. Then use the probe to find the actual values.

Half-life	0	1	2	3	4	5
Time (seconds)						
Predicted # radioactive atoms						
Actual # radioactive atoms						

4. <u>Calculate</u>: Calculate the percentage of radioactive atoms that are left after each half-life.

Half-life	0	1	2	3	4	5
Percentage radioactive atoms						

5. <u>Apply</u>: Suppose you found a material in which 12.5% of the original radioactive atoms were

   present. If the half-life is 47 years, how old is the material? _____

(Activity B continued on next page)

Activity B (continued from previous page)

6. <u>Apply</u>: Use the Gizmo to find the half-life of **Isotope B**. What is it? _____

7. <u>Practice</u>: Click **Reset**. Select the **Mystery half-life** from the left menu. In this setting, the half-life will be different each time you run the simulation. Run at least three experiments. In each experiment, measure the half-life using the **Half-life probe** on the graph. (The half-life will be different each time.)

   When you have found the half-life, click the camera (📷) icon. Right-click the image, and click Copy. Then paste the image into a blank document, and label each image with the half-life. Print out this document and turn it in with this sheet.

8. <u>Explore</u>: Use the Gizmo to explore whether the number of atoms present affects the half-life that you measure. Describe your findings below:

   _____

   _____

   _____

   _____

9. <u>Extend your thinking</u>: The slow decay of radioactive materials can be used to find the age of rocks, fossils, and archaeological artifacts. In a process called **radiometric dating**, scientists measure the proportions of radioactive atoms and daughter atoms in an object to determine its age. Carbon-14 is a useful isotope because it is found in wood, ash, bone, and any other organic materials.

   You can use the *Half-life* Gizmo to model the decay of Carbon-14, which has a half-life of approximately 6,000 years (actual value is 5,730 years). In the Gizmo, select **User chooses half-life** and **Theoretical decay**. Set the **Half-life** to 6 seconds (to represent 6,000 years) and the **Number of atoms** to 100.

   Use the Gizmo to estimate the age of each of the objects below. For these questions, each second in the Gizmo represents 1,000 years.

Description	Age (years)
Egyptian papyrus with 63% of its original carbon-14 atoms	
Aboriginal charcoal with 22% of its original carbon-14 atoms.	
Mayan headdress with 79% of its original carbon-14 atoms	
Neanderthal skull with 3% of its original carbon-14 atoms	