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School district: Hamilton Township, NJ

Lesson Title: Simulation of Radioactive Decay

Grades: 9,10,11,12

Overview: You will be able to make a mental model of how the nuclei of radioactive atoms decay.

Objectives: Simulate decay, graph results, determine half life.
Materials & Resources:

- Paper cups
- Pea, lima beans or lentils (split peas represent nuclei; lima beans or lentils represent decay product nuclei)
- Large trays
- Zip lock bags

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RADIOACTIVE DECAY—A SIMULATION

Certain elements are made up of atoms whose nuclei are naturally unstable. The atoms of these elements are said to be radioactive. The nucleus of a radioactive atom will decay into the nucleus of another element by emitting particles of radiation. It is impossible to predict when the nucleus of an individual radioactive atom will decay. However, if a large number of nuclei are present in a sample, it is possible to predict the time period in which half the nuclei in the sample will decay. This time period is called the half-life of the element.

Radioactive materials are harmful to living tissues. Their half-lives are difficult to measure without taking safety precautions. To eliminate these problems, you will simulate the decay of unstable nuclei by using harmless materials that are easy to observe. In this experiment you will use dried split peas to represent the unstable nuclei of one element. Dried lima beans will represent the stable nuclei of another element. Your observations will allow you to make a mental model of how the nuclei of radioactive atoms decay.

Objectives

In this experiment, you will

- simulate the decay of nuclei of a radioactive element,
- graph the results of the simulated decay, and
- determine the half-life of the element.

Equipment

- small bag of dried split peas
- Paper Cup
- bag of dried lima beans
- large pizza or baking tray

Procedure

1. Count out 200 dried split peas and place them in a paper cup
2. Record the number of split peas in Table A-1 as Observation 0.
3. Place the pizza or baking tray on a flat surface.
4. Hold the beaker over the tray and sprinkle the split peas onto the tray. Try to produce a single layer of split peas on the tray.
5. Remove all the split peas that have NOT landed flat side down. Count the split peas that you have removed and return them to the cup. Replace the number of peas that you have removed from the tray with an equal number of lima beans. Count the number of peas and the number of lima beans on the tray. Record these values in Table A-1 as Observation 1.
6. Scoop the peas and beans from the tray and place them into the paper cup

7. Predict how many split peas you will remove if you repeat steps 4 and 5. Enter your prediction in the Data and Observations section.
8. Repeat steps 4 through 6, recording your data in the data table as Observation 2.
9. Predict how many observations you will have to make until there are no split peas remaining. Enter your prediction in the Data and Observation section.
10. Repeat steps 4 through 6 until there are no split peas remaining.

Analysis

In this experiment each split pea represents the nucleus of an atom of radioactive element A. A split pea that has landed flat side down represents the nucleus of an atom of radioactive element A that has not yet decayed. Each split pea that has NOT landed flat side down represents the nucleus of an element A atom that has decayed. Each lima bean represents the nucleus of an element B atom that was formed by the decay of the nucleus of an element A atom.

Assume that the time period between each observation was 5 minutes. Observation 1 will have been made at 5 minutes, observation 2 at 10 minutes, and so on. Complete the Time column in Table A-1.

1. Use Graph A-1 in the Data and Observations section to graph the results of your experiment. Plot on one axis the number of nuclei of element A atoms remaining after each observation. Plot the time of the observation on the other axis. Determine which variable should be represented by each axis.
2. Use Graph A-1 to construct another graph. Plot on one axis the number of nuclei of element B atoms remaining after each observation. Plot the time of the observation on the other axis.
3. Determine the approximate half-life of element A from your graph.

Conclusions

1. What is the approximate half-life of element A? _____
2. Use your graph to determine the number of nuclei of element A atoms remaining after 2 half-lives. After 3 half-lives. _____
3. Why did you replace split peas but not lima beans during this experiment?
4. The two graphs that you constructed look like mirror-images. Explain why this is so.

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5. Suppose you were given 400 dried split peas to do this experiment. Explain which of the following questions you could answer before starting the experiment.
   a. Can you identify which split peas will fall flat side up?
   b. Can you predict when an individual split pea will fall flat side up?
   c. Can you predict how many split peas will be remaining after 3 observations?

Going Further

How does the shape of the object representing the nucleus of a radioactive atom affect the outcome of the experiment? Repeat this experiment using sugar cubes instead of split peas. Paint a dot on one surface of each cube. If a cube falls dot-side down, it represents a nucleus of an atom that has decayed. Before repeating the experiment, predict how the graph of the remaining nuclei will compare with that made using split peas. Predict if the radioactive atom represented by a sugar cube will have a longer or shorter half-life than that represented by a split pea.

Discover

The half-lives of radioactive isotopes vary greatly. Use reference materials to find out the range of half-lives of radioactive elements. Investigate how extremely short half-lives and extremely long half-lives are determined. Write a report summarizing what you discovered.

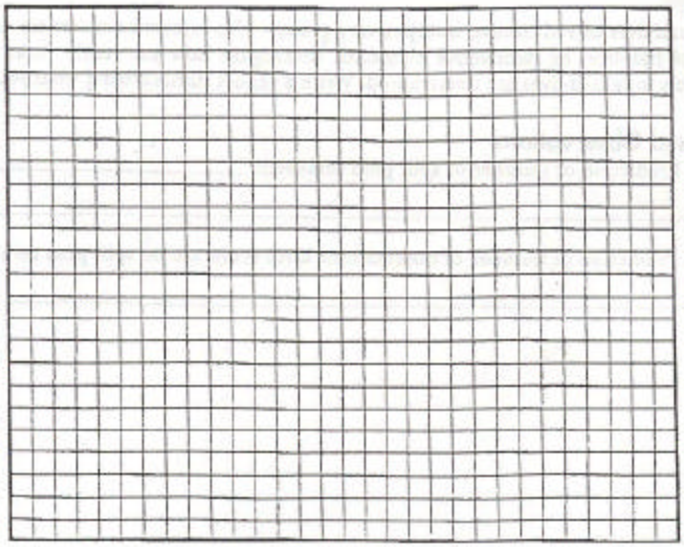
Data and Observations

Step 7. Prediction of number of split peas removed: _____

Step 9. Prediction of number of observations until there are no split peas remaining:

Table A-1

Observation	Time (minutes)	Split peas	Lima beans
0	0		0
1	5		
2	10		



GRAPH A-1