Energy Education Resources

Half-life Activity

Adapted from the American Nuclear Society

Prep Time: 30 minutes to gather materials

Activity Time: 45 minutes

Materials:

- M&M's ®, pennies or puzzle pieces
- Graph paper and pencils
- Plastic sandwich bags

North Carolina Education Standard: PSc.2.3

- **PSc.2.3.1** Compare nuclear reactions including alpha decay, beta decay and gamma decay; nuclear fusion and nuclear fission.
- **PSc.2.3.2** Exemplify the radioactive decay of unstable nuclei using the concept of half-life.

South Carolina Education Standard: H.P.3

- **H.P.3G.2** Develop and use models to communicate the similarities and differences between fusion and fission. Give examples of fusion and fission reactions and include the concept of conservation of mass-energy.
- **H.P.3G.4** Use mathematical and computational thinking to predict the products of radioactive decay

Background

If two nuclei have different masses, but the same atomic number, those nuclei are considered to be isotopes. Isotopes have the same chemical properties, but different physical properties.

For example, natural uranium ore consists of three isotopes: uranium-238 (U238), uranium-235 (U235) and uranium-234 (U234). All three isotopes contain 92 protons in the atom's nucleus (which is what makes it uranium), but the U238 atoms contain 146 neutrons, the U235 atoms contain 143 neutrons and the U234 atoms contain only 142 neutrons. (The total number of protons plus neutrons gives the atomic mass of each isotope – 238, 235, or 234, respectively.)

When uranium is mined, it contains primarily U238. The fuel for nuclear reactors has to have a higher concentration of U235 than exists in natural uranium ore because U235 is what starts and sustains a nuclear reaction. To make nuclear fuel, natural uranium is enriched, meaning the amount of the U235 isotope is increased to about 5 percent.

The nucleus of a radioactive isotope (radioisotope) is unstable. In an attempt to reach a more stable arrangement of its protons and neutrons, the nucleus will spontaneously decompose to form a different nucleus. During radioactive decay an unstable nucleus gives off radiation in the form of atomic particles.

Not all of the atoms of a radioactive isotope (radioisotope) decay at the same time. Rather, the atoms decay at a rate that is characteristic to the isotope. The rate of decay is a fixed rate called a half-life.

DUKE ENERGY®

Procedure

1. Give each student a copy of the data sheet, 10 M&M's® candies and a plastic bag. Tell students the candies represent uranium, the fuel used in a nuclear reactor.

2. Have the student put the M&M's® into the zip lock bag, shake the bag and then pour the candies onto a flat surface.

3. Instruct the students to pick up ONLY the candies with the "m" showing – these are still radioactive. Students should count the "m" candies as they return them to the bag and record the number under the next trial.

4. Students should move the candies that are blank on the top to the side – these have now decayed to a stable state.

5. Repeat steps 2 through 4 until all the candies have decayed or until they have completed Trial 7.

6. Students should record the results for nine other groups in their data tables and total all the trials for the 100 candies.

Discussion

1. Define the term half-life. What does it mean when we say an atom has "decayed?"

2. What happened to the total number of candies with each trial (half-life)?

3. Did each group get the same results?

4. Did any group still have candies remaining after Trial 7?

5. Do the number of atoms you start with affect the outcome? Explain.

6. Why do the totals for the 10 groups better show what happens during half-life rather than any other group's results?

7. Have students plot the total results on a graph with number of candies on the vertical axis and trial number on the horizontal axis. Is the result a straight or a curved line? What does the line indicate about the nature of decay of radionuclides?

Half Life Student Data Collection Sheet

Procedure

1. Place your candies into a plastic bag. Each group is starting with 10 candies, which is recorded as Trial 0 in the data table. All of the candies are radioactive.
2. Shake the bag and spill out the candies onto a flat surface.
3. Pick up ONLY the candies with the “m” showing – these are still radioactive. Count the “m” candies as you return them to the bag.
4. Record the number of candies you returned to the bag under the next trial.
5. Move the candies that are blank on the top to the side – these have now decayed to a stable state.
7. Repeat steps 2 through 5 until all the candies have decayed or until you have completed Trial 7.
8. Record the results for the nine other groups and total all the trials for the 100 candies.

Results

	Trial 0	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
Group 1	10						
Group 2	10						
Group 3	10						
Group 4	10						
Group 5	10						
Group 6	10						
Group 7	10						
Group 8	10						
Group 9	10						
Group 10	10						
Total	100						