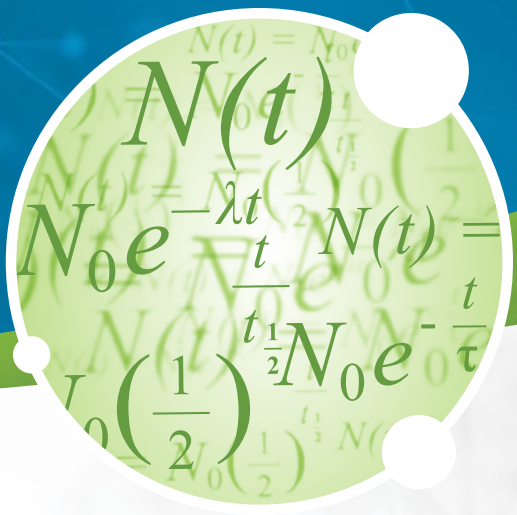
lesson plan

Radioactive Half-Life: The Whole Story

What does "radioactive half-life" mean and how can it be calculated?



overview

LESSON CONTEXT

Most atoms on Earth are stable and never change. However, some atoms, like the radioactive isotope carbon-14, are not stable and they decay, or undergo a transmutation, into a totally new atom of a different element. The process of transmutation of radioactive isotopes into stable isotopes may take only a few milliseconds or, as in the case of uranium, billions of years. The amount of time it takes a radioactive isotope to decay into a stable isotope is different for each radioactive isotope and is characterized by its half-life.

LEARNING GOALS

- Investigate the process of radioactive decay using a model.
- Perform simple, non-logarithmic half-life calculations.
- Analyze data on radioactive decay to predict half-life.
- Understand the concepts of nuclear decay and half-life.

LEARNING ACTIVITIES

In this lesson, students will use coins/chips to represent radioactive isotopes in order to simulate radioactive decay and perform half-life calculations.

BIG IDEAS

The amount of time it takes for half the number of atoms of a radioactive isotope to decay into a stable isotope is known as its half-life.

time
80-95
MINUTES

subjects
SCIENCE
PHYSICS

skills
COLLABORATION
COMMUNICATION

assessment & evaluation

PRIOR KNOWLEDGE AND SKILLS

- Basic understanding of isotopes
- Ability to construct and interpret line graphs
- Ability to calculate averages

SUCCESS CRITERIA

- Students participate meaningfully in hands-on investigation
- Students demonstrate understanding of nuclear decay processes during class discussions

ASSESSMENT STRATEGIES

- Review of **Radioactive Half-Life Application Questions BLM**
- Review of **Radioisotopes Investigation BLM**

resources & materials required

- DOC PDF **BLM – Isotopes Info Sheet** – one per student
- DOC PDF **BLM – Radioisotopes Investigation** – one per student
- DOC PDF **BLM – Radioactive Half-Life Application Questions** – one per student
- PDF **BLM – Radioactive Half-Life Application Questions Answer Page** – for teacher use
- PDF Curriculum alignment
- Coins/chips – 100 per pair of students
- Large, flat plastic container (or shoebox) with lid – one per pair of students
- Electronic device with internet access

minds-on

30 MINUTES

- Have the students read through the **Isotopes Info Sheet BLM**. Encourage the students to write point form notes about what they think is important information.
- Afterwards, discuss the concept of radioisotopes and radioactive decay. Questions for discussion can include:
  - » *What is the major factor that makes some isotopes unstable?*

    The major factor is the relative number of neutrons and protons. If the number of neutrons and protons in a nucleus is relatively equal or there is a slightly greater number of neutrons than protons then the nucleus is generally stable (generally a ratio between 1:1 and 1.5:1). If there is a larger ratio of neutrons to protons (usually greater than 1.5) then the nucleus generally becomes radioactive or unstable.
  - » *What is radioactive decay?*

    Radioactive decay is the process by which unstable isotopes change into more stable isotopes.
  - » *What is the name for isotopes that undergo radioactive decay?*

    Radioisotopes.
  - » *Is energy absorbed or released during the decay process?*

    Energy is released during the nuclear decay process.
  - » *What are some of the applications of energy released by radioisotopes?*

    Radioisotopes are used in medicine for diagnosis and treatment, in the automotive industry to test the quality and thickness of materials, in construction to check for defects and gauge density, etc.

action

30 MINUTES

- Explain to the students that it takes time for radioactive isotopes to decay into stable isotopes. The amount of time is different for each isotope. Some take thousands of years and others take only a few seconds.
- To learn more about the process of radioactive decay, the students will be using coins/chips to represent unstable radioisotopes.
- Provide students with the **Radioisotopes Investigation BLM** and have the students complete steps 1 through 10.

  Note: After 10 events all or most of the coins/chips should have flipped (decayed).

IMPLEMENTATION OPTIONS

- If you have enough coins/chips, students could do the activity individually.
- Students could use 50 coins/chips instead of 100 coins/chips.
- The students could use M&M'S® or Skittles® instead of coins/chips (and eat the isotopes which decay)!
- As students remove the coins/chips that have turned up tails, they could line up the coins/chips from each nuclear decay event to create a concrete object graph of the results. This could benefit visual-spatial learners.

consolidation

20–30 MINUTES

- After the students have completed steps 1 through 10, discuss what the students observed and graphed. Questions for discussion can include:
  - » *Looking at GRAPH ❶ on page 2 of the **Radioisotopes Investigation BLM**, what is the shape of the line? Why do you think it is this shape? (Question 8)*

    The line should have the shape of a decreasing logarithmic curve.
  - » *Why were the coins/chips removed from the container once they flipped over and became stable? Why aren't they left in for the subsequent trials? (Question 9)*

    Once isotopes become stable, they cannot become unstable again.
  - » *What factors may have influenced the number of coins/chips which flipped? (Question 10)*

    Factors could include how vigorously the containers were shaken, the shape of the containers, the sample size, etc.
- The students may have noticed that the number of coins/chips seems to decrease by approximately half each time. Explain to the students that the amount of time it takes for half of the number of atoms of a radioactive isotope to decay into a stable isotope is termed its half-life. This rate is a fixed rate and is unique to each radioisotope.
- Have the student observe on GRAPH ❶ if their line crosses the 50 line at the beginning of event 2 (chances are that it will not). To determine how many events it did take for 50 coins/chips to be flipped, have the students see where their line did cross the 50 line (Question 11). This is the half-life of their coins/chips.
- Have each group submit to you their half-life value and compute an average of the values for the class. The students can then answer an application question using this value (Question 12). The answer will vary depending on your class' half-life value.
- In order to apply their understanding of radioactive half-life, students could complete the **Radioactive Half-Life Application Questions BLM**. Answers for these questions can be found on the **Radioactive Half-Life Application Questions Answer Page BLM**.

IMPLEMENTATION OPTION

- Students could complete the application questions individually or in small groups during class time or outside of class time.

extensions

- The students could write a short summary explaining how the investigation illustrates the concept of radioactive half-life.
- Students could do research to determine in which professions knowledge of half-life information is part of the job (e.g. in medicine, agriculture, manufacturing, etc.).
- Students could research how the half-lives of uranium and carbon are used to date samples of rocks and minerals.

DID YOU KNOW?

Since radioactivity is itself a random process, it is impossible to know when any given radioactive atom will decay; however, because we know the probability of decay for each isotope it is possible to say with great certainty when half of any given collection will disappear – the half-life.

additional resources

CANADIAN NUCLEAR ASSOCIATION WEB PAGES

- **What is radiation?**
- **Quantifying radiation**

RELATED TEACHNUCLEAR LESSON PLANS

- **Fission vs. Fusion**
- **It's All Greek to Me: Radioactive Decay**
- **Understanding Isotopes**

background information

(Retrieved August 2019)

- **Radioactive Dating Game – PhET Interactive Simulations, University of Colorado Boulder**
  In this java applet about the radioactive half-life of isotopes, students can observe a simulation of decay and at the same time observe a dynamic graph of the number of atoms decayed vs. time. There are several different types of isotopes to try.
- **Table of Isotopes and Radioactive Isotopes – The Lund/LBNL Nuclear Data Search**
  Using interactive charts from the Department of Physics at the Lund University and the Lawrence Berkley National Library, select an element and see a listing of all of its isotopes. It includes the half-life for each isotope as well as the decay mode (alpha decay, beta decay, etc.).
- **Radioactive Half-Life – Hyper Physics, Department of Physics and Astronomy, Georgia State University**
  Examine the mathematical equations which allow scientists to calculate nuclear decay and half-life.
- **Half-life – BBC Bitesize Science**
  Information and graphics about radioactive half-life and radioactive decay including a glossary.
- **Half-life: Calculating Radioactive Decay and Interpreting Decay Graphs – Chemistry 101: General Chemistry (Chapter 4, Nuclear Chemistry), Study.com**
  This online portal offers an array of courses using video, video transcript and quiz (quiz through registration only).