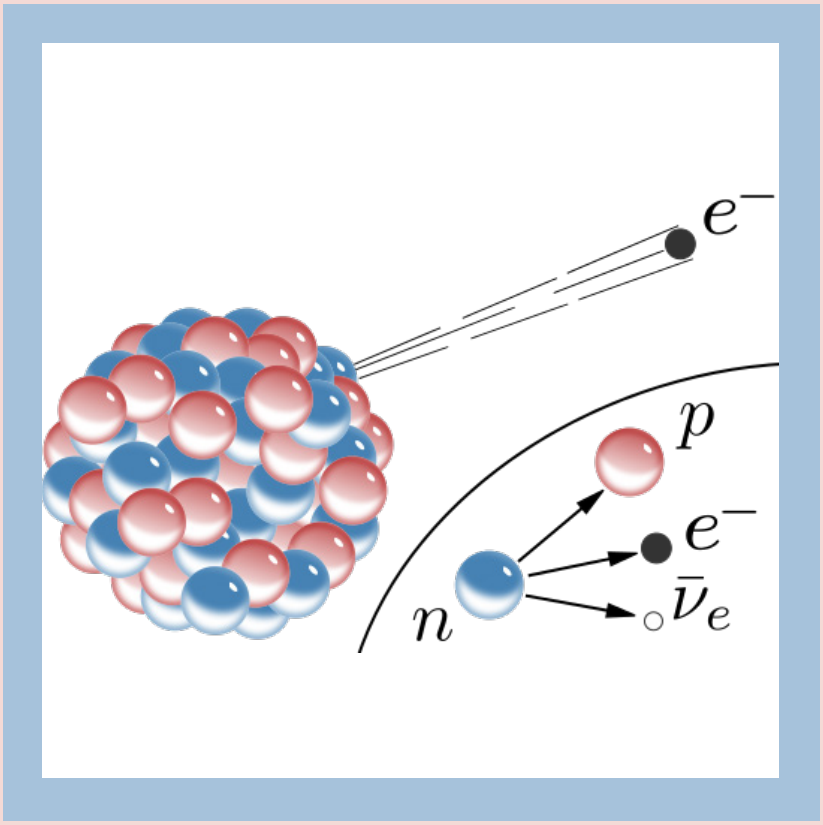
STEM Sims™

Betavoltaics



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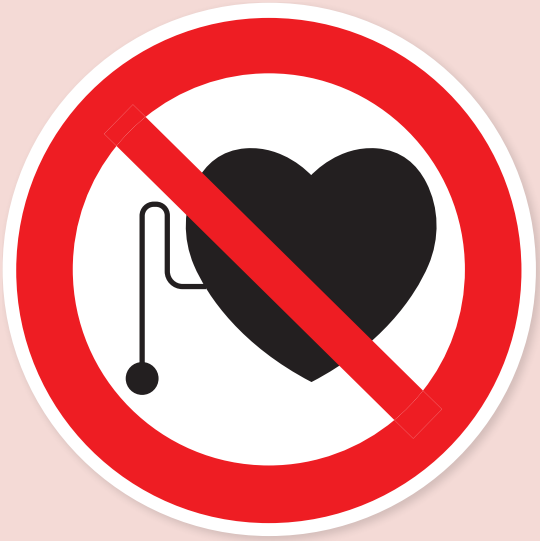
Betavoltaics

Do you need an idea for a scientific study?
Try out one of our ideas or make one of your own.

Start learning right now about how different energy sources are used in a variety of applications. Take the following brief quiz to see how much you already know about batteries and betavoltaics. See the bottom of page 4 to check your answers.

1. A pacemaker is an electronic device implanted into a person's chest to help regulate heart rate. How long does a typical pacemaker battery last?
   a. 1 year
   b. 5 years
   c. 10 years
   d. 50 years



2. Which of the following is *not* a beta emitter?
   a. carbon-12
   b. strontium-90
   c. nickel-63
   d. phosphorus-32

3. What is another name for a beta particle?
   a. proton
   b. neutron
   c. quark
   d. electron

4. In which decade were betavoltaics first developed as an energy source replacement for batteries?
   a. 1900s
   b. 1960s
   c. 1990s
   d. 2010s

5. Tritium is an isotope of which element?
   a. oxygen
   b. copper
   c. carbon
   d. hydrogen

Being Half Right

Half-life is defined as the length of time it takes one-half of the mass of a sample to undergo radioactive decay. Different materials have different half-lives ranging from fractions of a second to millions of years. Scientists use the half-life of a given material to determine the age of a sample such as a fossil or rock. In this activity, you will model the process of radioactive decay and determine the half-life of a sample.

Materials

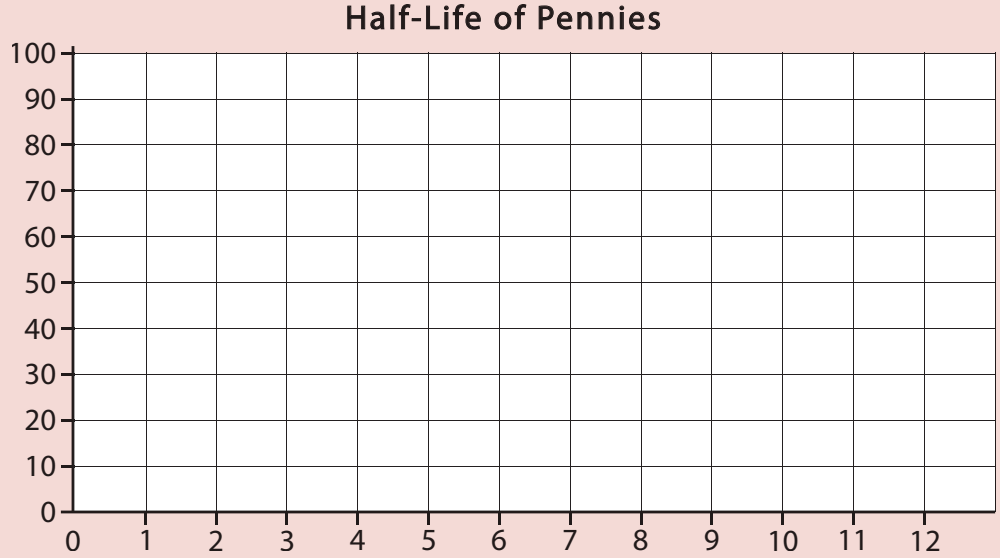
Empty shoe box with lid 100 pennies

Procedure

1. Place all 100 pennies heads-side-up inside the shoe box.
2. Securely place the lid on the shoe box and shake the box vigorously for 5 seconds.
3. Open the lid and remove all of the pennies that are now tail-side-up. Do not add these pennies back to the shoe box.
4. Count and record in Table 1 the number of head-side-up pennies that remain in the shoe box.
5. Repeat steps 2-4 until all pennies have been removed from the shoe box. Make sure to record your data for each round in Table 1.
6. Graph your results from Table 1 on the graph below.

Table 1.

Round	Number pennies in box	Round	Number pennies in box
0	100	7	
1		8	
2		9	
3		10	
4		11	
5		12	
6		13	



Question

1. What is the half-life of your box of pennies? (Hint: Use your graph to determine this value.)

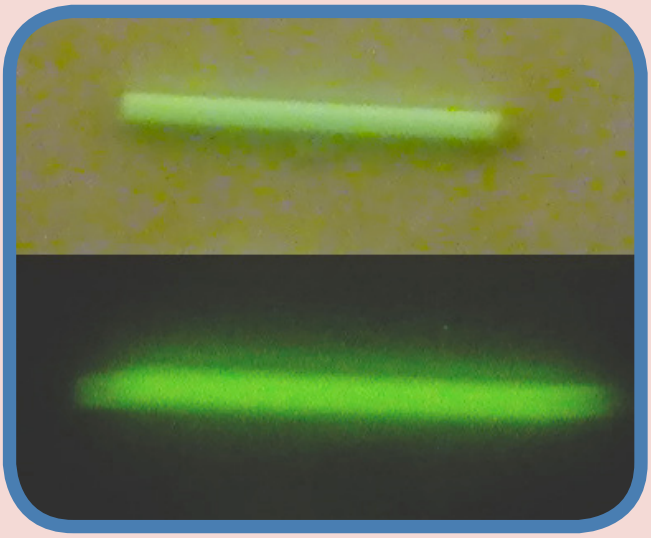
Betavoltaics

An Aging Beta Emitter

Beta decay refers to the process in which a neutron located in the nucleus of an atom splits apart into a proton (with a positive charge), an electron (with a negative charge), and some energy. The electron that emerges from the neutron is called a beta particle. The beta particle has the same mass and charge as an electron found in the energy levels around the nucleus.

One application of beta decay is to power electronic devices. Other beta emitters can be harnessed for very different applications. The carbon-14 beta emitter is one such example. Carbon-14 is an isotope of the carbon-12 atom, only carbon-14 has two more neutrons than its more common elemental cousin. Both isotopes of carbon have the same number of protons and electrons. The extra neutrons make carbon-14 an unstable atom, which causes the atom to undergo nuclear decay over a long period. The equation below shoes how one carbon-14 neutron is converted into a proton (that remains in the nucleus) and an electron (that leaves the nucleus). The addition of the extra proton in the nucleus transforms the carbon atom into a nitrogen atom.

$$^{14}C_6 \longrightarrow {}^{14}N_7 + e^{-1} + \text{energy}$$



Living organisms take in carbon-12 and carbon-14 while alive due to their normal metabolic processes. However, once an organism dies, this update of carbon ceases. The carbon-14 begins the decay process. It takes one-half of the mass of a carbon-14 sample about 5,700 years to decay and turn into a nitrogen isotope. Scientists use the precise timing of the decay process to determine the age of a long-dead organism by determining the ratio of carbon-14 to carbon-12 present in the sample. The smaller the relative amount of carbon-14 in a sample, the older the sample. This technique is called carbon-14 dating.

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Answers: Page 2 Answers: 1) c. 2) a. 3) d. 4) b. 5) d. **Page 3 Answers:** Answers will vary; however, students should find that the half-life of the box of pennies was about one round.

The Green Engineering Magnet (GEM) project was funded in part under the National Science Foundation grant contract #IIP-1127544. Its contents are solely the responsibilities of the authors and do not necessarily represent the official views of the National Science Foundation.