Name

What is Radioactivity? – Vocabulary

Use web resources to define the following terms:

Atomic nuclei:

Ionizing radiation:

Penetrating radiation:

Progeny:

Isotope:

Radioactive decay:

Radioactivity:

Teacher Comments:

Lab 1: Vapor Trails

Guiding Question: How can you see high-energy particles?

In this lab, two to three cloud chambers will be set up. Each chamber will contain a different source material.
Follow the directions below to complete this lab.

Student Observations:

1. Once the lights are turned off, view the inside of each chamber for a minimum of three minutes. Describe your observations.

2. Are any of your observations measurable or quantifiable? If so, please describe.

3. Two to three different tracks or trails should be emitted from one or more of the source materials. Develop a table below to record your data (e.g., estimate the length, describe the shape or speed of your observations, etc.).

4. Hypothesize as to the relationship between your observations and the source material(s).

5. One or more of the source materials provided contained radioactive isotopes. (Note: These isotopes emit very low-level radiation and are not harmful.) Radioactive isotopes are unstable, and therefore they are constantly decaying and emitting radiation. There are three main types of radiation emitted during radioactive decay – Alpha and Beta particles and Gamma rays. Alpha particles are slower moving particles that extend in a straight line approximately one centimeter or less in length. Beta particles move at a faster speed than alpha particles, and extend in thinner straight lines approximately three to ten centimeters in length. Gamma rays (if present) may be seen as fast, spiraling puffs of vapor.

   Using your data and answers from question 3, determine if the tracks you observed were Alpha or Beta particles, and/or Gamma rays. Support your findings with data.

6. If possible, view the chambers for two to three more minutes to confirm your observations above. Record any new or revised observations below.

7. Based on your observations how would you modify your data table?

8. If you had a sample of Polonium-214 (a radioactive isotope known to emit alpha particles) what would you expect to see? Explain your reasoning.

Teacher Comments:

COMPREHENSION 1

What is Radiation?

INTRODUCTION

During the formation of the Earth nearly 4.6 billion years ago, radioactive minerals became a small but significant part of the Earth's crust. Today, these minerals can be found naturally in the environment in rocks, soil, and water. Radioactive minerals exist in most countries and within all 50 states.

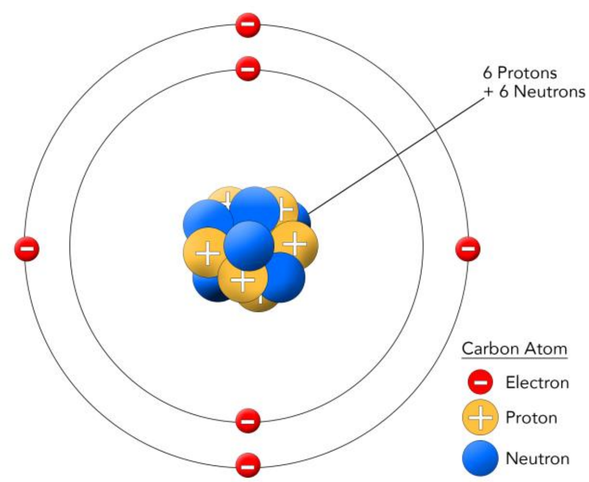
In order to gain an understanding of radioactivity, one must have a basic understanding of radiation science.

WHAT IS RADIATION?

Radiation is a general term, defined as a process in which energy is transmitted or propagated through matter or space. Radiation exists on Earth and comes to Earth from outer space from the sun and in the form of cosmic rays. Light, sound, microwaves, radio waves, and diagnostic x-rays are all examples of radiation. Most radiation is not detected by our senses – we cannot feel it, hear it, see it, taste it, or smell it. However, if radiation is present it can be detected and measured.

The Discovery of Radioactive Minerals. Radioactivity was discovered in 1896 by Henri Becquerel and grew as a result of later investigations, including those of Pierre and Marie Curie. In 1902, Ernest Rutherford and Frederick Soddy determined that radioactivity results from the spontaneous decomposition of an atom (i.e., radioactive decay), resulting in the formation of a new element. These changes are often accompanied by the emission of particles and/or rays.

Ionizing Radiation. Although not all radiation is harmful, *ionizing radiation* (or radiation that alters chemical bonds and produces ions) often comes to mind when the topic is discussed. To understand ionization, it is important to review the basic composition of an atom. An atom consists of a central nucleus that contains comparatively larger particles known as protons and neutrons. These particles are orbited by smaller particles known as electrons. Their relative masses are displayed in the sidebar. One way to think of an atom is to



Relative Masses

Proton – 1.6727×10^{-24} g

Neutron – 1.6750×10^{-24} g

Electron – 9.110×10^{-28} g

visualize a miniature solar system where the sun represents the nucleus and the orbiting planets represent electrons. In a normal situation or in the case of a neutral atom, the number of electrons orbiting a nucleus equals the number of protons in the nucleus.

When an atom or molecule gains or loses electrons, it becomes an ion. Ions can be either positively or negatively charged. A positively charged ion (i.e., cation) results from the removal of one or more electrons, while a negatively charged ion (i.e., anion) results from gaining extra electrons.

Radiation that has enough energy to remove or knock out electrons from atoms, and thus create positively charged ions is known as ionizing radiation. Many types of ionizing radiation exist, but the most well known include *alpha, beta and gamma* radiation. These basic types of ionizing radiation are also emitted during the process of radioactive decay, which is described below.

Radioactive Decay. Many atomic nucleuses are radioactive or in other words, unstable. As a result, these nuclei often give up energy to shift to a more stable state. Known as radioactivity, this spontaneous disintegration of unstable atomic nuclei, results in the emission of radiation.

Sources of Radiation Exposure. We are exposed to radiation every day. For example, radon is a radioactive gas produced from uranium decay. Radon gas can be dispersed into the air as well as ground and surface water. Radioactive potassium (which comes from uranium, radium, and thorium in the Earth's crust) can be found in our food and water. Radiation can also come to us via cosmic rays and the sun. These are all examples of natural or background radiation. In the United States, it is estimated that a person is exposed to an average of 300 millirems of background radiation each year. However, 300 millirems only equates to half of an adult's average yearly exposure. The other 300 millirems of exposure come from manmade sources of radiation, primarily from medical tests such as x-rays and CT scans. Some additional manmade radiation sources that people can be exposed to include: tobacco or cigarettes, television, smoke detectors, antique/vintage Fiesta dinnerware, lantern mantles, and building materials.

Radioactive Isotopes. An isotope of an element is a form of a chemical element that has the same atomic number (proton number) but a different atomic mass (protons + neutrons). An element can have more than one isotope. For example, Thorium, a heavy metal that occurs naturally in the Earth's crust, has 26 known isotopes. Although most elements have isotopes, not all isotopes are radioactive. For example, the most common isotopes of hydrogen and oxygen are stable or non-reactive.

A commonly studied radioactive isotope is Uranium-238 (U-238). When U-238 decays over time, a cascade of different decay products (also known as daughters or progeny) are formed. Of these daughters or progeny, a number

Radioactive decay processes can be natural or manmade.

Different units exist for radiation. These units are dependent on what is being measured:

Biological damage from radiation is measured in millirems.

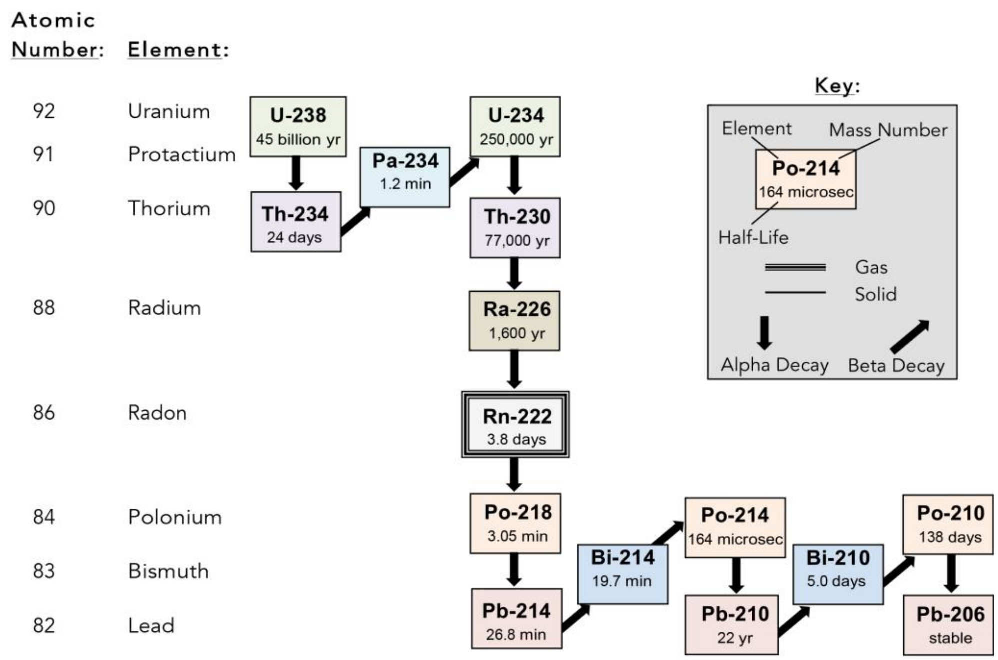
Absorbed energy from radiation is measured in rads.

The decay rate of a radioactive substance is measured in curies.

Radiation intensity of x-rays or gamma rays is measured in roentgens.

The biological equivalent dose to human tissue is measured in sieverts.

of them also go through radioactive decay leaving Lead-206 (Pb-206) remaining. This cascade of decay stops with Pb-206 because it is a stable isotope.



Name

Comprehension 1 - Guiding Questions

1. Explain the difference between radiation and radioactivity.

2. Who was primarily responsible for the discovery of radioactivity? When was this discovery made?

3. Explain how ionizing radiation affects an atom. What radioactive particles are primarily responsible for causing ionization to occur? How are those radioactive particles produced?

4. What is an isotope? Why do some isotopes produce high-energy, radioactive particles?

5. A number of radioactive progeny are produced by the decay of Uranium 238. Why does the decay ultimately end?

<u>Teacher Comments:</u>

Name

Lab 2: Pennicium, Pennithium, & Pennium

Guiding Question: How can the rate of radioactive decay be determined by using isotopes of Pennicium, Pennithium, and Pennium?

In this activity, you will be working with three distinct isotopes, Pennicium-100, Pennithium-80, and Pennium-30. Follow the directions below to determine the rate of radioactive decay for each isotope.

Student Directions

1. Obtain 100 pennies (i.e., Pennicium-100) and place them in a cup or Ziploc bag.
2. Shake the contents of your container and empty the pennies onto a flat surface.
3. Remove all of the pennies with the tails side facing up.
4. Record the number of "heads" that remain in the table below. **Note:** One or more heads must remain each time to record an observation. If no heads remain, simply return the remaining pennies to your container and repeat steps 2-4.
5. Weigh each group of "heads" and record your findings in the table below. Note: If a scale is not available, you can assume each penny weighs 1 g.
6. Place the remaining pennies back in the container and repeat steps 2-4 four more times.
7. Repeat steps 1-5 for Pennithium-80 and Pennium-30, beginning with 80 pennies for trial 2, and 30 pennies for trial 3.
8. Graph your results from each experiment on one sheet of graph paper using different colored pens. **Note:** Make sure you put your independent and dependent variables on the correct axis, include a graph title, and label your axes.

Shakes/rolls	**Pennicium-100**	**Mass (g)**	**Pennithium-80**	**Mass (g)**	**Pennium-30**	**Mass (g)**
0	100		80		30	
1						
2						
3						
4						
5						

9. Using the information below, determine what type of trend line/regression type will produce the line of best fit for your data. Record your answer below.

   Linear: A linear trend line is used when data points resemble a straight line that increase or decrease at a steady rate.

   Logarithmic: A logarithmic trend line is a curved line where the data increases or decreases at a steady rate and then levels outs. A logarithmic line can contain negative and/or positive values.

   Exponential: An exponential trend line is a curved line that is used when values rise or fall at constantly increasing rates. An exponential trend line will approach zero or infinity, however data points will never include zero or negative values.

   Polynomial: A polynomial trend line is a curved line that is used when data fluctuates (e.g., one or more bends in the data).

   Power: A power trend line is a curved line that is best used when data increases at a specific rate. A power trend line cannot contain zero or negative values.

10. Using a TI graphing calculator or the online Meta-Calculator 2.0 (http://bit.ly/HXcjnE), enter your data points (shakes/rolls and mass) for Pennicium-100 in the appropriate columns. **If using a TI Calculator**: select STAT, Edit, and enter data points in L_1 and L_2. **If using the Meta-Calculator:** select "Statistics Calculator" and then select the "Regression Analysis" tab; enter data points in the x_i and f_i columns. Determine the line of best fit using the regression type you chose above in question 8 (**TI Hint:** STAT, CALC; **META Hint:** select type of regression and click "Analyze"). Write the equation below.

11. Graph your equation from question 10 with the data points you entered in question 9. (**TI Hint:** Y=; enter equation; make sure Plot 1 is turned on; ZOOM; select 9; **Meta Hint:** "Plot Graph", note: you may need to change the bounds to view full graph). How well does the line fit your data? If the line is not a good fit, review the definitions in question 8 to determine if there is another regression type that may produce a better fit.

12. Repeat steps 9 through 11 with Pennithium-80 and Pennium-30. Record the type of regression used and the equation for each line of best fit below.

13. Write the equations for the lines of best fit for Pennicium-100, Pennithium-80, Pennium-30 below. What does each of your equations have in common?

14. Thinking about the material (pennies) you began each experiment with, what does the similarity you identified in question 13 model?

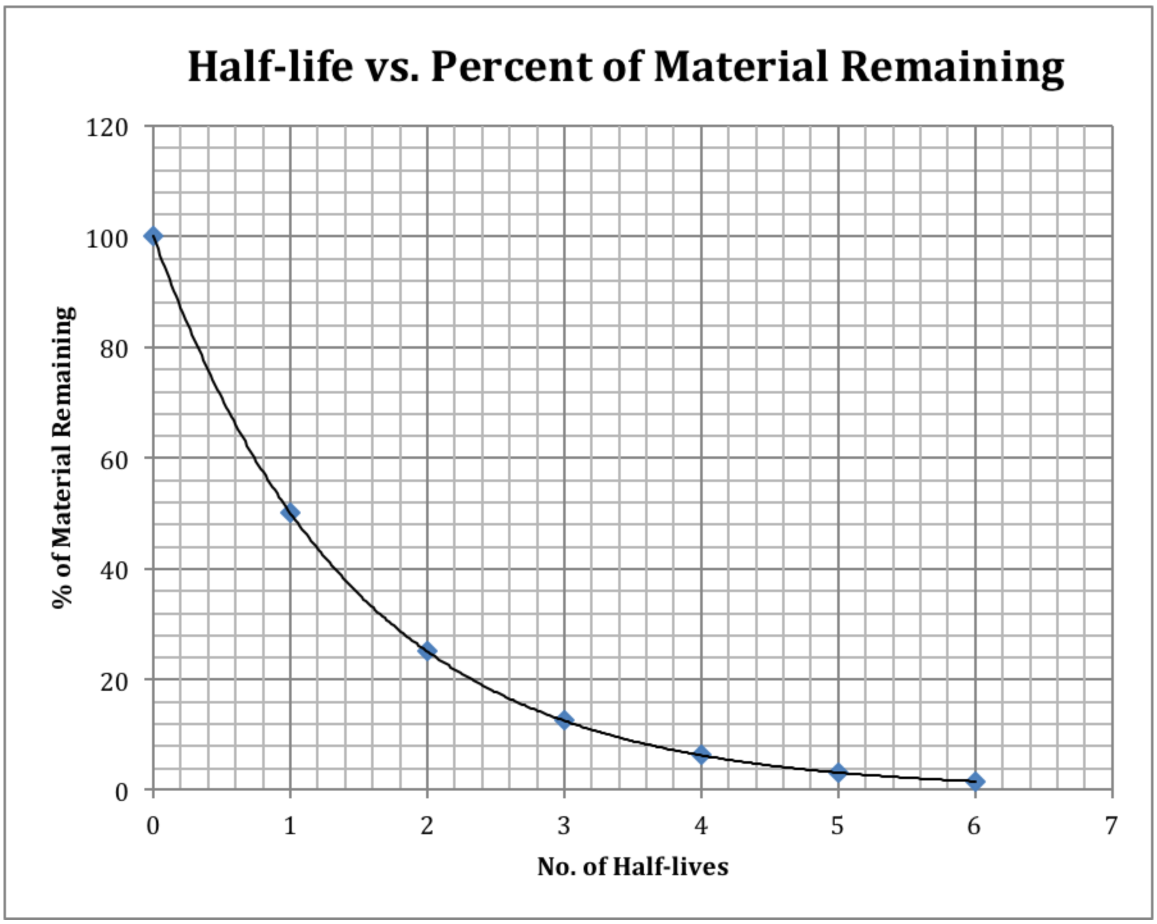
15. If you were given a 200g sample of the isotope Pennercum-200, what would the data table and graph for its radioactive decay look like? Use the space below to sketch your data table and graph.

Teacher Comments:

Calculating Half-Life (A)

Guiding Question: *How are half-lives calculated?*

The graph you developed in the Pennicium, Pennithium, & Pennium lab should resemble the graph below and illustrates the concept of half-life or the exponential nature of decay exhibited by radioactive materials. Radioactive decay is important in a variety of fields from medicine to energy production, astronomy, and geology. Some of the applications of the radioactive decay process include determining how long spent nuclear fuel poses an environmental danger and dating geological materials based on their half-lives.



When appropriate, use the graph to solve the following problems:

Example: *Francium-223, one of the most unstable and reactive elements, has a half-life of approximately 22 minutes. If you initially had a 10.0 g of Francium-223, how many grams would remain after 55 minutes?*

First, determine the number of half-lives that have occurred:

$$\frac{22\ min}{1\ half\text{-}life} = \frac{55\ min}{x\ half\text{-}lives} \qquad x\ half\text{-}lives = 55min \times \frac{1\ half\text{-}life}{22\ min} = 2.5\ half\text{-}lives$$

Using the graph, determine what percent of the material remains after 2.5 half-lives.

$$10.0\ g \times 0.18 = 1.8\ g\ Francium\text{-}223\ remaining$$

1. *Iodine-131 (I-131) has a half-life of approximately 8.0 days. If you started with an 80.0g sample, how many grams of I-131 would be left after 2 days?*

2. *There are 200.0 grams of an isotope with a half-life of 42 hours present at time zero. How much time will have elapsed when 76.0 grams remain?*

3. *After 15 days, approximately 70% of a sample of a radioactive isotope remains from the original material. What is the half-life of the sample?*

4. *The half-life of the radioactive isotope phosphorus-32 is approximately 14.3 days. How long until a sample loses 98% of its radioactivity?*

5. *Uranium-238 has a half-life of 4.46 x 10^9 years. How much U-238 should be present in a sample 2.5 x 10^9 years old, if 2.00 grams was present initially?*

Name

Calculating Half-Life (B)

Guiding Question: *How are half-lives calculated?*

The equations you calculated in the Pennicium, Pennithium, & Pennium experiment should resemble $y = a\left(\frac{1}{2}\right)^x$ *where a equals the number of pennies in the beginning, x is the number of shakes/rolls, and y is the number of pennies remaining after that throw. This equation illustrates the concept of half-life or the exponential nature of decay exhibited by radioactive materials. Radioactive decay is important in a variety of fields from medicine to energy production, astronomy, and geology. Some of the applications of the radioactive decay process include determining how long spent nuclear fuel poses an environmental danger and dating geological materials based on their half-lives. A common equation that is used for the exponential decay process (shown below) is very similar to the equation you developed and can also be used to solve half-life or radioactive decay problems.*

$$N(t) = N_o\left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$

Where:

- $N(t) = the\ amount\ of\ a\ substance\ that\ remains\ after\ a\ specific\ time\ (t)\ of\ decay$
- $N_o = the\ orignal\ amount\ of\ the\ substance\ that\ will\ decay$
- $t = time$
- $T_{1/2} = half\text{-}life\ of\ the\ decaying\ substance$

Using the equation above, solve the following problems:

Example: There are 200.0 grams of an isotope with a half-life of 42 hours present at time zero. How much time will have elapsed when 76.0 grams remain?

$$Using\ the\ radioactive\ decay\ equation, N(t) = No\left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}\ to\ solve\ for\ t:$$

$$76g = 200g\left(\frac{1}{2}\right)^{\frac{t}{42\ hours}}$$ → *To solve for t, you need to take the log of each side.*

$$Log\left(\frac{76g}{200g}\right) = \left(\frac{t}{42\ hours}\right)Log\left(\frac{1}{2}\right) \rightarrow Log\left(\frac{76g}{200g}\right) = -.420 \rightarrow Log\left(\frac{1}{2}\right) = -.301$$

$$\left(\frac{-.420}{-.301}\right) * 42\ hours = t \rightarrow t = 58.6\ hours$$

1. Iodine-131 (I-131) has a half-life of 8.0197 days. If you started with an 80.0g sample, how many grams of I-131 would be left after 2 days? Use the radioactive decay equation to solve the problem then compare your result with the original result derived from using the graph.

2. After 15 days, two-thirds of a sample remains. If the original sample was 87mg, what is the half-life of the sample?

3. Radon-222 has a half-life = 3.8235 days. How many grams of a 64.0 g sample of Rn-222 will remain after 11.5 days?

4. The isotope Radium-226 has a half-life of 1640 years. Chemical analysis of a certain chunk of concrete from an atomic-bombed city, preformed by an archaeologist in the year 6264 AD, indicated that it contained 2.50 g of Ra-226. By comparing the amount of Ra-226 to its end product Lead-206, it was determined the original amount of Ra-226 was 9.962 g. What was the year of the nuclear war?

5. Carbon-14 has a half-life of 5730 years making it useful for dating organic materials. A piece of charcoal found by an archaeologist at an excavation of an ancient campsite was found to have 30.0% of that in living trees. What is the approximate age of the piece of charcoal?

Application: Balancing Radioactive Equations

Balance the following reactions, identify product X, and determine what type of decay occurs.

A) $^{214}_{82}Pb \rightarrow \, ^{214}_{83}Bi + x$ $\quad X =$ $\quad$ *Alpha Decay or Beta Decay*

B) $^{238}_{92}U \rightarrow x + \, ^{4}_{2}He$ $\quad X =$ $\quad$ *Alpha Decay or Beta Decay*

C) $^{24}_{11}Na \rightarrow x + \, ^{0}_{-1}e$ $\quad X =$ $\quad$ *Alpha Decay or Beta Decay*

D) $^{52}_{26}Fe \rightarrow \, ^{52}_{27}Co + x$ $\quad X =$ $\quad$ *Alpha Decay or Beta Decay*

E) $^{232}_{90}Th \rightarrow \, ^{228}_{88}Ra + x$ $\quad X =$ $\quad$ *Alpha Decay or Beta Decay*

Extensions: Distribute suggested readings about beneficial uses of radiation, Marie Curie, and Mars travel.

Have students view the Khan Academy's video "Types of Decay" available at: http://bit.ly/S9Rmav

Students can calculate their personal annual radiation dose by completing the "Annual Radiation Dose Worksheet" or visiting: http://bit.ly/PMU9w4

Teacher Comments:

COMPREHENSION 2

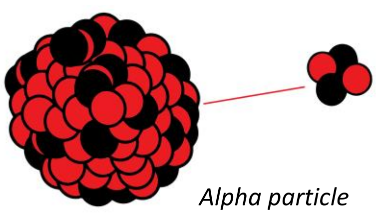
How does Radioactive Decay Occur?

HALF-LIFE OF RADIOACTIVE ISOTOPES

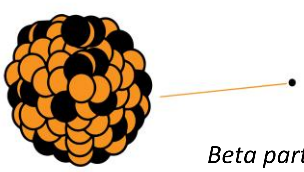
We cannot determine when radioactive materials will decay and give off radiation. However, there is a pattern we can use to estimate how long it takes for an isotope to lose half of its radioactivity. This pattern is known as half-life. For example, if an isotope has a half-life of 20 years, half of the original substance will decay in 20 years. Then in another 20 years, half of the substance that remained will decay. This process will continue every 20 years. It is important to note that a radioactive substance will never completely decay, no matter how insignificant or small of an amount is left.

The half-life of a radioactive isotope is important as it dictates its behavior, its effects on the environment, and the amount of radiation it emits. For example, a radioactive isotope with a long half-life will emit its radiation infrequently. However, a radioactive isotope with a short half-life will emit its radiation repeatedly in a short period of time.

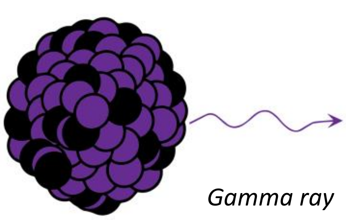
Not only is radiation emitted when the radioactive isotope decays, but the decay products of an isotope can also give off radiation. As discussed earlier, these decay products are referred to as daughters or progeny.



Alpha particle



Beta particle

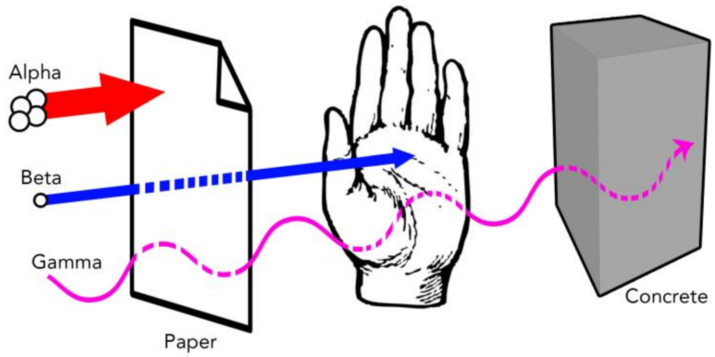


Gamma ray

Alpha, Beta, and Gamma Radiation. Although there are several forms of ionizing radiation (i.e., when the energy produced is strong enough to knock electrons out of molecules and create ions or free radicals, we will concentrate on just three. These three types of radiation - alpha, beta, and gamma - result from the decay of radioactive isotopes.

An alpha particle, beta particle, or gamma ray is emitted during radioactive decay. Each time an alpha particle is emitted the number of protons decreases by 2 and the number of neutrons decreases by 2. This is always the same because an alpha particle is made up of 2 protons and 2 neutrons, identical to a helium nucleus (i.e., He^{+}). A beta particle is formed when a neutron breaks apart into a proton and an electron. A beta particle is essentially an electron emitted from a nucleus. When a beta particle (i.e., the newly formed electron) is emitted, the atomic number increases by one. This can be thought of as a conversion of one neutron into one proton to account for the loss of the negatively charged beta particle. Although the atomic number changes during beta emission (thus creating a new element), the mass number stays the same.

Alpha particles are comparatively larger particles with an electrical charge (+2). For these reasons, alpha particles travel at relatively slow velocities and have low penetration depths. Alpha particles can be stopped by one to two inches in air, a thin sheet of paper, or the body's outer layer of skin. Outside of the human body, alpha particles are not considered a hazard because they are stopped by our body's first line of defense – the skin. However, when alpha particles are inhaled or swallowed, they interact with live tissues and cells. When this occurs, alpha particles can produce large amounts of ionizing radiation, thus causing internal tissue and cell damage.



Compared to alpha particles, beta particles are much faster and lighter. Beta particles can also travel farther (~ 10 feet in air) and can penetrate past the most outer (dead) layer of skin. Since beta particles can cause damage to the skin, they are considered both an internal and external hazard. Solid materials such as clothing or a thin layer of metal or plastic can stop these particles and the effects of damaging radiation.

Gamma rays are high energy, electromagnetic waves that travel at the speed of light. Gamma rays have no mass and can travel farther distances than alpha and beta particles, reaching distances up to thousands of yards in air. Gamma rays can pass through human tissue and can only be stopped by dense materials such as lead, cement, or steel. X-rays, another type of electromagnetic radiation, are similar to gamma rays and also produce penetrating radiation (i.e., radiation capable of penetrating the skin and reaching internal organs and tissues.)

The ionizing radiation produced from alpha, beta, or gamma decay can be especially harmful because it can change the chemical makeup of many things, including the chemistry of the human body and other living organisms. X-rays and CT scans are good examples of ionizing radiation. If possible, it is good to avoid any unnecessary exposure to ionizing radiation.

Balancing Radioactive Equations. Another way to understand radioactive decay is to understand how to describe the process in the form of an equation. Writing and balancing an equation for radioactive decay is different than writing and balancing an equation for a chemical reaction. In addition to writing the symbols for various chemical elements, the protons, neutrons, and electrons associated with that element or isotope are also included in the equation.

The accepted way of denoting the atomic number (i.e., protons or *p*) and mass number (i.e., protons plus neutrons or *p + n*) of Uranium is shown below:

$$ {}^{Mass\#}_{Atomic\#} \quad {}^{238}_{92}U \text{ or } {}^{p+n}_{p}U $$

As we discussed before, alpha decay occurs when a particle with two protons and two neutrons is emitted. This alpha particle is identical to a helium nucleus or ${}^{4}_{2}He$. As shown below, the original element's (E_1) mass decreases by four, and it's atomic number decreases by two. This results in a new element (E_2) and a helium nucleus.

$$ {}^{p+n}_{p}E_1 \rightarrow {}^{(p+n)-4}_{p\text{-}2}E_2 + {}^{4}_{2}He $$

Now let's look at a real-world example of alpha decay, such as Radium-226. When Radium-226 decays, the resulting products are Radon-222 and an alpha particle (or He). Notice in the equation below, that the same number of protons and neutrons exist on both sides of the equation, resulting in a balanced equation.

$$ {}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He $$

In beta decay, an unstable neutron turns into a proton and an electron. This results in a gained proton, while a neutron is lost. The beta particle is actually the newly formed electron being emitted from the nucleus. This decay process results in a new atomic number (i.e., from gaining a new electron), while the mass actually stays the same (i.e., a neutron was turned into a proton).

$$ {}^{P+N}_{P}E_1 \rightarrow {}^{(P+1)+(N\text{-}1)}_{P+1}E_2 + {}^{0}_{-1}e $$

Another example of beta decay is when Cesium decays to Barium, resulting in the emission of an electron. This reaction is shown below. Notice once again, the equation is balanced and the number of protons and neutrons on the left equals the number on the right.

$$ {}^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + {}^{0}_{-1}\epsilon $$

The last type of decay we discussed, gamma decay, is very different from alpha and beta decay. In gamma decay, the number of protons and neutrons does not change and it is not possible to show the decay process in the form of an equation. Essentially, the protons and neutrons reconfigure themselves within the nucleus, and release high levels of energy in the form of electromagnetic rays or gamma rays.

Application: Balancing Radioactive Equations

Balance the following reactions, identify product X, and determine what type of decay occurs.

A) $^{214}_{82}Pb \rightarrow\ ^{214}_{83}Bi + x$ $X =$ $Alpha\ Decay\ or\ Beta\ Decay$

B) $^{238}_{92}U \rightarrow x + ^{4}_{2}He$ $X =$ $Alpha\ Decay\ or\ Beta\ Decay$

C) $^{24}_{11}Na \rightarrow x + ^{0}_{-1}e$ $X =$ $Alpha\ Decay\ or\ Beta\ Decay$

D) $^{52}_{26}Fe \rightarrow\ ^{52}_{27}Co + x$ $X =$ $Alpha\ Decay\ or\ Beta\ Decay$

E) $^{232}_{90}Th \rightarrow\ ^{228}_{88}Ra + x$ $X =$ $Alpha\ Decay\ or\ Beta\ Decay$

Extensions: Distribute suggested readings about beneficial uses of radiation, Marie Curie, and Mars travel.

Have students view the Khan Academy's video "Types of Decay" available at: http://bit.ly/S9Rmav

Students can calculate their personal annual radiation dose by completing the "Annual Radiation Dose Worksheet" or visiting: http://bit.ly/PMU9w4

Comprehension 2 – Guiding Questions

1. Does radioactive decay proceed at the same rate for every radioactive isotope? How do nuclear scientists determine how long it takes for a radioactive isotope to decay? Why is the rate of decay important?

2. Will a radioactive element with a relatively short half-life emit more or less radiation than a radioactive element with a relatively long half-life?

3. When comparing alpha and beta radiation to gamma radiation, what is the basic difference?

4. When balancing radioactive chemical equations, how is alpha decay different from beta decay?

5. When balancing radioactive chemical equations, how is alpha decay the same as beta decay?

6. What are the biological hazards associated with alpha and beta particles, and gamma rays respectively?

Teacher Comments:

Name

Annual Radiation Dose Worksheet

Where you live

1. Cosmic radiation at sea level (from outer space) ---------- 26

2. Select the number of millirems for your elevation (in feet)

up to 1000 ft. = **2** | 1000-2000 ft. = **5**
2000-3000 ft. = **9** | 3000-4000 ft. = **9**
4000-5000 ft. = **21** | 5000-6000 ft. = **29**
6000-7000 ft. = **40** | 7000-8000 ft. = **53**
8000-9000 ft. = **70**

Elevation of some U.S. cities (in feet): Atlanta, 1050; Chicago, 595; Dallas, 435; Denver, 5280; Las Vegas, 2000; Minneapolis, 815; Pittsburg, 1200; Salt Lake City, 4400; Spokane, 1890; Washington, DC, 25.

add this number: ---------- ______

3. Terrestrial (from the ground):
If you live in states that border the Gulf or Atlantic Coast, **add 23** ---------- ______
If you live in the Colorado Plateau area (around Denver), **add 90** ---------- ______
If you live in middle America (rest of the U.S.), **add 46** ---------- ______

4. House construction:
If you live in a stone, brick, or concrete building, **add 7** ---------- ______

What you eat and drink

5. Internal radiation (in your body):*
From food and water ---------- 40
From air (radon) ---------- 200

Other sources

6. Weapons test fallout (less than 1):** ---------- 1
7. Jet plane travel:
For each 1,000 miles you travel, **add 1** ---------- ______
8. If you have porcelain crowns or false teeth, **add 0.07** ---------- ______
9. If you use gas lantern mantles when camping, **add 0.003** ---------- ______
10. If you wear a luminous wristwatch (LCD), add **0.006** ---------- ______
11. If you use luggage inspection at airports (using typical x-ray machine), **add 0.002** ---------- ______
12. If you watch TV**, **add 1** ---------- ______
13. If you use a video display terminal**, **add 1** ---------- ______
14. If you have a smoke detector, **add 0.008** ---------- ______
15. If you wear a plutonium-powered cardiac pacemaker, **add 100** ---------- ______
16. If you have had medical exposures:*
Diagnostic X-rays (e.g., upper and lower gastrointestinal, chest), **add 40** ---------- ______
If you have had nuclear medical procedures (e.g., thyroid scans), **add 14** ---------- ______
17. If you live within 50 miles of a nuclear power plant (pressurized water reactor), **add 0.0009** ---------- ______
18. If you live within 50 miles of a coal-fired electrical utility plant, **add 0.03** ---------- ______

My total annual mrems dose: ---------- ______

Some of the radiation sources listed in this chart result in an exposure to only part of the body. For example, false teeth result in a radiation dose to the mouth. The annual dose numbers given here represent the "effective dose" to the whole body.

*These are yearly average dose.
The value is actually less than 1. ***Retrieved from:* http://www.nrc.gov/reading-rm/basic-ref/teachers/average-dose-worksheet.pdf

Name

'What is Radioactivity?' Evaluation Questions

For questions 1-5, write the letter of the best answer in the space before the question.

1. ____ Radiation and radioactivity are synonymous terms.

   A. true B. false

2. ____ U-238 and U-234 are examples of _____.

   A. allotropes B. complementary ions C. progeny D. isotopes

3. ____ Which of the following would represent the penetrating power of alpha, beta, and gamma radiation ranked from highest penetrating power to the lowest?

   A. alpha, beta, gamma B. beta, gamma, alpha C. gamma, beta, alpha D. none of the above

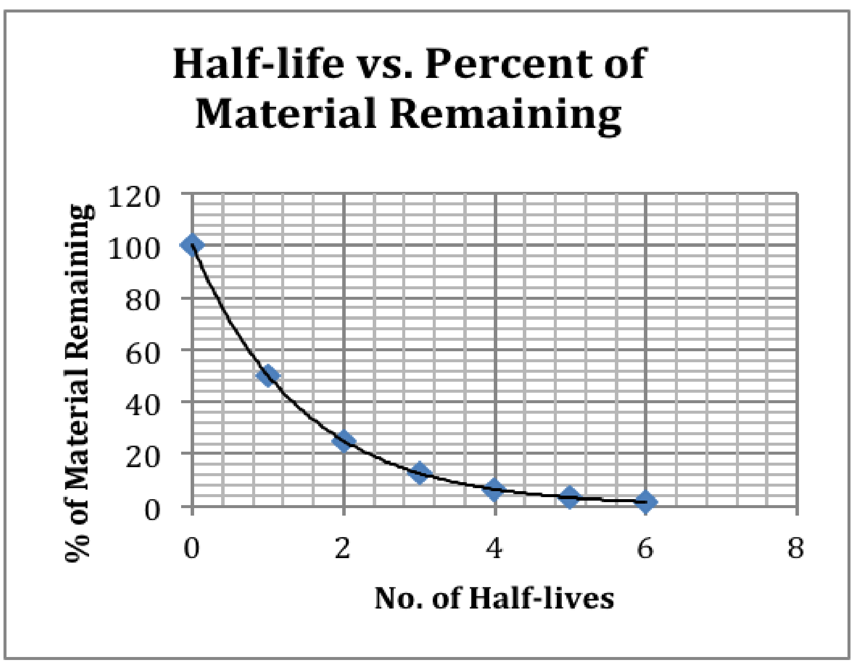
4. ____ Which of the above-mentioned types of radiation does not involve the emission of a particle?

   A. alpha B. beta C. gamma D. none of the above

5. ____ The vapor trail produced by alpha radiation is longer than that produced by beta radiation.

   A. true B. false

6. Use the radioactive decay curve to answer questions 7-12 below.



7. What radioactive isotope does your decay curve describe?

8. Using the radioactive decay curve, what percentage of your radioactive isotope exists after three half lives?

9. Carbon 14 has a half-life of 5,730 years. If you have a .01 gram sample of carbon 14, what is the mass of carbon 14 remaining after two half-lives?

10. The element Osmium-182 has a half-life of 21.5 hours. How much time would have elapsed if a 10.0 g sample of Os-182 decays so that a 1.8 g sample remains?

11. In a galaxy far, far away there exists a material known as Confusium-406, Cn-406. Over a 24.0-day period, 128.0 g of Cn-406 will decay so that 5.12 g of the original material remains. What is the half-life of Cn-406?

Use the half-life equation $N(t) = N_o \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$ **to answer questions 12-17:**

12. At time zero, there are 10.0 grams of Tungsten-187. If the half-life is 23.9 hours, how much W-187 will be present at the end of two days?

13. The half-life of Hydrogen-3, also known as tritium, is 12.26 years? How much time will be required for a sample of tritium to lose 75% of its radioactivity?

14. The bristle cone pine, found in the White Mountains of California, is the oldest living thing on earth and they are unusual in that their cones are blue. Some samples of these blue cones dating back 10,000 years have been identified. Suppose you have a sample from such a cone that presently contains 5.00 g of Carbon-14, half-life=5730 yrs. Determine the amount of C-14 that was present in the cone sample 10,000 years ago.

15. In the equation above, what kind of decay particle is produced?

16. What kind of radioactive decay produces a helium nucleus?

17. For the decay chart of uranium 238 to lead 206, provide 2 examples of transition to a different element that produce beta particles.

Teacher Comments: