1 FOCUS

Objectives

10.1.1 **Describe** the process of nuclear decay.
10.1.2 **Classify** nuclear radiation as alpha particles, beta particles, or gamma rays.
10.1.3 **Balance** nuclear equations.
10.1.4 **Identify** sources of nuclear radiation, and **describe** how nuclear radiation affects matter.
10.1.5 **Describe** methods of detecting nuclear radiation.

Reading Focus

Build Vocabulary L2

Word-Part Analysis Point out the two vocabulary terms that contain the word *radiation (nuclear radiation, background radiation).* Explain that the word comes from a Latin word meaning "to spread out from a point."

Reading Strategy L2

Student answers may include:
a. Nuclear decay is the spontaneous change of one isotope into another. **b.** What are the types of nuclear radiation? **c.** What are the effects of nuclear radiation? **d.** One effect of nuclear radiation is the ionization of matter. **e.** How can nuclear radiation be detected? **f.** Nuclear radiation can be detected by a Geiger counter or film badge.

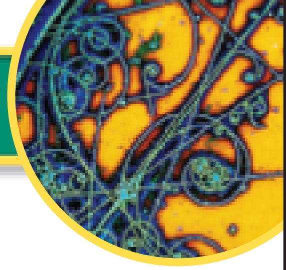
2 INSTRUCT

Nuclear Decay

Address Misconceptions L2

Many students think that gamma rays, X-rays, and visible light are unrelated. Point out that all three are different parts of the continuous electromagnetic spectrum. Explain that the photographic plate in Becquerel's experiment detected all three kinds of electromagnetic waves. Just as photographic film can detect visible light, it can detect X-rays and gamma rays emitted during nuclear decay. Students will read about the electromagnetic spectrum in Chapter 18. **Logical**

10.1 Radioactivity



Reading Focus

Key Concepts

- What happens during nuclear decay?
- What are three types of nuclear radiation?
- How does nuclear radiation affect atoms?
- What devices can detect nuclear radiation?

Vocabulary

- radioactivity
- radioisotope
- nuclear radiation
- alpha particle
- beta particle
- gamma ray
- background radiation

Reading Strategy

Previewing Copy the table below. Before you read the section, rewrite the topic headings as *how, why,* and *what* questions. As you read, write an answer to each question.

Question	Answer
What is nuclear decay?	a. ____?____
b. ____?____	Alpha, beta, gamma
c. ____?____	d. ____?____
e. ____?____	f. ____?____

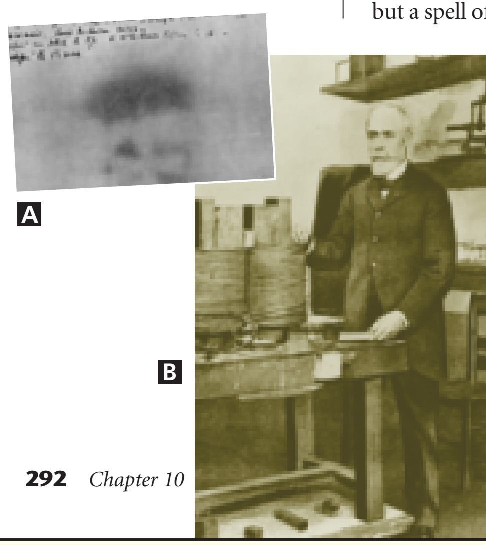


Figure 1 Due to rainy weather, Henri Becquerel postponed his intended experiment with uranium salts. **A** Without any exposure to sunlight, the salts still produced a foggy image on a photographic plate. **B** For his discovery of radioactivity, Becquerel shared the 1903 Nobel Prize for Physics with Marie and Pierre Curie.

In 1896, French physicist Antoine Henri Becquerel (1852–1908) was experimenting with uranium salts. He hypothesized that the salts, which glow after being exposed to light, produced X-rays while they glowed. To test his hypothesis, Becquerel performed an experiment. First, he wrapped a photographic plate in paper. Then, he placed some uranium salts on the plate and set it outside in the sunlight, which caused the salts to glow. When Becquerel developed the plate, he got a foggy image. At the time, Becquerel thought that X-rays from the salts had penetrated the paper and fogged the plate.

Like any good scientist, Becquerel wanted to repeat his experiment, but a spell of bad weather forced him to wait. In the meantime, he left a wrapped photographic plate and uranium salts in a desk drawer. After several days, Becquerel decided to develop the plate without exposing the uranium to sunlight. To his surprise, he got the foggy image shown in Figure 1A. Later, Becquerel determined that the uranium salts had emitted rays that had never been observed before.

Nuclear Decay

Becquerel's experiment marked the discovery of radioactivity. **Radioactivity** is the process in which an unstable atomic nucleus emits charged particles and energy. Any atom containing an unstable nucleus is called a radioactive isotope, or **radioisotope** for short.

Section Resources

Print
- ***Laboratory Manual,*** Investigation 10B
- ***Reading and Study Workbook With Math Support,*** Section 10.1 and **Math Skill:** Nuclear Equations for Alpha Decay
- ***Math Skills and Problem Solving Workbook,*** Section 10.1
- ***Transparencies,*** Chapter Pretest and Section 10.1

Technology
- ***Interactive Textbook,*** Section 10.1
- ***Presentation Pro CD-ROM,*** Chapter Pretest and Section 10.1
- ***Go Online,*** *Planet Diary,* Radioactivity activity

Radioisotopes of uranium—primarily uranium-238—were the source of radioactivity in Becquerel's experiment. (Recall that the name of an isotope includes its mass number.) Another common radioisotope is carbon-14, which can be found in fossils like the ones shown in Figure 2.

Unlike stable isotopes such as carbon-12 or oxygen-16, radioisotopes spontaneously change into other isotopes over time. When the composition of a radioisotope changes, the radioisotope is said to undergo nuclear decay. **During nuclear decay, atoms of one element can change into atoms of a different element altogether.** For example, uranium-238 decays into thorium-234, which is also a radioisotope.

Figure 2 About 26,000 years ago, more than 100 mammoths died at a sinkhole in Hot Springs, South Dakota. Scientists figured out how old the remains were by measuring amounts of the radioisotope carbon-14 contained in the mammoth bones.

Types of Nuclear Radiation

Scientists can detect a radioactive substance by measuring the nuclear radiation it gives off. **Nuclear radiation** is charged particles and energy that are emitted from the nuclei of radioisotopes. **Common types of nuclear radiation include alpha particles, beta particles, and gamma rays.** Figure 3 shows the properties of these three types of radiation.

Alpha Decay When a uranium-238 sample decays, it emits alpha particles. An **alpha particle** is a positively charged particle made up of two protons and two neutrons—the same as a helium nucleus. It has a 2+ charge. The common symbol for an alpha particle is $^{4}_{2}He$. The subscript is the atomic number (the number of protons). The superscript is the mass number (the sum of the numbers of protons and neutrons). Another symbol for an alpha particle is the Greek letter α.

Alpha decay, which refers to nuclear decay that releases alpha particles, is an example of a nuclear reaction. Like chemical reactions, nuclear reactions can be expressed as equations. The following nuclear equation describes the alpha decay of uranium-238.

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

In alpha decay, the product isotope has two fewer protons and two fewer neutrons than the reactant isotope. In the equation above, the mass number on the left (238) equals the sum of the mass numbers on the right (234 + 4). Also, the atomic number on the left (92) equals the sum of the atomic numbers on the right (90 + 2). In other words, the equation is balanced.

Alpha particles are the least penetrating type of nuclear radiation. Most alpha particles travel no more than a few centimeters in air, and can be stopped by a sheet of paper or by clothing.

Figure 3 Within a few years of Becquerel's discovery of radioactivity, Ernest Rutherford classified three types of nuclear radiation based on his own studies of uranium compounds. Comparing and Contrasting *How do alpha particles, beta particles, and gamma rays differ in terms of charge? In terms of mass?*

Characteristics of Nuclear Radiation

Radiation Type	Symbol	Charge	Mass (amu)	Common Source
Alpha particle	α, $^{4}_{2}He$	2+	4	Radium-226
Beta particle	β, $^{0}_{-1}e$	1−	$\frac{1}{1836}$	Carbon-14
Gamma ray	γ	0	0	Cobalt-60

Types of Nuclear Radiation

Build Science Skills L2

Inferring Have students look at Figure 3, which shows the particles emitted in nuclear decay. Explain that a nucleus that emits an alpha particle gives up two protons and two neutrons (a helium nucleus). A nucleus that emits a beta particle (an electron) gives up a neutron but gains a proton, because a neutron decomposes into a proton and an electron during beta decay. Ask, **Which type of radioactive decay causes the largest change in the atomic number of a nucleus?** *(Alpha decay, which reduces the atomic number of the nucleus by two)*
Logical, Visual

Build Reading Literacy L1

Compare and Contrast Refer to page **226D** in **Chapter 8**, which provides the guidelines for comparing and contrasting.

Ask students to construct a compare/contrast table. Have them skim the sections on alpha decay, beta decay, and gamma decay. Then, ask students to describe similarities and differences of the decay types in their table.
Verbal, Visual

Customize for English Language Learners

Build a Science Glossary
Encourage English language learners to make a science glossary as they read the section. Suggest that they start with the vocabulary terms and then add any other new terms they encounter. Encourage students to copy the table in Figure 3 into their glossary, as these particles are key to understanding the chapter. Model how to divide words into parts such as prefix, root word, and suffix. Posting a list of suffixes and prefixes with their meanings in the classroom will help students when they encounter new words.

Answer to . . .

Figure 3 *Alpha particles have a charge of 2+; beta particles have a charge of 1−; gamma rays have no charge. Alpha particles have a mass of 4 amu; beta particles have a mass of $\frac{1}{1836}$ amu; and gamma rays have no mass.*

Use Visuals

L1

Figure 4 Emphasize that beta and gamma rays will pass through paper and that gamma rays will also pass through a thin sheet of aluminum. Ask, **What materials would effectively shield a radioactive source that emitted only beta particles?** *(Aluminum or concrete)* **Why might concrete be insufficient protection from gamma rays?** *(Some gamma rays will pass through concrete, and a concrete wall would have to be several meters thick to ensure that the gamma rays were effectively blocked.)* **Visual, Logical**

Teacher Demo

Stopping Radiation

L2

Purpose Demonstrate to students that radiation can be blocked to varying degrees by different materials.

Materials medical X-ray image or photograph of a medical X-ray image

Procedure Show students the medical X-ray image. Tell students that where the X-rays reached the film, it is black, and where the X-rays were completely blocked, the film is clear. When light shines through the clear part of the X-ray, it looks white. Ask, **Which blocks X-rays better, bone or soft tissue?** *(Bone, because the white area on the image means that the X-rays did not reach the film.)* **How can X-rays tell you about the thickness of bone?** *(Thick bone is really clear on the film or white in the image because it absorbs most of the X-rays. Thinner bone is light gray because some X-rays pass through the bone.)* **What do you think a metal object would look like on an X-ray image?** *(It would be white because it would block the X-rays.)*

Expected Outcome Students should be able to relate the penetrating power of X-rays to the penetrating power of nuclear radiation. **Visual, Verbal**

Go Online PLANETDIARY

Find links to additional activities and have students monitor phenomena that affect Earth and its residents.

Go Online PLANETDIARY

For: Activity on radiation
Visit: PHSchool.com
Web Code: ccc-1101

Beta Decay When thorium-234 decays, it releases negatively charged radiation called beta particles. A **beta particle** is an electron emitted by an unstable nucleus. In nuclear equations, a beta particle is written as ${}^{0}_{-1}e$ or β. Because of its single negative charge, a beta particle is assigned an atomic number of −1. In Chapter 4, you learned that an electron has very little mass when compared with a proton. For this reason, a beta particle is assigned a mass number of 0.

How can an atomic nucleus, which has a positive charge, emit a negatively charged particle? During beta decay, a neutron decomposes into a proton and an electron. The proton stays trapped in the nucleus, while the electron is released. The following equation describes the beta decay of thorium-234.

$$ {}^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\mathrm{e} $$

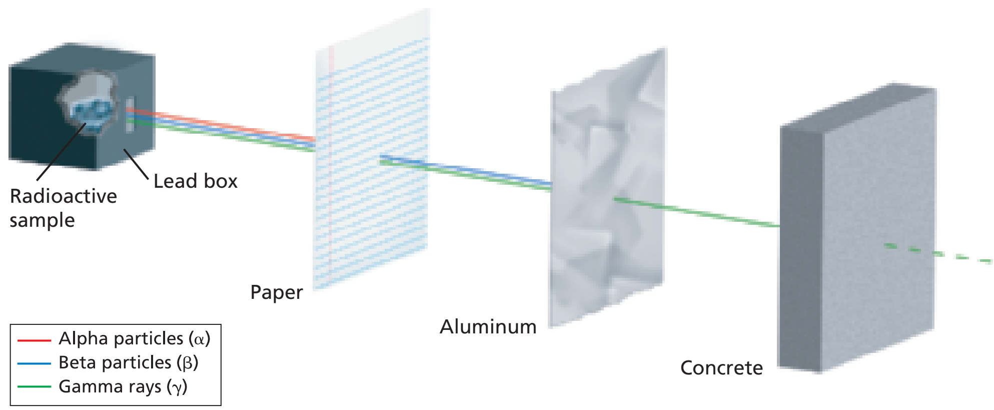
In beta decay, the product isotope has one proton more and one neutron fewer than the reactant isotope. The mass numbers of the isotopes are equal because the emitted beta particle has essentially no mass.

Due to their smaller mass and faster speed, beta particles are more penetrating than alpha particles. As Figure 4 illustrates, beta particles pass through paper, but can be stopped by a thin sheet of metal.

Reading Checkpoint ***What is a beta particle?***

Gamma Decay Not all nuclear radiation consists of charged particles. A **gamma ray** is a penetrating ray of energy emitted by an unstable nucleus. The symbol for a gamma ray is γ. Gamma radiation has no mass and no charge. Like X-rays and visible light, gamma rays are energy waves that travel through space at the speed of light.

Figure 4 Alpha particles (shown in red) are the least penetrating type of nuclear radiation. Gamma rays (shown in green) are the most penetrating. A concrete slab can block most but not all of the gamma rays released by a radioactive source. Interpreting Diagrams ***Which type of radiation can penetrate paper but is blocked by aluminum foil?***



Facts and Figures

Explaining Energy The amount of energy emitted in alpha and gamma decay is equal to the energy difference of the nucleus before and after emission. However, this is not true in beta decay. Physicists had difficulty explaining this discrepancy, because the law of conservation of energy states that the total energy should remain unchanged during the process. In 1930, physicist Wolfgang Pauli proposed that an undetected particle, called the neutrino, was emitted along with the beta particles, accounting for some of the energy change in beta decay. In 1956, the neutrino was directly observed for the first time by American physicists Frederick Reines and Clyde Cowan.

Math Skills

Balancing Nuclear Equations

Write a balanced nuclear equation for the alpha decay of polonium-210.

1 Read and Understand

What information are you given?

Reactant isotope = polonium-210

Radiation emitted = $^{4}_{2}$He (alpha particle)

Use the periodic table to obtain the atomic number of polonium.

Reactant isotope = $^{210}_{84}$Po

2 Plan and Solve

What unknowns are you trying to calculate?

Atomic number of product isotope, Z = ?

Mass number of product isotope, A = ?

Chemical symbol of product isotope, X = ?

What equation contains the given information?

$$^{210}_{84}\text{Po} \rightarrow {}^{A}_{Z}\text{X} + {}^{4}_{2}\text{He}$$

Write and solve equations for atomic mass and atomic number.

$210 = A + 4$ $\quad$ $84 = Z + 2$

$210 - 4 = A$ $\quad$ $84 - 2 = Z$

$206 = A$ $\quad$ $82 = Z$

According to the periodic table, the element with an atomic number of 82 is lead, Pb. So, X is Pb. The balanced nuclear equation is shown below.

$$^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^{4}_{2}\text{He}$$

3 Look Back and Check

Is your answer reasonable?

The mass number on the left equals the sum of the mass numbers on the right. The atomic number on the left equals the sum of the atomic numbers on the right. The equation is balanced.

Math Practice

1. Write a balanced nuclear equation for the alpha decay of thorium-232.
2. Write a balanced nuclear equation for the beta decay of carbon-14.
3. Determine the product of alpha decay for americium-241.
4. Determine the product of beta decay for strontium-90.

Math Practice

Solutions L2

1. $^{232}_{90}\text{Th} \longrightarrow {}^{A}_{Z}\text{X} + {}^{4}_{2}\text{He}$

$A = 232 - 4 = 228$

$Z = 90 - 2 = 88$

X = Ra

$^{232}_{90}\text{Th} \longrightarrow {}^{228}_{88}\text{Ra} + {}^{4}_{2}\text{He}$

2. $^{14}_{6}\text{C} \longrightarrow {}^{A}_{Z}\text{X} + {}^{0}_{-1}\text{e}$

$A = 14 - 0 = 14$

$Z = 6 - (-1) = 7$

X = N

$^{14}_{6}\text{C} \longrightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}\text{e}$

3. $^{241}_{95}\text{Am} \longrightarrow {}^{A}_{Z}\text{X} + {}^{4}_{2}\text{He}$

$A = 241 - 4 = 237$

$Z = 95 - 2 = 93$

X = Np

$^{A}_{Z}\text{X} = {}^{237}_{93}\text{Np}$

4. $^{90}_{38}\text{Sr} \longrightarrow {}^{A}_{Z}\text{X} + {}^{0}_{-1}\text{e}$

$A = 90 - 0 = 90$

$Z = 38 - (-1) = 39$

X = Y

$^{A}_{Z}\text{X} = {}^{90}_{39}\text{Y}$

Logical

For Extra Help L1

Remind students that when they write and solve the equation for atomic mass and atomic number, they must remember to change the sign of the constant when it is moved to the left side of the equation.
Logical

Direct students to the **Math Skills** in the **Skills and Reference Handbook** at the end of the student text for additional help.

Additional Problems

1. Write a balanced nuclear equation for the alpha decay of uranium-238.
($^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$)

2. Write a balanced nuclear equation for the beta decay of sodium-24.
($^{24}_{11}\text{Na} \longrightarrow {}^{24}_{12}\text{Mg} + {}^{0}_{-1}\text{e}$)

Logical, Portfolio

Answer to . . .

Reading Checkpoint *A beta particle is an electron emitted by an unstable nucleus.*

Figure 4 *Gamma rays are the most penetrating type of nuclear radiation shown in the diagram.*

Effects of Nuclear Radiation

Use Community Resources L2

Arrange to have someone from your state or local health department come to your class to talk about the hazards of radon. Have students prepare questions for the speaker in advance. The speaker can inform students about the possible dangers of radon in their homes and what kinds of tests are available. The speaker may also provide information on what the EPA considers to be safe radon levels. Have pairs or groups of students write thank-you notes to the speaker, incorporating a few of the facts that students learned from the presentation. **Interpersonal, Group**

Integrate Earth Science L2

Radon is a naturally occurring radioactive element that is formed in the decay chain of uranium-238. Uranium can be found in almost all rocks and soil. Fortunately, in most areas the amount of uranium in rocks and soil is very small. Higher concentrations of uranium and its minerals are commonly found in light colored igneous rocks, granite, dark shale, phosphate-containing sedimentary rocks, and metamorphic rocks derived from these rocks. Soils derived from these rocks also have high uranium concentrations. Encourage students to work in small groups to research the concentrations of uranium in their community. They may use library resources, such as the Internet, to assist them in their research. **Group, Portfolio**

Figure 5 The mineral autunite is an important source of uranium.

During gamma decay, the atomic number and mass number of the atom remain the same, but the energy of the nucleus decreases. Gamma decay often accompanies alpha or beta decay. For example, thorium-234 emits both beta particles and gamma rays (abbreviated as γ) as it decays.

$$^{234}_{90}\text{Th} \rightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{-1}\text{e} + \gamma$$

Gamma rays are much more penetrating than either alpha particles or beta particles. It can take several centimeters of lead or several meters of concrete to stop gamma radiation.

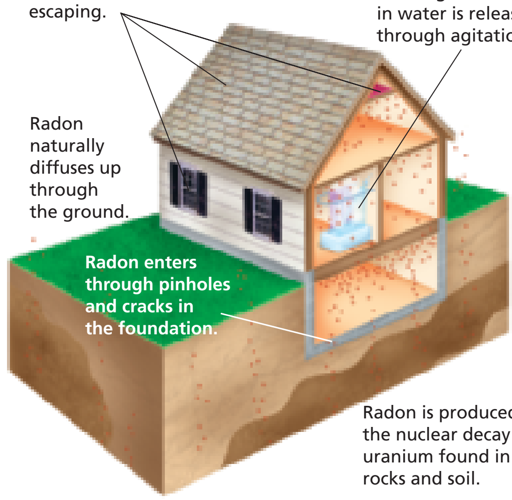
Effects of Nuclear Radiation

You may not realize it, but you are exposed to nuclear radiation every day. Most of this is **background radiation,** or nuclear radiation that occurs naturally in the environment. Radioisotopes in air, water, rocks, plants, and animals all contribute to background radiation. Most rocks, such as the one in Figure 5, contain at least trace amounts of radioactive elements. Another source of background radiation is cosmic rays. Cosmic rays are streams of charged particles (mainly protons and alpha particles) from outer space. Collisions between cosmic rays and Earth's atmosphere shower the surface below with nuclear radiation. All this radioactivity may sound dangerous. However, background radiation levels are generally low enough to be safe.

When nuclear radiation exceeds background levels, it can damage the cells and tissues of your body. **Nuclear radiation can ionize atoms.** When cells are exposed to nuclear radiation, the bonds holding together proteins and DNA molecules may break. As these molecules change, the cells may no longer function properly.

Alpha particles, beta particles, and gamma rays are all forms of ionizing radiation. Alpha particles can cause skin damage similar to a burn, but they are not a serious health hazard unless an alpha-emitting substance is inhaled or eaten. For example, radon gas is a potentially dangerous natural source of alpha particles because it can be inhaled. Radon-222 is formed through a series of nuclear decays that begins with uranium-238 in rocks deep underground. As radon-222 is produced, it seeps upward toward the surface. It sometimes collects in the basements of buildings that lack proper ventilation, as shown in Figure 6. Prolonged exposure to radon-222 can lead to lung cancer.

Figure 6 Radon gas is produced underground as the uranium in rocks and soil decays. As the radon seeps up through the ground, it can get into buildings by passing through cracks or holes in their foundations.
Inferring ***How would ventilation of the basement affect radon levels in the house shown below?***



Facts and Figures

Radon Radon is a colorless, odorless, tasteless gas. The most stable isotope, radon-222, is produced by the alpha decay of radium-226. The fact that radon may be a serious health hazard was not recognized until the late 1980s. Today, radon is considered by some to be the second leading cause of lung cancer in the United States, after smoking. Cigarette smokers who become exposed to radon are at particularly high risk of lung cancer.

There are three naturally occurring isotopes of radon. Radon-222 has the longest half-life, 3.82 days. Radon-220, with a half-life of 51.5 seconds, is formed in the decay chain of thorium-232. Radon-219, with a half-life of 3.92 seconds, is formed in the decay chain of actinium-227.

Answer to . . .

Figure 6 *Radon enters buildings from underground. Therefore, ventilating the basement of the house in Figure 6 would help reduce overall radon levels.*

When exposure to nuclear radiation is external, the amount of tissue damage depends on the penetrating power of the radiation. For example, beta particles can damage tissues in the body more than alpha particles, but less than gamma rays. Gamma rays can penetrate deeply into the human body, potentially exposing all organs to ionization damage.

Detecting Nuclear Radiation

Although you can't see, hear, or feel the radioactivity around you, scientific instruments can measure nuclear radiation. **Devices that are used to detect nuclear radiation include Geiger counters and film badges.** A Geiger counter, shown in Figure 7, uses a gas-filled tube to measure ionizing radiation. When nuclear radiation enters the tube, it ionizes the atoms of the gas. The ions produce an electric current, which can be measured. The greater the amount of nuclear radiation, the greater the electric current produced in the tube is.

Recall that in Becquerel's experiment, nuclear radiation left an image on a photographic plate. Today, many people who work with or near radioactive materials wear film badges to monitor their exposure to nuclear radiation. A film badge contains a piece of photographic film wrapped in paper. The film is developed and replaced with a new piece periodically. The exposure on the film indicates the amount of radiation exposure for the person wearing the badge.

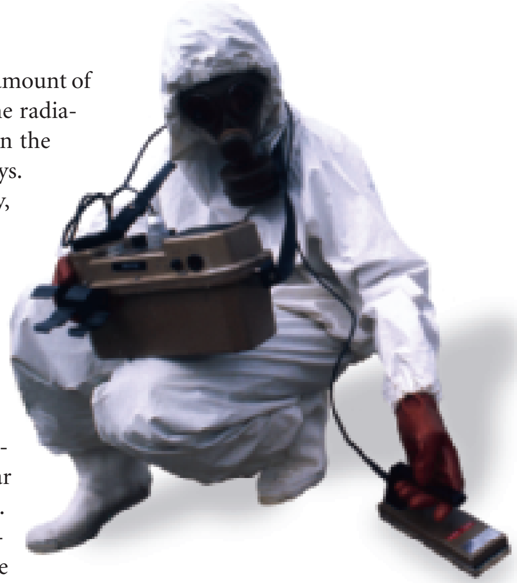


Figure 7 Wearing protective clothing, a firefighter uses a Geiger counter to test the ground for radioactivity. Firefighters sometimes help clean up accidents involving radioactive materials.

Section 10.1 Assessment

Reviewing Concepts

1. How does an element change during nuclear decay?
2. What are three types of nuclear radiation?
3. How are atoms affected by nuclear radiation?
4. What devices can be used to detect nuclear radiation?
5. How do types of nuclear radiation differ in electric charge?
6. Describe the penetrating power of each common type of radiation.
7. What is background radiation? List some of its sources.

Critical Thinking

8. **Predicting** What is the effect of beta decay on the composition of a nucleus?
9. **Inferring** Why do you think airplane pilots wear film badges?

Math Practice

10. Write a balanced nuclear equation for the alpha decay of radium-226.
11. Write a nuclear equation that describes the beta decay of hydrogen-3.

Detecting Nuclear Radiation

Use Visuals L1

Figure 7 Have students carefully examine the photograph. Ask, **Why is it important to wear protective clothing around radioactive materials?** *(Protective clothing keeps radioactive materials away from skin.)* Tell students that the EPA recommends heavy clothing as protection from beta radiation. Ask, **Does a Geiger counter protect against the effects of nuclear radiation?** *(No. The Geiger counter serves only as a monitoring device, not a shielding device.)*
Visual, Logical

3 ASSESS

Evaluate Understanding L2

Randomly ask students to name the symbol or charge for each type of nuclear decay.

Reteach L1

Use Figure 4 to summarize the three different types of nuclear decay and how each type affects matter.

Math Practice

Solutions

10. $^{226}_{88}\text{Ra} \longrightarrow {}^{A}_{Z}\text{X} + {}^{4}_{2}\text{He}$

$A = 226 - 4 = 222$; $Z = 88 - 2 = 86$;

$\text{X} = \text{Rn}$; $^{226}_{88}\text{Ra} \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

11. $^{3}_{1}\text{H} \longrightarrow {}^{A}_{Z}\text{X} + {}^{0}_{-1}\text{e}$

$A = 3 - 0 = 3$; $Z = 1 - (-1) = 2$;

$\text{X} = \text{He}$; $^{3}_{1}\text{H} \longrightarrow {}^{3}_{2}\text{He} + {}^{0}_{-1}\text{e}$

Interactive Textbook If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 10.1.

Section 10.1 Assessment

1. During nuclear decay, atoms of one element can change into atoms of another element.
2. Three types of nuclear radiation are alpha particles, beta particles, and gamma rays.
3. Nuclear radiation can ionize atoms.
4. Geiger counters and film badges are two devices used to detect nuclear radiation.
5. Alpha particles have a charge of 2+; beta particles have a charge of 1−; gamma rays have no charge.
6. Alpha particles are the least penetrating. Most alpha particles can be stopped by a sheet of paper or by clothing. Beta particles pass through paper, but can be stopped by metal foil. Gamma rays, which are much more penetrating than either alpha particles or beta particles, can pass through several meters of concrete.
7. Background radiation is nuclear radiation that occurs naturally in the environment. Sources of background radiation include cosmic rays, and rocks and minerals that contain radioactive elements.
8. In beta decay, a neutron decomposes into a proton and an electron. Therefore, the mass number stays the same while the atomic number (the number of protons) increases by one. The net effect of beta decay is that the number of neutrons in the nucleus decreases by one and the number of protons increases by one.
9. Because they work at high altitudes, pilots are exposed to high levels of background radiation from cosmic rays. To monitor their radiation exposure, pilots wear film badges.