QUESTIONS AND PROBLEMS

Nuclear Equations

4.13 Write a balanced nuclear equation for the alpha decay of each of the following:

a. $^{208}_{84}Po$ **b.** $^{232}_{90}Th$ **c.** $^{251}_{102}No$ **d.** $^{220}_{86}Rn$

4.14 Write a balanced nuclear equation for the alpha decay of each of the following:

a. $^{243}_{96}Cm$ **b.** $^{252}_{99}Es$ **c.** $^{251}_{98}Cf$ **d.** $^{261}_{107}Bh$

4.15 Write a balanced nuclear equation for the beta decay of each of the following:

a. $^{25}_{11}Na$ **b.** $^{20}_{8}O$

c. strontium-92 **d.** potassium-42

4.16 Write a balanced nuclear equation for the beta decay of each of the following:

a. $^{44}_{19}K$ **b.** iron-59 **c.** iron-60 **d.** $^{141}_{56}Ba$

4.17 Write a balanced nuclear equation for the positron decay of each of the following:

a. $^{26}_{14}Si$ **b.** $^{54}_{27}Co$ **c.** $^{77}_{37}Rb$ **d.** $^{93}_{45}Rh$

4.18 Write a balanced nuclear equation for the positron decay of each of the following:

a. $^{8}_{5}B$ **b.** $^{13}_{7}N$ **c.** $^{40}_{19}K$ **d.** $^{118}_{54}Xe$

4.19 Complete each of the following nuclear equations:

a. $^{28}_{13}Al \longrightarrow ? + {}^{0}_{-1}e$

b. $? \longrightarrow {}^{86}_{36}Kr + {}^{1}_{0}n$

c. $^{66}_{29}Cu \longrightarrow {}^{66}_{30}Zn + ?$

d. $? \longrightarrow {}^{4}_{2}He + {}^{234}_{90}Th$

e. $^{188}_{80}Hg \longrightarrow ? + {}^{0}_{+1}e$

4.20 Complete each of the following nuclear equations:

a. $^{11}_{6}C \longrightarrow {}^{7}_{4}Be + ?$

b. $^{35}_{16}S \longrightarrow ? + {}^{0}_{-1}e$

c. $? \longrightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$

d. $^{210}_{83}Bi \longrightarrow ? + {}^{4}_{2}He$

e. $? \longrightarrow {}^{135}_{59}Pr + {}^{0}_{+1}e$

4.21 Complete each of the following bombardment reactions:

a. $^{9}_{4}Be + {}^{1}_{0}n \longrightarrow ?$

b. $^{32}_{16}S + ? \longrightarrow {}^{32}_{15}P$

c. $? + {}^{1}_{0}n \longrightarrow {}^{24}_{11}Na + {}^{4}_{2}He$

d. $^{27}_{13}Al + {}^{4}_{2}He \longrightarrow ? + {}^{1}_{0}n$

4.22 Complete each of the following bombardment reactions:

a. $^{40}_{18}Ar + ? \longrightarrow {}^{43}_{19}K + {}^{1}_{1}H$

b. $^{238}_{92}U + {}^{1}_{0}n \longrightarrow ?$

c. $? + {}^{1}_{0}n \longrightarrow {}^{14}_{6}C + {}^{1}_{1}H$

d. $? + {}^{64}_{28}Ni \longrightarrow {}^{272}_{111}Rg + {}^{1}_{0}n$

QUESTIONS AND PROBLEMS

Half-Life of a Radioisotope

4.29 What is meant by the term *half-life*?

4.30 Why are radioisotopes with short half-lives used for diagnosis in nuclear medicine?

4.31 Technetium-99m is an ideal radioisotope for scanning organs because it has a half-life of 6.0 h and is a pure gamma emitter. Suppose that 80.0 mg were prepared in the technetium generator this morning. How many milligrams would remain after the following intervals?

a. one half-life **b.** two half-lives
c. 18 h **d.** 24 h

4.32 A sample of sodium-24 with an activity of 12 mCi is used to study the rate of blood flow in the circulatory system. If sodium-24 has a half-life of 15 h, what is the activity of the sodium after 2.5 days?

4.33 Strontium-85, used for bone scans, has a half-life of 65 days. How long will it take for the radiation level of strontium-85 to drop to one-fourth of its original level? To one-eighth?

4.34 Fluorine-18, which has a half-life of 110 min, is used in PET scans. (See section 4.5.) If 100 mg of fluorine-18 is shipped at 8 A.M., how many milligrams of the radioisotope are still active if the sample arrives at the radiology laboratory at 1:30 P.M.?

4.5 Medical Applications Using Radioactivity

LEARNING GOAL

Describe the use of radioisotopes in medicine.

To determine the condition of an organ in the body, a radiologist may give a patient a radioisotope that concentrates in that organ. The cells in the body do not differentiate between a nonradioactive atom and a radioactive one. However, radioactive atoms can be detected because they emit radiation. Some radioisotopes used in nuclear medicine are listed in Table 4.10.

FIGURE 4.7 A CT scan shows a brain tumor (yellow area) in the center of the right side of the brain.

Q What is the type of radiation used to give a CT scan?

FIGURE 4.8 An MRI scan of the heart and lungs, with the left ventricle shown in red.

Q What is the source of energy in an MRI?

QUESTIONS AND PROBLEMS

ical Applications Using Radioactivity

one and bony structures contain calcium and phosphorus.

. Why would the radioisotopes of calcium-47 and phosphorus-32 be used in the diagnosis and treatment of bone diseases?

. The radioisotope strontium-89, a beta emitter, is used to treat bone cancer. Write the nuclear equation and explain why a strontium radioisotope would be used to treat bone cancer.

. Technetium-99m emits only gamma radiation. Why would this type of radiation be used in diagnostic imaging rather than an isotope that also emits beta or alpha radiation?

b. A patient with polycythemia vera (excess production of red blood cells) receives radioactive phosphorus-32. Why would this treatment reduce the production of red blood cells in the bone marrow of the patient?

4.37 In a diagnostic test for leukemia, a patient receives 4.0 mL of a solution containing selenium-75. If the activity of the selenium-75 is 45 μCi/mL, what is the dose received by the patient?

4.38 A vial contains radioactive iodine-131 with an activity of 2.0 mCi per milliliter. If the thyroid test requires 3.0 mCi in an "atomic cocktail," how many milliliters are used to prepare the iodine-131 solution?

ADDITIONAL QUESTIONS AND PROBLEMS

For instructor-assigned homework, go to ***www.masteringchemistry.com.***

4.51 Give the number of protons and number of neutrons in the nucleus of each the following:
a. sodium-25 **b.** nickel-61
c. rubidium-84 **d.** silver-110

4.52 Give the number of protons, neutrons, and electrons in atoms of the following isotopes:
a. boron-10 **b.** zinc-72
c. iron-59 **d.** gold-198

4.53 Describe alpha, beta, and gamma radiation in terms of the following:
a. type of radiation **b.** symbols

4.54 Describe alpha, beta, and gamma radiation in terms of the following:
a. depth of tissue penetration
b. type of shielding needed for protection

4.55 Identify each of the following as alpha decay, beta decay, positron emission, or gamma radiation:
a. $^{27m}_{13}\text{Al} \longrightarrow {}^{27}_{13}\text{Al} + {}^{0}_{0}\gamma$
b. $^{8}_{5}\text{B} \longrightarrow {}^{8}_{4}\text{Be} + {}^{0}_{+1}e$
c. $^{220}_{86}\text{Rn} \longrightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\text{He}$

4.56 Identify each of the following as alpha decay, beta decay, positron emission, or gamma radiation:
a. $^{127}_{55}\text{Cs} \longrightarrow {}^{127}_{54}\text{Xe} + {}^{0}_{+1}e$
b. $^{90}_{38}\text{Sr} \longrightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}e$
c. $^{218}_{85}\text{At} \longrightarrow {}^{214}_{83}\text{Bi} + {}^{4}_{2}\text{He}$

4.57 Write a balanced nuclear equation for each of the following:
a. Th-225 (α decay)
b. Bi-210 (α decay)
c. cesium-137 (β decay)
d. tin-126 (β decay)
e. nitrogen-13 (β^+ emission)

4.58 Write a balanced nuclear equation for each of the following:
a. potassium-40 (β decay)
b. sulfur-35 (β decay)
c. platinum-190 (α decay)
d. Ra-210 (α decay)
e. In-113m (γ emission)

4.59 Complete each of the following nuclear equations:
a. $^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \longrightarrow ? + {}^{1}_{1}\text{H}$
b. $^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \longrightarrow {}^{30}_{14}\text{Si} + ?$
c. $^{235}_{92}\text{U} + {}^{1}_{0}n \longrightarrow {}^{90}_{38}\text{Sr} + 3{}^{1}_{0}n + ?$

4.60 Complete each of the following nuclear equations:
a. $^{59}_{27}\text{Co} + ? \longrightarrow {}^{56}_{25}\text{Mn} + {}^{4}_{2}\text{He}$
b. $? \longrightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}e$
c. $^{76}_{36}\text{Kr} + {}^{0}_{-1}e \longrightarrow ?$

4.61 Write the symbols and a balanced nuclear equation for the following:
a. When two oxygen-16 atoms collide, one of the products is an alpha particle.
b. When californium-249 is bombarded by oxygen-18, a new isotope and four neutrons are produced.
c. Radon-222 undergoes alpha decay.
d. The particle from **c.** undergoes alpha decay.

4.62 Write the symbols and a balanced nuclear equation for the following:
a. Polonium-210 decays to give lead-206.
b. Bismuth-211 decays by emitting an alpha particle.
c. The product from **b.** emits a beta particle.
d. When an alpha particle bombards aluminum-27, one product is silicon-30.

4.63 If the amount of radioactive phosphorus-32 in a sample decreases from 1.2 g to 0.30 g in 28 d, what is the half-life of phosphorus-32?

4.64 If the amount of radioactive iodine-123 in a sample decreases from 0.4 g to 0.1 g in 26.2 h, what is the half-life of iodine-123?

4.65 Iodine-131, a beta emitter, has a half-life of 8.0 d.
a. Write the nuclear equation for the beta decay of iodine-131.
b. How many grams of a 12.0-g sample of iodine-131 would remain after 40 d?
c. How many days have passed if 48 g of iodine-131 decayed to 3.0 g of iodine-131?

4.66 Cesium-137, a beta emitter, has a half-life of 30 y.
a. Write the nuclear equation for the beta decay of cesium-137.
b. How many grams of a 16-g sample of cesium-137 would remain after 90 y?
c. How many years will be needed for 28 g of cesium-137 to decay to 3.5 g of cesium-137?

4.67 A nurse was accidentally exposed to potassium-42 while doing some brain scans for possible tumors. The error was not discovered until 36 h later when the activity of the potassium-42 sample was 2.0 μCi. If potassium-42 has a half-life of 12 h, what was the activity of the sample at the time the nurse was exposed?

4.68 A wooden object from the site of an ancient temple has a carbon-14 activity of 10 counts per minute compared with a reference piece of wood cut today that has an activity of 40 counts per minute. If the half-life for carbon-14 is 5730 y, what is the age of the ancient wood object?

4.69 A 120-mg sample of technetium-99m is used for a diagnostic test. If technetium-99m has a half-life of 6.0 h, how much of the technetium-99m sample remains 24 h after the test?

4.70 The half-life of oxygen-15 is 124 s. If a sample of oxygen-15 has an activity of 4000 Bq, how many minutes will elapse before it reaches an activity of 500 Bq?

4.71 What is the purpose of irradiating meats, fruits, and vegetables?

4.72 The irradiation of foods was approved in the United States during the 1980s.
a. Why have we not seen many irradiated products in our markets?
b. Would you buy foods that have been irradiated? Why or why not?

4.73 What is the difference between fission and fusion?

4.74 a. What are the products in the fission of uranium-235 that make possible a nuclear chain reaction?
b. What is the purpose of placing control rods among uranium samples in a nuclear reactor?

4.75 Where does fusion occur naturally?

4.76 Why are scientists continuing to try to build a fusion reactor even though the high temperatures needed have been difficult to reach and maintain?

CHALLENGE QUESTIONS

4.77 Identify each of the following nuclear reactions as alpha decay, beta decay, positron emission, or gamma radiation:

a. $^{27}_{13}\text{Al} \longrightarrow {}^{27}_{13}\text{Al} + {}^{0}_{0}\gamma$

b. $^{8}_{5}\text{B} \longrightarrow {}^{8}_{4}\text{Be} + {}^{0}_{+1}e$

c. $^{90}_{38}\text{Sr} \longrightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}e$

d. $^{218}_{85}\text{At} \longrightarrow {}^{214}_{83}\text{Bi} + {}^{4}_{2}\text{He}$

4.78 Complete and balance each of the following nuclear equations:

a. $^{23m}_{12}\text{Mg} \longrightarrow \_\_\_\_ + {}^{0}_{0}\gamma$

b. $^{61}_{30}\text{Zn} \longrightarrow {}^{61}_{29}\text{Cu} + \_\_\_\_$

c. $^{241}_{95}\text{Am} + {}^{4}_{2}\text{He} \longrightarrow \_\_\_\_ + 2{}^{1}_{0}n$

d. $^{126}_{50}\text{Sn} \longrightarrow \_\_\_\_ + {}^{0}_{-1}e$

4.79 Uranium-238 decays in a series of nuclear changes until stable $^{206}_{82}\text{Pb}$ is produced. Complete the following nuclear equations that are part of the $^{238}_{92}\text{U}$ decay series:

a. $^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + ?$

b. $^{234}_{90}\text{Th} \longrightarrow ? + {}^{0}_{-1}e$

c. $? \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

4.80 The iceman known as "Ötzi" was discovered in a high mountain pass on the Austrian-Italian border. Samples of his hair and bones had carbon-14 activity that was about 50% of that present in new hair or bone. Carbon-14 is a beta emitter.

a. How long ago did "Ötzi" live if the half-life for C-14 is 5730 y?

b. Write a nuclear equation for the decay of carbon-14.

4.81 The half-life for the radioactive decay of calcium-47 is 4.5 d. If a sample has an activity of 4.0 μCi after 18 d, what was the initial activity of the sample?

4.82 A 16-μg sample of sodium-24 decays to 2.0 μg in 45 h. What is the half-life of sodium-24?

4.83 Write a balanced equation for each of the following radioactive emissions:

a. an alpha particle from Hg-180

b. a beta particle from Sn-126

c. a positron from Mn-49

4.84 Write a balanced equation for each of the following radioactive emissions:

a. an alpha particle from Gd-148

b. a beta particle from Sr-90

c. a positron from Al-25

ANSWERS

ANSWERS TO STUDY CHECKS

4.1 Distance from the radioactive source and minimizing the time of exposure

4.2 $^{214}_{84}\text{Po} \longrightarrow {}^{210}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

4.3 $^{131}_{53}\text{I} \longrightarrow {}^{131}_{54}\text{Xe} + {}^{0}_{-1}e$

4.4 $^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \longrightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}n$

4.5 For β, the factor is 1; rads and rems are equal.

4.6 0.50 g

4.7 17 200 y

4.8 $^{10}_{5}\text{B} + {}^{1}_{0}n \longrightarrow {}^{4}_{2}\text{He} + {}^{7}_{3}\text{Li}$

ANSWERS TO SELECTED QUESTIONS AND PROBLEMS

4.1 **a.** Both an alpha particle and a helium nucleus have two protons and two neutrons.

b. α, $^{4}_{2}\text{He}$

c. An α-particle is emitted from an unstable nucleus during radioactive decay.

4.3 **a.** $^{39}_{19}\text{K}$, $^{40}_{19}\text{K}$, $^{41}_{19}\text{K}$

b. They all have 19 protons and 19 electrons, but they differ in the number of neutrons.

4.5 Medical Use	Atomic Symbol	Mass Number	Number of Protons	Number Neutron
Heart imaging	$^{201}_{81}\text{Tl}$	201	81	120
Radiation therapy	$^{60}_{27}\text{Co}$	60	27	33
Abdominal scan	$^{67}_{31}\text{Ga}$	67	31	36
Hyperthyroidism	$^{131}_{53}\text{I}$	131	53	78
Leukemia treatment	$^{32}_{15}\text{P}$	32	15	17

4.7 **a.** α, $^{4}_{2}\text{He}$ **b.** $^{1}_{0}n$, n **c.** β, $^{0}_{-1}e$ **d.** $^{15}_{7}\text{N}$ **e.** $^{125}_{53}\text{I}$

4.9 **a.** β or $^{0}_{-1}e$ **b.** α or $^{4}_{2}\text{He}$ **c.** $^{1}_{0}n$ **d.** $^{24}_{11}\text{Na}$ **e.** $^{14}_{6}\text{C}$

4.11 **a.** Because β particles are much smaller and move faster than α particles, they can penetrate farther into tissue.

b. When radiation interacts with the components of the cells, reactive species are formed that cause undesirable reactions.

c. Radiation technicians leave the room to increase the distance between them and the radiation. Also, a wall that contains lead shields them.

d. Wearing gloves shields the skin from α and β radiation.

4.13 **a.** $^{208}_{84}\text{Po} \longrightarrow {}^{204}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

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

c. $^{251}_{102}\text{No} \longrightarrow {}^{247}_{100}\text{Fm} + {}^{4}_{2}\text{He}$

d. $^{220}_{86}\text{Rn} \longrightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\text{He}$

4.15 **a.** $^{25}_{11}\text{Na} \longrightarrow {}^{25}_{12}\text{Mg} + {}^{0}_{-1}e$

b. $^{20}_{8}\text{O} \longrightarrow {}^{20}_{9}\text{F} + {}^{0}_{-1}e$

c. $^{92}_{38}\text{Sr} \longrightarrow {}^{92}_{39}\text{Y} + {}^{0}_{-1}e$

d. $^{42}_{19}\text{K} \longrightarrow {}^{42}_{20}\text{Ca} + {}^{0}_{-1}e$

4.17 **a.** $^{26}_{14}\text{Si} \longrightarrow {}^{26}_{13}\text{Al} + {}^{0}_{+1}e$

b. $^{54}_{27}\text{Co} \longrightarrow {}^{54}_{26}\text{Fe} + {}^{0}_{+1}e$

c. $^{77}_{37}\text{Rb} \longrightarrow {}^{77}_{36}\text{Kr} + {}^{0}_{+1}e$

d. $^{93}_{45}\text{Rh} \longrightarrow {}^{93}_{44}\text{Ru} + {}^{0}_{+1}e$

4.19 **a.** $^{28}_{14}\text{Si}$ **b.** $^{87}_{36}\text{Kr}$ **c.** $^{0}_{-1}e$

d. $^{238}_{92}\text{U}$ **e.** $^{188}_{79}\text{Au}$

4.21 **a.** $^{10}_{4}\text{Be}$ **b.** $^{0}_{-1}e$ **c.** $^{27}_{13}\text{Al}$ **d.** $^{30}_{15}\text{P}$

4.23 **a.** When radiation enters the Geiger counter, charged particles are produced that create a burst of current that is detected by the instrument.

b. becquerel (Bq), curie (Ci)

c. gray (Gy), rad

d. 1000 Gy

4.25 294 μCi

4.27 When pilots are flying at high altitudes, there is less atmosphere to protect them from cosmic radiation.

4.29 A half-life is the time it takes for one-half of a radioactive sample to decay.

4.31 **a.** 40.0 mg

b. 20.0 mg

c. 10.0 mg

d. 5.00 mg

4.33 130 days, 195 days

4.35 **a.** Because the elements Ca and P are part of bone, their radioactive isotopes will also become part of the bony structures of the body where their radiation can be used to diagnose or treat bone diseases.

b. $^{89}_{38}\text{Sr} \longrightarrow {}^{89}_{39}\text{Y} + {}^{0}_{-1}e$

Strontium (Sr) acts much like calcium (Ca) because both are Group 2A (2) elements. The body will accumulate radioactive strontium in bones in the same way that it incorporates calcium. Once the strontium isotope is absorbed by the bone, the beta radiation will destroy cancer cells.

4.37 180 μCi

4.39 Nuclear fission is the splitting of a large atom into smaller fragments with the release of large amounts of energy.

4.41 $^{103}_{42}\text{Mo}$

4.43 **a.** fission

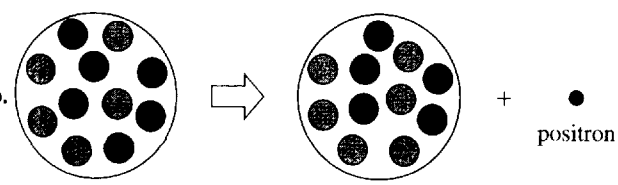
b. fusion

c. fission

d. fusion

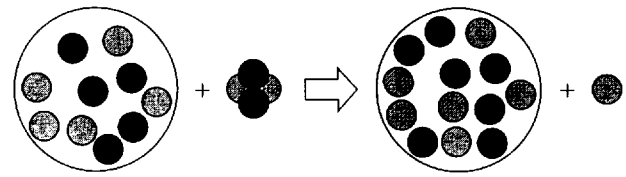
4.45 **a.** $^{11}_{6}\text{C}$

b.



positron

4.47



4.49 17 200 years old

4.51 **a.** 11 protons and 14 neutrons

b. 28 protons and 33 neutrons

c. 37 protons and 47 neutrons

d. 47 protons and 63 neutrons

4.53 **a.** In alpha decay, a helium nucleus is emitted from a radioisotope. In beta decay, a neutron in an unstable nucleus is converted to a proton and electron, which is emitted as a beta particle. In gamma emission, high-energy radiation is emitted from the nucleus of a radioisotope.

b. α, $^{4}_{2}\text{He}$ β, $^{0}_{-1}e$ γ, $^{0}_{0}\gamma$

4.55 **a.** gamma radiation

b. positron emission

c. alpha decay

4.57 **a.** $^{225}_{90}\text{Th} \longrightarrow {}^{221}_{88}\text{Ra} + {}^{4}_{2}\text{He}$

b. $^{210}_{83}\text{Bi} \longrightarrow {}^{206}_{81}\text{Tl} + {}^{4}_{2}\text{He}$

c. $^{137}_{55}\text{Cs} \longrightarrow {}^{137}_{56}\text{Ba} + {}^{0}_{-1}e$

d. $^{126}_{50}\text{Sn} \longrightarrow {}^{126}_{51}\text{Sb} + {}^{0}_{-1}e$

e. $^{13}_{7}\text{N} \longrightarrow {}^{13}_{6}\text{C} + {}^{0}_{+1}e$

4.59 **a.** $^{17}_{8}\text{O}$ **b.** $^{1}_{1}\text{H}$ **c.** $^{143}_{54}\text{Xe}$

4.61 **a.** $^{16}_{8}\text{O} + {}^{16}_{8}\text{O} \longrightarrow {}^{4}_{2}\text{He} + {}^{28}_{14}\text{Si}$

b. $^{249}_{98}\text{Cf} + {}^{18}_{8}\text{O} \longrightarrow {}^{263}_{106}\text{Sg} + 4{}^{1}_{0}n$

c. $^{222}_{86}\text{Rn} \longrightarrow {}^{218}_{84}\text{Po} + {}^{4}_{2}\text{He}$

d. $^{218}_{84}\text{Po} \longrightarrow {}^{214}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

4.63 14 d

4.65 **a.** $^{131}_{53}\text{I} \longrightarrow {}^{0}_{-1}e + {}^{131}_{54}\text{Xe}$

b. 0.375 g **c.** 32 d

4.67 16 μCi

4.69 7.5 mg

4.71 The irradiation of meats, fruits, and vegetables kills bacteria such as *E. coli* that can cause food-borne illnesses. In addition, spoilage is deterred, and shelf life is extended.

4.73 In the fission process, an atom splits into smaller nuclei. In fusion, small nuclei combine (fuse) to form a larger nucleus.

4.75 Fusion occurs naturally in the sun and other stars.

4.77 **a.** gamma radiation

b. positron emission

c. beta decay **d.** alpha decay

4.79 **a.** $^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$

b. $^{234}_{90}\text{Th} \longrightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{-1}e$

c. $^{226}_{88}\text{Ra} \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

4.81 4 half-lives; 64 μCi

4.83 **a.** $^{180}_{80}\text{Hg} \longrightarrow {}^{176}_{78}\text{Pt} + {}^{4}_{2}\text{He}$

b. $^{126}_{50}\text{Sn} \longrightarrow {}^{126}_{51}\text{Sb} + {}^{0}_{-1}e$

c. $^{49}_{25}\text{Mn} \longrightarrow {}^{49}_{24}\text{Cr} + {}^{0}_{+1}e$