24–1 Practice Problems

1. The half-life of cesium-137 is 30.2 years. If the initial mass of a sample of cesium-137 is 1.00 kg, how much will remain after 151 years?

\[
\frac{100\%}{2^{151/30.2}} = \frac{151}{30.2} \approx 5 \text{ h}, \\
\frac{100}{14.3} = 7 \text{ h}, \\
\frac{1000}{7} = 7.81 \text{ g}
\]

2. Given that the half-life of carbon-14 is 5730 years, consider a sample of fossilized wood that, when alive, would have contained 24 g of carbon-14. It now contains 1.5 g of carbon-14. How old is the sample?

\[
24 \times \frac{1}{4} = 4 \text{ h}, \\
4 \times 5730 = 22920 \text{ yrs}
\]

3. A 64-g sample of germanium-66 is left undisturbed for 12.5 hours. At the end of that period, only 2.0 g remain. What is the half-life of this material?

\[
64 \times 2 = 5 \text{ h}, \\
12.5 \times 5 = 2.5 = +\frac{1}{2}
\]

4. With a half-life of 28.8 years, how long will it take for 1 g of strontium-90 to decay to 125 mg?

\[
28.8 \times 3 = 86.4 \text{ yrs}
\]

5. Cobalt-60 has a half-life of 5.3 years. If a pellet that has been in storage for 26.5 years contains 14.5 g of cobalt-60, how much of this radioisotope was present when the pellet was put into storage?

\[
\frac{26.5}{5.3} = 5 \text{ h}, \\
14.5 \times (2)^5 = 464 \text{ g}
\]

6. A 1.000-kg block of phosphorus-32, which has a half-life of 14.3 days, is stored for 100.1 days. At the end of this period, how much phosphorus-32 remains?

\[
\frac{100\%}{2^{100.1/14.3}} = \frac{100}{14.3} \approx 7 \text{ h}, \\
\frac{1000}{7} = 7.14 \text{ g}
\]

7. A sample of air from a basement is collected to test for the presence of radon-222, which has a half-life of 3.8 days. However, delays prevent the sample from being tested until 7.6 days have passed. Measurements indicate the presence of 6.5 µg of radon-222. How much radon-222 was present in the sample when it was initially collected?

\[
6.5 \times \frac{1}{(2)^7} = 26 \mu g
\]

8. A 0.500 M solution of iodine-131, which has a half-life of 8.0 days, is prepared. After 40 days, how much iodine will remain in 1.0 L of solution? Express the result in moles.

\[
\frac{1000 \text{ mol}}{(2)^{40}} = 0.156 \text{ mol}
\]

9. The half-life of sodium-25 is 1.0 minute. Starting with 1 kg of this isotope, how much will remain after half an hour?

\[
\frac{1000}{(2)^{30}} = 9.31 \times 10^{-7}
\]

10. What is the half-life of polonium-214 if, after 820 seconds, a 1.0-g sample decays to 31.25 mg?

\[
\frac{1000}{820} = \frac{31.25}{5} = 164 \text{ sec}
\]
24–1 Practice Problems (continued)

11. Bombardment of aluminum-27 by alpha particles produces phosphorus-30 and one other particle. Write the nuclear equation for this reaction and identify the other particle.

\[ {}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_1^1\text{n} \]

16. Alpha-particle bombardment of plutonium-239 produces a neutron and another isotope. Write the nuclear equation for this reaction and identify the isotope.

\[ {}_{94}^{239}\text{Pu} + {}_2^4\text{He} \rightarrow {}_{96}^{239}\text{Cm} + {}_1^1\text{n} \]

12. Plutonium-239 can be produced by bombarding uranium-238 with alpha particles. How many neutrons will be produced as a byproduct of each reaction? Write the nuclear equation for this reaction.

\[ {}_{92}^{235}\text{U} + {}_2^4\text{He} \rightarrow {}_{94}^{239}\text{Pu} + 3{}_1^1\text{n} \]

17. One possible result of the impact of a neutron on a uranium-235 nucleus is the splitting of the uranium into tellurium-137, zirconium-97, and two other particles. Write the nuclear equation for this reaction and identify the two other particles.

\[ {}_{92}^{235}\text{U} + {}_1^1\text{n} \rightarrow {}_{73}^{137}\text{Te} + {}_{40}^{97}\text{Zr} + 2{}_0^1\text{n} \]

13. When bombarded with neutrons, cobalt-59 is converted to cobalt-60. What is the nuclear equation for this reaction?

\[ {}_{27}^{59}\text{Co} + {}_1^1\text{n} \rightarrow {}_{27}^{60}\text{Co} \]

18. When bombarded with neutrons, lithium-6 produces an alpha particle and an isotope of hydrogen. Write the nuclear equation for this reaction. What isotope of hydrogen is produced?

\[ {}_{3}^{6}\text{Li} + {}_1^1\text{n} \rightarrow {}_2^4\text{He} + {}_1^3\text{H} \]

14. One method for producing plutonium-239 is by bombarding uranium-238 with deuterium (hydrogen-2), which produces neptunium-238 and 2 neutrons. The unstable neptunium then decays to form plutonium-238. Write the nuclear equations for this two-step reaction. What other particle is produced in the second reaction?

\[ {}_{92}^{238}\text{U} + {}_1^1\text{H} \rightarrow {}_{93}^{238}\text{Np} + 2{}_0^1\text{n} \]

19. With what particle would you bombard sulfur-32 to produce hydrogen-1 and phosphorus-32? Write the appropriate nuclear equation.

\[ {}_{16}^{32}\text{S} + {}_1^1\text{n} \rightarrow {}_1^1\text{H} + {}_{15}^{32}\text{P} \]

15. Neutron bombardment of plutonium-239 yields americium-240 and another particle. Write the nuclear equation and identify the other particle produced.

\[ {}_{94}^{239}\text{Pu} + {}_1^1\text{n} \rightarrow {}_{95}^{240}\text{Am} + {}_1^0\text{e} \]

20. With what particle would you bombard bismuth-209 to produce astatine-211 and 2 neutrons? Express this reaction in the form of a nuclear equation.

\[ {}_{83}^{209}\text{Bi} + {}_2^4\text{He} \rightarrow {}_{85}^{211}\text{At} + 2{}_0^1\text{n} \]