Skills Worksheet

Name: _____

Half-Life

Complete the following half-life problems be sure to show your thinking when solving problems.

PROBLEM

If 100.0 g of carbon-14 decays until only 25.0 g of carbon is left after 11,460 y, what is the half-life of carbon-14?

SOLUTION

Step 1: Write down the equation relating half-life, the number of half-lives, and the decay time, and rearrange it to solve for half-life.

$$\text{total time of decay} = \text{number of half-lives} \times \frac{\text{number of years}}{\text{half-life}}$$

$$\frac{\text{number of years}}{\text{half-life}} = \frac{\text{total time of decay}}{\text{number of half-lives}}$$

Step 2: Calculate how many half-lives have passed during the decay of the 100.0 g sample.

$$\text{fraction of sample remaining} = \frac{\text{final mass of sample}}{\text{initial mass of sample}} = \frac{25.0\text{ g}}{100.0\text{ g}} = \frac{1}{4}$$

after one half-life = $\frac{1}{2}$; after two half-lives = $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ of sample

Two half-lives have passed.

Step 4: Calculate the half-life.

$$\frac{\text{number of years}}{\text{half-life}} = \frac{11{,}460\text{ y}}{2\text{ half-lives}} = \frac{5{,}730\text{ y}}{\text{half-life}}$$

half-life of carbon-14 = 5,730 y

Practice

1. What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 g of nitrogen-16 in 21.6 s?

2. All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 g sample of technetium-99 decays to 100.0 g of technetium-99 in 639,000 y, what is its half-life?

3. A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 h. What is the half-life of this radioactive isotope?

4. If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g?

5. The half-life of hafnium-156 is 0.025 s. How long will it take a 560 g sample to decay to one-fourth its original mass?

6. Chromium-48 has a short half-life of 21.6 h. How long will it take 360.00 g of chromium-48 to decay to 11.25 g?

7. Potassium-42 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-42 will be left after 62.0 hours?

8. Carbon-14 has a half-life of 5,730 y. How much of a 144 g sample of carbon-14 will remain after 1.719×10^4y?

9. If the half-life of uranium-235 is 7.04×10^8y and 12.5 g of uranium-235 remain after 2.82×10^9y, how much of the radioactive isotope was in the original sample?

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$$\text{total time of decay} = \text{number of half-lives} \times \frac{\text{number of years}}{\text{half-life}}$$

$$\frac{\text{number of years}}{\text{half-life}} = \frac{\text{total time of decay}}{\text{number of half-lives}}$$

Step 2: Calculate how many half-lives have passed during the decay of the 100.0 g sample.

$$\text{fraction of sample remaining} = \frac{\text{final mass of sample}}{\text{initial mass of sample}} = \frac{25.0\text{ g}}{100.0\text{ g}} = \frac{1}{4}$$

after one half-life = $\frac{1}{2}$; after two half-lives = $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ of sample

Two half-lives have passed.

Step 4: Calculate the half-life.

$$\frac{\text{number of years}}{\text{half-life}} = \frac{11{,}460\text{ y}}{2\text{ half-lives}} = \frac{5{,}730\text{ y}}{\text{half-life}}$$

half-life of carbon-14 = 5,730 y

Practice

1. What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 g of nitrogen-16 in 21.6 s?

$\frac{12.5\text{ g}}{100\text{ g}} = .125 = \frac{1}{8}$

$\frac{21.6\text{ s}}{3\text{ half-lives}} = 7.2\text{ s/half life}$

$100 \xrightarrow[\frac{1}{2}]{1\text{st}} 50 \xrightarrow[\frac{1}{4}]{2\text{nd}} 25 \xrightarrow[\frac{1}{8}]{3\text{rd}} 12.5\text{ g}$

2. All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 g sample of technetium-99 decays to 100.0 g of technetium-99 in 639,000 y, what is its half-life?

$\frac{100\text{ g}}{800\text{ g}} = \frac{1}{8} = 3\text{ Half-life}$

$\frac{639{,}000\text{ yrs}}{3\text{ half lives}} = 213{,}000\text{ yr}$ / 1 half life

3. A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 h. What is the half-life of this radioactive isotope?

$\frac{13\text{ g}}{208\text{ g}} = .0625 = 4\text{ half-life}$

$\frac{60.0\text{ hours}}{4\text{ half-lives}} = 15\text{ hrs}$

$208 \xrightarrow[\frac{1}{2}]{1\text{st}} 104 \xrightarrow[\frac{1}{4}]{2\text{nd}} 52 \xrightarrow[\frac{1}{8}]{3\text{rd}} 26 \xrightarrow[\frac{1}{16}]{4\text{th}} 13$

4. If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g?

$\frac{6.25\ g}{50.0\ g} = .125 = \frac{1}{8} = 3$ Half-life

8.10 days × 3 half-lives = 24.3 days

5. The half-life of hafnium-156 is 0.025 s. How long will it take a 560 g sample to decay to one-fourth its original mass?

$\frac{1}{4}$ = 2 half-lives

= .025 s × 2 half-lives = .050 sec.

6. Chromium-48 has a short half-life of 21.6 h. How long will it take 360.00 g of chromium-48 to decay to 11.25 g?

$\frac{11.25\ g}{360.00\ g} = .03125$

$.03125 = \frac{1}{32} = 5$ Half-lives

21.6 hours × 5 Half-lives

= 108 hours

7. Potassium-42 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-42 will be left after 62.0 hours?

$\frac{62\ h}{12.4\ h} = 5$ half-lives

$= \frac{1}{32}$

$\frac{1}{2}\ \frac{1}{4}\ \frac{1}{8}\ \frac{1}{16}\ \frac{1}{32}$

$848\ g \times \frac{1}{32} = 26.5\ g$ left

8. Carbon-14 has a half-life of 5,730 y. How much of a 144 g sample of carbon-14 will remain after 1.719×10^4 y?

$\frac{1.719 \times 10^4\ yr}{5.730\ yr} = 3$ half-lives

$= \frac{1}{8}$

$144\ g \times \frac{1}{8} = 18$ grams left

9. If the half-life of uranium-235 is 7.04×10^8 y and 12.5 g of uranium-235 remain after 2.82×10^9 y, how much of the radioactive isotope was in the original sample?

$\frac{2.82 \times 10^9\ yr}{7.04 \times 10^8\ yr} = 4$ half-lives

$= \frac{1}{16}$

$12.5\ g \times 16 = 200\ g$