Half Life/Decay Series Quiz

\[ \frac{t}{T} = N = N_0 \left( \frac{1}{2} \right)^n \]

1. How long would it take for an 88.0 gram sample to decay to only 5.50 grams if it has a half-life of 16.4 seconds?

\[ \frac{5.50}{88} = \frac{N}{N_0} \]

\[ \log \frac{0.0625}{88} = \log \frac{1}{2} \]

\[ 16.4 \cdot \left( \frac{1}{16.4} \right) = \frac{t}{16.4} \]

\[ t = 65.6 \text{ s} \]

2. If a sample has a half-life of 4.86 hours, what percent of the sample would remain after 29.16 hours?

\[ \frac{29.16}{4.86} = 6 \]

\[ N = 100\% \left( \frac{1}{2} \right)^6 = 1.56\% \]

3. A 128 gram sample decays so that only 16 grams of it remains after 4.23 years. What is the half-life of the sample?

\[ \frac{16}{128} = \frac{N}{N_0} \]

\[ \log 0.125 = \log \left( \frac{1}{2} \right)^n \]

\[ n = 3 \]

\[ 3 = \frac{4.23}{T} \]

\[ T = 1.41 \text{ years} \]

4. How many grams of a 216 sample would remain after 14.8 minutes if the sample has a half-life of 6.85 minutes?

\[ \frac{N}{216} = \frac{N}{N_0} \]

\[ \frac{14.8}{6.85} = 2.16 \]

\[ N = 216 \left( \frac{1}{2} \right)^{2.16} = 46.3 \text{ g} \]
8. The half-life of tritium (hydrogen-3) is 12.3 years. Suppose 48.0 mg of tritium is released from a nuclear power plant during the course of an accident.
   a. What mass of this nuclide will remain after 12.3 years?
   b. What mass will remain after 49.2 years?

\[
\begin{align*}
N &= \frac{48.0 \text{ mg}}{2^{12.3}} = 24.0 \text{ mg} \\
N &= \frac{48.0 \text{ mg}}{2^{49.2}} = 3 \text{ mg}
\end{align*}
\]

9. It takes 5.2 minutes for a 1.000-g sample of \(^{210}\text{Fr}\) to decay to 0.250 g. What is the half-life of \(^{210}\text{Fr}\)?

\[
T = \frac{\ln(2)}{\ln(0.250)} = 5.2 \text{ min}
\]

10. How much time is required for a 5.75 mg sample of \(^{21}\text{Cr}\) to decay to 1.50 mg if it has a half-life of 27.8 days?

\[
T = \frac{\ln(0.5)}{\ln(0.75)} = 54.0 \text{ days}
\]

11. Cobalt-60 has a half-life of 5.26 years. The Co-60 in a radiotherapy unit must be replaced when its radioactivity falls to 75% of the original sample. If the original sample was purchased in August 2005, when will it be necessary to replace the Co-60?

\[
T = \frac{\ln(0.75)}{\ln(0.5)} = 2.1 \text{ yr}
\]

12. The cloth shroud from around a mummy is found to have a \(^{14}\text{C}\) activity of 8.9 disintegrations per minute per gram of carbon as compared with living organisms that undergo 15.2 \(^{14}\text{C}\) disintegrations per minute per gram of carbon. Calculate the age of the shroud. The half-life for \(^{14}\text{C}\) decay is 5715 years.

\[
T = \frac{\ln(0.586)}{\ln(0.75)} = 4413 \text{ yrs}
\]

13. An experiment was designed to determine whether an aquatic plant absorbed iodide ion from water. Iodine-131 (\(t_{1/2} = 8.04\) days) was added as a tracer, in the form of iodide ion, to a tank containing the plants. The initial activity of a 1.00 \(\mu\text{L}\) sample of water was 184 counts per minute. After 30 days, the level of activity in a 1.00 \(\mu\text{L}\) sample was 13.5 counts per minute. Did the plants absorb iodide from the water? Justify.

\[
\frac{28}{13} \text{Al} \quad \frac{13 \text{p}(1.00 \times 10^{25})}{13 \text{n}} = 28.2317
\]

\[
= 2.29 \times 10^{21}
\]

\[
(2.29 \times 10^{21})(3.00 \times 10^{21}) = 6.87 \times 10^{41}
\]

\[
= 1.332 \times 10^{-11} \frac{\text{mole}}{\text{mol}}
\]