**Half-Life**

- Half-Life is defined as the amount of time it takes a radioisotope to decay to one half its original mass.
- The use of radioisotopes is varied and can be used in medicine to trace problems in your intestines or heart.
- Radiochemical dating is used to date fossils, wood and skeletons.
- Each radioisotope has a half-life and can be applied to several uses.

**The formula for half-lives**

- For example a particular isotope has a half life of 2.5 seconds, if a person is injected with 1.00 mg…
- How much remains after 7.5 seconds?
- 7.5 seconds = 3 half-lives, therefore \(\frac{1.00}{(2/2/2)}\) or 0.125 mg remains.
- How much time has passed by when 0.03125 mg remain?
- Since \(\frac{1.00}{(2/2/2/2)} = 0.03125\) mg = 5 half-lives or \(5(2.5\ s) = 12.50\) seconds
- What if it doesn’t work out perfect?

**Half-Lives Formulas**

- Activity (A) \(\propto\) number of radioactive atoms present (N)
- \(A = kN\)
- Where A = disintegrations/time and
- \(k = \) proportionality constant or decay constant
- And N = number of atoms
- A more usable equation is \(\ln N = -kt\)
- \(\frac{N}{N_0}\)

Where N = mass after time, \(N_0 = \) initial mass, k = decay constant and t = time passed
\[ \frac{A}{A_0} = \frac{N}{N_0} \text{ depends on problem} \]

- Final formula: \( t_{1/2} = \frac{.693}{k} \)
- dpm = disintegrations per minute a measure of activity
- Let’s use these formulas to solve some problems!

**PROBLEM 1**

- A sample of radioactive waste with a half-life of 200 years is buried. How much time is needed to reduce the activity from \( 6.50 \times 10^{12} \) dpm to a harmless activity of \( 3.00 \times 10^{-3} \) dpm?
- (do you feel like Erin Brockovich?)

**SOLUTION**

\[ k = \frac{.693}{t_{1/2}} = \frac{.693}{200 \text{ yr}} = .00347 \text{ yr}^{-1} \]

\[ \ln \left( \frac{3.00 \times 10^{-3} \text{ dpm}}{6.50 \times 10^{12} \text{ dpm}} \right) = -(0.00347 \text{ yr}^{-1})t \]

\[ t = 1.02 \times 10^4 \text{ yrs} \]

**PROBLEM 2**

- Technetium-99 is used in medical imaging. A sample of the isotope emits \( 3.28 \times 10^5 \) photons/s. After 1 hr, the emission has dropped to \( 2.92 \times 10^5 \) photons/s. Calculate the half-life.

**SOLUTION**

\[ \ln \left( \frac{2.92 \times 10^5 \text{ photons/s}}{3.28 \times 10^5 \text{ photons/s}} \right) = -k \ (1.0 \text{ hr}) \]

\[ k = .116 \text{ hr}^{-1} \]

\[ t_{1/2} = \frac{.693}{.116 \text{ hr}^{-1}} \]

\[ t_{1/2} = 5.96 \text{ hr} \]
Radiochemical Dating-Problem 3

• A sample of wood is found that has a carbon-14 mass of .756 g ($t_{1/2} = 5730$ years). The initial amount of carbon is determined to be 1.0056 g. How many years has this tree been underground? In what year did it die?

• SOLUTION
  
  - $t_{1/2} = .693/k$
  - $5730$ yr = .693 /k
  - $k = 1.21 \times 10^{-4}$ yr$^{-1}$
  - $\ln (.756$ g/1.0056 g) = $-(1.21 \times 10^{-4}$ yr$^{-1}$)t
  - $t = 2358$ yr
  - 2009 – 2358 = - 351
  - 351 b.c.e.

Problem 4

• You are on e-bay® and find an interesting item. This wooden cross is said to have been carried by Columbus on his voyage to America in 1492. You have it tested for element C-14 which has an activity of 15.3 counts per min. and a half-life of 5730 yr. The test yields findings of 14.5 counts per minute. Is it possible? What year did it originate?

Use the formula $\ln (N/N^0) = -kt$ and $t_{1/2} = .693/k$

$\ln (14.5/15.3) = -(0.693/5730)t$

$t = 444$ year

Year = 1564 not Possible