Half-Life

* • **Half life:** the time required for one half of the radioactive nuclei in a sample to spontaneously decay
    - The half-life is specific to the type of radioactive material (ie: different elements each have unique/different half-lives)
- The number of nuclei of the original radioisotope (ie. parent element) left in a sample after a given amount of time can be calculated using the following equation

$$N = N_o\left(\frac{1}{2}\right)^n$$

where N is the amount of radioactive material remaining after a given period of time
N_o is the original amount of sample before decay started
n is the number of half-lives that occurred over a given period of time

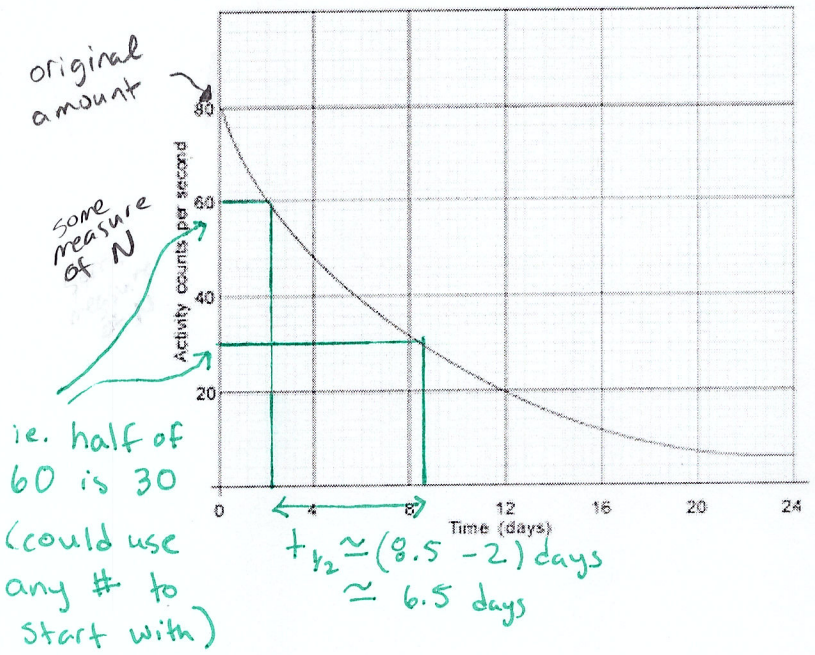
$$n = \frac{t}{t_{1/2}}$$ * not on data sheet

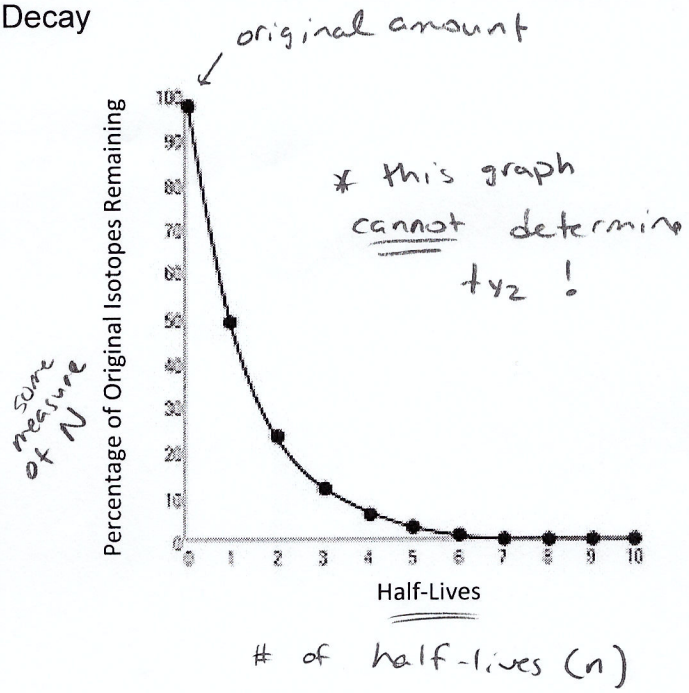
where t is the given time period
$t_{1/2}$ is the half-life of an element
} t & $t_{1/2}$ can be in any units, as long as they are the same units.

- The amount of a radioactive material may be expressed in different units (ie: mass, number of atoms, percent, decays/second, becquerels, counts per minute, activity, etc.), but as long as N and N_o are recorded in the *same* type of unit, the formula can handle any type of units

don't let units distract you from the actual problem

- Graphical Representation – Exponential Decay





EXAMPLES:

1. Carbon-14 has a half-life of 5730 years. How much carbon-14 will remain in a sample after 17190 years if the original sample contained 15.6g of carbon-14?

$t_{1/2} = 5730$ years

$t = 17190$ years

$N_0 = 15.6\,g$

$N = ?$

$$N = N_0\left(\tfrac{1}{2}\right)^n \quad (2)$$

$$n = \frac{t}{t_{1/2}} \quad (1)$$

(1) $$n = \frac{17190 \text{ years}}{5730 \text{ years}} = 3$$

(2) $$N = N_0\left(\tfrac{1}{2}\right)^n$$

$$N = 15.6\,g\left(\tfrac{1}{2}\right)^3 = 1.95\,g$$

$$\boxed{N = 1.95\,g}$$

2. Radium-226 has a half-life of 1600 years. What percentage of a sample of radium-226 will remain after 8000 years?

$t_{1/2} = 1600$ years

$\%_0 = ?$

$t = 8000$ years

$$\%_0 = \frac{N}{N_0} \times 100\% \quad (3)$$

$$N = N_0 \left(\tfrac{1}{2}\right)^n \quad (2) \qquad n = \frac{t}{t_{1/2}} \quad (1)$$

(1) $n = \dfrac{8000 \text{ years}}{1600 \text{ years}} = 5$

(2) $N = N_0 \left(\tfrac{1}{2}\right)^n \rightarrow \dfrac{N}{N_0} = \left(\tfrac{1}{2}\right)^n = \left(\tfrac{1}{2}\right)^5 = 0.03125$

(3) $\dfrac{N}{N_0} \times 100\% = \%_0 = 0.03125 \times 100\% = 3.125\%$

$\%_0 = 3.125\%$ remaining

Now try pg. 320 #2-5, 7-9, 11-14