Some Nuclear Physics

1. The half-life of a particular radioactive isotope is 6.5 h. If there are initially 48 x 10^{19} atoms of this isotope, how many atoms of this isotope remain after 26 h?

2. A radioactive isotope of mercury, ^{197}Hg, decays into gold, ^{197}Au, with a disintegration constant of 0.0108 h^{-1}. (a) What is its half-life? (b) What fraction of the original amount will remain after three half-lives? (c) What fraction will remain after 10.0 days?

3. The radionuclide ^{64}Cu has a half-life of 12.7 h. How much of an initially pure, 5.50-g sample of ^{64}Cu will decay during the 2.0-h period beginning 14.0 h later?

4. A sample of the isotope of iodine ^{131}I has an initial decay rate of 1.8 x 10^5 decays/s. This isotope has a half-life of 8.04 days. It is shipped to a medical diagnostic laboratory where it will be used as a radioactive tracer. When the shipment arrives at the lab the decay rate has fallen to 1.4 x 10^5 decays/s. How long did it take for the shipment to reach the laboratory?

5. The daughter nucleus formed in radioactive decay is often radioactive itself. Let N_{10} be the initial number of parent nuclei at $t = 0$, $N_1(t)$ be the number of parent nuclei at some later time t, and λ_1 be the decay constant. Suppose the number of daughter nuclei at $t = 0$ is zero and let $N_2(t)$ be the number of daughter nuclei at time t and λ_2 be the decay constant of the daughter. (a) Show that $N_2(t)$ satisfies

$$\frac{dN_2}{dt} = \lambda_1 N_1 - \lambda_2 N_2 \tag{1}$$

(b) Verify this differential equation has the following solution.

$$N_2(t) = \frac{N_{10}\lambda_1}{\lambda_1 - \lambda_2}\left(e^{-\lambda_2 t} - e^{-\lambda_1 t}\right) \tag{2}$$

(c) Where will $N_2(t)$ be a maximum?

6. Generate the decay chain of ^{239}Pu until it reaches a stable isotope. Use the interactive table of nuclides at `http://atom.kaeri.re.kr/`.