Class Tutorial 3 : 2NP Nuclear Physics

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1. Among the radioactive products emitted inthe 1986 Chernobyl reactor accident were ^{131}I ($t_{1/2}$ = 8.0 d) and ^{137}Cs ($t_{1/2}$ = 30 y). There would have been about 5 times as many ^{137}Cs atoms as ^{131}I atoms released, based on the fission reactions involved.

   (a) Which isotope contributes the greater activity to the radiation cloud?

   (b) How long after the original accident did the two activities become equal?

2. The human body contains on the average about 18% carbon and 0.2% potassium by mass.

   (a) Compute the intrinsic activity of the average person in Bq and Ci from ^{14}C and ^{40}K. The natural isotopic abundances of these two isotopes expressed as a fraction are 10^{-12} and 0.000117 respectively. The half-lives are 5730 years and 1.28×10^9 years, and the atomic masses are 14.003 and 39.964.

   (b) What are the most abundant isotopes of these two elements?

3. The decay chain ^{139}Cs $\rightarrow^{139}$Ba $\rightarrow^{139}$La is observed from an initially pure sample of 1 mCi of ^{139}Cs. The half-lives are ^{139}Cs, 9.5 min; ^{139}Ba, 82.9 min; ^{139}La, stable. What is the maximum ^{139}Ba activity, and when does it occur?

4. The α-decay of ^{238}U ($t_{1/2} = 4.47 \times 10^9$y) leads to ^{234}Th ($t_{1/2}$ = 24.1d). A sample of uranium ore should reveal ^{234}Th activity in secular equilibrium with the parent. The isotopic adundance of ^{238}U in natural uranium is 99.3%.

   (a) What would be the ^{234}Th activity in each gram of uranium?

   (b) How big (length of each side of a cube) is 1 g of uranium? The density of uranium metal is 18.95 g/cm^3.