PHY 3107, Spring 2016, Homework #8

due Friday, Apr. 1, at noon

1.) A) What is the radius of the nucleus of ^{56}Fe? B) What energy electrons and protons are required to measure the size of the nucleus of ^{56}Fe if you want to be able to resolve distances of the order of less than half the radius? [Hint: relate the de Broglie wavelength to the kinetic energy.]

2.) The more common isotope of uranium is ^{238}U, which decays by alpha emission: $^{238}\text{U} \rightarrow {}^{234}\text{Th} + \alpha$. A) Calculate the energy released (or the Q value) by looking up the masses of the particles involved. Express this energy in MeV. B) The energy is released in the form of kinetic energy of the α-particle and the daughter nucleus, ^{234}Th. Calculate the energy of each if the ^{238}U was initially at rest in the lab frame. [Hint: this is simple conservation of momentum.] C) A sample of uranium ore has a ratio of $^{234}\text{Th}/^{238}\text{U}$ of 0.06. How old is the ore? [You will need to look up the half life of ^{238}U.]

3.) The binding energy is given as $E_b = C_1 A - C_2 A^{\frac{2}{3}} - C_3 \frac{Z(Z-1)}{A^{\frac{1}{3}}} - C_4 \frac{(N-Z)^2}{A}$, where the constants are given in your book as $C_1 = 15.7$ MeV, $C_2 = 17.8$ MeV, $C_3 = 0.71$ MeV, $C_4 = 23.6$ MeV. Use these constants to calculate the binding energy for ^{40}Ca.

4.) In order for a decay to be allowed, the Q value must be greater than 0. A) Can ^{230}U decay via proton emission? B) Can ^{230}U decay via neutron emission? C) Can ^{230}U decay via α emission?

5.) Carbon dating is used to figure out how old stuff is. In carbon dating, the idea is to take advantage of the radioactive 14-carbon produced in our atmosphere by cosmic rays: $n + {}^{14}\text{N} \rightarrow {}^{14}\text{C} + p$. This reaction produces a "natural equilibrium" ratio of $^{14}\text{C}/^{12}\text{C}$ in the atmospheric CO_2 of 1.2×10^{-12}. Once something stops taking in this ^{14}C, the ratio decreases as the ^{14}C decreases.

A bone dug up in a field in Maine is suspected to be that of one of the Vikings, who visited North America in the 10^{th} century. One thing is certain – it is old! Accelerator techniques gave its 14C/12C ratio as 1.1×10^{-12}. Is the bone old enough?