

PHY 3107, Spring 2018, Homework #6

due Friday March 2

- 1.) A) What is the radius of the nucleus of ^{56}Fe ? B) What energy electrons and C) what energy 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 $E_b = C_1A - C_2A^{\frac{2}{3}} - C_3\frac{Z(Z-1)}{A^3} - C_4\frac{(N-Z)^2}{A}$, 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}C 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 10th century. One thing is certain – it is old! Accelerator techniques gave its $^{14}\text{C}/^{12}\text{C}$ ratio as 1.1×10^{-12} . Is the bone old enough?