PHYSICS 722/822 - Fall Semester 2018 - ODU

Nuclear Physics - Problem Set 1

Problem 1)

Collect and present (in a paragraph or two, plus tables and graphs if you like) all information you can gather on the nucleus ^{6}Li. Make sure you include information on the total mass of the nucleus, total and average (per nucleon) binding energy, removal energy for a single proton and a single neutron, charge (Z, N,…), spin, magnetic moment, approximate size, energy levels for the first few excited states, information on stability, deformation, and anything else noteworthy you may find. What other stable Li isotopes exist?

Problem 2)

a) Using the Mass formula discussed in class or on p. 19 in Povh et al., calculate the predicted masses of the nuclides ^{4}He, ^{197}Au and ^{193}Ir in MeV/c^2.
b) Compare your results to the ACTUAL masses of these nuclides. Can you explain why there is a the difference (apart from possible errors in the constants given)?
NOTE: The value for the atomic mass unit is $1u = 931.494$ MeV/c^2.
c) From your results under a), determine whether alpha-decay is energetically possible for ^{197}Au. Does your answer change if you use the actual masses (b)? How do you explain that ^{197}Au is a stable nucleus?
d) Using the formula for the energy of a uniformly charged sphere (from E&M) and the value for the average density of nucleons inside nuclei, estimate what the value of the "Coulomb term" a_C in the mass formula SHOULD be. Compare with the value given in the book.

Problem 3)

A piece of Uranium ore contains 1 kg of ^{238}U. Assume that it has been undisturbed for thousands of years, how many atoms of ^{234}Th do you expect to be present in this ore sample?
(Hint: The decay chain of ^{238}U is shown on p. 33 in Povh et al..)

Problem 4)

Show that the mass (including electrons!) of the nuclide ^{40}K (Z=19,N=21) is larger than the masses of both ^{40}Ar and ^{40}Ca (*i.e.* , M(Z,N)>M(Z-1,N+1) and M(Z,N)>M(Z+1,N-1)). Explain what this means for possible decay modes of ^{40}K.