Nuclear and Particle Physics - Problem Set 1

Problem 1)

Collect and present (in a paragraph or two, and/or tables and graphs if you like) all information you can gather on the nucleus ^{6}Li. 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, information on stability, deformation, and anything else noteworthy you may find. What other stable Li isotopes exist?

Problem 2)

a) Using the Mass formula on p. 19 in Povh et al., calculate the predicted mass of the nuclide ^{208}Pb in MeV/c^2. Compare your result to the ACTUAL mass of that nuclide (from whatever source you can find).
b) Using the formula for a uniformly charged sphere (e.g., from an E&M book) and the value for the average density of nucleons inside nuclei (Povh et al. p. 20), 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)

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. List all decay modes (β^+, β^-, electron capture,…) that are possible, and calculate the maximum energy released in each. Which of these decay modes actually occur in Nature?

Problem 4)

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? See Povh et al. Fig. 3.7 on page 33 for relevant information.

Problem 5) (Extra Credit):

We discussed that nearly all of the visible mass in the Universe is due to the masses of nuclei. Can you find out where most of the mass of NUCLEI and their constituent NUCLEONS comes from?