Queen Mary
University of London

Nuclear Physics & Astrophysics
Homework – 1

Proton mass m_p = 1.00727647 u
Neutron mass m_n = 1.00866501 u
Avogadro's number N_A=6.022 x 10^{23} mol^{-1}

1. Separate the nuclei below into pairs of isotopes, isobars, isotones, or isomers:
   $^{3}_{1}H$, $^{4}_{2}He$, $^{3}_{2}He$, $^{12}_{6}C$, $^{12}_{7}N$, $^{14}_{6}C$, $^{99}_{43}Tc$, $^{99}_{42}Mo$, $^{99m}_{43}Tc$, $^{100}_{44}Ru$ [8]

2. The constants of the Semi-empirical mass formula in units of MeV are:
   $a_V = 15.56$ $a_S = 17.23$ $a_C = 0.697$ $a_{asym} = 23.285$ $a_P = 12$
   Calculate the kinetic energy of the alpha particle emitted in the decay of $^{242}_{98}Cf$ assuming no recoil of the daughter nucleus. A value of 7.5 MeV is obtained in experiment. Compare and comment on the calculated and measured values. [6]

3. From the known masses of ^{15}O and ^{15}N compute the difference in binding energy. [5]
   Assuming this difference arises from the difference in Coulomb energy compute the nuclear radius of the two nuclei. [5]
   Coulomb repulsion to binding energy = $-\frac{3}{5}\frac{Z(Z-1)e^2}{4\pi\varepsilon_0 R_0 A^{1/3}}$

   Atomic mass of ^{15}N = 15.000109 u
   Atomic mass of ^{15}O = 15.003065 u

4. The ordering of the lowest nuclear energy levels is:
   $1s_{1/2}$ $1p_{3/2}$ $1p_{1/2}$ $1d_{5/2}$ $1d_{3/2}$ $2s_{1/2}$ $1f_{7/2}$ $2p_{3/2}$ $1f_{5/2}$
   Using this information determine the shell configuration of neutrons and protons and hence the ground state spin and parity assignments of the following nuclei:
   $^{3}_{2}He$ $^{20}_{10}Ne$ $^{27}_{13}Al$ $^{41}_{21}Sc$ $^{69}_{31}Ga$ [15]