Queen Mary University of London

PHYSICS department

Nuclear Physics & Astrophysics
Exercises – 4

Hand in on 1st floor by Friday 29th October 4pm

Proton mass m_p = 1.00727647 u
Hydrogen mass ^1H = 1.007825 u
Neutron mass m_n = 1.00866501 u
Avogadro's number N_A=6.022 x 10^{23} mol^{-1}
$e^2/4\pi\varepsilon_0$ = 1.439976 MeV fm

Assume the ordering of nuclear shells is:
$1s_{1/2}$; $1p_{3/2}$; $1p_{1/2}$; $1d_{5/2}$; $1d_{3/2}$; $2s_{1/2}$; $1f_{7/2}$; $2p_{3/2}$; $1f_{5/2}$; $2p_{1/2}$; $1g_{9/2}$; $1g_{7/2}$; $2d_{5/2}$

1. Starting with the definition of Q written in terms of <u>nuclear</u> masses for the β^+ decay process, derive the Q of this reaction in terms of <u>atomic</u> masses. [4]
[Hint: read Krane 9.1]

2. A particular nucleus is a negative beta emitter. Sketch a graph of the energy spectrum of the emitted anti-neutrino. [2]

3. Consider the alpha decay process: ${}^{A}_{Z}X_{N} \rightarrow {}^{A-4}_{Z-2}Y_{N-2} + \alpha$. Starting with the equation relating Q and the kinetic energies of the nuclei, and by assuming the nucleus X is at rest, show that the kinetic energy of the α –particle expressed in terms of the Q value of the above reaction (using non-relativistic mechanics) is:
$$T_\alpha = \frac{Q}{1+(m_\alpha / m_Y)}$$
In the limit of A>>4 show that the kinetic energy of the α –particle can be written as $T_\alpha = Q(1-4/A)$ [6]

4. The formula used to calculate the binding energy of a nucleus contains terms known as the asymmetry term and the pairing term. Give a brief explanation for the origin of these terms justifying them as far as possible. For the asymmetry term justify the specific A and Z dependence. [5]

5. Explain why water is an abundant substance in the universe [3]

No need to turn over