Problem Sheet 4

3C24

February 23, 2001

1. i)

$$
\begin{aligned}
E_{nucleus} &= Zm_p + Nm_n - B_{volume} - B_{surface} - B_{Coulomb} - B_{Symmetry} - B_{Pairing} \\
&= Zm_p + Nm_n - u_v A + u_c Z^2 A^{-\frac{1}{3}} + u_s A^{\frac{2}{3}} + u_a T^2 A^{-1} \pm \frac{\delta}{2A}
\end{aligned}
$$

Explain in detail each of the terms in this expression.[11]

ii) Obtain an expression for Z as a function of A for the stable isobars[8] (Stable : $\frac{\partial U}{\partial Z} = 0$

iii) Obtain an expression for the difference in energy of the parent nuclei and the decay products in alpha decay.[2]

iv) Show it can be written in the form: (You need to differentiate U wrt A)[8]

$$\frac{Z}{A^{\frac{1}{3}}}\left[\chi_1 - \chi_2 \frac{Z}{A}\right] + \frac{\chi_3}{A^{\frac{1}{3}}} - \chi_4 \left[1 - \frac{2Z}{A}\right]^2 - 28.1MeV$$

2. i) Write down a general expression for the energy released in a nuclear decay

$${}^{A}_{Z}\mathrm{W} \rightarrow {}^{A-X}_{Z-Y}\mathrm{B} + {}^{X}_{Y}\mathrm{C}$$

in terms of parameters of the SEMF. [2]

ii) Which parameter does not appear in the expression and why? [2]

iii) Show that if the two decay fragments are of equal size, (i.e. X=A/2,Y=Z/2) that [4]

$$
\begin{aligned}
\frac{Z^2}{A} &> \frac{u_s(2 - 2^{2/3})}{u_c(2^{2/3} - 1)} &\quad (1)\\
&> 18 &\quad (2)
\end{aligned}
$$

iv) Use this expression to estimate the energy given out in fission of ^{235}U to two equal sized fragments. [2]

3. i) Explain how the strong and electromagnetic forces are involved in the existence of stable nuclei.[5]

ii) Describe the three radioactive processes and explain the differences between them.[6]

iii) Explain why there are very few odd-odd even nuclei which are beta stable[4]

iv) Explain the requirements for X and Y isobars differing by one unit in Z being stable against beta decay and explain why this is a rare occurance. [4]