PHAS0040 Problem Sheet 3

Due through Moodle on Monday 18^{th} March at 4.59 pm

Question 1

In the semi-empirical mass formula (SEMF) which terms (a_v, a_s, a_c, a_a, a_p) decrease and which increase the binding energy? Roughly explain why. **[5]**

Question 2

Using the semi-empirical mass formula (SEMF) :

$$M(Z,A) = Zm_p + (A-Z)m_n - a_v A + a_s A^{2/3} + a_c Z^2 A^{-1/3} + a_a \left(Z - A/2\right)^2 A^{-1} \pm \delta a_p f(A)$$

find the most stable value of Z for a nucleus with $A = 145$. **[8]**

Numerical data: $a_v = 15.67$, $a_s = 17.23$, $a_c = 0.714$, $a_a = 93.15$, $a_p = 11.1$, all in MeV.

Question 3

Up to which element is fusion possible? Explain your answer. **[3]**

Question 4

Give the two most likely configurations for the first excited state of the nucleus ${}^{9}_{4}\text{Be}$, assuming that only neutrons are excited. **[8]**

Question 5

Write down the shell model configurations of the nuclei ${}^{40}_{18}\text{Ar}$, ${}^{39}_{19}\text{K}$ and ${}^{40}_{20}\text{Ca}$. **[9]**

Using the single-particle shell model, predict the spin and parity (J^P) of these nuclei. **[9]**

Is ${}^{40}_{20}\text{Ca}$ expected to be stable? Why? **[3]**

Question 6

A certain odd-parity shell-model state $(nl)_j$ has total and orbital angular momentum quantum numbers j and l, respectively. If the state can hold up to a maximum of 16 nucleons, what are the values of j and l ? **[5]**

Question 7

Brazil nuts contain a small amount of radium ${}^{226}_{88}\text{Ra}$. radium ${}^{226}_{88}\text{Ra}$ has a half-life of 1600 y. For a 1 g nut an activity of 0.37 Bq was measured. Estimate the percentage of the radium ${}^{226}_{88}\text{Ra}$ contained in the nut. **[7]**

Question 8

Each fission of ${}^{235}_{92}\text{U}$ releases about 200 MeV of energy. How many fissions per second must occur to produce a power of 10 kW. **[3]**