EASTERN UNIVERSITY, SRI LANKA

THIRD EXAMINATION IN SCIENCE - 2007/2008

FIRST SEMESTER (SPECIAL REPEAT)

(FEBRUARY 2010)

PH 303 NUCLEAR PHYSICS

Time: 01 hour.

Answer ALL Questions

You may find the following data useful:

$e = 1.6\times10^{-19}$C

$N = 6.023\times10^{23}$ per mole

1 MeV = 1.6×10^{-13}J

1 amu = 931.5 MeV/c^2

Atomic mass of ${}^{9}_{4}Be$= 9.012182 u

Atomic mass of ${}^{9}_{5}B$= 9.013329 u

Atomic masses of ${}^{12}_{16}C$ = 12.000000 u

Atomic masses of ${}^{13}_{7}N$ = 13.005739 u

Atomic masses of ${}^{1}_{1}H$ = 1.00727647 u

Atomic mass of nuetron= 1.00866501 u

Atomic mass of electron= 5.485803×10^{-4} u

1. The binding energy E_B of a nucleus by the semi-empirical mass formula is given by:

$$E_B = C_v A - C_s A^{2/3} - C_c \frac{Z(Z-1)}{A^{1/3}} - C_{asy}\frac{(A-2Z)^2}{A} \pm \delta, \text{ where } \delta = \begin{cases} +C_p A^{-3/4} & \text{- even 'A} \\ 0 & \text{- odd 'A'} \\ -C_p A^{-3/4} & \text{- even 'A} \end{cases}$$

Describe briefly the 'origin' of the various terms in the Semi-Empirical Mass Formula.

(a) Show that the mass of an atom can be written as:
$M_A(A, Z) = \alpha A + \beta Z + \gamma Z^2 \mp \delta$, where α, β, γ *and* δ are function of A

(b) Show that the mass of any odd A isobar nuclide can be given as:

$$M_A(A, Z) = M_A(A, Z_0) + \gamma(Z - Z_0)^2$$

where Z_0 is the atomic number of the most stable isobar.

In stars slightly more massive than the Sun, hydrogen burning is carried out mainly b the CNO cycle, whose first step is: $p + {}^{12}_{6}C \rightarrow {}^{13}_{7}N + \gamma$. Estimate the energy of th gamma (in MeV), assuming the two initial nuclei are essentially at rest. Justify an simplifying assumptions you make.

2. Define scattering process and elastic scattering.

For a reaction of the type X(a, b)Y show that:

$$Q = \left(\frac{m_a}{m_y} - 1\right) T_a + \left(\frac{m_b}{m_y} + 1\right) T_b - \frac{2}{m_y}\sqrt{(m_a m_b T_a T_b)} \cos\theta$$

where the symbols have their usual meanings and θ is the angle of particle b, with th direction of incidence.

Beryllium has only one stable isotope ${}^{9}_{4}Be$. When a 50 MeV proton strikes a berylliu target it is found that a high energy neutron is emitted from the target.

(i) Use the conservation laws appropriate to nuclear reactions to determine th residual nucleus in the reaction which produces the neutrons. Write down the fu nuclear reaction.

(ii) Determine the Q of the reaction and so estimate the energy of the neutron emitted in the forward direction i.e. the same direction of propagation as th incident protons.

D
A

1)

2).