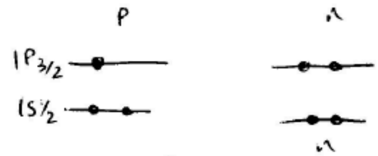
NPA Homework solutions 3

15/10/10

1)

a) $^{7}_{3}Li$: $n = 4$, $p = 3$



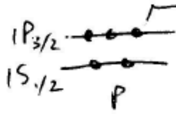
$J = \frac{3}{2}$ (1)

final p^+ in $p_{3/2}$ shell $\Rightarrow l = 1$

$\pi = (-1)^1 = -$ (1)

$\Rightarrow J^P = \frac{3}{2}^-$

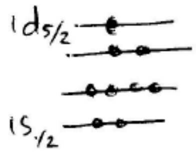
b) $^{11}_{5}B$ $n = 6$, $p = 5$ n shell closed



$\Rightarrow J = \frac{3}{2}$ (1) $L = 1 \Rightarrow P = -$ (1)

$\therefore J^P = \frac{3}{2}^-$

c) $^{15}_{6}C$ $p = 6$, $n = 9$ p shell closed



$J = \frac{5}{2}$ (1) $L = 2$ (1)

$\Rightarrow J^P = \frac{5}{2}^+$

2)

$$^{9}_{4}Be + p \rightarrow {}^{8}Be + {}^{2}H \qquad Q = 0.5595 \text{ MeV}$$

$$M({}^{9}Be) = 9.01218 \text{ u}$$

$$M_p = 938.28 \text{ MeV}$$

$$M({}^{2}H) = 2.014 \text{ u}$$

$$Q = M({}^{9}Be) + M_p - M({}^{8}Be) - M({}^{2}H)$$

$$Q = 7457.0987 - M({}^{8}Be)$$

$$M({}^{8}Be) = 7457.0987 - 0.5595$$

$$= 7456.539 \text{ MeV}$$

3)

2) $^{242}_{98}Cf \rightarrow ^{238}_{96}Cm + \alpha$

Use S.E.M.F. to calculate all 3 masses:

$$M(^A_ZX) = ZM_p + (A-Z)M_n - 15.56A + 17.23A^{2/3} + 0.697\frac{Z^2}{A^{1/3}} + 23.285\frac{(A-2Z)^2}{A} + \frac{12}{\sqrt{A}}$$

where $M(^A_ZX)$ is a nuclear mass because I used M_p & M_n in formula not (^1H) mass!

(2) ↳ +ve sign for all 3 nuclei as they are all ee nuclei

Easiest to program formula into ~~excel~~ Excel spreadsheet to avoid mistakes typing numbers into calculator:

(2) $M(^{242}_{98}Cf) = 225481 \text{ MeV}/c^2$ ($B = 1819.4$ MeV)

(2) $M(^{238}_{96}Cm) = 221745 \text{ MeV}/c^2$ ($B = 1798.8$ MeV)

(2) $M(\alpha) = 3733.66 \text{ MeV}/c^2$ ($B = 23.1$ MeV)

$$Q = \sum M_i - \sum M_f = \sum T_f - \sum T_i$$ initial & final kinetic energies

$= 225481 - 221745 - 3733.66$

$= 2.34 \text{ MeV} = T_\alpha + T_{cm}$ Assume Cf at rest and no recoil of Cm

$\therefore T_\alpha = \underline{2.34 \text{ MeV}}$ (2)

Note: This is likely to be an underestimate because S.E.M.F. underestimates the true mass of α particle

4)

n°s

$B(^{15}O) = 111.96$ MeV $n = 7$ $1p_{1/2}$

$B(^{16}O) = 127.62$ MeV $n = 8$ $1p_{1/2}$

$B(^{17}O) = 131.76$ MeV $n = 9$ $1d_{5/2}$, $1p_{1/2}$

binding energy of neutron in $1p_{1/2} = 127.62 - 111.96$

$= 15.66$ MeV

—— " —— " —— $1d_{5/2} = 131.76 - 127.62$

$= 4.14$ MeV

$\therefore$ difference between $1p_{1/2} - 1d_{5/2} = 15.66 - 4.14$

$= \underline{11.52 \text{ MeV}}$

5)

[2] marks for graph including axis labels and shape
[2] marks for correct location of arrow