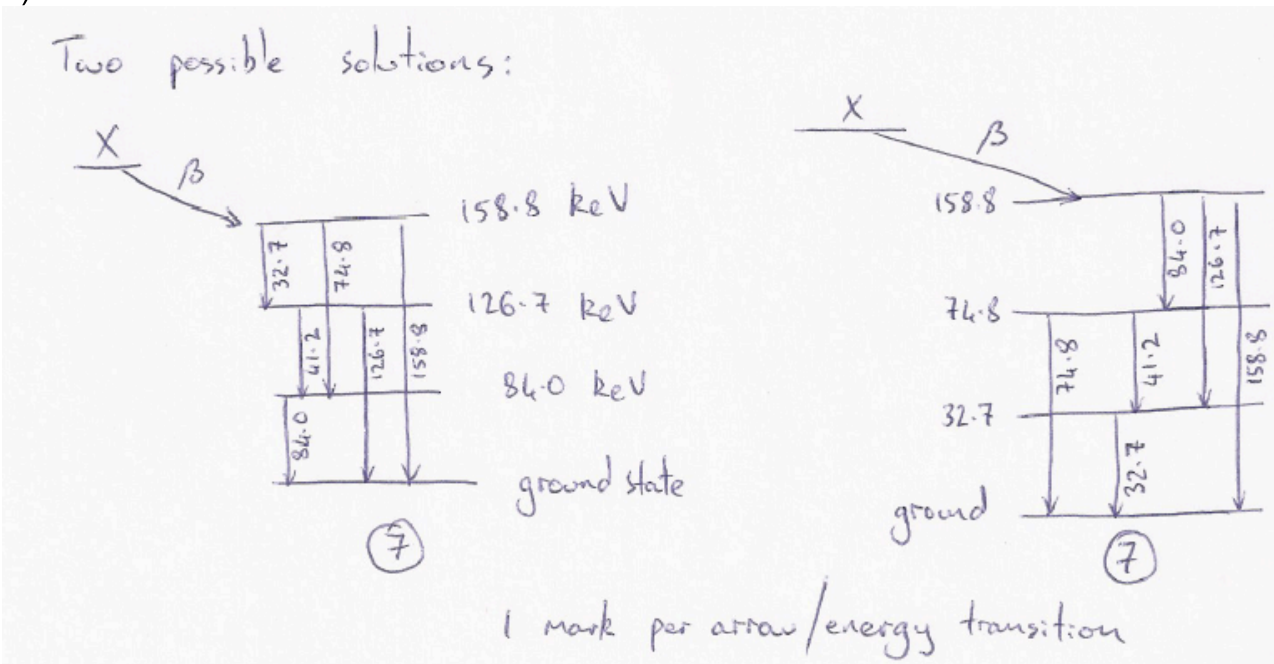
NPA Homework solutions 5 05/11/09

1)



2) Use atomic masses only! This will modify the equation for Q for beta- – no electron mass appears. If you use nuclear masses then then electron mass does appear!

a)

$$^{65}_{28}Ni \rightarrow {}^{65}_{29}Cu + e^- + \overline{\upsilon}_e$$

$$Q = m_A({}^{65}_{28}Ni) - m_A({}^{65}_{29}Cu) \quad \text{where } m_A \text{ are atomic masses} \quad [1]$$

$$Q = (64.930086 - 64.927793)u$$

$$Q = 2.15 \ \text{ MeV} \qquad [1]$$

b)

$$^{11}_{4}Be \rightarrow {}^{11}_{5}B + e^- + \overline{\upsilon}_e$$

$$Q = m_A({}^{11}_{4}Be) - m_A({}^{11}_{5}B) \quad \text{where } m_A \text{ are atomic masses} \quad [1]$$

$$Q = (11.021685 - 11.009305)u$$

$$Q = 11.53 \ \text{ MeV} \qquad [1]$$

c)

$$^{193}_{76}Os \rightarrow {}^{193}_{77}Ir + e^- + \overline{\upsilon}_e$$

$$Q = m_A({}^{193}_{76}Os) - m_A({}^{193}_{77}Ir) \quad \text{where } m_A \text{ are atomic masses} \quad [1]$$

$$Q = (192.964138 - 192.962917)u$$

$$Q = 1.14 \ \text{ MeV} \qquad [1]$$

3)

A thermal neutron has kinetic energy ~ 3/2 KT. At room temperature this is ~0.03 eV [1]

A fast neutron has kinetic energy >~ 1MeV [1]

Carbon or other light nuclei are used as moderators because neutron collisions with light nuclei are more likely to transfer kinetic energy from the neutron to the recoiling nucleus. [2]

Also the light nuclei are chosen such that they have very small neutron absorbtion cross sections [1 extra mark]

4)

a) $^{A}_{Z}X + e^- \rightarrow {}^{A}_{Z-1}Y + \nu_e$ (1) electron capture

atomic electron combines with p^+ to form a neutron. (1)

b) $^{A}_{Z}X^* \rightarrow {}^{A}_{Z}X^+ + e^-$ (1) internal conversion:

excited state X^* ~~dies~~ de-excites by emitting an atomic electron (1)

c) $^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^- + \bar{\nu}_e$ (1) β^- decay

electron comes from decay of neutron to a proton. (1)

d) $^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + e^+ + \nu_e$ (1) β^+ decay

electron (positron) comes from decay of proton to neutron (1)

5)

Neutron fluxes are dangerous to humans since neutrons do not interact via the Coulomb interaction and therefore they are very penetrating into all materials. [1]

Neutrons entering a human body will undergo scattering with the nuclei within which are mainly light nuclei such as H,C,O and therefore the neutrons are rapidly thermalised after only a few collisions, i.e. they readily give up their initial kinetic energy [1]

They cause damage to human tissue in one of two ways. They can either be absorbed by nuclei which then become beta emitters and emit an ionizing beta particle from within the body which can then directly damage human tissue, or the interacting nucleus can absorb the neutron leaving the new isotope in an excited state which de-excites via gamma ray emission. This gamma ray photon is then emitted and can cause subsequent ionization or pair-production of electron/positrons within the body which again damages the human tissue. [4]