Structure of The Nucleus Assignment ***SOLUTIONS***

1.

Number of protons	Number of neutrons	Mass number	Atomic number
6		12	
10	10		10
20	22	42	20
13			13
	132	216	84

/5

2. All nucleons exert a strong attractive force over very small distances /1

3.

a) A variation of the element (nucleus) with a particular number of neutrons /1

b) Chemical behaviour depends only on the electronic configuration (electrons and protons), and isotopes have the same number of those (neutrons are neutral). /2

4.

a)

$$m_{initial} = 7\times m_p + 7\times m_n = 7\times 1.673\times 10^{-27} + 7\times 1.675\times 10^{-27} = 2.3436\times 10^{-26}\,\text{kg}$$

$$m_{final} = 2.32\times 10^{-26}\ \text{kg}$$

$$\Delta m = m_{final} - m_{initial} = -2.36\times 10^{-28}\ \text{kg} = 2.36\times 10^{-28}\ \text{kg lost}$$

$$E_b = \Delta mc^2 = 2.36\times 10^{-28}\times\left(3.00\times 10^{8}\right)^2 = 2.12\times 10^{-11}\ \text{J (3 s.f.)}$$

$$\frac{2.12\times 10^{-11}}{1.60\times 10^{-19}} = 1.33\times 10^{8}\ \text{eV} = 133\ \text{MeV (3 s.f.)}$$

/3

b) Released (mass after is less than mass before) /1

5.

a)

(i) ${}^{4}_{2}\text{He} + {}^{9}_{4}\text{Be} \longrightarrow {}^{12}_{6}\text{C} + {}^{1}_{0}\text{n}$ /1

(ii) ${}^{27}_{13}\text{Al} + {}^{1}_{0}\text{n} \longrightarrow {}^{1}_{1}\text{H} + {}^{27}_{12}X$ /1

(iii) ${}^{241}_{94}\text{Pu} + {}^{1}_{0}\text{n} \longrightarrow {}^{242}_{94}\text{Pu} + \text{energy}$ /1

(iv) ${}^{226}_{88}\text{Ra} \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\alpha$ /1

b) $E_b = \Delta mc^2$

$$\therefore \Delta m = \frac{E_b}{c^2} = \frac{504\times 10^{6}\times 1.60\times 10^{-19}}{\left(3.00\times 10^{8}\right)^2} = 8.96\times 10^{-28}\ \text{kg}$$

/2

6.

a) Let the helium nucleus be body 1, and let the thorium nucleus be body 2.

Conservation of momentum states that total change is zero:

$\Delta\vec{p}_1 + \Delta\vec{p}_2 = 0$

$\therefore \Delta\vec{p}_1 = -\Delta\vec{p}_2$

$\therefore \Delta p_1 = \Delta p_2 \quad \{\text{considering only magnitudes}\}$

$\therefore p_1 = p_2 \quad \{\text{since they start at rest}\}$

$\therefore m_1 v_1 = m_2 v_2$

$\therefore \frac{v_2}{v_1} = \frac{m_1}{m_2} = \frac{234}{4} = 58.5$

/3

b) In order for momentum to be conserved for two products, they must both move off in opposite directions with equal magnitude of momentum. A product with less mass then will have more velocity, since $p = mv$. Since $K = \frac{1}{2}mv^2$, the smaller product will have more kinetic energy. /2

7.

a)

(i) neutrons emitted from a nuclear reactor hit nuclei of sulphur-32. The sulphur nuclei eject a photon in the process and the phosphorus-32 is created:

$$^{1}_{0}\text{n} + {}^{32}_{16}\text{S} \longrightarrow {}^{32}_{15}\text{P} + {}^{1}_{1}\text{H}$$

/2

(ii) hydrogen nuclei (protons) are accelerated to high energies in a cyclotron and then allowed to bombard oxygen-18 nuclei. A neutron is displaced from the oxygen and the fluorine absorbs the proton creating fluorine-18:

$$^{1}_{1}\text{H} + {}^{18}_{8}\text{O} \longrightarrow {}^{18}_{9}\text{F} + {}^{1}_{0}\text{n}$$

/2

(iii) nitrogen-14 is bombarded with deuterons (hydrogen-2 nuclei). The deuteron's proton is absorbed, a neutron is emitted during the reaction, and oxygen-15 is created:

$$^{2}_{1}\text{H} + {}^{14}_{7}\text{N} \longrightarrow {}^{15}_{8}\text{O} + {}^{1}_{0}\text{n}$$

/2

c) The treatment of excess blood cells, since phosphorus-32 suppresses the production of red blood cells in bone marrow. /1

TOTAL /31