PHYA5 Section A - Unofficial MS

Question 1 (6 marks)

(a) Alpha ✓ **(1)**

(b) (i) Range of alpha - Few centimetres e.g. 0.05m
Range of beta - Few tens of centimetres e.g. 0.5m or 1m **(2)**

(ii) Inverse square law means count rate drops significantly. **(1)**

(c) Dust contaminated with Americium (an alpha emitter) is hazardous when inhaled. Alpha particles are highly ionising and can therefore damage living cells. **(2)**

Question 2 (8 marks)

(a) (i) Electrostatic repulsion. **(1)**

(ii) There is no effect because isotopes of Au have the same number of protons in the nucleus, so the nuclear charge remains the same. **(1)**

(b) (i) Show that $r_0 \approx 1.4 \times 10^{-15}\, m$ **(1)**

(ii) Radius of ^{51}V nucleus $R = r_0 A^{\frac{1}{3}} = 5.2 \times 10^{-15}\, m$ **(2)**

(c) Density of ^{51}V nucleus $\rho = \dfrac{m}{V} \quad V = \dfrac{4}{3}\pi r^3 \quad \therefore \quad \rho = \dfrac{3m}{4\pi r^3} = 1.4 \times 10^{17}\, kg\, m^{-3}$ **(3)**

Question 3 (11 marks)

(a) ${}^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + {}^{0}_{-1}\beta^- + \bar{\nu}_e$ **(2)**

(b) (i) Show that $\lambda \approx 3.4 \times 10^{-6}\, s^{-1}$ **(2)**

(ii) $A = \lambda N \quad \therefore \quad N = \dfrac{A}{\lambda} = 2.4 \times 10^{17}$ **(1)**

(c) (i) When Uranium nuclei decay, neutrons are released which cause further fission. **(2)**

(ii) The moderator slows down neutrons (kinetic energy is transferred from the neutrons to the moderator nuclei). After about 50 collisions, the neutrons reach thermal speeds. **(2)**

(iii) Nuclei within the shielding absorb neutrons and become unstable. **(2)**

Question 4 (4 marks)

(a) 130J of energy is required to raise the temperature of 1 kg of lead by 1 K (without a change of state). **(1)**

(b) $Q = ml + mc\Delta T = 4.7 \times 10^4\, J$ **(3)**

Question 5 (11 marks)

(a) Describe an experiment that would allow you to determine a value for absolute zero. **(6)**

- Keep volume constant
- Measure pressure of gas at several temperatures
- Take repeat readings
- Plot a graph of pressure/Pa against temperature/°C
- Extrapolate line backwards until it touches temp axis (should be around -273 °C)
- This is absolute zero
- At absolute zero, the molecules have no kinetic energy (they are completely stationary)
- No force is exerted on the sides of the container (Newton's 2nd Law)
- Pressure is zero

$$F = \frac{\Delta mv}{t} \qquad p = \frac{F}{A}$$

(It would also be possible to describe an experiment that results in plotting a graph of volume against temperature).

(b) (i) Any two from:

- The molecules are in random motion (they move in all directions and have a range of speeds).
- Collisions are perfectly elastic.
- Newtonian mechanics apply. **(2)**

(ii) $(c_{rms})^2 = \dfrac{(2000^2 + 3000^2 + 7000^2)}{3} = 2.1 \times 10^7\ m^2\ s^{-2}$ **(1)**

(c) $E_k = \dfrac{3}{2}kT \quad \therefore \quad T = \dfrac{2E_k}{3k} = 319\ K$ **(2)**

Total for Section A - 40 marks