7 **(a)** A nucleus Z undergoes nuclear fission to form strontium-93 ($^{93}_{38}Sr$) and xenon-139 ($^{139}_{54}Xe$) according to

$$^{1}_{0}n + Z \rightarrow ^{93}_{38}Sr + ^{139}_{54}Xe + 2^{1}_{0}n$$

Fig. 7.1 shows the binding energies of the strontium-93 and xenon-139 nuclei.

Nucleus	binding energy / J
$^{93}_{38}Sr$	1.25×10^{-10}
$^{139}_{54}Xe$	1.81×10^{-10}

Fig. 7.1

The fission of 1.00 mol of Z releases 1.77×10^{13} J of energy.

Determine the binding energy per nucleon, in MeV, of Z.

binding energy per nucleon = ……………………………MeV [4]

(b) Plutonium-238 ($^{238}_{94}Pu$) is unstable and undergoes alpha decay.

The power source in a space probe contains 0.874 kg of plutonium-238. The half-life of plutonium-238 is 87.7 years.

(i) Show that the initial number N_0 of nuclei of plutonium-238 in the power source is 2.21×10^{24}.

[1]

(ii) Determine the initial activity of the source.

activity = ……………………………Bq [2]

(iii) The space probe will continue to function until the power output from the plutonium in the source decreases to 65.3% of its initial value.

Calculate the time, in years, for which the space probe will function.

time = ……………………………years [2]

(iv) An alternative power source uses energy generated from the radioactive decay of polonium-210. This isotope has a half-life of 0.378 years. The mass of the isotope needed for the same initial power output as produced by plutonium-238 is 3.37 g.

Suggest one disadvantage of using polonium-210 as the source of energy.

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[Total: 10]