6 Plutonium-239 has a half-life of 2.41×10^4 years. It decays to uranium-235 by alpha emission.

(a) **(i)** State what is meant by the half-life of plutonium-239.

……

……..…. [1]

(ii) A radioactive sample currently contains 6.2×10^{-9} kg of plutonium-239. Calculate the mass of plutonium-239 the sample would have contained 2000 years ago.

mass = ……. kg [2]

(iii) Calculate the current activity of the sample of plutonium-239.

[3]

(iv) The count rate of the plutonium sample was measured and used to calculate its activity. The value obtained for the activity of the sample was different from the calculated value obtained in **(a)(iii)**.

Give two reasons to account for this difference.

1. …….....

…….....

2. …….....

…….. [2]

(b) Data for the nuclei involved in the decay of plutonium-239 are given in Fig. 4.1.

nucleus	mass / u
α-particle $^{4}_{2}He$	4.00271
uranium-235 $^{235}_{92}U$	235.04393
plutonium-239 $^{239}_{94}Pu$	239.05216

Fig. 4.1

(i) Calculate the amount of energy released from the decay of a single plutonium-239 nucleus.

energy = ……. J [3]

(ii) State two harmful effects of being exposed to the radiation from the plutonium sample.

1. …….....

…….....

2. …….....

…….. [2]

(iii) State and explain whether a person standing 40 cm away from the plutonium sample is likely to experience harmful effects due to the radiation from the plutonium sample.

…….…….....

…….……..... [1]

(d) Uranium-235 has a half-life of 7.04×10^8 years, decaying by alpha emission to form an isotope of thorium. The isotope of thorium has a half-life of 25.5 h, decaying by beta emission to form an isotope of protactinium.

(i) Determine the number of protons and neutrons in the protactinium nucleus formed.

number of protons = …….

number of neutrons = …….
[2]

(ii) Trace amounts of the thorium isotope can still be found in samples of uranium which are 1000 years old.

Suggest an explanation for this phenomenon.

……..……

……..……

……..…….. [2]

(e) Fig. 4.2 shows a graph of the variation with mass number of the binding energy per nucleon.

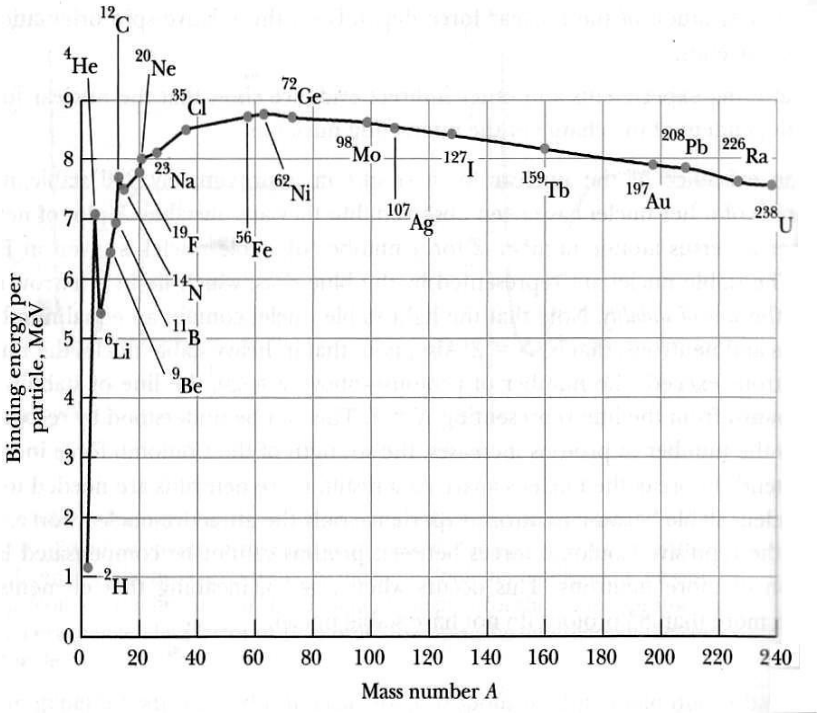

Fig. 4.2

With reference to Fig. 4.2, explain why fusion reactions of plutonium-239 and uranium-235 are not associated with a release of energy.

……..……..

……

…….. [2]