

- 9 The radioactive isotope americium-241 ($^{241}_{95}\text{Am}$) emits an α -particle as it decays to neptunium-237 ($^{237}_{93}\text{Np}$).

- (a) Data for the decay are given in Table 9.1.

Table 9.1

nucleus	mass of nucleus / 10^{-27} kg
americium-241	400.19774
neptunium-237	393.54304
helium-4	6.64466

- (i) Show that the energy released in the decay of an americium-241 nucleus is $9.0 \times 10^{-13}\text{ J}$.

[2]

- (ii) State the principle of conservation of linear momentum.

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[2]



- (iii) The kinetic energy of an α -particle emitted by the decay of a stationary americium-241 nucleus is 8.784×10^{-13} J.

Show that the kinetic energy of the neptunium-237 nucleus after the decay is 1.483×10^{-14} J.

[4]

- (iv) Suggest why the sum of the kinetic energies of the α -particle and the neptunium-237 nucleus after the decay is not equal to the energy released in the decay given in (a)(i).

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[1]





- (b) Americium-241 has a decay constant of $5.08 \times 10^{-11} \text{ s}^{-1}$.

A sample of pure americium-241 has an activity of 8.13 kBq at time $t = 0$.

- (i) Calculate the number of nuclei in the sample at $t = 0$.

$$\text{number of nuclei} = \dots \quad [2]$$

- (ii) Calculate the half-life of americium-241.

$$\text{half-life} = \dots \text{ s} \quad [1]$$

- (iii) On Fig. 9.1, draw a graph to show the variation of the number of americium-241 nuclei with t from $t = 0$ to $t = 6.0 \times 10^{10} \text{ s}$. Label this line **A**.

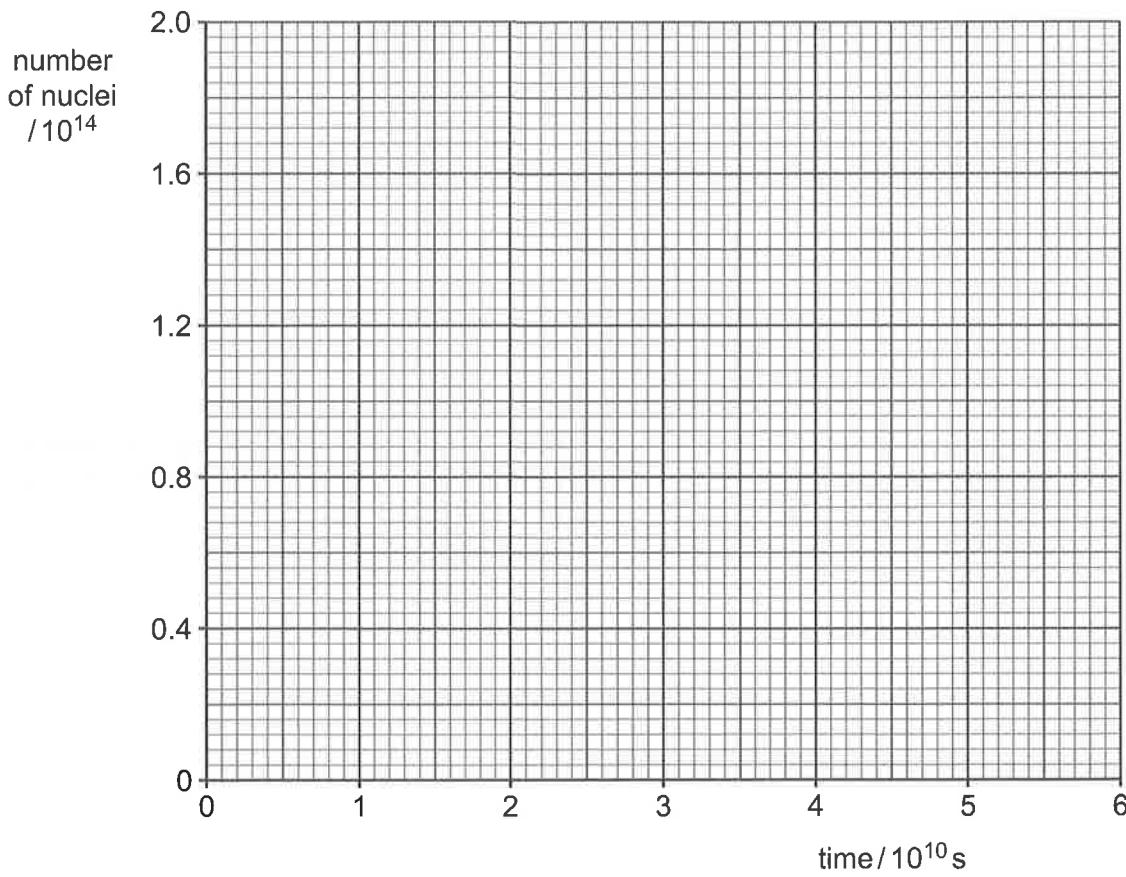


Fig. 9.1

[2]

- (iv) Draw a second line on Fig. 9.1 to show how the number of neptunium-237 nuclei present in the sample varies from $t = 0$ to $t = 6.0 \times 10^{10} \text{ s}$. Neptunium-237 does not decay significantly over this time. Label this line **N**.

[2]



- (c) A sample of a pure beta emitter has the same initial number of nuclei as the sample of americium-241 in (b). The pure beta emitter decays to a stable isotope. The probability of decay per unit time of a nucleus of the beta emitter is much greater than that of a nucleus of americium-241.

Describe and explain, without calculation, any difference in:

- (i) the initial activity of the sample of the beta emitter compared with the initial activity of the sample of americium-241

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[2]

- (ii) the time taken for the activity of the sample of the beta emitter to fall to 1 Bq compared with the time taken for the activity of the sample of americium-241 to fall to 1 Bq.

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[2]

[Total: 20]





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