

- 8 (a) An unstable nucleus of nucleon number (mass number) A undergoes α -decay, as illustrated in Fig. 8.1.

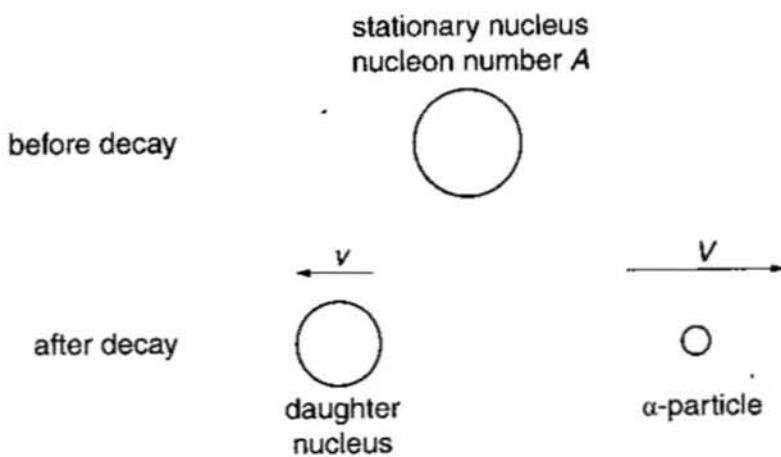


Fig. 8.1

The nucleus is stationary before the decay.

After the decay, the initial speed of the α -particle is V and that of the daughter nucleus is v .

- (i) State an equation, in terms of A , v and V , to represent conservation of linear momentum for this decay.

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[2]

- (ii) Show that the ratio

$$\frac{\text{initial kinetic energy of } \alpha\text{-particle}}{\text{initial kinetic energy of daughter nucleus}}$$

is equal to $(\frac{1}{4}A - 1)$.

[3]

- (b) Data for the α -decay of bismuth-212 ($^{212}_{83}\text{Bi}$) to form thallium-208 ($^{208}_{81}\text{Tl}$) are given in Fig. 8.2.

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nucleus	mass of nucleus / u
bismuth-212	211.9459
thallium-208	207.9374
helium-4	4.0015

Fig. 8.2

- (i) Use the data of Fig. 8.2 to calculate, to two places of decimals, the energy released during the decay.

$$\text{energy} = \dots \text{ MeV} [4]$$

- (ii) Use your answer in (i) to show that, based on the expression in (a)(ii), the energy of the α -particle is 6.42 MeV.

[2]

- (c) In practice, the α -particle is found to have an energy of 6.10 MeV, rather than 6.42 MeV, as calculated in (b)(ii).

Suggest

- (i) an explanation for the difference in energy,

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[1]

- (ii) why it is likely that the thallium nucleus and the α -particle do not move off in opposite directions.

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[3]

- (d) Some data for the half-lives and decay constants of bismuth-212 and thallium-208 are given in Fig. 8.3.

nucleus	half-life / s	decay constant / s^{-1}
bismuth-212	1.9×10^{-4}
thallium-208	190	3.7×10^{-3}

Fig. 8.3

- (i) Complete Fig. 8.3 by calculating the half-life of bismuth-212.

[1]

- (ii) Initially, a radioactive source contains N nuclei of bismuth-212.

After two hours, it is found that the number of bismuth-212 nuclei has reduced to approximately $\frac{1}{4}N$. However, although bismuth-212 decays to form thallium-208, the number of thallium nuclei is much less than $\frac{3}{4}N$.

Suggest an explanation for these observations.

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[4]