9 **(a)** An isotope of Americium, $^{241}_{95}\mathrm{Am}$, has a half-life of 432.2 years. It undergoes spontaneous nuclear decay and may be represented by the equation

$$^{241}_{95}\mathrm{Am} \rightarrow {}^{237}_{93}\mathrm{Np} + {}^{4}_{2}\mathrm{He}$$

where Neptunium $^{237}_{93}\mathrm{Np}$ is a daughter nuclide.

(i) Define *half-life.*

.....

..... [2]

(ii) Explain what is meant by *spontaneous decay.*

.....

..... [1]

(iii) Calculate the decay constant of $^{241}_{95}\mathrm{Am}$.

decay constant = ... s^{-1} [1]

(iv) Calculate the activity of 1.00 g of $^{241}_{95}\mathrm{Am}$.

activity = …… Bq [3]

(v) Calculate in MeV the total kinetic energy of the decay products, given the following data:

Nuclide	Atomic mass / u
$^{241}_{95}\mathrm{Am}$	241.0568229
$^{237}_{93}\mathrm{Np}$	237.0481673
$^{4}_{2}\mathrm{He}$	4.0026032

total kinetic energy = …… MeV [3]

(b) The variation with nucleon number A of the binding energy per nucleon B_E is shown in Fig. 9.1.

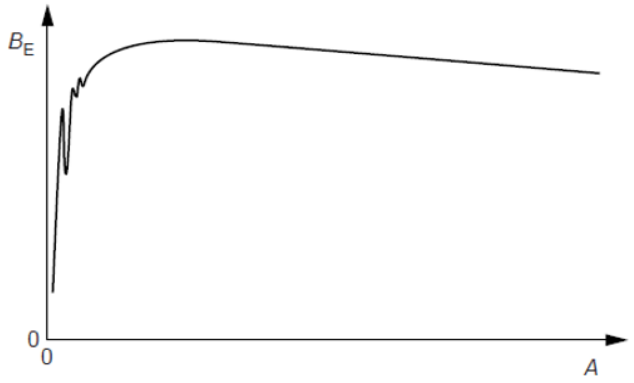

Fig. 9.1

Using Fig. 9.1, explain why fusion of nuclei having high nucleon numbers is not associated with a release of energy.

……..……..
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……..……...

……..……...

……..…….. [3]

(c) One possible nuclear reaction involves the bombardment of a stationary nitrogen-14 nucleus by an α-particle to form oxygen-17 and another particle.

(i) Complete the nuclear equation for this reaction.

$$^{14}_{7}\mathrm{N} + \overset{\cdots\cdots}{\underset{\cdots\cdots}{\alpha}} \rightarrow {}^{17}_{8}\mathrm{O} + \cdots\cdots\cdots\cdots$$

[2]

(ii) The total mass-energy of the nitrogen-14 nucleus and the α-particle is less than that of the particles resulting from the reaction. This mass-energy difference is 1.1 MeV.

1. Suggest how it is possible for mass-energy to be conserved in this reaction.

……..……...

…….. [1]

2. Calculate the speed of an α-particle having kinetic energy of 1.1 MeV.

speed = …… m s^{-1} [4]

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