OCR
Oxford Cambridge and RSA

A level Physics B

H557/01 Fundamentals of physics

Question Set 33

1 (a) This question is about the fusion of the nuclei of the hydrogen isotopes ^{2}H and ^{3}H to produce helium ^{4}He.

Fig. 1.1 shows the average binding energy per nucleon against the nucleon number.

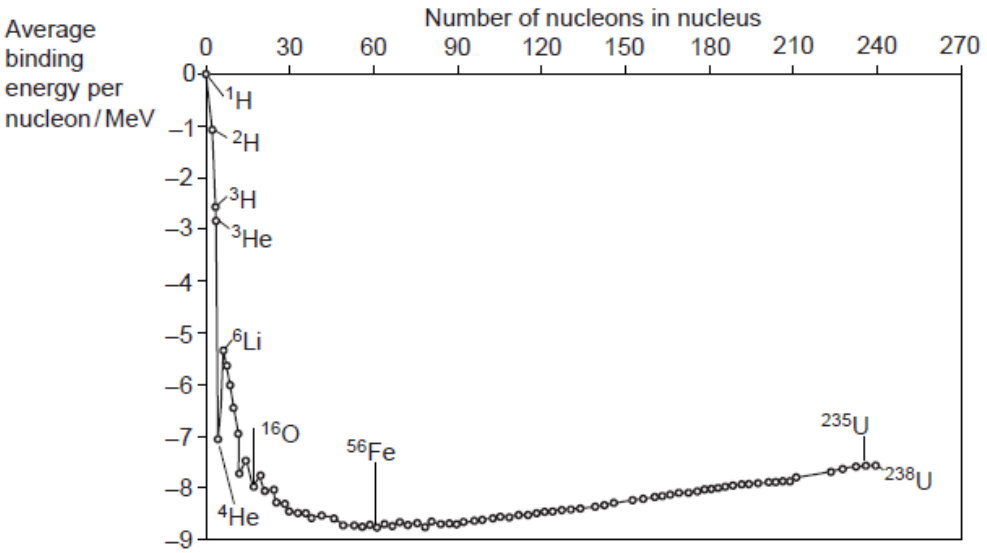

Fig. 1.1

(i) Complete the equation for this fusion reaction:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow \underset{\ldots\ldots}{^{4}He} + \underset{\ldots\ldots}{^{\ldots\ldots}n} + \text{released binding energy.}$$

[1]

(ii) Use data from **Fig. 1.1** to show that the binding energy released in this reaction is more than 15 MeV.

You should calculate the binding energy of the reactants (hydrogen nuclei) and products.

1. reactants binding energy = ...

2. products binding energy = ...

[2]

(iii) Use ideas about momentum to explain why the neutron carries away about $\frac{4}{5}$ of this energy.

[2]

(b) **(i)** To estimate the temperature at which ^2H and ^3H nuclei will fuse, a student writes down the formula:

$$\frac{e^2}{4\pi\varepsilon_0 R} \approx kT$$

Explain what the two sides of the approximation tell us:

1 $\frac{e^2}{4\pi\varepsilon_0 R}$

2 kT

[2]

(ii) Use the equation in **(b)(i)** to estimate this temperature when $R \approx 2 \times 10^{-14}$ m.

temperature =……K

[1]

(c)

An experimental fusion reactor uses many powerful lasers focused onto a small spherical bead of solid ^2H and ^3H. The volume of the bead is 4.2 mm^3. The aim is to produce a plasma implosion where fusion will begin when the temperature and density are high enough.

(i) The density of the bead of solid ^2H and ^3H (1:1 ratio by atoms) is 230 kg m^{-3}.

Estimate the energy needed to produce plasma at 400 MK from this bead of material.

energy =……J **[3]**

(ii) Compare this to the possible fusion energy released by the bead.

Use your answer to **(a)(ii)**. You can assume 100% conversion to ^4He.

[2]

(iii) Suggest **one** practical difficulty in obtaining energy by this method.

[1]

Total Marks for Question Set: 14