

## **A level Physics B**

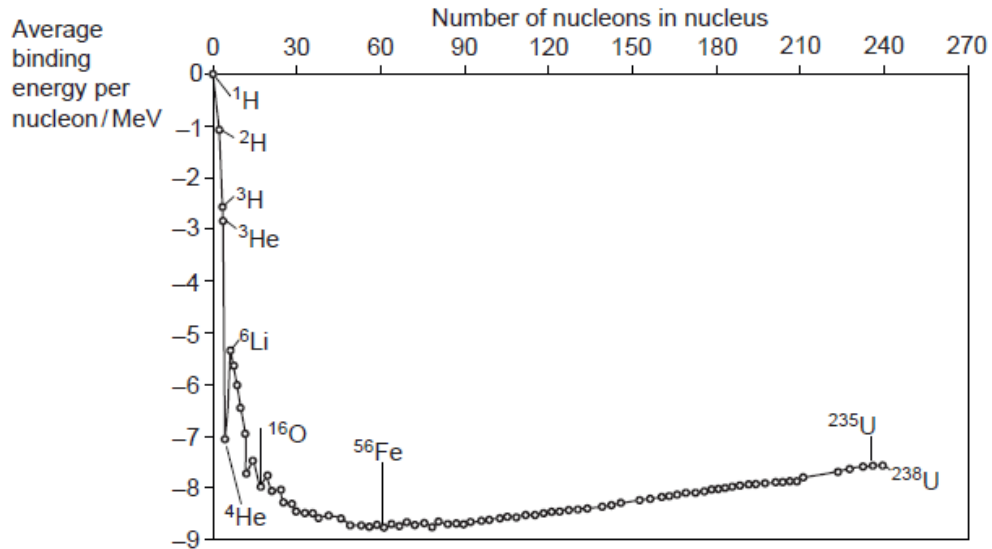
**H557/01** Fundamentals of physics

### **Question Set 33**

1 (a)

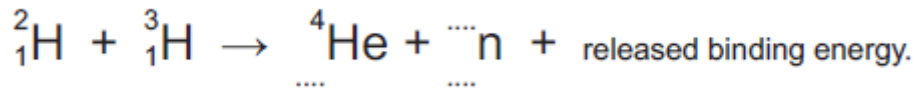
This question is about the fusion of the nuclei of the hydrogen isotopes  $^2\text{H}$  and  $^3\text{H}$  to produce helium  $^4\text{He}$ .

**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:



[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  $^2\text{H}$  and  $^3\text{H}$  nuclei will fuse, a student writes down the formula:

$$\frac{e^2}{4\pi\epsilon_0 R} \approx kT$$

Explain what the two sides of the approximation tell us:

$$1 \quad \frac{e^2}{4\pi\epsilon_0 R}$$

$$2 \quad kT$$

[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  $^2\text{H}$  and  $^3\text{H}$ . The volume of the bead is  $4.2 \text{ mm}^3$ . 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  $^2\text{H}$  and  $^3\text{H}$  (1:1 ratio by atoms) is  $230 \text{ kg m}^{-3}$ .

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  $^4\text{He}$ .

[2]

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

[1]

**Total Marks for Question Set: 14**

---

# OCR

Oxford Cambridge and RSA

## **Copyright Information**

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website ([www.ocr.org.uk](http://www.ocr.org.uk)) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge