8 **(a)** The data for iron-56 ($^{56}_{26}Fe$) nucleus is given below.

Mass of proton = 1.00728 u

Mass of neutron = 1.00866 u

Mass of iron-56 nucleus = 55.92132 u

Show that the binding energy per nucleon of iron-56 nucleus is 8.8 MeV. Explain your answer clearly.

[3]

(b) Fig. 8.1 shows the variation with nucleon number (mass number) A of the binding energy per nucleon E_B of nuclei.

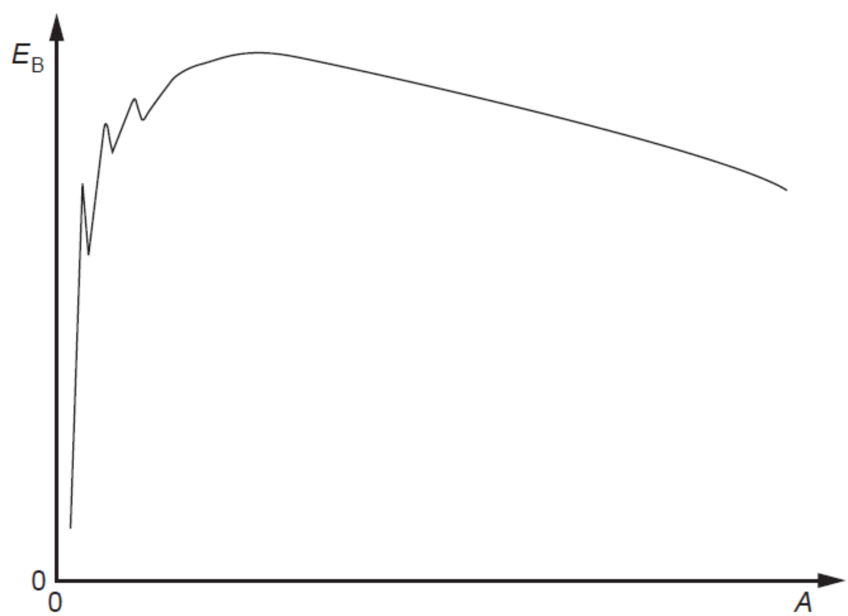

Fig 8.1

(i) On Fig 8.1, label the approximate position of iron-56 with the symbol Fe.

[1]

(ii) The nuclear fusion process in a particular star is described by

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + \mathrm{X}.$$

1. State the particle X.

………………………………………………………………………………………… [1]

2. Using Fig. 8.1, explain why the mentioned nuclear fusion process will result in a release of energy.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iii) Table 8.1 shows the mass defects of three nuclei.

Table 8.1

nucleus	mass defect / u
$^{2}_{1}\mathrm{H}$	0.002 388
$^{3}_{1}\mathrm{H}$	0.009 105
$^{4}_{2}\mathrm{He}$	0.030 377

Determine the energy released when one nucleus of $^{4}_{2}\mathrm{He}$ is formed in this fusion reaction.

energy released = …………………….. J [2]

(c) Thorium-234 ($^{234}_{90}\text{Th}$) undergoes β-decay to form an isotope of protactinium-234 (Pa).

The emitted β-particles have a range of energies up to a maximum value.

Use conservation laws to explain why this range of energies leads to the suggestion that another particle is emitted by the decaying thorium-234 nucleus together with the β-particle.

………

………

………

………

………

…………………………………………………………………………………………………… [3]

(d) The variation with time t of the number of unstable nuclei N in a sample of Thorium is shown in Fig. 8.2.

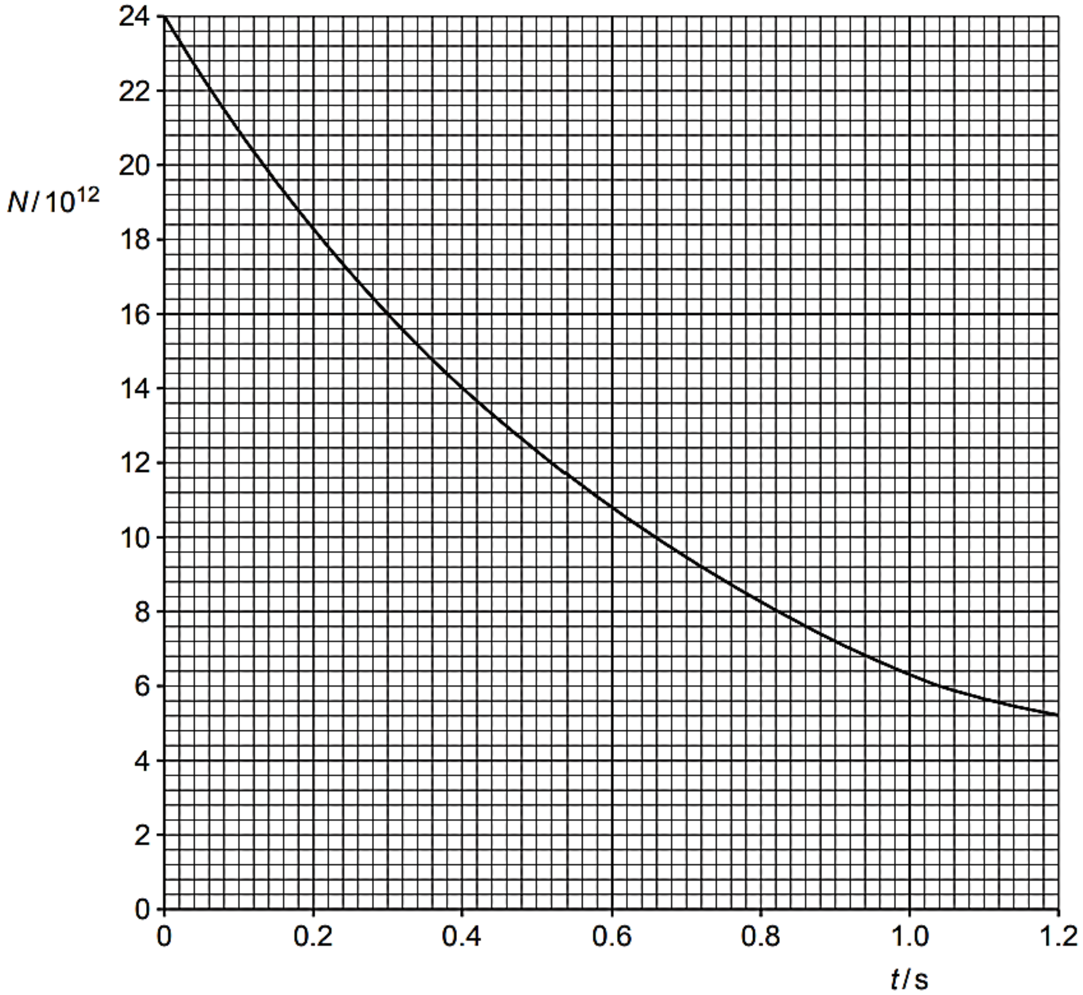

Fig. 8.2

At time t = 0 s, the sample contains only Thorium-234.

(i) Use Fig. 8.2 to determine the decay constant λ of Thorium-234.

λ = ………………….…….. s^{-1} [2]

(ii) Assuming that protactinium-234 is stable, on Fig. 8.2, sketch a line to show the variation with time t of the number of protactinium nuclei in the sample. Label this line P.

[2]

(iii) Determine the activity at time t = 1.5 s of the sample of Thorium-234.

activity = ……………………….. Bq [3]

(iv) A Geiger counter is used to measure the count rate at t = 1.5 s, explain why the value recorded is lower than the answer found in **(d)(iii)**.

……………………………………………………………………………………………………..

……………………………………………………………...……………………………… [1]

[Total: 20]