5 **(a)** A student suggests that one possible nuclear reaction is

$$^{56}_{26}\text{Fe} + ^{1}_{0}\text{n} \rightarrow ^{20}_{9}\text{F} + ^{37}_{17}\text{Cl}.$$

Explain why the reaction would not result in an overall release of energy.

……

……

…… [2]

(b) The graph in Fig. 6.1 shows the kinetic energy spectrum for β^- particles emitted in the decay of platinum $^{199}_{78}$ Pt to gold $^{199}_{79}$ Au.

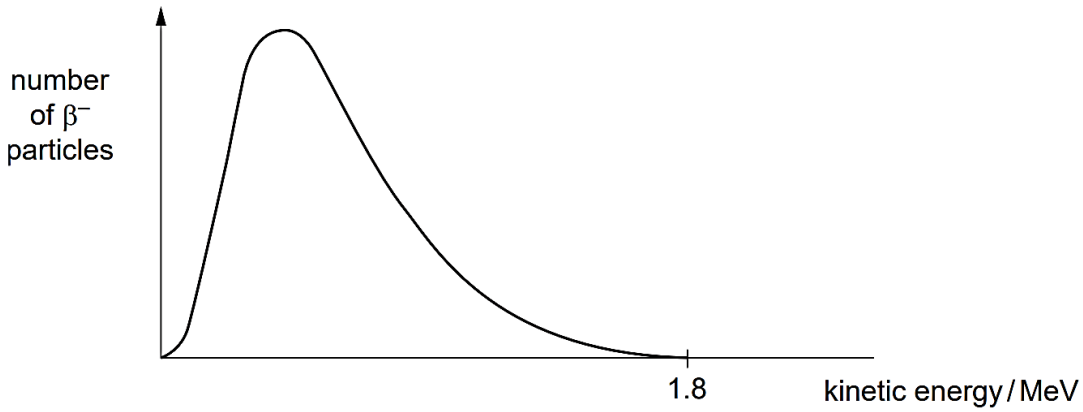

Fig. 6.1

Explain how a consideration of this kinetic energy spectrum provided evidence for the prediction of the existence of the neutrino.

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……

……

…… [3]

(c) Data for the α-decay of bismuth-212 ($^{212}_{83}Bi$) to form thallium-208 ($^{208}_{81}Tl$) are given in Fig. 6.2.

nucleus	mass of nucleus / u
Bismuth-212	211.9459
Thallium-208	207.9374
Helium-4	4.0015

Fig. 6.2

(i) Calculate the energy released during the decay.

energy released = …….. J [2]

(ii) For a stationary unstable nucleus of nucleon number *A* that undergoes α-decay, it can be shown that the ratio of the kinetic energy of α-particle to the daughter nucleus after decay is given by

$$\frac{\text{kinetic energy of } \alpha\text{-particle}}{\text{kinetic energy of daughter nucleus}} = 0.25A - 1$$

Using your answer in **(c)(i)** and the above equation, show that the energy of the α-particle is 6.4 MeV.

[3]

(iii) In practice, the α-particle is found to have an energy of 6.1 MeV, rather than 6.4 MeV as calculated in (c)(ii).

Suggest why in this case, it is likely that the thallium nucleus and the α-particle do not move off in opposite direction.

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……

……

…… [2]

(iv) **1.** 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 $0.25N$. However, although bismuth-212 decays to form thallium-208, the number of thallium nuclei is much less than $0.75N$.

Suggest an explanation for these observations.

……

…… [1]

2. The half-life of bismuth-209 is 1.9×10^{19} years.
Estimate the number of nuclei in a 10 kg sample of bismuth-209 that are likely to disintegrate in the next 100 years.

number of nuclei = …….. [3]