10 **(a)** Fig. 10.1 shows the variation with nucleon number of the binding energy per nucleon of a nucleus.

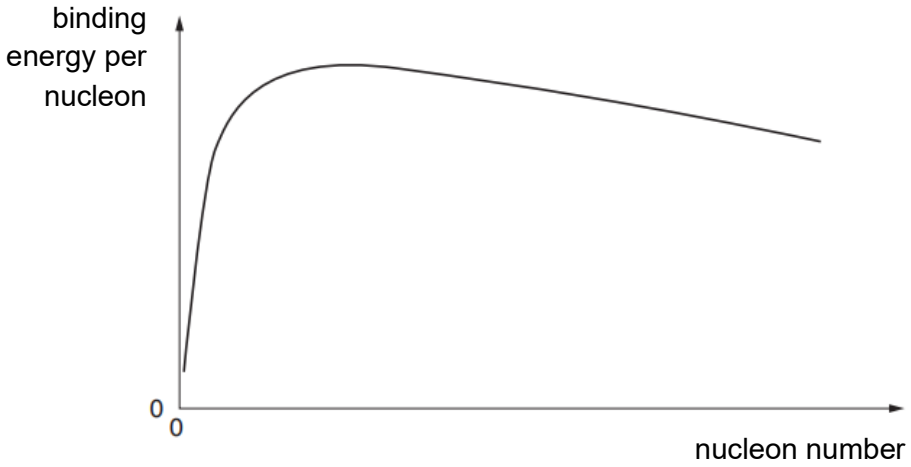

Fig. 10.1

(i) On Fig. 10.1, mark with the letter S the position of the nucleus with the greatest stability. [1]

(ii) One possible fission reaction is

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{144}_{56}\mathrm{Ba} + {}^{90}_{36}\mathrm{Kr} + 2\,{}^{1}_{0}\mathrm{n}$$

On Fig. 10.1, mark possible positions for

1. the Uranium-235 nucleus (label this position U),

2. the Krypton-90 nucleus (label this position Kr). [1]

(iii) The binding energy per nucleon of each nucleus is as follows.

$^{235}_{92}\mathrm{U}$: 1.2191×10^{-12} J
$^{144}_{56}\mathrm{Ba}$: 1.3341×10^{-12} J
$^{90}_{36}\mathrm{Kr}$: 1.3864×10^{-12} J

Determine the energy released in the fission reaction, give your answer to 5 significant figures.

energy = …… J [2]

(iv) Hence, determine the mass equivalent of the energy

mass = ……. kg [2]

(v) Explain why a release of energy occurs during such a fission reaction.

…….

…….. [1]

(vi) Suggest why the neutrons were not included in your calculation in **(a)(iii).**

…….

…….. [1]

(b) Carbon-14 is a radioactive isotope of carbon. Its presence in organic materials is the basis of radiocarbon dating.

(i) State what an isotope is.

…….

…….. [1]

(ii) Carbon-14 is unstable and goes through the following process.

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{Y}_{X}D + \bar{\nu}$$

Determine X, Y and hence state the identity of particle D.

Y = ……

X = ……

D = …… [2]

(iii) A student has a sample of Carbon-14. The student defined the half-life of Carbon-14 as the time taken for the number of nuclei inside the box to decay to one half of its initial value.

State and explain one reason why this definition is inappropriate.

…….

…….

…….. [2]

(c) Measurements are made of the activity of a specimen of carbon from pieces of wood found in a fireplace at an archaeological site. The specimen is found to contain one Carbon-14 atom per 8.6×10^{10} Carbon-12 atoms. Another sample was obtained from carbon from a modern fire, the concentration of Carbon-14 atoms is greater at one Carbon-14 atom per 3.3×10^{10} Carbon-12 atoms.

(i) Explain why the concentration of the two samples of carbon is different.

…….

…….. [1]

(ii) Given that the half-life of Carbon-14 is 5700 years, calculate the age of the wood from the ancient fire.

age = ……. years [4]

(iii) Suggest two constraints of this method of determining the age of a sample.

…….

…….

…….. [2]

End of Paper