7 **(a)** V and X are different isotopes of helium.

State one similarity and one difference between a nucleus of V and a nucleus of X.

.....

.....

..... [2]

(b) **(i)** The nuclear binding energy **per nucleon** varies with nucleon number.

On Fig. 7.1, draw a graph showing this variation for nuclei with nucleon number from 1 to 250. *Label the axes with appropriate values.*

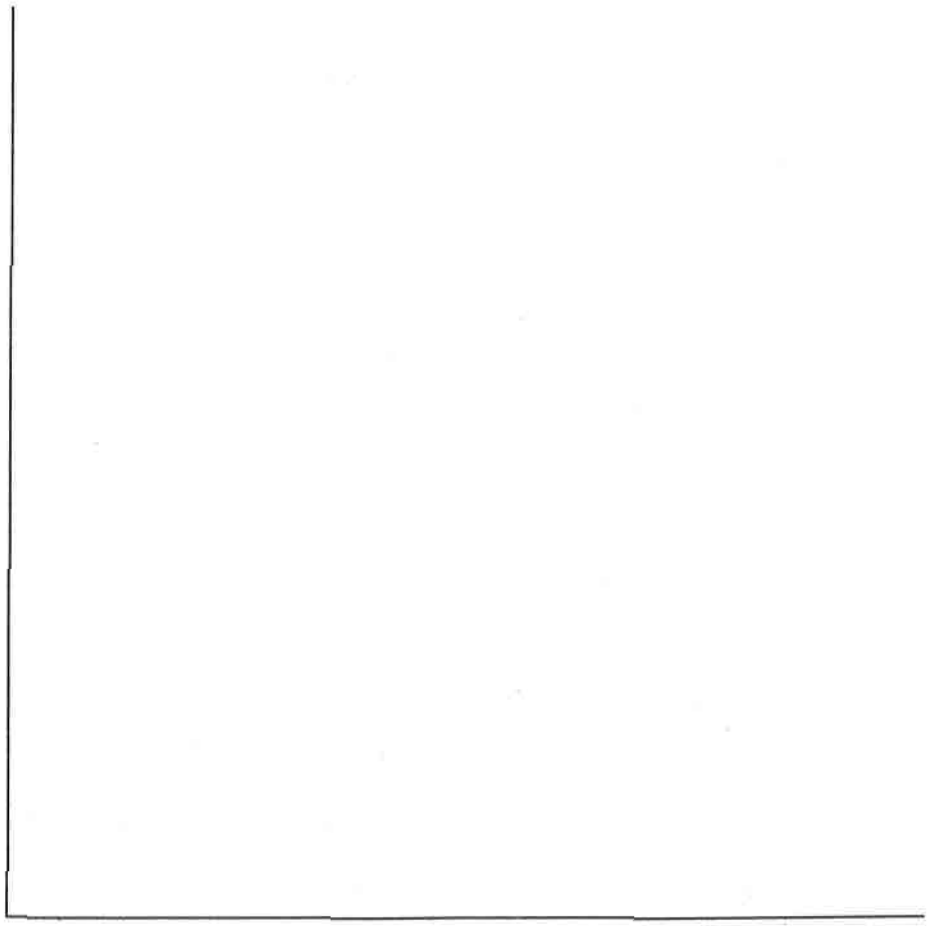

Fig. 7.1

[3]

(ii) Explain the significance of the nuclear binding energy per nucleon for nuclear fusion.

.....

.....

.....

..... [2]

(c) A $^{4}_{2}He$ nucleus is formed in this nuclear reaction:

$$^{2}_{1}H + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + Y$$

(i) State **three** quantities that are conserved in all nuclear reactions.

1. .....

2. .....

3. ..... [3]

(ii) Identify particle Y.

..... [1]

(iii) Explain, in terms of mass, why this nuclear reaction occurs.

.....

..... [1]

(iv) Calculate the amount of energy released in the nuclear reaction.

mass of $^{2}_{1}H$ is 2.0141 u

mass of $^{3}_{2}He$ is 3.0160 u

mass of $^{4}_{2}He$ is 4.0026 u

mass of Y is 1.0078 u

energy = ... J [4]

(v) Calculate the number of $^{3}_{2}\text{He}$ nuclei which must each fuse with a $^{2}_{1}\text{H}$ nucleus per second in order to emit energy at a rate of 20.0 W.

number = ... s^{-1} [2]

(vi) In a house, there are fifteen lamps which consume electrical energy at a rate of 20.0 W each. The lamps are only switched on in the evenings.

Estimate the mass of $^{3}_{2}\text{He}$ that is required in order for this reaction to release the same amount of energy as the lamps in the house consume in one year.

State any assumption made.

mass = ... kg [2]

[Total: 20]