4 **(a)** Explain what is meant by *nuclear fusion*.

.....

..... [2]

(b) In the Sun, the reactions occurring can be summarised as

$$4\,{}^{1}_{1}\mathrm{H} \longrightarrow {}^{4}_{2}\mathrm{He} + \text{energy}$$

The mass of ${}^{1}_{1}\mathrm{H}$ nucleus is 1.007293 u and the mass of ${}^{4}_{2}\mathrm{He}$ nucleus is 4.001572 u.

(i) Calculate the energy released in the production of one ${}^{4}_{2}\mathrm{He}$ nucleus.

energy released = ... J [3]

(ii) The average power emitted by the Sun is 3.85×10^{26} W.

Calculate the average rate of loss of mass of the Sun.

average rate of loss of mass = ... $\mathrm{kg\,s^{-1}}$ [2]

(c) The current mass of the Sun is 1.99×10^{30} kg. Assume a constant rate of loss of mass of the Sun.

(i) Calculate how long it will take for all the mass to be lost.

time = ... years [1]

(ii) Assess the validity of the time calculated in **(c)(i)**.

.....

.....

..... [2]

(d) **(i)** For a planet in a circular orbit about the Sun, relate Newton's law of gravitation to the centripetal acceleration that it causes and use this to show that:

$$T^2 = kr^3$$

where T is the time taken for one orbit (period), r is the radius of the orbit and k is a constant.

[3]

(ii) The Earth orbits around the Sun with a radius of 1.50×10^{11} m and Jupiter orbits the Sun at a radius of 7.79×10^{11} m.

Compare, quantitatively, the speeds and orbital periods of Earth and Jupiter.

.....

..... [4]

[Total: 17]