7 Hydrogen is the most abundant material in the universe and the most basic nuclear fusion reaction is the fusion of two hydrogen nuclei (^1_1H).

(a) State what is meant by *nuclear fusion*.

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..... [1]

(b) Given that the radius of a hydrogen nucleus is 1.2×10^{-15} m, show that the minimum kinetic energy of each hydrogen nucleus needed to trigger a ^1_1H - ^1_1H fusion reaction is 0.30 MeV. Assume fusion occurs when the two nuclei touch each other.

[2]

(c) ^1_1H - ^1_1H fusion occurs naturally in the Sun and in most other stars because there is sufficient thermal energy to trigger the reaction.

By assuming that hydrogen behaves as an ideal gas, estimate the temperature of such an environment.

temperature = ... K [2]

(d) There are two possible outcomes of such a fusion reaction. In reaction (1), a helium isotope $^{2}_{2}He$ is formed. In reaction (2) a deuteron $^{2}_{1}H$ and an unknown elementary particle X is formed.

reaction (1): $^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{2}He$

reaction (2): $^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}H + X$

(i) State the nuclear notation for X.

$\square^{\square}X$

[1]

(ii) Deuteron $^{2}_{1}H$ is readily found on Earth, but not the helium isotope $^{2}_{2}He$.
Suggest a possible reason for this observation and hence deduce which reaction releases more energy.

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..... [1]

(e) Data for the nuclei in reaction (2) are given in Fig. 7.1.

nucleus	mass / u
$^{1}_{1}H$	1.007825
$^{2}_{1}H$	2.014102
X	0.000549

Fig. 7.1

Calculate the energy released in reaction (2).

energy = ... J [2]

(f) Suggest one significant advantage in generating electrical power by a fission reaction compared to a fusion reaction.

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..... [1]

[Total: 10]