2019 Ph H2 Q8

Section: Particles and Waves

Topic: Nuclear Fusion in the Sun

The Sun emits 4.1×10^{26} J s^{-1} by nuclear fusion. One reaction is: $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + {}^{1}_{0}n$. (a) Name this type of reaction. (b) Using the given particle masses, calculate the energy released in one reaction. (c) Calculate how many such reactions occur each second to account for the Sun's power output.

Worked solution

(a) This is a nuclear fusion reaction — light nuclei join together to form a heavier nucleus, with release of energy due to mass defect.

(b) Mass difference = (2m_H) − (m_He + m_n).
= 2(3.3436e-27) − (5.0082e-27 + 1.6749e-27) kg.
= 4.100e-30 kg.

Energy released: $E = \Delta m\, c^2$.
= $4.100\text{e-}30 \times (3.0\times10^{8})^2 = 3.69\text{e-}13$ J.

Answer: 3.3×10^{-13} J

(c) Sun's power = 4.1×10^{26} J s^{-1}.
Number of reactions per second = P/E = 4.1×10^{26} / 3.69e-13.
= 1.11e+39.

Answer: 1.2×10^{39} reactions per second

Final answers

(a) Fusion

(b) Energy released ≈ 3.3×10^{-13} J

(c) Reactions per second ≈ 1.2×10^{39}

Revision tips

- Fusion is combining light nuclei, releasing energy.
- Mass defect Δm gives energy $E = \Delta m\, c^2$.
- In the Sun, vast numbers of fusion reactions occur each second.
- Compare power output with energy per reaction to find reaction rate.