2017 H2 Q9

Section: Particles and Waves

Topic: Nuclear fusion, mass defect and E = mc^2

(a) Definition of nuclear fusion

Nuclear fusion is when two light nuclei combine to form a heavier nucleus, releasing energy.

(b) Fusion of helium-3 with deuterium

Reaction: 3He + 2H -> 4He + 1H + energy.

(i) Why energy is released

The total mass of the products is less than the total mass of the reactants. The mass difference appears as released energy by E = dm c^2. Equivalently, the final nucleus has a higher binding energy per nucleon.

(ii) Energy released

Masses (kg): 3He = 5.008×10^-27, 2H = 3.344×10^-27, 4He = 6.646×10^-27, 1H = 1.673×10^-27.

Initial mass = 5.008×10^-27 + 3.344×10^-27 = 8.352e-27 kg.

Final mass = 6.646×10^-27 + 1.673×10^-27 = 8.319e-27 kg.

Mass defect dm = 3.300e-29 kg.

E = dm c^2 = 3.300e-29 × (3.00×10^8)^2 = 2.970e-12 J.

Answer: Energy released ≈ 3.0×10^-12 J.

Revision tips

- Fusion releases energy when the products have higher binding energy per nucleon (mass defect).
- Use consistent units (kg, m, s) when applying E = dm c^2 to get Joules.
- Mass tables can be used directly for dm; atomic binding energies are already included in tabulated atomic masses.