

Nuclear fusion



1. Consider the reaction represented by the equation:



- a) Use the relative atomic mass data below to find the energy released when a tritium nucleus fuses with a deuterium nucleus.

$${}^3\text{H} = 3.016049 \text{ u}$$

$${}^2\text{H} = 2.014102 \text{ u}$$

$${}^4\text{He} = 4.002604 \text{ u}$$

$$n = 1.008665 \text{ u}$$

- b) How much energy would become available from the fusion of about 2 grams of deuterium with 3 grams of tritium?

2. A thermonuclear reaction is one which is caused by the energetic collisions of nuclei in a gas at very high temperatures. What temperatures would give the particles a mean translational energy of about 0.2 fJ, and thus enable the reaction to proceed?
3. In the Sun, fusion may take place between deuterium and tritium nuclei (see the equation in Q1). The total final mass of the particles is 5.0113 u. The energy released is $2.8 \times 10^{-12} \text{ J}$.
- a) Find the mass equivalent, in kg, of the energy released.
 b) Find the mass equivalent, in u, of the energy released.
 c) Use the answer to b) to estimate the total mass of the nuclei, in u, before fusion.
4. Two almost stationary deuterium nuclei (${}^2\text{H}$) can fuse to form a tritium nucleus (${}^3\text{H}$) and a proton. This releases energy of $6.4 \times 10^{-12} \text{ J}$.
- a) In what form is the energy released?
 b) Write an equation for this reaction.
 c) Calculate the ratio of the speed of the proton to that of the tritium nucleus.
 d) Calculate the ratio of the kinetic energy of the proton to that of the tritium nucleus.
5. The solar constant (the mean intensity of solar radiation arriving at the Earth) is 1.4 kW m^{-2} . If the mean distance of the Earth from the Sun is $1.5 \times 10^{11} \text{ m}$, what is
- a) the power of the Sun
 b) the rate of loss of mass of the Sun?
6. Calculate the energy in MeV released in the fusion reaction:



Use data from Q1 (${}^3\text{H} = 1.007825 \text{ u}$; $1\text{u} = 1.66 \times 10^{-27} \text{ kg}$)

Answers: Q1. a) 2.8 pJ b) 1.7 TJ Q2. 10^7 K Q3. a) $3.1 \times 10^{-29} \text{ kg}$ b) 0.0187 u c) 5.0300 u Q4. c) 3:1 d) 3:1 Q5. a) $4.0 \times 10^{26} \text{ W}$ b) $4.4 \times 10^9 \text{ kg s}^{-1}$ Q6. 4.03 MeV

Q sources: Q1 [=63-45] & Q2 [=63-46] from pp 193 & 194, *Questions and problems in pre-university physics* (Whelan & Hodgson); Q3 [=3] & Q4 [=9], p 186, *Advanced level study guides: physics* (Arnold & Bloor); Q5 [=14.51], p157 *Practice in physics* (Akrill et al); Q6 [=Q3, Ex.29.1] p237, *Calculations in A-level physics* (Rounce & Lowe).

Fission Fusion Answer Key

RJ Alexander

A red circular graphic with a gradient, appearing as a stylized arrow or a partial circle, located to the right of the author's name.

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1. Understanding the eBook Fission Fusion Answer Key
 - The Rise of Digital Reading Fission Fusion Answer Key
 - Advantages of eBooks Over Traditional Books
2. Identifying Fission Fusion Answer Key
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Fission Fusion Answer Key
 - User-Friendly Interface
4. Exploring eBook Recommendations from Fission Fusion Answer Key

- Personalized Recommendations
- Fission Fusion Answer Key User Reviews and Ratings
- Fission Fusion Answer Key and Bestseller Lists
- 5. Accessing Fission Fusion Answer Key Free and Paid eBooks
 - Fission Fusion Answer Key Public Domain eBooks
 - Fission Fusion Answer Key eBook Subscription Services
 - Fission Fusion Answer Key Budget-Friendly Options
- 6. Navigating Fission Fusion Answer Key eBook Formats
 - ePub, PDF, MOBI, and More
 - Fission Fusion Answer Key Compatibility with Devices
 - Fission Fusion Answer Key Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Fission Fusion Answer Key
 - Highlighting and Note-Taking Fission Fusion Answer Key
 - Interactive Elements Fission Fusion Answer Key
- 8. Staying Engaged with Fission Fusion Answer Key
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Fission Fusion Answer Key
- 9. Balancing eBooks and Physical Books Fission Fusion Answer Key
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Fission Fusion Answer Key
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Fission Fusion Answer Key
 - Setting Reading Goals Fission Fusion Answer Key
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Fission Fusion Answer Key

- Fact-Checking eBook Content of Fission Fusion Answer Key
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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