

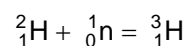
TAP 528- 4: Fusion questions

Nuclear fusion is the process in which nuclei combine to give heavier elements. In one fusion reaction, two atoms of deuterium (hydrogen-2) fuse together to give one atom of a helium isotope (helium-3) together with one other particle.

1. Write out a balanced equation for this fusion process and say what the fourth particle is?
2. Calculate the energy release in this equation. Values you need are in the table.

Particle	Mass (u)
${}^1_0\text{n}$	1.008 665
${}^2_1\text{H}$	2.014 102
${}^3_1\text{H}$	3.016 050
${}^3_2\text{He}$	3.016 030

Another possible fusion process is represented by:



(the formation of hydrogen-3, tritium, by a nucleus of deuterium absorbing a neutron). This equation is certainly balanced. But can it occur in practice?

3. Calculate the change in mass in this reaction.
4. Is the reaction possible or not?

Practical advice

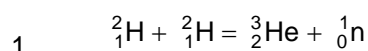
These questions revise basic conversions between electron volts and joules and atomic mass units and kilograms. Students will need to be familiar with gigawatts (GW) and terawatts (TW) in powers of 10. The questions could be extended either verbally or in writing to ask students about the volume of deuterium inside the core and about the equivalent volumes of coal or oil that might be required in a conventional power station. For example, 1 megatonne of coal is equivalent to

29×10^{15} J, 1 megatonne of oil is equivalent to 42×10^{15} J.

Social and human context

The questions provide an opportunity for debate about fusion power generation.

Answers and worked solutions



2. mass of two hydrogen-2 = $2 \times 2.014102 \text{ u} = 4.028204 \text{ u}$

mass of helium-3 plus neutron = $3.016030 \text{ u} + 1.008665 \text{ u} = 4.024695 \text{ u}$

$\Delta m = 4.028204 \text{ u} - 4.024695 \text{ u} = 0.003509 \text{ u}$

$\Delta E = 0.003509 \text{ u} \times 931.3 \text{ MeV u}^{-1} = 3.27 \text{ MeV}$

3. mass of hydrogen-2 plus neutron = $2.014102 \text{ u} + 1.008665 \text{ u} = 3.022767$

$\Delta m = 3.022767 - 3.016050 \text{ u} = 0.006717 \text{ u}$.

4. The reaction can occur with a release $\Delta E = 0.006717 \text{ u} \times 931.3 \text{ MeV u}^{-1} = 6.26 \text{ MeV}$

External reference

This activity is taken from Advancing Physics chapter 18, 250S