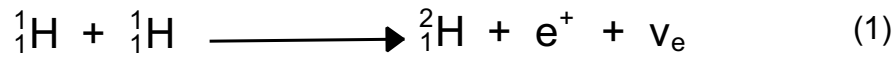


Nuclear reactions

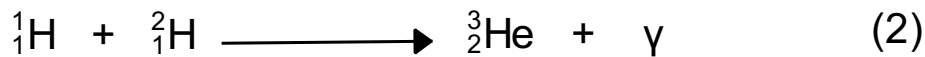
Verify that the fusion of four protons release 25 MeV for the **proton-proton fusion cycle**.

Solution:

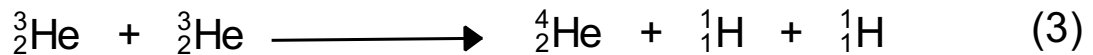
The fusion of two hydrogen atoms produces one deuterium atom



The fusion of deuterium with hydrogen produces the helium atom

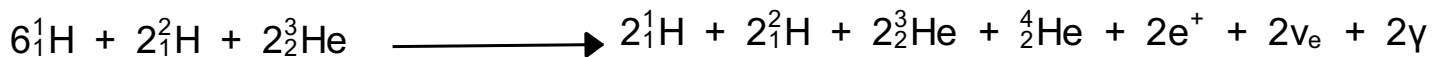
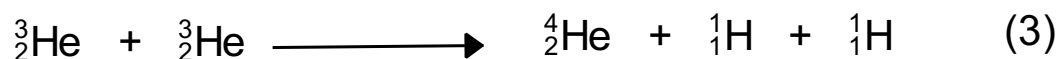
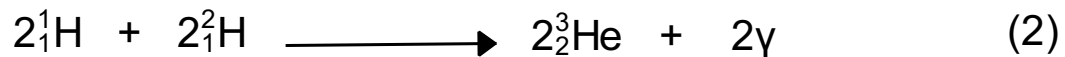
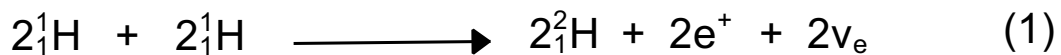


The fusion of helium with helium gives



The chain of events (1), (2) and (3) is known as the proton-proton cycle, which is one of the schemes offered to describe the conversion of hydrogen atoms into helium atoms in stars.

If we multiply equations (1) and (2) by two and sum that with equation (3), we get



Before the reaction the total nuclear mass is:

$$\begin{aligned} 4 \times (\text{Atomic mass of hydrogen}) &= 4 \times 1.0073 \text{ amu} \\ &= 4.0292 \text{ amu} \end{aligned}$$

After reaction the total mass is

$$\begin{aligned} \text{Atomic mass of } ^4\text{He} + 2 \times (\text{mass of positron}) \\ = (4.0015 + 2 \times 0.0011) \text{ amu} = 4.0026 \text{ amu} \end{aligned}$$

The energy released in the fusion reaction is equivalent to the difference in mass:

$$\begin{aligned} 4.0292 - 4.0026 &= 0.0266 \\ &= (931 \text{ MeV/amu}) (0.0266 \text{ amu}) = 25 \text{ MeV} \end{aligned}$$