

896.

Problem 55.54 (RHK)

Ordinary water consists of 0.015% by mass of “heavy water,” in which one of the two hydrogen atoms is replaced with deuterium, ${}^2\text{H}$. We have to estimate the average fusion power that could be obtained if we “burned” all the ${}^2\text{H}$ in 1 litre of water in 1 day through the reaction ${}^2\text{H} + {}^2\text{H} \rightarrow {}^3\text{He} + \text{n} + 3.27 \text{ MeV}$.

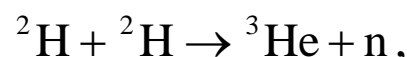
Solution:

Ordinary water consists of 0.015% by mass of “heavy water,” in which one of the two hydrogen atoms is replaced with deuterium, ${}^2\text{H}$. Therefore, mass of “heavy water” in 1 litre of water will be
 $= 1000 \times 0.00015 \text{ g} = 0.15 \text{ g}$.

Number of molecules of “heavy water” in 0.15 g, which will also be the number of ${}^2\text{H}$, will be

$$N_{{}^2\text{H}} = \frac{6.02 \times 10^{23} \times 0.15}{19} = 4.75 \times 10^{21}.$$

In fusion of two ${}^2\text{H}$ nuclei through the process



3.27 MeV energy is released. Therefore, the total energy that can be released by burning off all ^2H nuclei contained in 1 litre of water will be

$$E = \frac{3.27 \times 4.75 \times 10^{21}}{2} \text{ MeV}$$
$$= 7.77 \times 10^{21} \times 1.6 \times 10^{-13} \text{ J} = 12.42 \times 10^8 \text{ J}.$$

If the burning of ^2H nuclei contained in 1 litre of water occurs in 1 day ($8.60 \times 10^4 \text{ s}$), the average fusion power that will be available will be

$$P = \frac{12.42 \times 10^8 \text{ J}}{8.60 \times 10^4 \text{ s}} = 1.44 \times 10^4 \text{ W}.$$

