Problem-20

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How long can an electric lamp of 100W be kept glowing by fusion of 2.0 kg of deuterium? Take the fusion reaction as :

$$_1H^2 + _1H^2 \longrightarrow _2He^3 + _0n^1 + 3.27\ MeV.$$

Solution:-

Mass of deuterium = 2.0 Kg = 2000 g

No. of nuclei

$$n = \frac{N_A \times m}{A}$$

$$\therefore n = \frac{6.023 \times 10^{23} \times \cancel{2000}^{1000}}{\cancel{2}}$$

$$\therefore n = 6.023 \times 10^{26} \text{ nuclei.}$$

Energy released per fusion reaction = 3.27 MeV.

In a fusion reaction, two deuterium nuclei are involved.

$\therefore$ Energy released per deuterium nucleus

$$= \frac{3.27}{2}\ MeV.$$

$\therefore$ Total energy released in fusion of 2.0 Kg of deuterium

$$E = 6.023 \times 10^{26} \times \frac{3.27}{2}$$

$\therefore E = 9.843 \times 10^{26}$ MeV.

$\therefore E = 9.843 \times 10^{26} \times 1.6 \times 10^{-13}$ J

$\therefore E = 1.574 \times 10^{14}$ J

Now, power of lamp = 100W

Power = $\frac{\text{energy (E)}}{\text{time}}$ $\left[P = \frac{\text{work}}{\text{time}} \right]$

$\therefore \text{time} = \frac{E}{P}$

$\therefore \text{time } t = \frac{1.574 \times 10^{14}}{100}$

$\therefore \text{time } t = 1.574 \times 10^{12}$ s

$\therefore \text{time } t = \frac{1.574 \times 10^{12}}{365 \times 24 \times 60 \times 60}$

$\therefore t = 5.0 \times 10^{4}$ years. Ans

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