883.

Problem 55.39 (RHK)

We have to estimate the time for which a 100-W *lamp can be kept burning by the fusion of* 1.00 kg *of deuterium. The nuclear reaction for the fusion of deuterium is*

$$^{2}\mathrm{H} + {}^{2}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \mathrm{n} \, . \qquad \left(Q = 3.27 \text{ MeV}\right)$$

The atomic mass of deuterium is 2.014 u.

Solution:

The atomic mass of deuterium is 2.014 u. Therefore, number of atoms in 1.00 kg of deuterium will be

$$N = \frac{1.00 \text{ kg}}{2.014 \times 1.6605 \times 10^{-27} \text{ kg}} = 2.99 \times 10^{26}.$$

The Q for fusion of two deuterium nuclides is 3.27 MeV. Therefore, the energy that can be liberated in fusion of 1.0 kg of deuterium will be

$$E = \frac{NQ}{2} = \frac{2.99 \times 10^{26} \times 3.27}{2} \text{MeV}$$

$$= 4.888 \times 10^{26} \text{ MeV} = 4.888 \times 10^{26} \times 1.6 \times 10^{-13} \text{ J}$$

$$= 7.822 \times 10^{13} \text{ J}.$$

A 100-W bulb consumes 100 J of energy per second. Therefore, the bulb will light with the energy liberated from 1.0 kg of deuterium for

$$t = \frac{7.822 \times 10^{13}\ \text{J}}{10^{2}\ \text{J s}^{-1}} = 7.822 \times 10^{11}\ \text{s} = \frac{7.822 \times 10^{11}}{3.156 \times 10^{7}}\ \text{y}$$

$$= 2.48 \times 10^{4}\ \text{y}.$$