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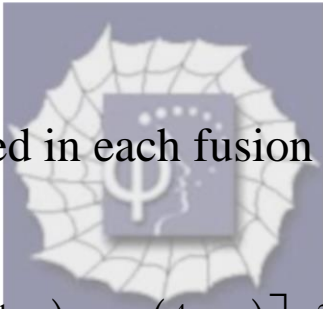
Problem 55.43 (RHK)

We have to calculate and compare the energy in MeV released by (a) 1.0 kg of hydrogen deep within the Sun and (b) the fission of 1.0 kg of ^{235}U in a fission reactor.

Solution:

(a)

The energy released in each fusion cycle of 4 protons into a ^4He is


$$\begin{aligned} Q &= \Delta mc^2 = [4m(^1\text{H}) - m(^4\text{He})]c^2 \\ &= [4 \times 1.007825 - 4.002603] \text{ uc}^2 \\ &= 0.028697 \text{ uc}^2 = 0.028697 \times 931.5 \text{ MeV} \\ &= 26.7 \text{ MeV}. \end{aligned}$$

The number of protons in 1.0 kg of hydrogen is

$$\begin{aligned} N_p &= \frac{1.0 \text{ kg}}{1.007825 \times 1.6605 \times 10^{-27} \text{ kg}} = \frac{1.0}{1.6476 \times 10^{-27}} \\ &= 0.6069 \times 10^{27}. \end{aligned}$$

Therefore, the total energy that will be released in fusion of 1.0 kg of hydrogen will be

$$E_{\text{p-fusion}} = \frac{0.6069 \times 10^{27} \times 26.7}{4} \text{ MeV}$$
$$= 4.05 \times 10^{27} \text{ MeV.}$$

(b)

We will assume that the average energy released per fission of ^{235}U is 200 MeV.

The number of ^{235}U atoms in 1.0 kg of uranium will be

$$N_{\text{u}} = \frac{6.02 \times 10^{26}}{235} = 2.56 \times 10^{24}.$$

The energy that will be released in fission of 1.0 kg of ^{235}U in a nuclear reactor will be

$$E_{\text{u-fission}} = 2.56 \times 10^{24} \times 200 \text{ MeV}$$
$$= 5.12 \times 10^{26} \text{ MeV.}$$
