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<u>Problem 55.43 (RHK)</u>

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.*

<u>Solution:</u>

(a)

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

$$Q = \Delta m c^2 = \left[4m\left({}^{1}\text{H}\right) - m\left({}^{4}\text{He}\right)\right]c^2$$

$$= \left[4 \times 1.007825 - 4.002603\right]\ \text{u}c^2$$

$$= 0.028697\ \text{u}c^2 = 0.028697 \times 931.5\ \text{MeV}$$

$$= 26.7\ \text{MeV}.$$

The number of protons in 1.0 kg of hydrogen is

$$N_{\text{p}} = \frac{1.0\ \text{kg}}{1.007825 \times 1.6605 \times 10^{-27}\ \text{kg}} = \frac{1.0}{1.6476 \times 10^{-27}}$$

$$= 0.6069 \times 10^{27}.$$

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

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

$$= 5.12 \times 10^{26} \text{ MeV.}$$