887.

Problem 55.44 (RHK)

The Sun has a mass of 2.0×10^{30} kg *and radiates energy at the rate of* 3.9×10^{26} W. (a) *We have to find the rate with which the mass of the Sun is decreasing*. (b) *We have to find the fraction of the original mass of the Sun that it has lost in this way since it began to burn hydrogen* 4.5×10^{9} y *ago*.

Solution:

(a)

The Sun has a mass of 2.0×10^{30} kg and radiates energy at the rate of 3.9×10^{26} W. We use the Einstein's mass-energy relation for calculating the rate of decrease in mass of the Sun.

$$\frac{dM_{\text{sun}}}{dt}=\frac{3.9\times10^{26}\ \text{W}}{c^2}=\frac{3.9\times10^{26}\ \text{J s}^{-1}}{\left(3\times10^{8}\ \text{m s}^{-1}\right)^2}$$

$$=4.33\times10^{9}\ \text{kg s}^{-1}.$$

(b)

The mass lost by the Sun since it began to radiate 4.5×10^{9} y ago will be

$$\Delta M_{\text{sun}} = 4.5\times10^{9}\times3.156\times10^{7}\times4.33\times10^{9}\ \text{kg}$$
$$= 6.15\times10^{26}\ \text{kg}.$$

The fraction of the original mass of the Sun lost till now will therefore be

$$\frac{\Delta M_{\text{sun}}}{M_{\text{sun}}+\Delta M_{\text{sun}}};\ \frac{\Delta M_{\text{sun}}}{M_{\text{sun}}} = \frac{6.15\times10^{26}\ \text{kg}}{2.0\times10^{30}\ \text{kg}} = 3.1\times10^{-4}.$$