892.

Problem 55.50 (RHK)

We have to calculate (a) *the rate at which the Sun is generating neutrinos. Assume that the energy production is entirely by the proton-proton cycle*. (b) *We have to find the rate with which the solar neutrinos impinge the Earth.*

Solution:

(a)

The Sun radiates energy at the rate of 3.9×10^{26} W. In a p-p cycle there is a fusion of four protons and two electrons to form one alpha particle, two neutrinos and six gamma ray photons. That is the p-p nuclear process is

$$4^{1}\mathrm{H}+2e\rightarrow{}^{4}\mathrm{He}+2\nu+6\gamma.$$

The energy released in the p-p cycle is 26.7 MeV. Assuming that the energy production is entirely by the proton-proton cycle, we find that the number of such nuclear processes that are taking place in the Sun per second is

$$= \frac{3.9 \times 10^{26} \text{ J s}^{-1}}{26.7 \times 1.6 \times 10^{-13} \text{ J}} = 9.129 \times 10^{37} \text{ p-p cycles per second.}$$

As 2 neutrinos are produced per p-p cycle, the rate at which the Sun is generating neutrinos is

$= 2 \times 9.129 \times 10^{37}$ neutrinos per second

$= 1.83 \times 10^{38}$ neutrinos per second.

(b)

The mean orbital radius of the Earth is 1.50×10^{11} m, and the mean radius of the Earth is 6.37×10^{6} m. Therefore, the rate with which the solar neutrinos impinge the Earth is

$$= \frac{1.83 \times 10^{38} \times \pi \times \left(6.37 \times 10^{6}\right)^{2}}{4\pi \times \left(1.50 \times 10^{11}\right)^{2}} \text{ neutrinos per second}$$

$= 8.25 \times 10^{28}$ neutrinos per second.