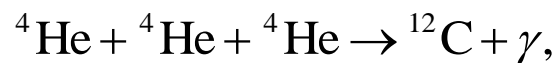


890.

Problem 55.48 (RHK)

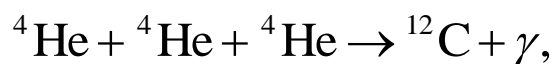
After converting all its hydrogen to helium, a particular star is 100% helium in composition. It now proceeds to convert the helium to carbon via the triple alpha process



$Q = 7.27$ MeV. The mass of the star is 4.6×10^{32} kg, and it generates energy at the rate of 5.3×10^{30} W. We have to calculate the time in which all helium will be converted into carbon.

Solution:

Helium is converted by fusion in a star to carbon via the triple alpha process



$Q = 7.27$ MeV. The mass of the star is 4.6×10^{32} kg. It generates energy at the rate of 5.3×10^{30} W.

The mass of a ${}^4\text{He}$ atom is 4.002603 u. The total number of ${}^4\text{He}$ atoms in the star will be

$$N_{4\text{He}} = \frac{4.6 \times 10^{32} \text{ kg}}{4.002603 \times 1.6605 \times 10^{-27} \text{ kg}}$$

$$= 6.92 \times 10^{58}.$$

Three ${}^4\text{He}$ nuclides undergo fusion to form a ${}^{12}\text{C}$ atom by releasing 7.27 MeV energy. Therefore, the total energy that will be released by conversion of all helium of the star will be

$$E = \frac{N_{4\text{He}} Q}{3} = \frac{6.92 \times 10^{58} \times 7.27 \times 1.6 \times 10^{-13}}{3} \text{ J}$$

$$= 2.68 \times 10^{46} \text{ J}.$$

The star is generating energy at the rate of $5.3 \times 10^{30} \text{ W}$. Therefore, the time in which all its helium will be converted into helium will be

$$t = \frac{2.68 \times 10^{46} \text{ J}}{5.3 \times 10^{30} \text{ W}} = 5.056 \times 10^{15} \text{ s}$$

$$= \frac{5.056 \times 10^{15}}{3.156 \times 10^7} \text{ y} = 1.60 \times 10^8 \text{ y}.$$