HW3 of Plasma

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1. (a) 4 protons (hydrogen) create 26.7 MeV for luminosity.

so total number of H is N:

$$N = T \cdot 4 \cdot L_\odot / 26.7\,\mathrm{MeV}$$

$$N = 5\times10^9 \times 365\times24\times3600 \times 4 \times \frac{4\times10^{33}/10^7}{26.7\times10^6\times1.602\times10^{-19}} = 5.90\times10^{55}$$

and total mass consumed is: $M = m_H \cdot N$

$$M = 5.90\times10^{55} \times 1.673\times10^{-27} = 9.87\times10^{28}\ \mathrm{kg}$$

(b). total number of neutrinos per second n is:

$$n = 2 \times L_\odot / 26.7\,\mathrm{MeV} = 1.87\times10^{38}\ /\mathrm{s}$$

and neutrino received by John is:

$$n_J = n \cdot \frac{S}{4\pi L^2}$$

for $S = 1\,\mathrm{cm}^2 = 10^{-4}\,\mathrm{m}^2$, $L = 150\times10^6\,\mathrm{km} = 1.5\times10^{11}\,\mathrm{m}$

$$n_J = 6.61\times10^{10}\ /\mathrm{s}$$

2. D-T reaction consumes one tritium and produces $14.1\ MeV = E$

so number of annual consumption is. $N = T \cdot \frac{Power}{E}$

$$N = 365 \times 24 \times 3600 \times \frac{10^9}{14.1 \times 10^6 \times 1.602 \times 10^{-19}} = 1.396 \times 10^{28}$$

3. given beta number $\beta = \frac{P}{P_B} \leq 10\%$

also $n \cdot k_B (T_i + T_e) \Big/ \frac{B^2}{2\mu_0} = \beta$

so plasma density upper limit n_m is:

$$n_m = \frac{B^2}{2\mu_0} \cdot \frac{\beta_{max}}{k_B (T_i + T_e)}$$

apply $B = 5T$, $\beta_{max} = 0.1$ $k_B (T_i + T_e) = 20\ keV$

$$n_m = 3.105 \times 10^{20}\ m^{-3}$$