(Stacey, 6-2) A D-T particle flux of 3×10^{21} m^{-2}s^{-1} strikes the surface of a stainless steel first wall. The average particle energy is 200 eV. Calculate the rate of impurity production in a tokamak with major radius $R = 5$ m and plasma radius $a = 1$ m. (Use Fe sputtering yields)

Solution)

Sputtering yield

$Y_{Fe}(200\text{ eV}) \approx 0.02$ (From Fig. 6.1.1)

The surface area

$$2\pi a \times 2\pi R = 4\pi^2 Ra = 20\pi^2 \ \ (\mathrm{m}^2)$$

∴Total sputtered impurities

$$= 3\times10^{21}\times 20\pi^2 \times 0.02$$
$$= 1.18\times10^{22} \ \ (\#/\mathrm{sec})$$

(Harms, 13-5) Evaluate impurity effects on the Lawson criterion.

Solution)

Lawson criterion

$$P_{rad} + P_{th} < \eta_{in}\eta_{out}\left(P_f + P_{rad} + P_{th}\right)$$
$$\left(1-\eta_{in}\eta_{out}\right)\left(P_{rad} + P_{th}\right) < \eta_{in}\eta_{out}P_f$$

assume $n_e \sim n_i$ and $n_i = \sum n_{Z,j}$ $T_e = T_i$

$$\frac{1-\eta_{in}\eta_{out}}{\eta_{in}\eta_{out}}\left(A_{br}\sum Z_j^2 n_{Z,j} n_e\sqrt{T_e} + \frac{3}{2}\frac{n_i kT + n_e kT}{\tau_E}\right) \langle\ n_1 n_2 < \sigma v >_{12} Q_{12}$$

$$let\ \gamma = \frac{n_{Z,1}n_{Z,2}}{n_i^2}, \overline{Z} = \frac{\sum Z_j n_{Z,j}}{n_i} \text{ and } \overline{Z^2} = \frac{\sum Z_j^2 n_{Z,j}}{n_i}$$

$$n_i\tau_E > \frac{3\left(1-\eta_{in}\eta_{out}\right)kT}{\eta_{in}\eta_{out}\gamma\frac{<\sigma v>_{12}}{1+\delta_{12}}Q_{12} - \left(1-\eta_{in}\eta_{out}\right)A_{br}\overline{Z}\overline{Z^2}\sqrt{kT}}$$

Therefore... if $\overline{Z}$ and $\overline{Z^2}$ increase , $n_i\tau_E$ increase!!