NE 180
Midterm I
Fall Semester 2001
Solutions

October 18, 2001

1. a.

$$B_{pol}(a) = \frac{B_\phi}{q(a)A}$$

$$\boxed{= 4.0/(2.5 \cdot 3) = 0.533 \text{ T}}$$

1. b.

of $T_e = T_i$= constant:

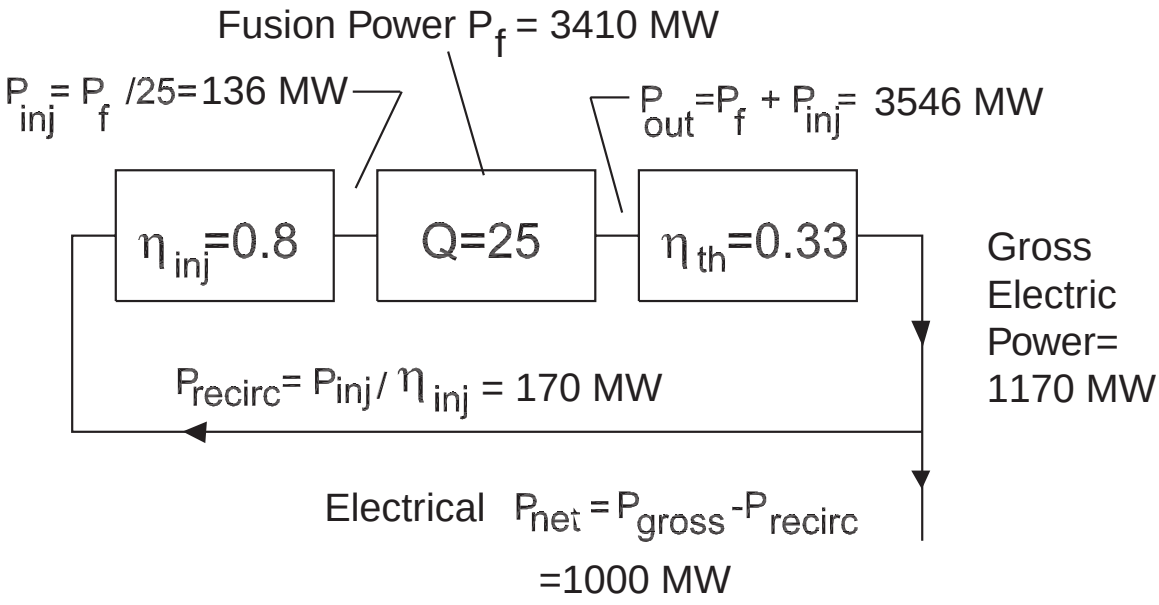
$$< n >= \frac{< p >}{2T}$$

By Bennet Pinch Theorem:

$$< p >= \frac{B_{pol}^2(a)}{2\mu_0}$$

and thus $\boxed{< n >= B_{pol}^2(a)/\mu_0 T = 2.35 \times 10^{20} \text{ m}^{-3}}$

1. c.



$$\eta_{plant} = P_{el}/P_f = \eta_{th}(1 + 1/Q) - 1/(Q\eta_I) = 0.2932$$

So $\boxed{P_f = 1000/0.2932 = 3410 \text{ MW}}$

1. d.

$$P_f(MW/m^3) = 1.86\ n_{20}^2$$

$$= 0.1027 MW\ m^{-3}$$

$$\boxed{\text{Volume} = 3410/.1027 = 33198 \text{m}^3}$$

1. e.

$$\text{Volume} = \frac{2\pi^2 R^3}{A^2}$$

$$P_f = 1.86 \cdot \text{Volume} = 1000 MW$$

$$R^3 = \frac{A^2(3410)}{2\pi^2(0.1027)}$$

$$\boxed{R = 24.7m}$$

1. f.

$$n\tau_E = \frac{3T}{(1/4) < \sigma v > E_f(1/Q + f_c(1 - \chi_R))}$$

$$\chi_R = 2 \times \text{“clean”}\ \chi_R = 2 \times 0.055 = 0.11$$

$$n\tau_E = \frac{3(15 \times 10^3)}{0.25(2.65 \times 10^{22})(17.6 \times 10^6)(0.04 + 0.2(1 - 0.11))}$$

$$\boxed{\tau_E = 1.77\,s}$$

2. a.

NOT Fully stripped because

$$\boxed{13.6\,Z^2 = 23990\,eV\ >> 3T_e}$$

2. b.

Fully stripped because

$$\boxed{13.6\,Z^2 = 23990\,eV\ < 3T_e}$$

2. c.

$$\boxed{P_{dirty}/P_{clean} = (1 + fZ)(1 + fZ^2) = (1.042)(2.764) = 2.88}$$

3. a. ,b

$$n = \rho/MN_A = 6.02 \times 10^2 4\text{cm}^{-3}$$

, So:

$$f_{pe} = 89 \times 10^9 (n_{14}^{0.5} = 2.18 \times 10^{16}\text{Hz}$$

Wavelength is $\boxed{c/f_{pe} = 137\ \mathring{A}}$ Photon energy is $12,400/\lambda$=$\boxed{90\text{ eV}}$

3. d.

Setting $B^2/(2\mu_0) = 2nT$, we have:

$$\boxed{B = (4\mu_0 nT)^{0.5} = 2.7 \times 10^5\ \text{T}}$$