$\frac{1}{n} = \frac{kT}{P}$ $p = nkT$

SM 307 #1

a) $n_c = n_{c0} e^{\epsilon d/kT}$

Ground State: $\epsilon = -13.6$ eV

$N = 1$

Excited State: $\epsilon = 0$

$N = 0$

$$Z = \sum_s e^{-(\epsilon - N\mu)/kT}$$

$$Z = 1 + e^{-(\epsilon - \mu)/kT}$$

$$1 + e^{\epsilon_b/kT} e^{\mu/kT}$$

$$\mu_{id} = -kT \ln\left[\frac{1}{n}\left(\frac{2\pi m kT}{2\pi \hbar^2}\right)^{3/2}\right]$$

$$P(\text{no } e^-) = \frac{1}{Z}$$

$$P(\text{with } e^-) = \frac{e^{\epsilon_b/kT} e^{\mu/kT}}{Z}$$

$$\frac{P(\text{no } e^-)}{P(\text{with } e)} = e^{-\epsilon/kT} e^{-\mu/kT}$$

$$\frac{n_p}{n_H} = e^{-\epsilon/kT} \frac{1}{n}\left(\frac{mkT}{2\pi\hbar^2}\right)^{3/2}$$

$\frac{\epsilon}{kT} = 100$

$kT = \frac{\epsilon}{100}$

$$n = e^{-\epsilon/kT}\left(\frac{mkT}{2\pi\hbar^2}\right)^{3/2}$$

$$n = e^{-100}\left(\frac{mkT}{2\pi\hbar^2}\right)^{3/2}$$

$$e^{-100}\left(\left(\frac{m_e c^2}{c^2}\right)\frac{1}{2\pi\hbar^2}\frac{\epsilon}{100}\right]^{3/2}$$

$$= e^{-100}\left[\frac{5e5}{(2000)^2}\frac{1}{2\pi}\frac{13.6}{100}\right]^{3/2} \approx 5.23 \cdot 10^{-48} \frac{1}{Å^3}$$

$$5.23 \cdot 10^{-48} \frac{1}{\text{Å}^3} \frac{1\ \text{Å}^3}{10^{-30}\ m^3} \approx \boxed{5.23 \cdot 10^{-18} \frac{1}{m^3}}$$

b)

$$\frac{n_p}{n_H} = e^{-E/kT} \frac{1}{n_{pc}} \left(\frac{mkT}{2\pi\hbar^2}\right)^{3/2}$$

$$n_{H0} + n_{p0} = n_{Hf} + n_{pf}$$

$$\frac{1}{10} = \frac{11}{2} \frac{1}{n_{p0}} e^{-E/kT} \left(\frac{mkT_0}{2\pi\hbar^2}\right)^{3/2}$$

$$n_{pf} = \frac{1}{10} n_{Hf}$$

$$10 n_{pf} = n_{Hf}$$

$$2 n_{p0} = 11 n_{pf}$$

$$n_{pf} = \frac{2}{11} n_{p0}$$

$$\frac{2}{110} n_{p0} \left(\frac{2\pi\hbar^2}{mkT_0}\right)^{3/2} = e^{-E/kT}$$

$$\frac{-E}{kT} = \ln\left[\frac{2}{110} n_{p0} \left(\frac{2\pi\hbar^2}{mkT_0}\right)^{3/2}\right]$$

$$\frac{E}{kT} = 104 \qquad kT = \frac{E}{104}$$

$$kT_f \approx .131\ eV$$

$$kT_i = .136\ eV$$

$$\boxed{\Delta(kT) \approx -.005}$$