Physics 112, Fall 2017: Holzapfel
Problem Set 7 (6 Problems). Due Monday, October 23, 2017, 5 PM

Problem 1: **Distribution Function for Double Occupancy Statistics**
Kittel 6.3

Problem 2: **Energy of Gas of Extreme Relativistic Particles**
Kittel 6.4

Problem 3: **The Relation Between Pressure and Energy Density Revisited**
a) Kittel 6.7

b) Calculate the pressure of a Fermi gas (in atmospheres) at zero temperature using the electron density for Copper ($n_e = 8 \times 10^{22}\text{cm}^{-3}$).

Problem 4: **Gas of Atoms with Internal Degrees of Freedom**
Kittel 6.9

Problem 5: **Ideal Gas in Two Dimensions**
Kittel 6.12

Problem 6: **Chemical Equilibrium Between Electrons and Holes**
An electron in the conduction band interacts with a hole in the valance band. The excess energy is carried away by a phonon, a particle whose chemical potential is zero because its number is not conserved. The condition for equilibrium between electrons and holes is:

$$\mu_e + \mu_h = 0\,.$$

Assume that the electrons and holes each form an ideal gas and that the conduction band is separated from the valance band by an energy gap E_g.

(a) Show that the density of electrons in the conduction band is given by:

$$n_e = 2\left(\frac{\tau\sqrt{m_e m_h}}{2\pi\hbar^2}\right)^{3/2} \exp\left(-\frac{E_g}{2\tau}\right)\,,$$

where m_e and m_h are the effective masses of the electrons and holes.

(b) Use your result from part (a) to show that:

$$\mu_e = \frac{E_g}{2} + \frac{3\tau}{4}\ln\left(\frac{m_h}{m_e}\right)\,.$$

(c) Now consider a semiconductor that also contains a density n_D of donors that each contribute one electron to the conduction band. Show that the electron density is now:

$$n_e' = \frac{n_D}{2} + \sqrt{\frac{n_D^2}{4} + n_e^2}\,.$$