Physics 410 - 2004

Thermal Physics

Problem Set 12

1. Chapter 8, p. 258, problem 3 (6 pt)

2. Chapter 8, p. 258, problem 4 (5 pt)

3. Chapter 8, p. 258, problem 6 (5 pt)

4. Chapter 8, p. 259, problem 10 (6 pt) Expansion into vacuum is irreversible, pressure is equal to zero.

5. A simple model of an intrinsic (no charged defects) semiconductor is as follows: there is a valence band and a conduction band, separated by an energy gap E_g. For $T = 0$, the valence band is occupied by electrons, and the conduction band is empty. As you raise temperature, some electrons go from the valence band to the conduction band. In such a process, a hole is created in the valence band, with energy $p^2/2m_h$ counted off from the top of the valence band (p can be thought to be the momentum of the hole), and an electron emerges in the conduction band, with energy $p^2/2m_e$ counted off from the bottom of the conduction band (m_e and m_h are called the electron and hole effective masses, respectively). Find the electron and hole densities n and p for nonzero temperatures, assuming that $\beta E_g \gg 1$. Find the position of the chemical potential. (5 pt)

You need to have 25 points out of 27 (2 points are extra credit).

The problems are from Kittel & Kroemer, *Thermal Physics*, 2nd edition, (Freeman, NY 1980).