Homework # 1

EE 3161 - Spring 2008

Due Monday, February 11 in class

1) If we have a heated gas of hydrogen atoms:
   a) According to the Bohr model, what are the velocities of the electrons in each of the first three orbitals of the atom?
   b) What are the wavelengths (and colors) of light that will be emitted from the gas if we consider only the three Balmer series shown in figure A.2 of the text?

2) Problem 2.4 of Pierret

3) If the densities of states of a semiconductor are given as follows:

$$g_c(E) = constant = \frac{N_c}{kT} \qquad g_v(E) = constant = \frac{N_v}{kT}$$

Then redraw the carrier distributions of Fig. 2.16 in Pierret.

4) For an n-type impurity in GaAs, the orbital radius of the loosely held electron can be roughly approximated as

$$r = \frac{\epsilon_{GaAs}}{\frac{m^*}{m}} \times 0.529\text{Å}.$$

   a) At what doping concentration do the impurity orbitals begin to overlap? (The molecular density of GaAs is 2.2×10^{22} molecules/cm^3, ϵ_{GaAs} = 13.1, and m^*/m = 0.06.)
   b) Is there any significance to this overlap? What does it do to the band diagram of the system?
   c) Based on your answer to b), what happens to the size of the bandgap under conditions of extremely high doping?

5) Consider a silicon crystal doped with 1.5×10^{16} cm^{-3} phosphorus atoms and 7×10^{15} cm^{-3} boron atoms.
   a) What is the overall charge of the silicon?
   b) Is the material p-type or n-type? What is the free electron density in the crystal?
   c) What is the free hole density in the crystal?
   d) What is the ionized donor density in the crystal?
   e) What is the neutral donor density in the crystal?

6) [*Problem 1, midterm exam #1, spring 2007*]
A new semiconductor is discovered that has $N_c=10^{20}$cm^{-3}, $N_v=10^{16}$cm^{-3}, and E_g=5eV.
Let T=300K.
   a) What doping level in this semiconductor leads to degeneracy? What does this mean?\
   b) What is n_i?
   c) Draw the band diagram in equilibrium and quantify the position of E_i relative to E_c and E_v.