ENEE312H Spring 2002 http://www.ece.umd.edu/~pabshire/enee312.htm
Homework 1 due Thursday, February 7, 2002

1) A sample of silicon is uniformly doped with 10^{16} arsenic atoms per cm^3 and $5x10^{15}$ boron atoms per cm^3. Assuming n_i is 10^{10} cm^{-3} at 300K determine the following for this sample at ~300K:
   a. The type (n or p)
   b. The majority carrier concentration
   c. The minority carrier concentration

   Repeat when:
   d. The sample instead contains 10^{17} cm^{-3} Al and 10^{16} cm^{-3} Sb.
   e. The sample instead contains 10^{15} cm^{-3} Ga and $5x10^{15}$ cm^{-3} B.

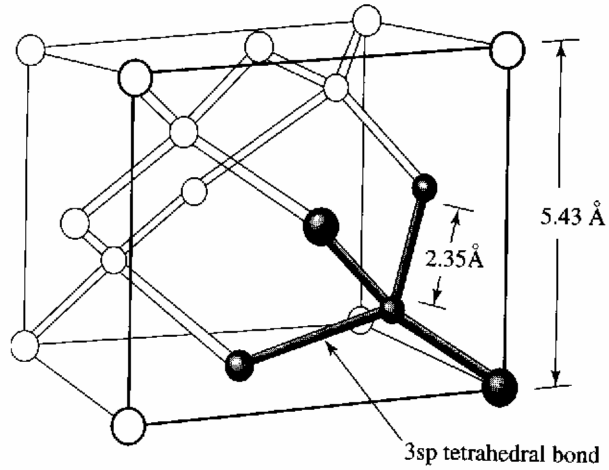
2) How large must $|N|/n_i$ be in order for the minority carrier concentration to be less than 10 percent of the majority density? Less than 1 percent?

3) Five different semiconductors and their bandgap energies are listed below. For each semiconductor calculate the longest wavelength of light that will pass through it, without being absorbed to create electron-hole pairs. Note that wavelength in microns and energy in electron volts are related as λ (μm) = 1.237/E_g (eV), and that visible light falls between 0.4μm and 0.7μm.
   a. AlSb aluminum antimonide E_g = 1.63 eV
   b. GaP gallium phosphide E_g = 2.24 eV
   c. ZnS zinc sulfide E_g = 3.6 eV
   d. InAs indium arsenide E_g = 0.33 eV
   e. Si silicon E_g = 1.124 eV

4) In modern VLSI processes, the dimensions of device structures are less than 1μm^3. For a donor concentration N_d = $5x10^{15}$ cm^{-3}, find the number of electrons and the number of holes in this volume. Note: this is one of the reasons why there is a tendency for doping concentrations to increase as device dimensions are scaled into the submicron region.

5) Given the crystalline structure of silicon in the diamond lattice as shown in the figure on the following page and the lattice spacing of 5.43Å per unit cell, compute the atomic density of pure silicon (in atoms per cubic cm).

Research question:
Neils Bohr was awarded the Nobel Prize in physics in 1922 “for his services in the investigation of the structure of atoms and of the radiation emanating from them”. For what element(s) does Bohr’s model hold, and what is his prediction for the energy levels of those atoms?



➤ **Figure 2.1** Unit cell of crystalline silicon (After R. S. Muller and T.I. Kamins, *Device Electronics for Integrated Circuits,* 2nd ed., Wiley, 1986.)

adapted from Microelectronics: an integrated approach, Howe/Sodini, 1997.