ECE 340 # Homework Assignment #3 **Fall 2015**

DUE: FRIDAY, SEPTEMBER 18, 2015

Print your **name** and **NetID** legibly. Follow the guidelines and format given in the syllabus. Staple multiple pages. Show all units. Homework must be turned in at the **beginning** of class and any late homework assignments will not be accepted. Please contact the course director, Professor Dallesasse, should any issues with late homework arise.

1. FERMI-DIRAC STATISTICS

Show that

$$n_0 = N_c e^{-(E_c - E_F)/kT} \tag{1.1}$$

$$p_0 = N_v e^{-(E_F - E_v)/kT} \tag{1.2}$$

can be written as

$$n_0 = n_i e^{(E_F - E_i)/kT} \tag{1.3}$$

$$p_0 = n_i e^{(E_i - E_F)/kT} \tag{1.4}$$

If $n_0 = 10^{15}$ cm^{-3}, where is the Fermi level relative to E_i in Si at room temperature(300K)?

2. INTRINSIC CARRIER CONCENTRATION VS. TEMPERATURE 1

The electron concentration in a bar of silicon is 2×10^{13} cm^{-3} at 300K under equilibrium conditions.

(A). What is the hole concentration?

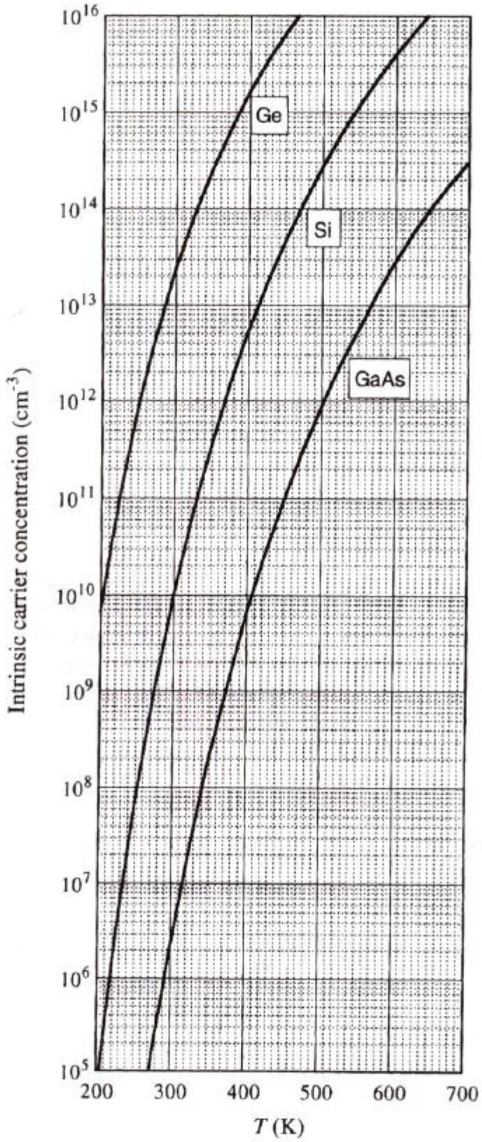
(B). Where is E_F positioned relative to E_i?

(C). Draw the energy band diagram for the material.

(B). Repeat parts A, B, and C for the same sample if the temperature is 400K (refer to Fig. 3-17 in the Streetman text to obtain the intrinsic carrier concentration at 400K). You are given that the band gap energy is reduced to 1.08eV at 400K.

3. Intrinsic Carrier Concentration Vs. Temperature 2

(A). Refer to the figure below.



Si

T(°C)	n_i(cm^{-3})
0	8.86×10^{8}
5	1.44×10^{9}
10	2.30×10^{9}
15	3.62×10^{9}
20	5.62×10^{9}
25	8.60×10^{9}
30	1.30×10^{10}
35	1.93×10^{10}
40	2.85×10^{10}
45	4.15×10^{10}
50	5.97×10^{10}
300 K	1.00×10^{10}

GaAs

T(°C)	n_i(cm^{-3})
0	1.02×10^{5}
5	1.89×10^{5}
10	3.45×10^{5}
15	6.15×10^{5}
20	1.08×10^{6}
25	1.85×10^{6}
30	3.13×10^{6}
35	5.20×10^{6}
40	8.51×10^{6}
45	1.37×10^{7}
50	2.18×10^{7}
300 K	2.25×10^{6}

Determine the temperature at which the intrinsic carrier concentration in Si and GaAs are equal to the room temperature (300K) intrinsic carrier concentration of Ge.

(B). Semiconductor A has a bandgap of 2.5eV. Semiconductor B has a bandgap of 1.5eV. What is the ratio of the intrinsic carrier concentrations (n_{iA}/n_{iB}) at 300K? Assume any differences in the carrier effective masses may be neglected.

4. Carrier Concentrations of Compensated Semiconductors

A compensated Germanium sample ($n_i = 2 \times 10^{13}$ cm^{-3}) is doped with 10^{15} cm^{-3} acceptors and 4×10^{13} cm^{-3} donors.

(A). Calculate the electron and hole concentrations at room temperature (300K) under equilibrium conditions.

(B). Repeat part (A) for 10^{14} cm^{-3} acceptors and 4×10^{13} cm^{-3} donors.

(C). Repeat part (A) for 4.1×10^{13} cm^{-3} acceptors and 4×10^{13} cm^{-3} donors.

(D). Determine the percentage of error in each case for the majority carrier concentration if one simply assumes that the majority carrier concentration approximately equals the difference between the donor and acceptor doping. What can you say about the accuracy of this approximation?