EE128 Homework Set 1

Question 1:

1. An intrinsic semiconductor has an electron concentration of 1×10^9 cm^{-3}, what is the hole concentration?
2. If a Si wafer is doped with 10^8 As atoms/cm^3. Will the Si be n-type, p-type or intrinsic at room temperature, if $ni=1.5x10^{10}cm^{-3}$ at room temperature?
3. Which semiconductor would be better suited for high temperature (Pick a Temp between 400K and 500K) operation, GaAs or SiC? Justify your answer by comparing the approximate ratios of $ni_{GaAs}:ni_{SiC}$.
4. SiC is a compound semiconductor made up of elements from group IV of the periodic table. Which group of elements should behave as acceptors (make p-type SiC) and which should behave as donors (make n-type SiC)?
5. Indicate on the chart below which temperature range Si doped with 10^{14} B atoms/cm^3 will be intrinsic.
6. In the non-intrinsic temperature range, Si doped with 10^{14} P atoms/cm^3 will be either (choose one) n-type p-type or amphoteric?

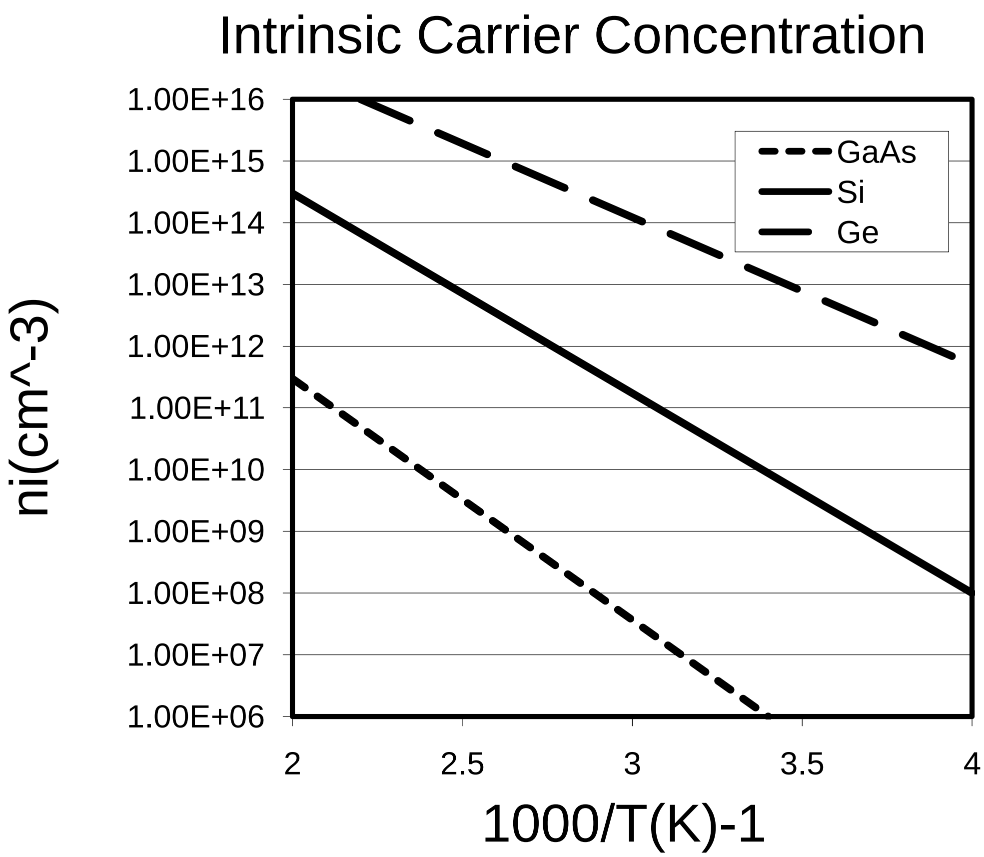

Figure 1: Figure for questions 5 and 6.

7. Label which energy band diagrams below are p-type, which are n-type, and which are intrinsic.
8. Label which energy band diagrams are under thermal equilibrium.
9. Label which energy band diagram represents a semiconductor with the highest intrinsic carrier concentration compared with the other three. (All are at same temperature.)

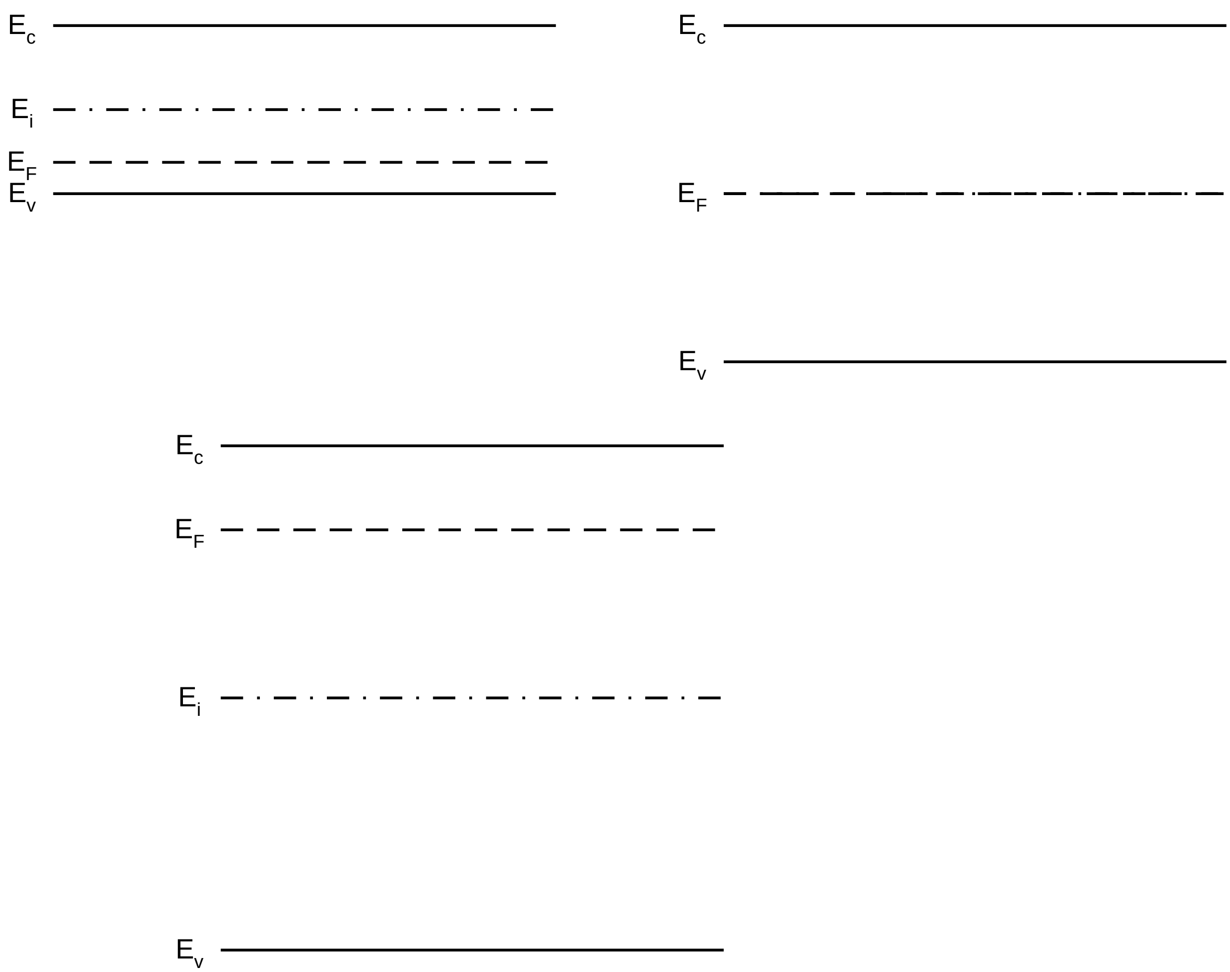

Figure 2: Figures for questions 7, 8, and 9.

10. Since the effective mass of electrons in a conduction band decreases with increasing curvature of the band according to Equation 3-3 in the text, comment on the electron effective mass in the Γ valley of GaAs compared to the indirect valley or L valleys (fig 3-10).
11. How is the effective mass difference reflected in the electron mobility for GaAs and GaP as shown in Appendix III?
12. From figure 3-10 what would you expect to happen to the conductivity of GaAs if the Γ valley electrons drifting in an electric field were suddenly promoted to the L valley?
13. How long does it take an average electron to drift 1 micron in pure Si at an electric field of 100V/cm? Repeat for 10^5V/cm.