SEMICONDUCTOR PHYSICS **ECE 1336**

Problem Set #10: Uniform Electronic Semiconductors in Equilibrium

1.

Through the relations:

$$n_o = 2\left(\frac{2\pi m_n^* kT}{h^2}\right)^{\frac{3}{2}} \mathrm{e}^{\frac{-(\mathrm{E_c}-\mathrm{E_f})}{\mathrm{kT}}}$$

$$p_o = 2\left(\frac{2\pi m_p^* kT}{h^2}\right)^{\frac{3}{2}} \mathrm{e}^{\frac{-(\mathrm{E_f}-\mathrm{E_v})}{\mathrm{kT}}}$$

we can define the parameters N_c and N_v known as the *effective density of states* in the conduction band and valence band respectively, where:

$$N_c = 2\left(\frac{2\pi m_n^* kT}{h^2}\right)^{\frac{3}{2}}$$

$$N_v = 2\left(\frac{2\pi m_p^* kT}{h^2}\right)^{\frac{3}{2}}$$

(a) Calculate N_c and N_v for the following semiconductors at T=300K (note m_o is the rest mass of an electron) :

(i) Si: $m_n^* = 1.08m_o$ and $m_p^* = 0.56m_o$

(ii) GaAs: $m_n^* = 0.067m_o$ and $m_p^* = 0.48m_o$

(iii) Ge: $m_n^* = 0.55m_o$ and $m_p^* = 0.37m_o$

(b) Comment on the similarity of the effective density of states in the above semiconductors.

(c) Calculate the thermal equilibrium electron and hole concentration in Si at T=300K for the following cases:

(i) when the Fermi energy level is at the mid gap.

(ii) when the Fermi energy level is 0.22eV below the conduction band.

2. The mass action relation dictates that for a semiconductor in equilibrium:

$$n_o p_o = n_i^2$$

Through this relation it can be seen that for an extrinsic (doped) semiconductor the minority carrier concentration will decrease below its intrinsic value. Provide a physical explanation for why this occurs.

3. For a given intrinsic semiconductor, the effective mass of holes is greater than the effective mass of electrons. Is the Fermi level above or below the mid gap level? Provide a physical relational for your answer.