HW #3  
Due October 2 (Thursday) in class

1. Problem 9.6 in Chuang.

2. Consider an optical transition from $E_a$ to $E_b$ in a 10-nm wide GaAs single quantum well. Here, $E_a$ and $E_b$ are related by an optical transition (i.e., they have the same k). Use the following effective masses: $m_e^* = 0.067m_0$ and $m_h^* = 0.5m_0$. The bandgap energy of GaAs is 1.42 eV. Use infinite potential well for the calculation. Use the valence band edge as the reference for all energies (i.e., $E_V = 0$ eV).
   
   a. Find $E_a$ and $E_b$ as functions of the photon energy, $\hbar\omega$.
   
   b. Derive the Fermi-Dirac distribution for electrons in the first conduction subband with a quasi-Fermi level of $F_c$, $f_c(E_b(\hbar\omega))$, as a function of $\hbar\omega$.
   
   c. Similarly, derive the Fermi-Dirac distribution for electrons in the first valance subband with a quasi-Fermi level of $F_v$, $f_v(E_a(\hbar\omega))$, as a function of $\hbar\omega$.
   
   d. Calculate and plot optical gain spectra for the GaAs quantum well for photon energy from 1.4 eV to 2 eV at $T = 300$ K. Plot the spectra for two quasi Fermi level separations: $\Delta F = 1.5$ and 1.8 eV. (Again, use your numeric program for calculation and plotting)
   
   e. Calculate and plot the spontaneous emission spectra for the GaAs quantum well for photon energy from 1.4 eV to 2 eV at $T = 300$ K. Plot the spectra for two quasi Fermi level separations: $\Delta F = 1.5$ and 1.8 eV. (Again, use your numeric program for calculation and plotting)