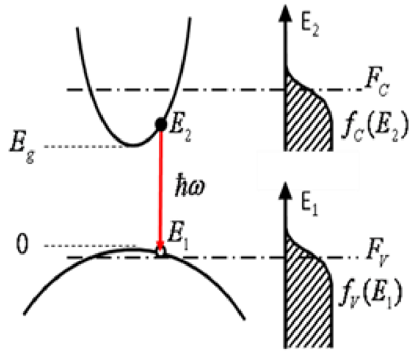
HW #2

Due 3/2/17 in class.

**Use your favorite program (e.g., Matlab) for numerical calculation and plotting.**

1. Refer to the diagram on the right. Under biased condition, both conduction and valence bands are populated. The electron distribution in conduction band is described by Fermi-Dirac distribution, $f_C(E_2)$, with quasi-Fermi energy $F_C$. The electron distribution in valence band is described by Fermi-Dirac distribution, $f_V(E_1)$, with quasi-Fermi energy $F_V$. Here, $E_1$ and $E_2$ are related by an optical transition (i.e., they have the same k). The optical matrix element is




$$\left|\hat{e}\cdot\vec{P}_{cv}\right|^2 = \frac{m_0}{6}E_p \quad \text{with} \quad E_p = 25.7 \text{ eV}$$

   a. Use the energy reference below (i.e, $E_V = 0$ and $E_C = E_g$, the bandgap energy), find $E_1$ and $E_2$ as functions of the photon energy, $\hbar\omega$.
   b. Derive $f_C(E_2)$ as a function of $\hbar\omega$.
   c. Derive $f_V(E_1)$ as a function of $\hbar\omega$.
   d. Assuming $E_g = 1$ eV, $F_C - F_V = 1.2$ eV, $m_e^* = 0.1m_0$, $m_h^* = 0.4m_0$. Calculate and plot the emission probability $f_e(E_2) = f_C(E_2)[1 - f_V(E_1)]$ for photon energies from 0.8 to 1.5 eV. Plot for two temperatures: T = 0 and T = 300 K.
   e. Repeat part d) for the Fermi inversion factor: $f_g(E_2) = f_C(E_2) - f_V(E_1)$ .
   f. Plot the gain spectra for T = 0 and T = 300 K for the condition given in d).
   g. Plot the spontaneous emission spectra for T = 0 and T = 300 K for the condition given in d).