HW #1

Due September 12 (Tuesday) in class

1. The US energy consumption is about 3 x 10^{13} kW-h/year. If one were to generate 10% of the energy by solar cells, what percentage of US area needs to be covered by solar cells? The power density of solar radiation on earth surface is about 1.4 kW/m^2. For simplicity, assume the wavelength of sunlight to be 500 nm. The efficiency of solar cells is about 25% (i.e., the electrical energy output is about 25% of incident light energy).

2. The separation of the quasi-Fermi levels (E_{fc} - E_{fv}) is a measure of the semiconductor's deviation from equilibrium. In the following, you will be asked to express E_{fc} and E_{fv} in terms of the concentration of the injected electron-hole pairs Δn $(=\Delta p)$. For simplicity, assume T= 0 K and $\Delta n >> n_0$.
   a. Using $n = \int_{E_C}^{\infty} \rho_c(E) \cdot f(E) dE = n_0 + \Delta n \approx \Delta n$, show that $E_{fC} = E_C + (3\pi^2)^{2/3} \frac{\hbar^2}{2m_C} (\Delta n)^{2/3}$.
   b. Under similar assumptions, show that $E_{fV} = E_V - (3\pi^2)^{2/3} \frac{\hbar^2}{2m_V} (\Delta n)^{2/3}$.
   c. From (a) and (b), show that $E_{fC} - E_{fV} = E_g + (3\pi^2)^{2/3} \frac{\hbar^2}{2m_r} (\Delta n)^{2/3}$. Explain the physical meaning of (E_{fc} - E_{fv}).
   d. For GaAs, m_C= 0.067 m_0 and m_V= 0.45 m_0 and $E_g = E_C - E_V$ = 1.42 eV, plot E_{fc} and E_{fv} versus Δn in the following semi-log plot (E_{fc} and E_{fv} in linear scale, Δn in log scale). Which quasi-Fermi level moves faster with increase of Δn?