Midterm Solution Winter 2013

1.

$$c = \lambda * f$$

$$f = \frac{c}{\lambda}$$

$$\lambda = 0.4 - 0.7\mu m \Rightarrow f = 4.27E14 - 7.47E14Hz$$

$$E = h * f$$

$$E = 1.77 - 3.09eV$$

Energy band gaps smaller than 1.77eV are non transparent (Si, GaAs).
Energy band gaps greater than 3.09eV are transparent (GaN).
Energy band gaps between 1.77eV-3.09eV are partially transparent (GaP).

2.

$$\mu = \frac{q\bar{\tau}}{m_e^*}$$

$$\bar{\tau} = 2.6 \times 10^{-13} s$$

3.

a)

$$\tau_D = \frac{\varepsilon}{\sigma}$$

$$\sigma = q\mu_p N_a$$

$$\tau_D = 4.65 \times 10^{-12} s$$

b)

$$\tau_D = \frac{\varepsilon}{\sigma}$$

$$\sigma = qn_i(\mu_n + \mu_p)$$

$$\tau_D = 3.6 \times 10^{-7} s$$

c)

$$L_D = \sqrt{\frac{\varepsilon kT}{q^2 N_a}}$$

` $L_D = 4.8 \times 10^{-5} cm$

$$L_D = 0.48\mu m$$

4.

Indirect recombination is a defect-assisted recombination. During indirect recombination, the electrons "falls" in a trap and is confined in a small space. From Heisenberg uncertainty principle, $\Delta p \Delta x \geq h/4\pi$, a small uncertainty in space leads to a large uncertainty in momentum. This uncertainty in momentum accounts for any momentum change that might have been observed.

5.

$$n_i = 2 * \left(\frac{2\pi kT}{h^2}\right)^{3/2} (m_e^* m_p^*)^{3/4} e^{-E_g/2kT}$$

$$n_i(77k) = 5.57 \times 10^{-13} m^{-13} = 5.57 \times 10^{-19} cm^{-3}$$

$$n_i(300k) = 7.12 \times 10^9 cm^{-3}$$

$$n_i(600k) = 1.01 \times 10^{15} cm^{-3}$$

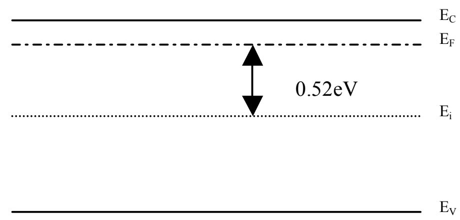
a)

$$n_0 = n_i e^{(E_F - E_i)/kT}$$

$$n_0 = N_D$$

$$(E_F - E_i) = kT * Ln\left(\frac{N_D}{n_i}\right)$$

$$(E_F - E_i) = 0.52eV$$



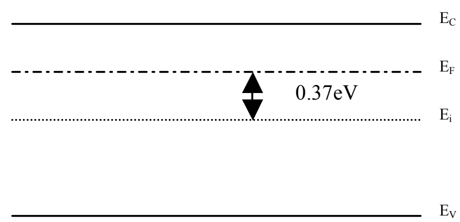
b)

$$n_0 = n_i e^{(E_F - E_i)/kT}$$

$$n_0 = N_D$$

$$(E_F - E_i) = kT * Ln\left(\frac{N_D}{n_i}\right)$$

$$(E_F - E_i) = 0.37eV$$



c)

$$n_0 = n_i e^{(E_F - E_i)/kT}$$

$$n_0 = N_D$$

$$(E_F - E_i) = kT * Ln\left(\frac{N_D}{n_i}\right)$$

$$(E_F - E_i) = 0.12eV$$