MIDTERM EXAM #1 SOLUTIONS

EE 3161 SPRING 08

(1.) $\rho = \dfrac{1}{q(n\mu_n + p\mu_p)}$

a.) intrinsic $\rho = \dfrac{1}{q n_i (\mu_n + \mu_p)}$

$$\rho = \frac{1}{q\sqrt{N_c N_v}\, e^{-E_g/2kT} \left(\mu_n(300)\, T^{-3/2} + \mu_p(300)\, T^{-3/2}\right)}$$

$$\rho = \frac{1}{q\, e^{-E_g/2kT} \sqrt{N_c(300) N_v(300)}\; T^{3/2}\, T^{-3/2} \left(\mu_n(300) + \mu_p(300)\right)}$$

$$\rho = \frac{1}{q e^{-E_g/2kT} \sqrt{N_v(300) N_c(300)} \left(\mu_n(300) + \mu_p(300)\right)}$$

$\rho_{II} = 1.87\ \Omega\text{-cm}$ for $T = 700K$

$\rho_I = 22.6\ \Omega\text{-cm}$ for $T = 550K$

$$R_I = \frac{\rho_I L_I}{A_I} = \frac{(22.6\ \Omega\text{-cm})(.5cm)}{(.6cm)(.1mm)}$$

$$R_I = 188\ \Omega$$

$$R_{II} = \frac{\rho_{II} L_{II}}{A_{II}} = \frac{(1.87\ \Omega\text{-cm})(.5cm)}{(.6cm)(.1)}$$

$$R_{II} =$$

$$R_{TOT} = R_I + R_{II} = 16\ \Omega$$

$$\boxed{R_{TOT} = 204\ \Omega}$$

b.) $n_i = \sqrt{N_c(300)\frac{T^{3/2}}{(300)^{3/2}} N_v(300)\frac{T^{3/2}}{(300)^{3/2}}}\, e^{-E_g/2kT}$

$n_i(550K) = (4.2\times 10^{19})e^{-1.1/2kT} = 3.7\times 10^{14}$

$n_i(700K) = (6.1\times 10^{19})e^{-1.1/2(0.0603)} = 6.6\times 10^{15}\ cm^{-3}$

$n_i(700K) \gg N_D$

but $T = 550K$

$n \sim n_i$ $\quad n = \frac{N_D - N_A}{2} + \sqrt{\left(\frac{N_D - N_A}{2}\right)^2 + n_i^2}$

$n = \frac{N_D}{2} + \sqrt{\frac{N_D^2}{4} + n_i^2}$

$n = 4.2\times 10^{14}\ cm^{-3}$

$p = \frac{n_i^2}{n} = 3.2\times 10^{14}\ cm^{-3}$

For $T = 200K$, $\rho = 1.87\ \Omega\text{-cm}$ as before

For 550K, $\rho = \frac{1}{q(n\mu_n + p\mu_p)}$

$\longrightarrow$

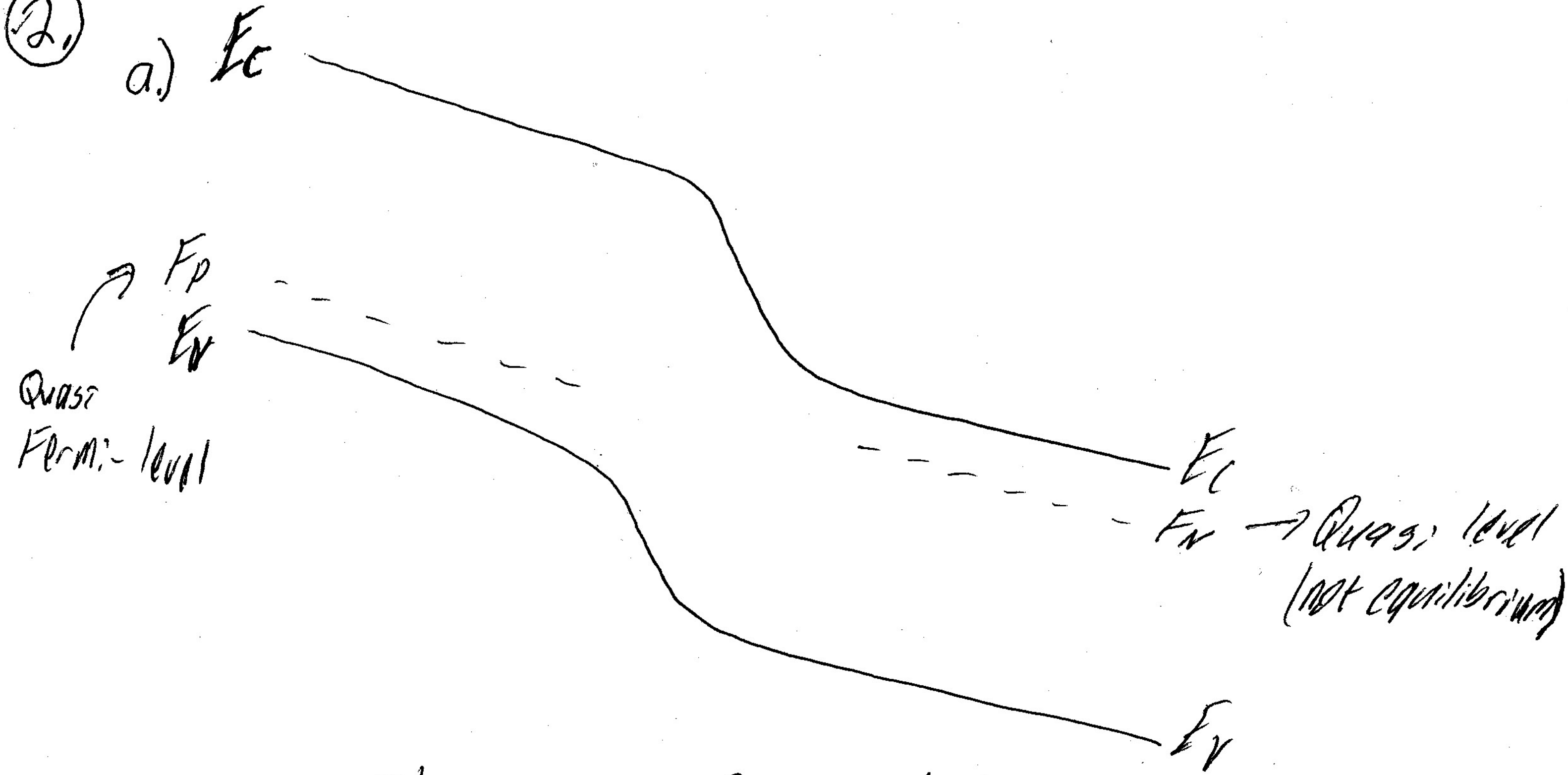
$$= \frac{1}{q\left[(4.2\times10^{14})\,\mu_n(300)\left(\frac{550}{300}\right)^{-3/2} + (3.2\times10^{14})\,\mu_p(300)\left(\frac{550}{300}\right)^{-3/2}\right]}$$

$$\rho = 21.6\ \Omega\text{-cm}$$

$$R_{TOT} = (\rho_I + \rho_{II})\frac{L}{A} = \frac{(1.87 + 21.6)(.5)}{(.6)(.1)}$$

$$\boxed{R_{TOT} = 196\ \Omega}$$

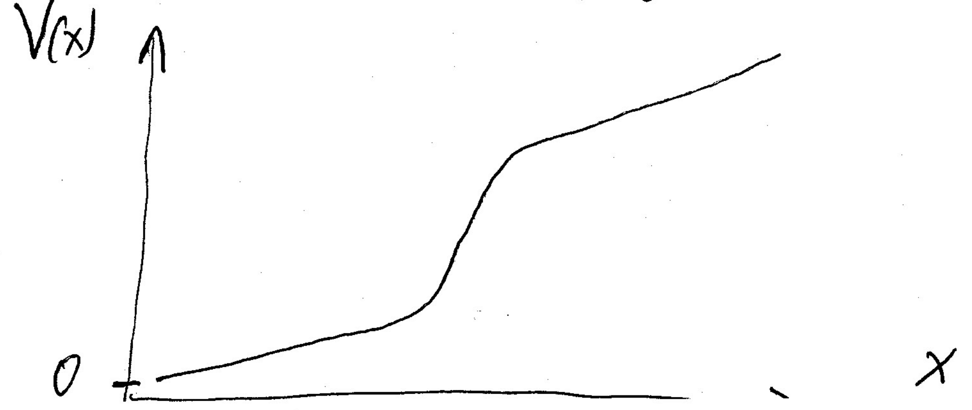
2. a)



This is a forward biased diode with voltage drops in the quasi-neutral regions (due to current flow, $V=IR$).

b.) The potential is essentially the band diagram inverted. I'll choose to plot

$$-\frac{(E_c - E_{ref})}{q}$$ → an arbitrary but constant reference level



C.)