2.626 / 2.627: Fundamentals of Photovoltaics
In-class Problem Set, Fall 2013 (9/26)
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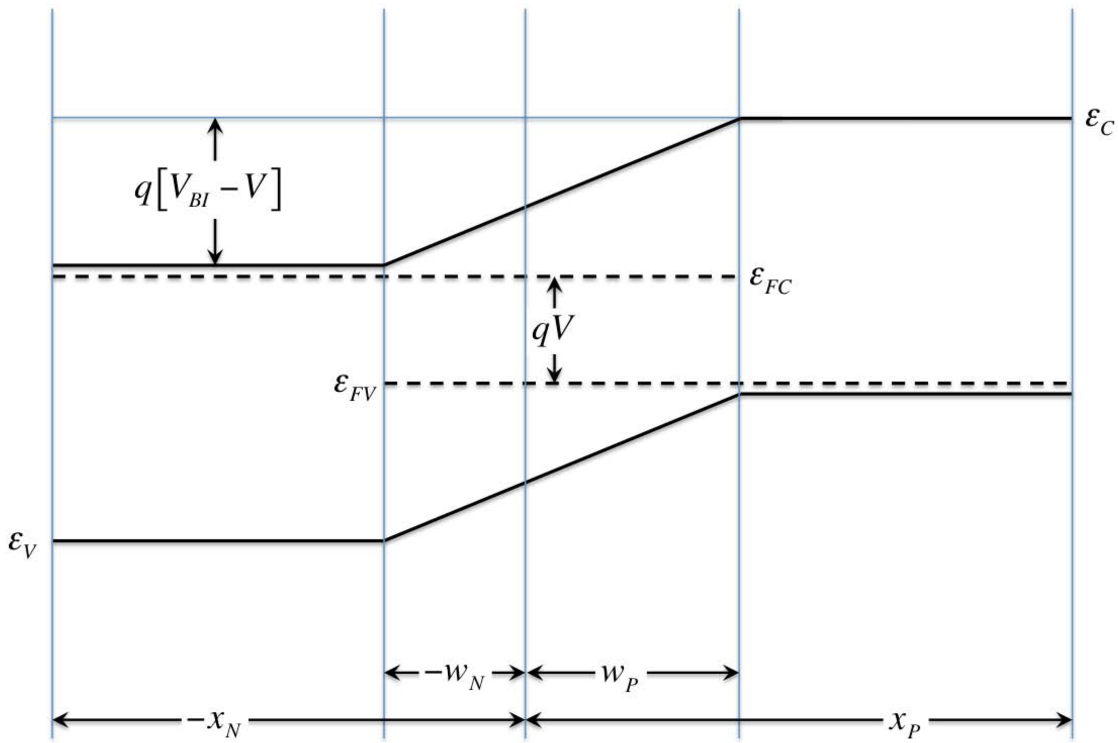
Please note: These should be done analytically.



Question #1

Current density and electric field in the quasi-neutral regions.

From the conditions of quasi-neutrality and surface recombination, show that the resulting electric field in the quasi-neutral regions is zero and, subsequently, that all current density in the quasi-neutral regions is diffusional in nature, given that the pn junction is operating in the low injection limit. Note: Current density at the surfaces of the quasi-neutral regions can be expressed as

$$\vec{J}_\nu(x = -x_N, x_P) = Q\Delta\nu(x)\vec{S}_\nu$$

where $Q = \pm q$ and $\nu = p, n$ for holes and electrons, respectively.

Question #2

a. Given the pn junction energy band diagram above, show that anywhere within the space-charge region, the following condition holds

$$np = {n_i}^2 exp(\beta qV)$$

b. From the above expression, show that at $x = -w_N$, the minority charge carrier concentration is

$$p_N(-w_N) = \frac{{n_i}^2}{N_D} exp(\beta qV)$$

and likewise at $x = w_P$, the minority charge carrier concentration is

$$n_P(w_P) = \frac{{n_i}^2}{N_A} exp(\beta qV)$$

c. Show that the difference between biased and unbiased charge carrier concentrations at the space-charge region edges are

$$\Delta p_N(-w_N) = \frac{{n_i}^2}{N_D}[exp(\beta qV) - 1]$$

and

$$\Delta n_P(w_P) = \frac{{n_i}^2}{N_A}[exp(\beta qV) - 1]$$

respectively.

Question #3

a. Solve for the minority charge carrier concentrations in the quasi-neutral regions as a function of position under dark (i.e. non-illuminated) conditions.

b. Solve for the subsequent current density in the quasi-neutral regions as a function of position.