

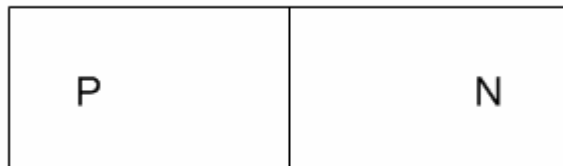
EECS 40/42/100, Spring 2007
Prof. Chang-Hasnain

Homework #11

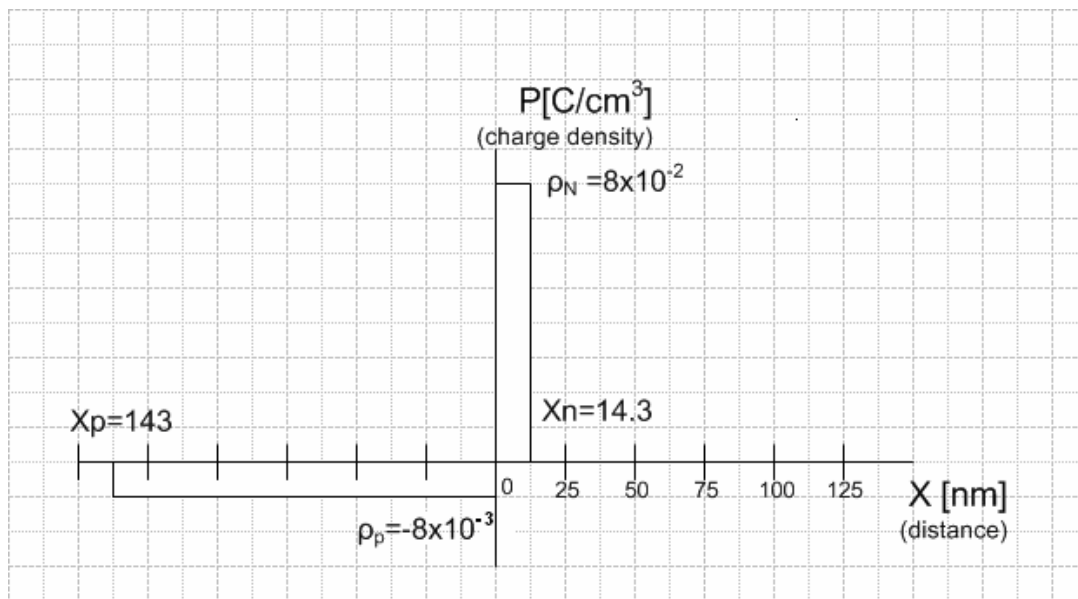
Due at 6 pm in 240 Cory on Wednesday, 04/25/07
Total Points: 100

- Put (1) your name and (2) **discussion section number** on your homework.
 - You need to put down all the derivation steps to obtain full credits of the problems. Numerical answers alone will at best receive low percentage partial credits.
 - No late submission will be accepted expect those with prior approval from Prof. Chang-Hasnain.
 - *Note: Power gain is defined as the ratio between power to a load and power from an input source.
1. **(10pts)** Consider a Ge material at T=300K. Calculate the concentrations of electrons and holes for $N_d=5 \times 10^{15} \text{ cm}^{-3}$, $N_a=0$
(For Ge, bandgap= 0.66eV, $N_c=1.04 \times 10^{19} \text{ cm}^{-3}$, $N_v=6 \times 10^{18} \text{ cm}^{-3}$)
Hint: refer to Sec. 3.1.3 of the course reading
 2. **(10pts)** Consider a uniformly doped GaAs PN junction at T=300K. At zero bias, 20% of the depletion region falls in the p-type semiconductor and 80% of the depletion region falls in the n-type semiconductor. The built-in potential barrier is $V_{bi}=1.2\text{V}$. For zero bias, determine (a) N_a (b) N_d (c) x_{n0} (d) x_{p0} (e) E_{max}
(n_i of GaAs= $1.8 \times 10^6 \text{ cm}^{-3}$, dielectric constant=13.1)
Hint: refer to Sec3.3 of the course reading
 3. **(EE40 only: 20pts)** This problem will explore the relationship between the charge density, electrical field, and voltage potential in the depletion region.
Hint: Course reading Sec. 3.3
 - a) What is the *approximation* in the Depletion Approximation? (4pts)

b) Give the following PN Junction, sketch the depletion region and label the charges seen in each region. (4pts)



c) The charge profile in the PN Junction is shown below.



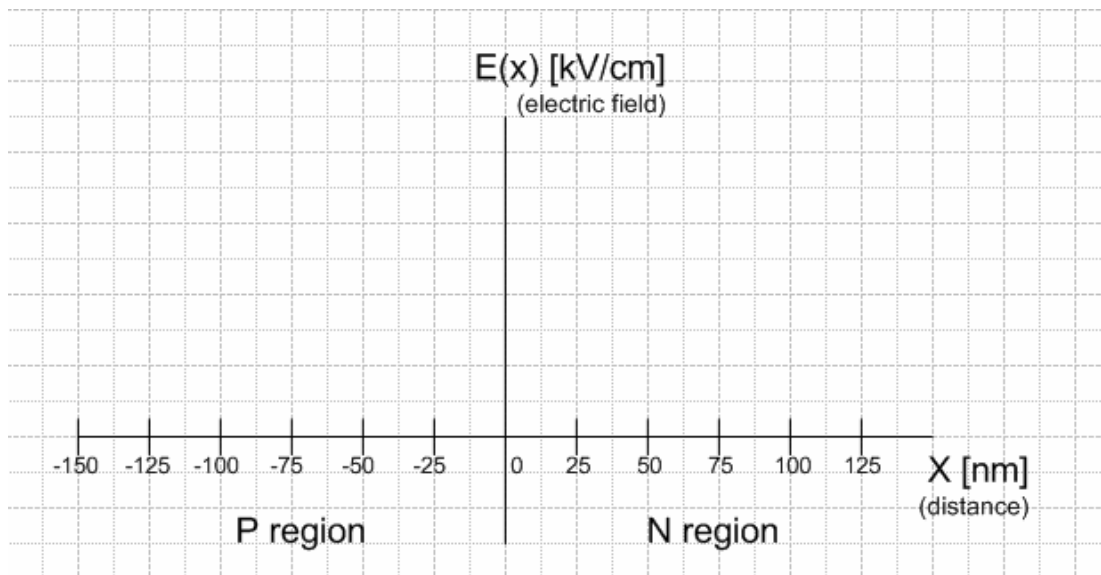
Given this charge profile, use Gauss Law to find and sketch the Electric Field within the depletion region as a function of x , where $x = 0$ represents the origin of the x -axis. X_n and X_p represent the width of the depletion region in the P and N

regions, respectively. P_n and P_p represents the charge density of the depletion region in the P and N regions, respectively. Remember that the Electric Field outside of the depletion region is 0. (4pts)

Note:

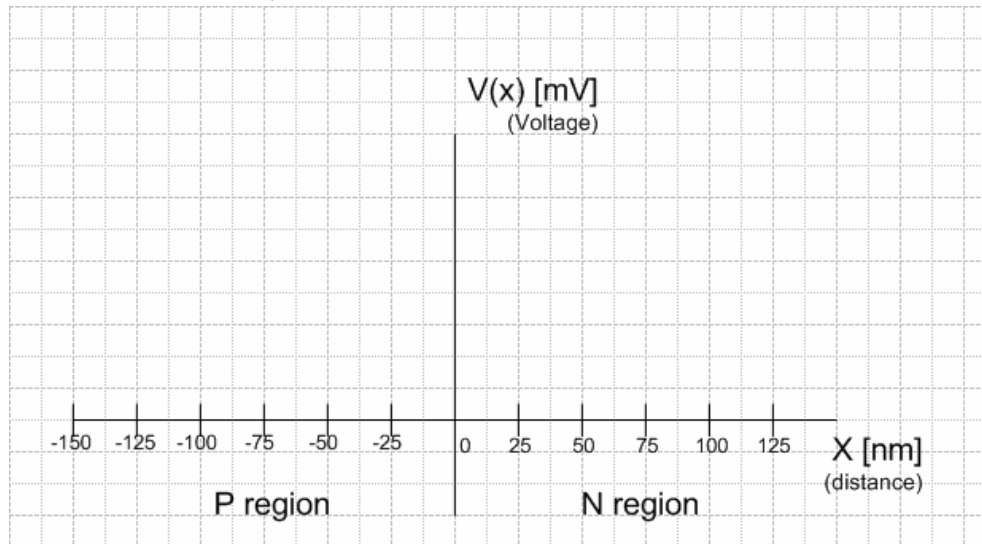
Gauss Law:

$$\frac{dE}{dx} = \frac{P(x)}{\epsilon}, \text{ where } P(x) \text{ is the charge density and } \epsilon \text{ is } 11.7 \times 8.85 \times 10^{-14} \text{ F/cm.}$$



- d) Having solved for the electric field $E(x)$, why is the depletion region in the P region much wider than that in the N region of the PN Junction? (4pts)
- e) Given the Electric Field found above, find the Voltage across the depletion region in terms of x . Assume $V_0 @ -150\text{nm} = 0\text{V}$ (4pts)

Note: $V(x) = V_0 + \int_0^x -E(x)dx$



4. **(10pts)** Hambley, P7.5
5. **(10pts)** Hambley, P7.12
6. **(10pts)** Hambley, P7.23
7. **(10pts)** Hambley, P7.26
8. **(10pts)** Hambley, P7.29
9. **(10pts)** Hambley, P7.43