Name: ___________________________________

SAMPLE EXAM #1

*Closed book, closed notes. Calculators may be used for numeric computations only. All work is to be your own **- show your work** for maximum partial credit.*

Fundamental Constants

$k = 1.38 \times 10^{-23}$ J/K

$\mathrm{q} = 1.60 \times 10^{-19}$ C

$K = 273 + °C$

$V_T = \dfrac{kT}{q}$

Semiconductor constants for Si

$E_g = 1.12 eV$

$n_i(T = 300K) = 1.5 \times 10^{10} cm^{-3}$

PN junction Equations

$V_{bi} = V_T \ln\left(\dfrac{N_A N_D}{n_i^2}\right)$

$N_A x_p = N_D x_n$

$i_D = I_S\left(\mathrm{e}^{\frac{V_D}{V_T}} - 1\right) \; A$

Carrier Transport Equations

$J_{n,drift} = qn\mu_n \mathrm{E}$

$J_{p,drift} = qp\mu_p \mathrm{E}$

$J_{n,diff} = qD_n \dfrac{dn}{dx}$

$J_{p,diff} = -qD_p \dfrac{dp}{dx}$

$D = \mu V_T$

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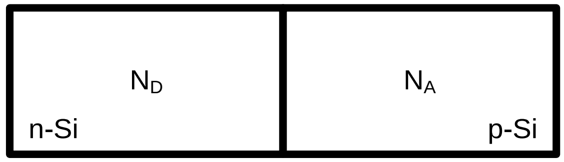
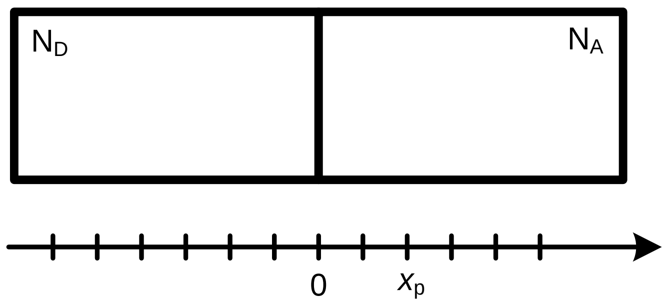
1. (20 points) A **pn** junction is created as shown below with $N_A=10^{16}$ cm^{-3} and $N_D=10^{18}$ cm^{-3}. Assuming equilibrium conditions, find the majority and minority carrier concentrations in the n and p regions.



2. (20 points) A diode is formed from a **pn** junction, where the p-type material is doped **twice as heavily** as the n-type material. In general, the depletion region width is given by

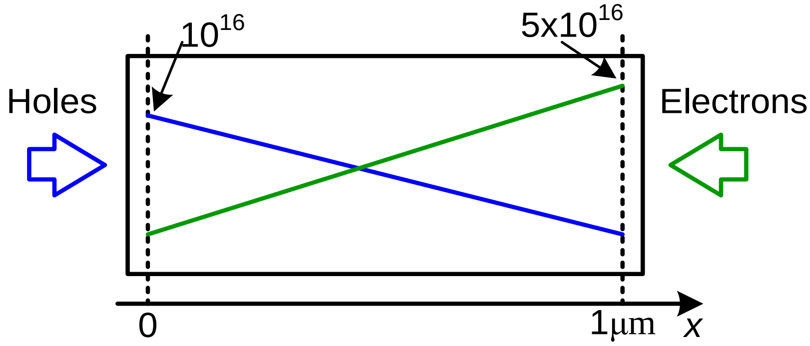
$$w_{d0} = x_n + x_p = \sqrt{\frac{2\varepsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)V_{bi}}$$

(a) If the width of the depletion region in the p-type material (x_p) is as shown below, indicate what the width of the depletion region in the n-type material (x_n) is.



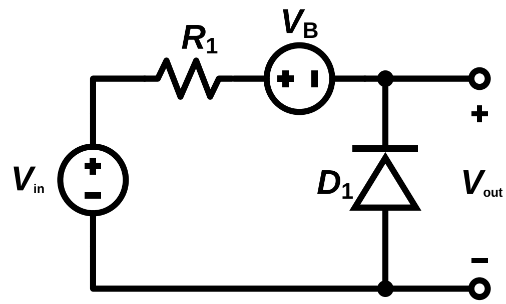
(b) When designing a Zener diode device, a narrow depletion region is required. How can this be achieved?

3. (30 points) A p-type bar of silicon is subjected to carrier injection as shown in the figure below. Determine the total current flowing through the device if the cross section area is 1μm^2.



Use: D_n=30 cm^2/s and D_p= 10 cm^2/s
L_n=2μm and L_p=3μm

4. (30 points) Plot input/output characteristics for the circuit shown below using:
(a) Ideal diode model ($V_{D,on}$=0V)
(b) Constant diode voltage model ($V_{D,on}$=0.8V)
Assume V_B=2V.



(c) In part (a), the input is given by $V_{in}(t)=V_p\sin(\omega t)$, where V_p=5V and $\omega=2\pi\cdot 60$ rad/s. Plot input and output waveforms, $V_{in}(t)$ and $V_{out}(t)$ respectively.