ENGR338 HW 6 Diodes

1. Explain what are n_i, n_n, n_p, p_n, p_p, N_A, *and* N_D. (10 points)

2. Consider an n-type silicon for which the dopant concentration N_D=10^17/cm^3. Find the electron and the hole concentration at T=300K (room temperature). Show the calculation process for the credit. (10 points)

3. Find the resistivity of (a) intrinsic silicon and (b) *n*-type silicon with $N_D=10^{15}$/cm^3. Use n_i=1.5x10^{10}/cm^3, and assume that for intrinsic silicon μ_n=1350 cm^2/V s and μ_p=480 cm^2/V s, and for the doped silicon μ_n=1000 cm^2/V s and μ_p=400 cm^2/V s. (q=1.6x10^{-19} C). (10 points)

4. Draw the pn junction and explain: (30 points)

1) Without an external voltage, the formation of a depletion region, and the formation of the diffusion current and the drift current.

2) With an external voltage, explain the changes of the width of the depletion region under 'forward bias' and 'reverse bias' operations.

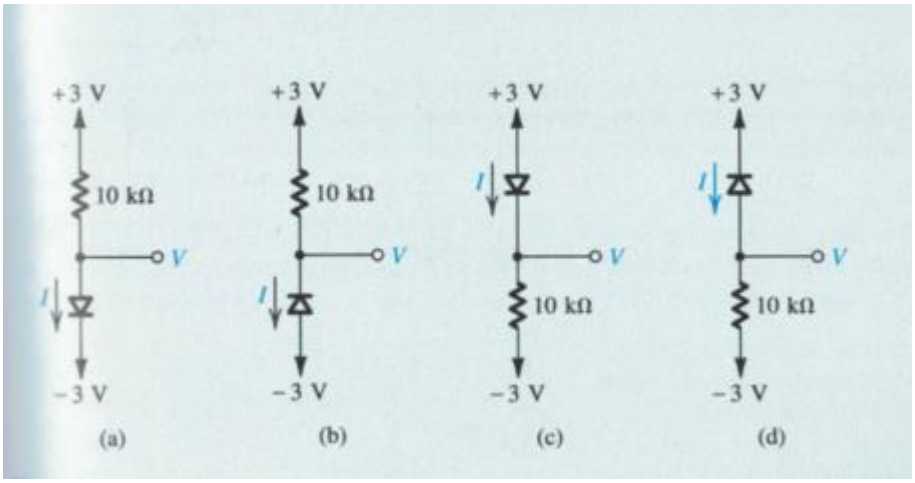
3) Explain how the depletion region will be changed, and how the diode capacitance will be changed with an increasing voltage under both 'forward bias' and 'reverse bias' operations?

4) If a pn junction is reverse biased, is I_D larger or I_s larger? What if it is forward biased?

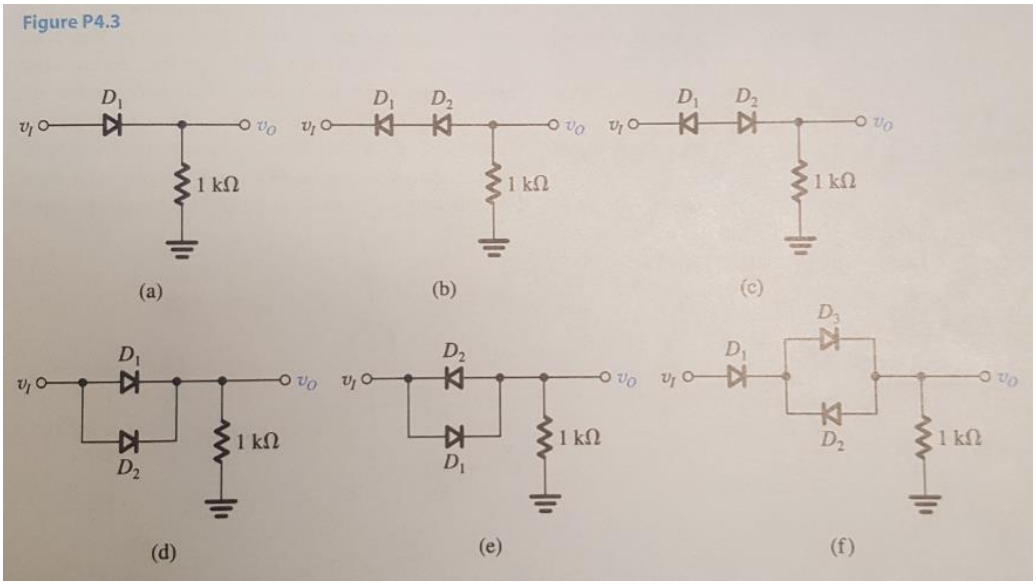
5) Hand-draw the I-V curve of a real diode (with a 0.7 built-in voltage and no reverse breakdown) and the IV curve of an ideal diode.

6) Hand-draw the IV curve of a real Zener diode (with a 0.7 built-in voltage and a -Vz) and the IV curve of an ideal Zener diode.

5 Ideal diodes (no built-in voltages and no reverse breakdown) find the values of the voltages and currents indicated in the following figure. (10 points)



6. In the following figure, Vi is a 1kHz 5-V peak-peak sine wave (centered at 0V), sketch the waveform of Vo and label the peak values. (ideal diodes, no built-in voltages and no reverse breakdown). (10 points)



7. The following circuit is being used for ESD (Electrostatic discharge) protection in ICs. The SPICE code is to simulate the accidental high voltage discharge from the input (Vin). Depends on

Vin, draw the Vout of this circuit. (assume 10V is the safe voltage for the digital circuit. You don't need to run this in LTSpice, just hand draw it). (the diodes are real diodes with a 0.7 built-in voltage and no reverse breakdown). (20 points)