UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE 105 Prof. Pister
Spring 2011

Homework Assignment #2 (corrected)

Due in the 105 box on the 2nd floor of Cory, 5pm Friday 1/28/2010

1. Integrated circuits are typically required to operate over a temperature range from -40C to +85C, or in Kelvin, 273-40=233 to 273+85=358. For convenience, people often call 27C = 300K "room temp", even though that's a pretty warm room (20—25C is more typical). Calculate the value of k_BT at -40, room temp, and 85 centigrade. All of your answers should be to two significant digits. k_B = 8.62e-5 eV/K
2. Calculate the intrinsic carrier concentration, n_i, of silicon at -40, room temp, and 85 centigrade. One significant digit. Use E_g = 1.1 eV
3. For a silicon sample doped with N_D=1e16 phosphorous atoms/cc, calculate the minority carrier concentration at -40, room temp, and +85. 1 significant figure.
4. What is the resistance of an n-type bar of silicon 10 um long and 1 um square in cross section? Assume a doping level from the previous problem, and an electron mobility of 800 cm^2/Vs.
5. Does the resistance of the bar depend much on temperature? What if it were an undoped piece of silicon?
6. At room temperature, you run 1mA through a diode and measure a voltage drop of 0.6V. If you increase the current to 2.717 mA, how will the voltage drop change? Use 2 significant digits. If you do the same experiment at -40C and +85C, how will the voltage change? Do your answers have anything to do with your answer to problem 1?
7. Same as question 6, but you increase the current to 10mA.
8. You have a silicon diode with an n-type doping of 1e18/cc and a p-type doping of 1e16/cc. Calculate the built-in potential at room temp, V_0, the width of the depletion region in both the n and p sides, x_{n0} and x_{p0}, and the zero-bias junction capacitance per unit area, C_{j0}. All quantities to two significant digits.

9. Short answer questions. Use one or two sentences and/or formulas to explain your answer.

a) Silicon has 14 electrons per atom. Why don't we include them when we calculate drift currents, conductivity, etc.?

b) In an unbiased PN junction, there is a huge gradient in the carrier concentration on each side of the junction. Why doesn't that lead to a huge diffusion current?

c) Which of these contributes primarily to the reverse bias current in a diode: n_n, n_p, p_n, p_p ?

d) Your friend from Stanford tells you that he has made a diode that obeys the exact same equations that you just learned, but works with forward bias up to 2V. He says that his diode conducts a current of 1mA at 700mV. Estimate the current in the diode at a forward bias of 1V, 1.5V, and 2V. Try to make your estimates without using a calculator.