March 14, 2001 - Quiz #1

problem	grade
1	
2	
3	
4	
5	
6	
total	

Name: _____

Recitation: _____

General guidelines (please read carefully before starting):

- Make sure to write your name on the space designated above.
- **Open book**: you can use any material you wish.
- All answers should be given in the space provided. Please do not turn in any extra material. If you need more space, use the back page.
- You have **120 minutes** to complete your quiz.
- Make reasonable approximations and *state them*, i.e. quasi-neutrality, depletion approximation, etc.
- Partial credit will be given for setting up problems without calculations. NO credit will be given for answers without reasons.
- Use the symbols utilized in class for the various physical parameters, i.e. μ_n, I_D, E, etc.
- Every numerical answer must have the proper units next to it. Points will be subtracted for answers without units or with wrong units.
- Use $\phi = 0$ at $n_o = p_o = n_i$ as potential reference.
- Use the following fundamental constants and physical parameters for silicon and silicon dioxide at room temperature:

$$n_i = 1 \times 10^{10}\ cm^{-3}$$
$$kT/q = 0.025\ V$$
$$q = 1.60 \times 10^{-19}\ C$$
$$\epsilon_s = 1.05 \times 10^{-12}\ F/cm$$
$$\epsilon_{ox} = 3.45 \times 10^{-13}\ F/cm$$

1. *(10 points)* Compute the equilibrium electron and hole concentrations, n_o and p_o, for silicon at room temperature doped with:

(1a) *(2 points)* Boron (B) concentration $= 10^{17}\ cm^{-3}$.

(1b) *(2 points)* Phosphorus (P) concentration $= 5 \times 10^{16}\ cm^{-3}$ and Antimony (Sb) concentration $= 5 \times 10^{16}\ cm^{-3}$.

(1c) *(2 points)* Arsenic (As) concentration $= 10^{17}\ cm^{-3}$ and Boron (B) concentration $= 10^{16}\ cm^{-3}$.

(1d) *(4 points)* In (1a) above, what is the magnitude of the electric field that must be applied to the sample for the magnitude of the majority carrier drift velocity to be equal to $10^6\ cm/s$?

2. *(10 points)* An engineer is told that a region of silicon of length 20 μm, width 5 μm and thickness 1 μm is uniformly doped with a single kind of dopant with a concentration of 10^{20} cm^{-3}. Ohmic contacts are formed at the ends of the region and she measures the I-V characteristics given in the table below. Is the sample n-type or p-type? Explain how you reach this conclusion. *[Hint: think about the sample resistance.]*

voltage (V)	current (A)
0	0
1	0.025
2	0.05