NAME:________________________________ **PUID: :**________________________________

ECE 305 Exam 2: Spring 2015
February 13, 2015

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This is a closed book exam. You may use a calculator and the formula sheet at the end of this exam. Following the ECE policy, the calculator **must** be a Texas Instruments TI-30X IIS scientific calculator.

There are three equally weighted questions. To receive full credit, you must **show your work** (scratch paper is attached).

The exam is designed to be taken in 50 minutes.

Be sure to fill in your name and Purdue student ID at the top of the page.

DO NOT open the exam until told to do so, and stop working immediately when time is called.

The last page is an equation sheet, which you may remove, if you want.

75 points possible, 10 per question

1) 25 points (5 point per part)

2) 25 points (5 points per part)

3) 25 points (5 points per part)

------------------------ Course policy ------------------------

I understand that if I am caught cheating in this course, I will earn an F for the course and be reported to the Dean of Students.

Read and understood: ____________________________________
signature

Answer the **five multiple choice questions** below by **drawing a circle** around the **one, best answer**.

1a) Consider holes diffusing down a concentration gradient. What force pushes them down?

a) $+q\mathcal{E}$

b) $-q\mathcal{E}$

c) $+D_p \, dp/dx$

d) $-D_p \, dp/dx$

e) none of the above

1b) For a semiconductor in equilibrium at very low temperatures, what is the most important scattering mechanism?

a) Lattice scattering.

b) Ionized impurity scattering.

c) Auger scattering.

d) Impact ionization scattering.

e) Polar optical phonon scattering.

1c) Which of the following is a statement of "low-level injection" in a p-type semiconductor?

a) $N_D << N_A$.

b) $N_A << N_D$.

c) $p_0 << N_A$.

d) $\Delta n << N_A$.

e) $\Delta p << n_i$.

1d) To write the steady-state, minority carrier diffusion equation for a p-type semiconductor of length, *W*, as $d^2 \Delta n_p / dx^2 = 0$, which one of the following must be true of the diffusion length, L_n?

a) $L_n << W$.

b) $L_n >> W$.

c) $L_n = W$.

d) $L_n << L_p$.

e) There is no restriction on L_n.

1e) If the quasi-Fermi level splitting is $F_n - F_p = 10k_BT$, then what is np?

a) $10n_i^2$

b) $\ln(10)n_i^2$

c) $e^{10}n_i^2$

d) n_i^2

e) $\sqrt{10}n_i^2$

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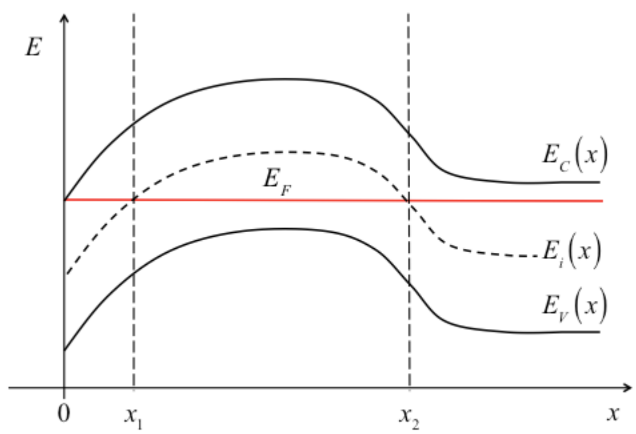
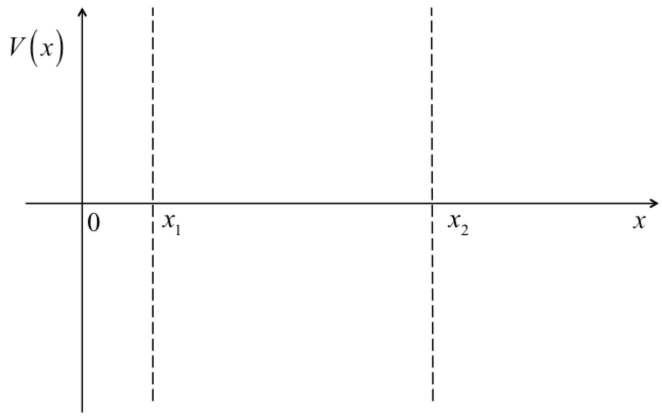
2) This problem concerns the energy band diagram shown below. Answer each of the questions that follow.



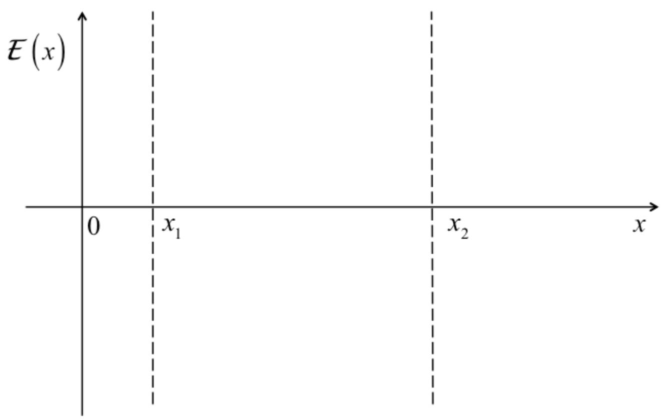
2a) Assume that the semiconductor is Si at room temperature. Determine the electron density at $x = 0$ (a numerical answer is required).

2b) Assume that the semiconductor is Si at room temperature. Determine the electron density at $x = x_1$ (a numerical answer is required).

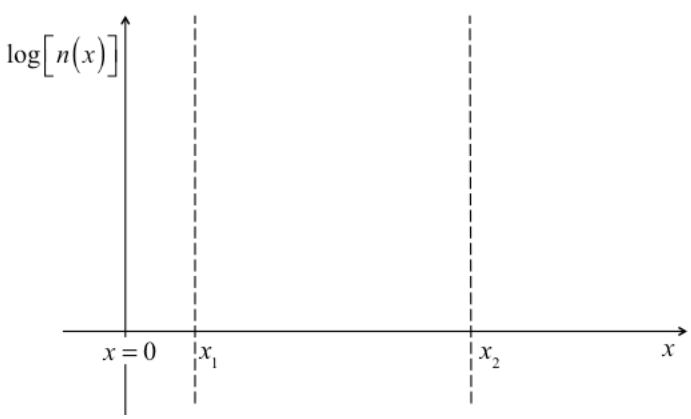
2c) Sketch the electrostatic potential vs. position. Assume that $V = 0$ for $x >> x_2$. Make your sketch as accurate as possible without putting numbers on the vertical axis.



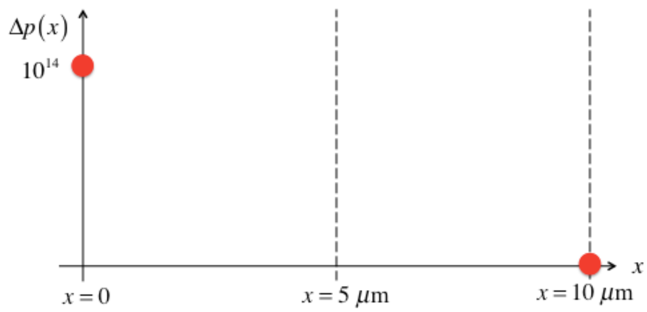
2d) Sketch the electric field vs. position. Make your sketch as accurate as possible without putting numbers on the vertical axis.



2e) Sketch the electron density, $\log[n(x)]$ vs. position. Make your sketch as accurate as possible without putting numbers on the vertical axis.



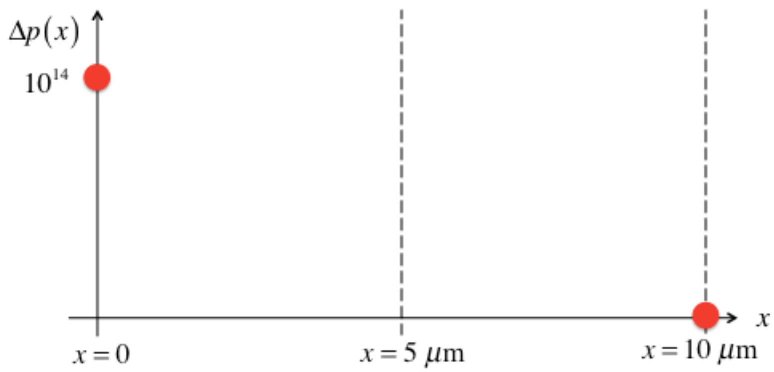
3) This problem concerns an n-type semiconductor at room temperature, in steady-state and low level injection with no optical generation. The hole mobility is $\mu_p = 500\ \mathrm{cm^2/V\text{-}s}$ for $0 \le x \le 5\ \mu\mathrm{m}$ and $\mu_p = 50\ \mathrm{cm^2/V\text{-}s}$ for $5 \le x \le 10\ \mu\mathrm{m}$. The minority hole lifetime is $\tau_p = 10^{-4}\ \mathrm{s}$. The excess hole densities at left and right ends in the figure below are $\Delta p(x=0) = 10^{14}\ \mathrm{cm^{-3}}$ and $\Delta p(x = 10\ \mu\mathrm{m}) = 0$. Answer the following questions.



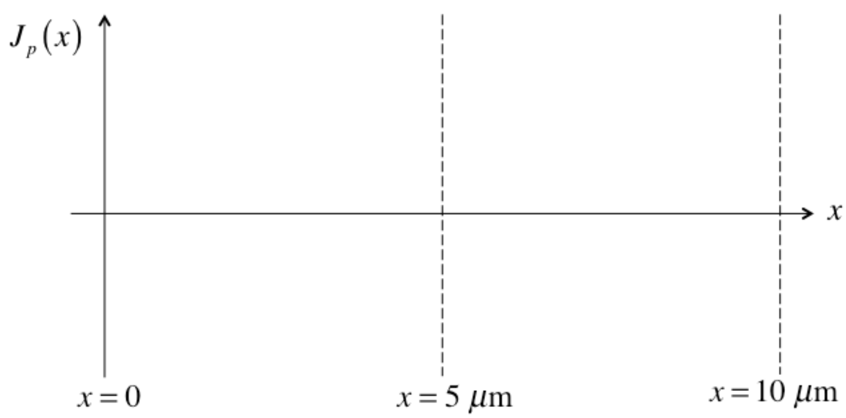
3a) Simplify the general minority carrier diffusion equation for $0 \le x \le 5\ \mu\mathrm{m}$. You must show your work and explain how you get your answer. Draw a box around your answer. **You do not need to solve the equation.**

3b) Simplify the general minority carrier diffusion equation for $5 \le x \le 10\ \mu\mathrm{m}$. You must show your work and explain how you get your answer. Draw a box around your answer. **You do not need to solve the equation.**

3c) Sketch and **explain** the solution for $0 \le x \le 10\ \mu\text{m}$.



3d) Sketch and **explain** the diffusion current, $J_p = -qD_p\, dp/dx$ vs. position.



3e) Solve for $\Delta p(x = 5\ \mu\text{m})$.