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

EE 130/230M — Spring 2013
Integrated Circuit Devices — Prof. Liu & Dr. Xu

QUIZ #3
Time allotted: 25 minutes

NAME: _____ _____ _____
(print) Last First Signature

STUDENT ID#: _____

1. **Use the values of physical constants provided below.**
2. **SHOW YOUR WORK, and write legibly!**
3. **Underline or box numerical answers, and specify units where appropriate.**

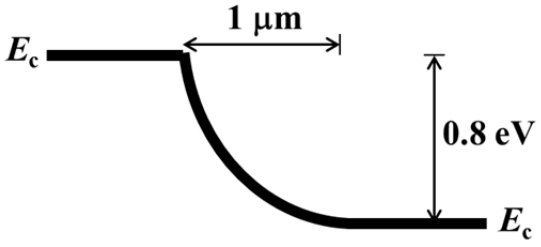
Physical Constants

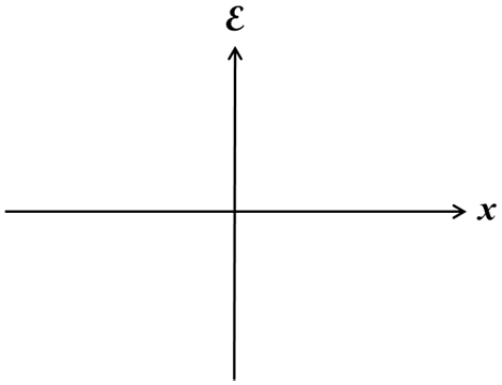
Description	Symbol	Value
Electronic charge	q	1.6×10^{-19} C
Thermal voltage at 300K	kT/q	0.026 V

Properties of silicon (Si) at 300K

Description	Symbol	Value
Energy band gap	E_G	1.12 eV
Intrinsic carrier concentration	n_i	10^{10} cm^{-3}
Permittivity	ε_{Si}	1.0×10^{-12} F/cm

Problem 1 [13 points]
The conduction band edge (E_c) profile for a Si pn step junction in equilibrium at T = 300K is shown below.





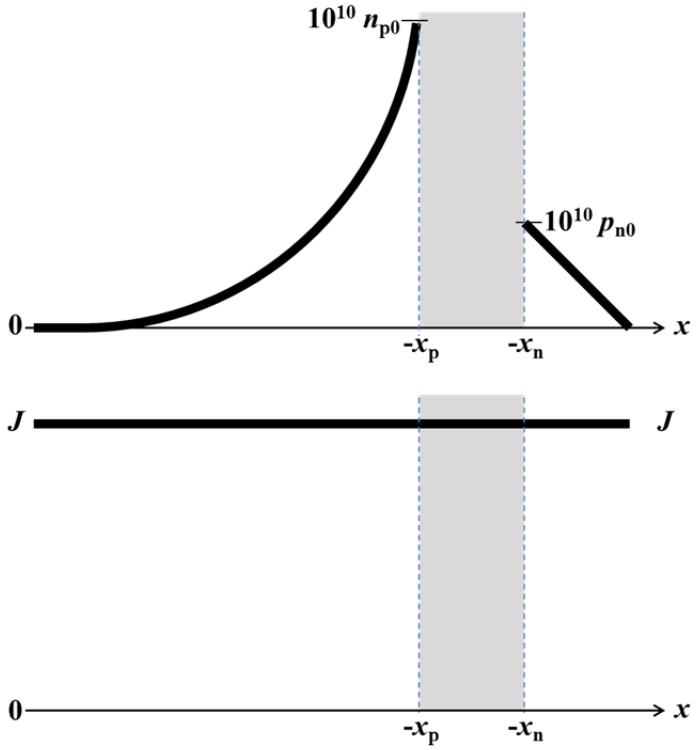
a) Which side is more heavily doped? Justify your answer. [2 pts]

b) What is the dopant concentration on the more lightly doped side of the pn junction? [4 pts]

c) Sketch the electric field ($\mathcal{E}$-field) distribution on the axes provided above. Indicate the peak value. [4 pts]

d) Qualitatively show how the band edge profile and $\mathcal{E}$-field distribution change under forward bias. [3 pts]

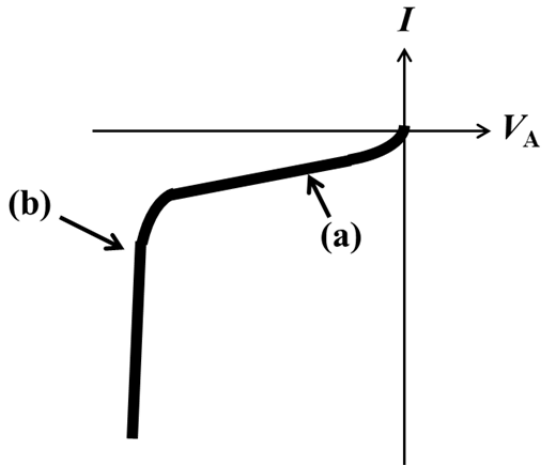
Problem 2 [7 points]
The excess minority carrier concentrations within the quasi-neutral regions of a Si pn step junction maintained at T = 300K are plotted on a linear scale below:



a) What is the magnitude of the applied bias voltage, V_A? [3 pts]
$(kT/q)\cdot ln(10) = 0.06$ V

b) Sketch the hole and electron current density components (J_P and J_N) on the plot provided above. [4 pts]

Problem 3 [5 points]
The reverse-bias I-V characteristic of a non-degenerately doped pn junction diode maintained at T = 300K is shown below. Indicate the causes of the indicated non-ideal behaviors below:



(a) _____ [2 pts]

_____

_____

(b) _____ [1 pt]

_____

_____

(c) Show how the characteristic would change if the temperature were to be increased. [2 pts]