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 #2
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

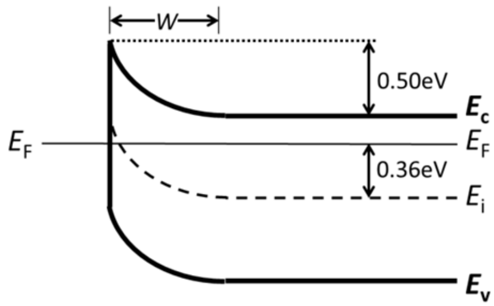
Description	**Symbol**	**Value**
Electronic charge	q	1.6×10^{-19} C
Thermal voltage at 300K	kT/q	0.026 V

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 [11 points]

The equilibrium energy band diagram for a rectifying metal-Si contact is shown below. T = 300K.



a) What is the value of the Schottky barrier height, Φ_B? **Indicate it on the band diagram above.** [3 pts]

b) What is the width of the depleted region, W? [4 pts]

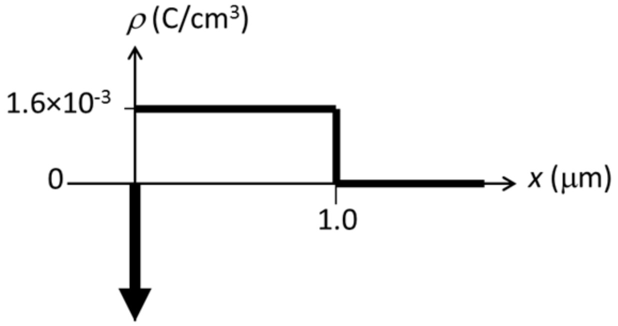
$$\sqrt{\frac{10}{1.6}} = 2.5$$

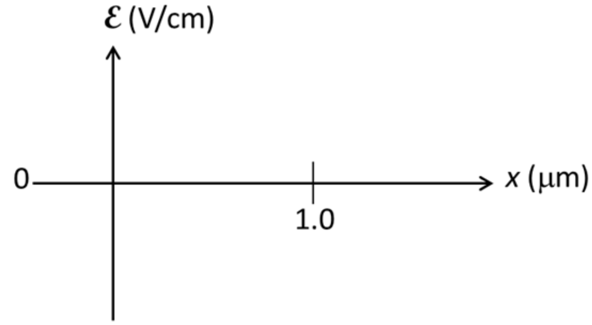
$$\sqrt{\frac{1}{1.6}} = 0.8$$

d) Carefully sketch E_v **corresponding to a reverse bias of 0.25 V** on the band diagram above. [2 pts]

e) Explain how this contact can be made to be practically ohmic. [2 pts]

Problem 2 [8 points]
Consider the following charge density distribution for a Schottky diode under reverse bias:

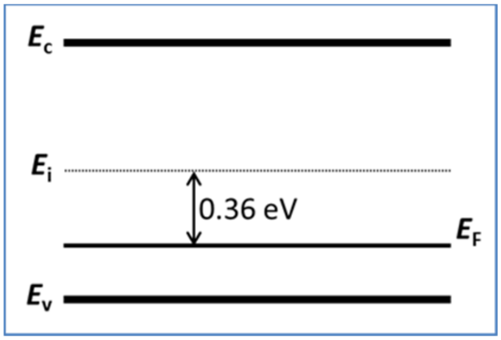




a) Sketch the electric field distribution on the axes provided. Indicate the numerical value of $\mathcal{E}$ at $x = 0$. [5 pts] (Note that Coulomb = Farad × Volt)

b) If the cross-sectional area of this diode is 1 mm × 1 mm, what is its small-signal capacitance? [3 pts]

Problem 3 [6 points]
The equilibrium energy band diagram for a uniformly doped Si sample with minority-carrier lifetime $\tau_n = 10^{-6}$ s is shown below. Suppose this sample is illuminated uniformly with light beginning at time $t = 0$, generating electron-hole pairs at a rate $G_L = 10^{19}/cm^3/s$ throughout the sample, so that the excess carrier concentration increases with time as shown below.



a) Indicate the final positions of the electron and hole quasi-Fermi levels (F_N and F_P, respectively) in this sample (*i.e.* at $t = \infty$). [4 pts] $kT\, ln(10) = 0.06$ eV

b) Indicate on the plot above how $\Delta p_n(t)$ would change if G_L were to be increased. [2 pts]