Spring 2012 EE 331 Exam 1 Version A

Name:_____ Student Number:_____

Useful units and constants

Definition of electron volt: 1 eV = 1.6×10^{-19} J

Electronic charge: $q = 1.6 \times 10^{-19}$ C

Boltzmann constant: $k = 8.62 \times 10^{-5}$ eV/K = 1.38×10^{-23} J/K

Thermal voltage at room temperature: $kT / q = 0.0259$ V

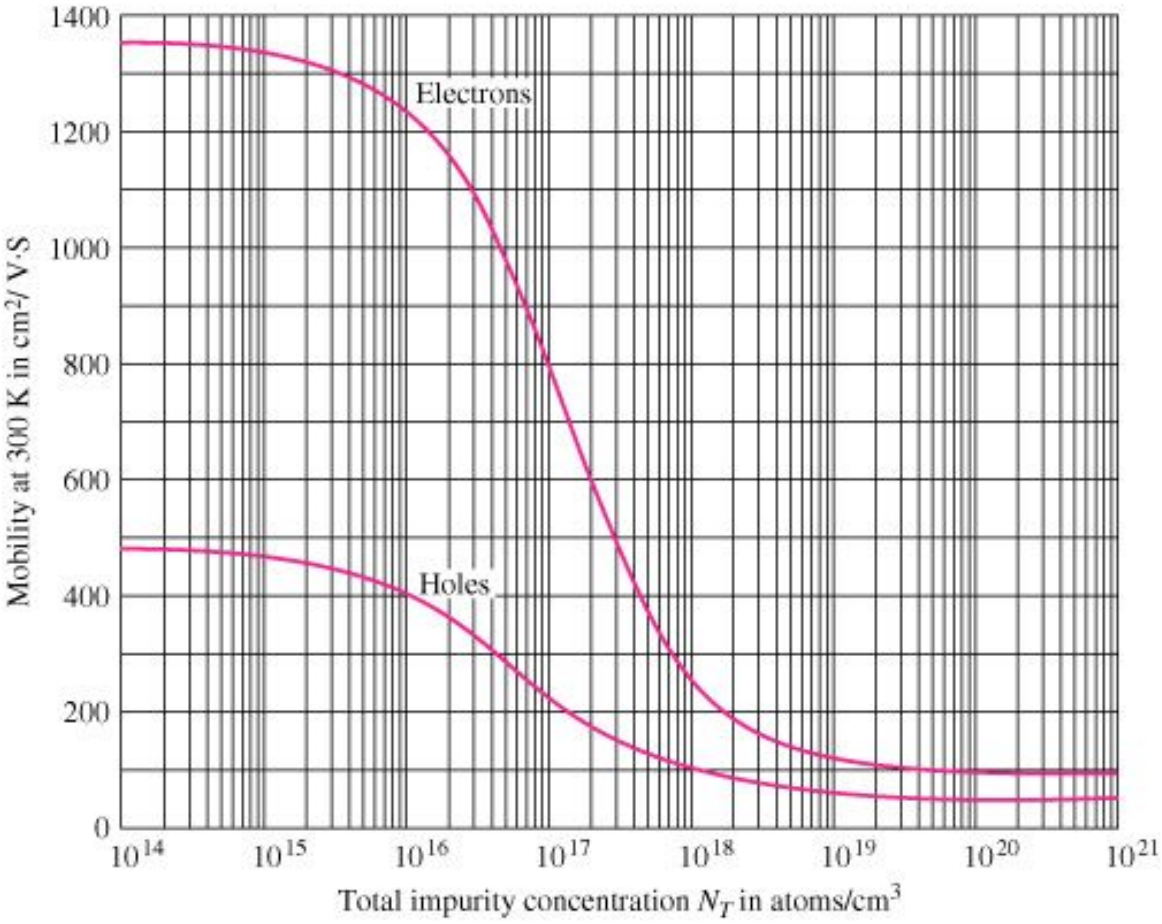
Relative permittivity of silicon: $\varepsilon_r = 11.7$

Permittivity of free space: $\varepsilon_0 = 8.854 \times 10^{-14}$ F/cm

Silicon intrinsic carrier density at room temperature: $n_i = 10^{10}/\text{cm}^3$

Band gap for silicon: $E_G = 1.12$ eV

Carrier density constant for silicon: $B = 2.23 \times 10^{31}$ $\text{K}^{-3}\text{cm}^{-6}$



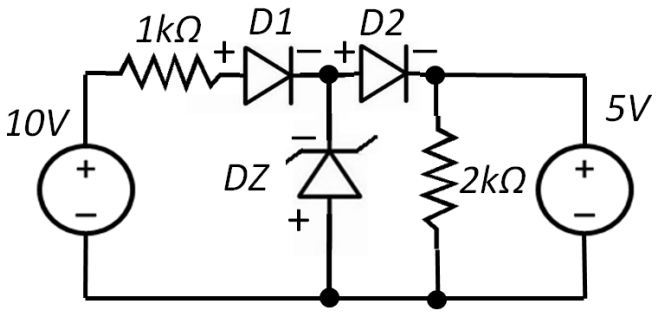
1. A silicon pn junction has uniform doping concentrations of $N_A = 2\times10^{18}/cm^3$ and $N_D = 10^{16}/cm^3$ on the two sides of the junction, respectively. The widths of the undepleted regions are W_p'=100 nm and W_n'=500 μm. The minority carrier lifetimes are $\tau n_p = 0.1$ μs and $\tau p_n = 2$ μs The diode has a cross sectional area of 20 μm×100 μm. (40)

a) Is the n side of the device short base or long base?
b) Calculate the reverse leakage current I_S (you can assume p-side is short base).
c) What is the resistance of the undepleted n-region?
d) If a current of 1 mA was passed through this diode, what would be the voltage measured (including neutral n-region)?

2. In the circuit below, use the constant voltage diode model for D1 and D2 with a threshold (turn-on) voltage of 0.70 V. The reverse breakdown voltage of the Zener diode (DZ) is -5V and the series resistance is 250 Ω. (30)

a) Assume that D1 is on, D2 is off and DZ is in reverse breakdown. Calculate the voltage across and current through each diode.

b) Check the each of the assumptions made in (a). Which mode is each diode actually in (on, off, breakdown)?



3. For the power supply circuit shown below, the rms value of v_S is 10 V, the operating frequency is 50 Hz, C = 2000 μF, and the on-voltage of the diode is 0.70 V. The load sinks up to 5 mA. State your assumptions clearly and check them if possible. (40)

(a) What is the dc output voltage V_O if the ripple voltage is small?

(b) What is the maximum value of the ripple voltage at V_O ?

(c) What is the minimum PIV rating for the diode?

(d) What is the maximum current through the diode during start-up transient ($v_C = 0$)?