ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FIRST SEMESTER EXAMINATION, 2017/2018 ACADEMIC SESSION

COURSE TITLE: PHYSICAL ELECTRONICS

COURSE CODE: EEE 319

EXAMINATION DATE: 27TH MARCH, 2018

COURSE LECTURER: DR. A.M. JUBRIL

HOD's SIGNATURE

TIME ALLOWED: 3 HOURS

INSTRUCTIONS:

1. ANSWER FOUR QUESTIONS ONLY
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE **NOT** ALLOWED TO BORROW ANY WRITING MATERIALS DURING THE EXAMINATION.

Question One (25 marks)

(a) Consider a metal with an FCC structure and an atomic weight of 92.9. When monochromatic x-radiation having a wavelength of 0.1028 nm is focused on the crystal, the angle of diffraction (2θ) for the (311) set of planes in this metal occurs at 71.2 degrees (for the first order reflection n=1).

- (i) Calculate the interplanar spacing for this set of planes.
- (ii) Calculate the lattice parameter for this metal.
- (iii) Calculate the density of the metal (units of g/cm3)

(b) For a bcc lattice of identical atoms with a lattice constant of 5 Å, calculate the maximum packing fraction and the radius of the atoms treated as hard spheres with the nearest neighbors touching.

(c) Label the planes illustrated in Figures 1a and 1b.

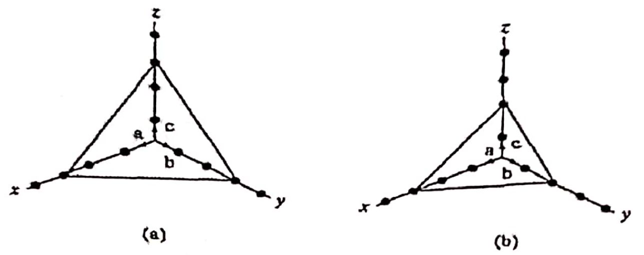

Figure 1

Question Two (25 marks)

(a) A Si sample is doped with 10^{17} As atoms/cm³. What is the equilibrium hole concentration P_o at 300 K? Where is E_F relative to E_i? Sketch the resulting band diagram.

(b) Consider a semiconductor bar in Figure 2 with $w = 0.1$ mm, $t = 10$ µm, and $L = 5$ mm. For $\mathfrak{B}$= 10 kg in the direction shown (1 kG = 10^{-5} Wb/cm²) and a current of 1 mA, if $V_{AB} = -2$ mV, V_{CD}= 100 mV and $\mathfrak{B}_z = 10^{-4}$ Wb/cm². Find the type, concentration, and mobility of the majority carrier.

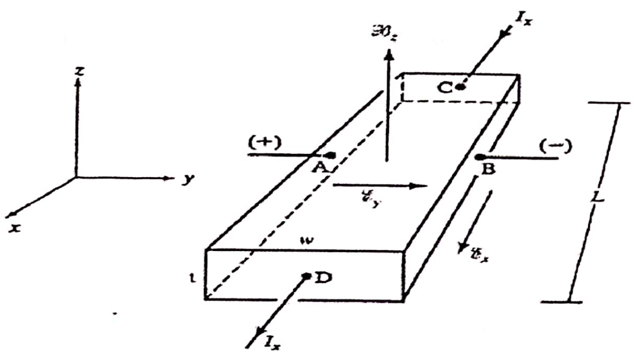

Figure 2

Question Three (25 marks)

(a) An unknown semiconductor has E_g = 1.1 eV and N_c = N_v. It is doped with 10^{15} cm^{-3} donors, where the donor level is 0.2 eV below *Ec*. Given that is E_F is 0.25 eV below E_c, calculate n_i and the concentration of electrons and holes in the semiconductor at 300 K.

(b) Show that the minimum conductivity of a semiconductor sample occurs when $n_o = n_i\sqrt{\frac{\mu_p}{\mu_n}}$. *Hint*, begin with $J_x = q(n\mu_n + p\mu_p)\mathcal{E}_x = \sigma\mathcal{E}_x$ and apply $n_o p_o = n_i^2$. What is the expression for the minimum conductivity σ_{min}? .Calculate σ_{min} for Si at 300 K and compare with the intrinsic conductivity.

Question Four (25 marks)

(a) In a very long p-type Si bar with cross-sectional area = 0.5 cm^2 and N_a =10^{17} cm^{-3}, holes are injected such that the steady state *excess* hole concentration is 5 x 10^{16} cm^{-3} at x = 0. What is the steady state separation between F_p and E_c at x = 1000 Å? What is the hole current there? How much is the excess stored hole charge? Assume that μ_p= 500 cm^2/V-s and τ_p = 10^{-10}s.

(b) In an n-type semiconductor bar, there is an increase in electron concentration from left to right and an electric field pointing to the left. With a suitable sketch, indicate the directions of the electron drift and diffusion current flow and explain why. If the electron concentration is doubled everywhere, what happens to the diffusion current and the drift current? If a constant concentration of electrons is added everywhere, what happens to the drift and diffusion currents? Explain your answers with appropriate equations.

Question Five (25 marks)

(a) Consider the equilibrium band diagram in Figure 3 for a portion of a semiconductor sample with a built-in electric field $\mathcal{E}$.

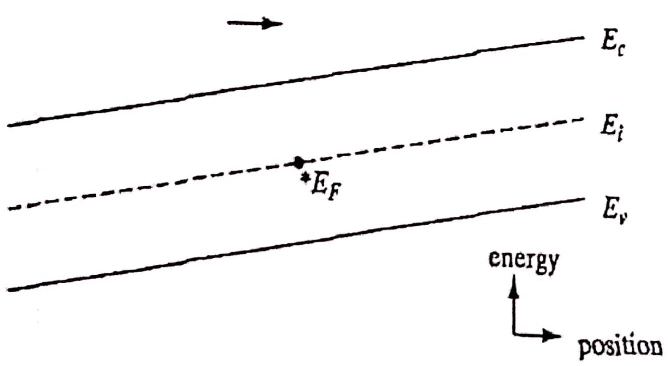

Figure 3

Sketch the Fermi level as a function of position *through* the indicated point, E_F, across the width of the band diagram above.

- On the band diagram, sketch the direction of the electric field. Is the field constant or position dependent?

(b) Derive an expression that relates the carrier diffusivity, D to Mobility μ by the thermal voltage KT/q.

Question Six (25 marks)

(a) An abrupt Si p-n junction (A = $10^{-4}cm^2$) has the following properties at 300 K:

P-side	N-side
$N_a = 10^{17} cm^{-3}$	$N_d = 10^{15} cm^{-3}$
$\tau_n = 0.1 \mu s$	$\tau_p = 10 \mu s$
μ_p= 200 cm^2/V-s	μ_n= 1300 cm^2/V-s
μ_n= 700 cm^2/V-s	μ_p= 450 cm^2/V-s

The junction is forward biased by 0.5 V. What is the forward current? What is the current at a reverse bias of -0.5 V?

(b) An abrupt Si p-n junction has $N_a = 10^{18} cm^{-3}$ on one side and $N_d = 5 \times 10^{15} cm^{-3}$ on the other. (i) Calculate the Fermi level positions at 300 K in the p and n regions. (ii) Draw an equilibrium band diagram for the junction and determine the contact potential V_o from the diagram. (iii) Compare the results of part (ii) with the calculated value of V_o.