[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 7374 **L**

Unique Paper Code : 2513040026

Name of the Paper : Semiconductor Device Modeling and Simulation

Name of the Course : **B.Sc. (H) Instrumentation**

Semester : VIII

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory. **All** questions carry equal marks. Attempt any **5** questions in all.
3. Use of scientific calculator is allowed.

Q.1 (a) The probability that a state is filled at the conduction band edge (E_C) is precisely equal to the probability that a state is empty at the valence band edge (E_V). Where is the Fermi level located? (2)

(b) What are degenerate semiconductors? Draw energy-band diagram of degenerated n-type semiconductor. (2)

(c) Draw Energy - Momentum diagram for a direct band gap semiconductor. (2)

(d) Mention any two industry standard Technology Computer Aided Design (TCAD) tools used for simulation of semiconductor devices. (2)

(e) Name any two multi gate advanced semiconductor devices. (2)

(f) The electron concentration in a piece of Si maintained at 300K under equilibrium conditions is $10^5/cm^3$. What is the hole concentration? (2)

Q.2 (a) What is semiconductor device Modeling? What are the three levels of modeling w.r.t semiconductor industry? (5)

(b) What is Fermi function? Express it mathematically. (4)

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(c) Name three fundamental equations used in modeling of semiconductor devices. (3)

Q.3 (a) Plot and compare Fermi function F(E) vs ($E-E_F$) at T=0K and T=300K. (5)

(b) A silicon ingot is doped with 10^{16} Arsenic atoms/cm^3. Find the carrier concentrations and the Fermi level at room temperature (300 K). (4)

(c) A Si wafer is uniformly doped p–type with $N_A = 10^{15}/cm^3$. At T=0K, what are the equilibrium electron and hole concentrations? (3)

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Q.4 (a) For an intrinsic semiconductor, plot- energy band diagram, density of states, Fermi distribution function and carrier concentration. (5)

(b) Define mobility w.r.t semiconductors. How is mobility related to scattering? (4)

(c) Write charge neutrality equations for a uniformly doped semiconductor to be charge neutral. Briefly explain each term. (3)

Q.5 (a) What is recombination? Explain any two types of recombination processes using suitable energy-band diagrams. (5)

(b) Explain two dominant scattering phenomenon which exist in non-degenerate semiconductors. (4)

(c) Assume that, in an n-type semiconductor at T = 300K, the electron concentration varies linearly from 2×10^{18} to 8×10^{17} cm^{-3} over a distance of 0.1 cm. Calculate the diffusion current density if the electron diffusion coefficient is D_n = 22.5 cm^2/s. (3)

Q.6 (a) Draw a flowchart illustrating the sequential steps involved in simulating a n-MOSFET using an industry-standard Technology Computer Aided Design (TCAD) tool to analyse its electrical characteristics. (5)

(b) State the general form of the continuity equation for electrons in a semiconductor. Explain what each term physically represents? (4)

(c) A Si step junction maintained at room temperature under equilibrium conditions has a p-side doping of $N_A = 2 \times 10^{15}$ cm^{-3} and n-side doping of $N_D = 10^{15}$ cm^{-3}. Calculate (i) Vbi (ii) Depletion width on p side- x_p (3)

Q.7 (a) For a step graded p-n junction under equilibrium, plot (5)

(i) Net doping profile in the depletion region
(ii) Space charge density in the depletion region
(iii) Electric field in the depletion region
(iv) Electrostatic potential in the depletion region

(b) What are the differences between a compact model and a Technology Computer Aided Design (TCAD) model? Name any 2 compact models. (4)

(c) What is Shockley model for diodes? What are its limitations? (3)