VIT

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

CHENNAI

Reg. Number:	24BLC1075

Continuous Assessment Test (CAT) – I - AUGUST 2025

Programme	:	B.Tech. (ECE/ECM)	Semester	:	Fall 2025-26
Course Code & Course Title	:	BECE201L Electronic Materials and Devices	Class Number	:	CH2025260100428 CH2025260100429 CH2025260100427
Faculty	:	Dr. ANITH NELLERI Dr. CHANDRASEKARAN N Dr. B PRASHANTH KUMAR	Slot	:	G1+TG1
Duration	:	90 min	Max. Mark		50

General Instructions:

- Write only your registration number on the question paper in the box provided and do not write other information
- Use statistical tables supplied from the exam cell as necessary
- Use graph sheets supplied from the exam cell as necessary
- Only non-programmable calculator without storage is permitted

Physical constants: $N_A = 6.022 \times 10^{23}\ mol^{-1}$, $k_B = 1.3807 \times 10^{-23}\ JK^{-1}$, $k_BT = 0.0259\ eV$ at 300K, $m_e = 9.1 \times 10^{-31}\ kg$, $e = 1.6 \times 10^{-19}\ C$, $h = 6.626 \times 10^{-34}\ J\ s$, $\varepsilon_0 = 8.854 \times 10^{-12}\ Fm^{-1}$,
Constants for Silicon: $E_g = 1.1\ eV$ and relative permittivity $\varepsilon_r = 11.8$.

Answer all questions

Q. No	Description	Marks	CO	BT Level
1	A bar of $n-type$ Germanium (Ge) of dimensions Length $(L) = 0.010\ m$, width $(W) = 0.001\ m$ and thickness $(T) = 0.001\ m$ is mounted in a magnetic field of $0.2\ T$. The electron concentration in the bar is $7 \times 10^{21}\ electrons/m^3$. If a potential difference of 1 millivolt $(1\ mV)$ is applied across the long ends of the bar: a) Calculate the current flowing through the bar. [5 Marks] b) Calculate the Hall voltage developed between electrodes placed across the short dimension of the bar. Assume the mobility of electrons is $0.39\ m^2\ V^{-1}s^{-1}$. Use the charge of an electron, $e = 1.6 \times 10^{-19} C$. [5 marks]	[10]	1	2
2	The conductivity σ of a metal is 6.0×10^7 S/m, the concentration of conduction electrons n is $8 \times 10^{28}\ m^{-3}$, and the electron mass m is 9.1×10^{-31} kg. Calculate the relaxation time τ. Also, explain the physical processes that determine the relaxation time in a real metal. [P. T. O.]	[10]	1	2

3	a) Explain the concept of the Fermi energy level in a semiconductor and discuss its significance for $n-type$ and $p-type$ materials. [4 Marks] b) Consider silicon at $T = 300K$ so that $N_c = 2.8 \times 10^{19}\ cm^{-3}$ and $N_v = 1.04 \times 10^{19}\ cm^{-3}$. Assume that the Fermi energy is 0.25 eV below the conduction band and the bandgap energy of silicon is 1.12 eV. Calculate the thermal equilibrium concentrations of free electrons and holes for the given Fermi energy. You may use, $k_B T \approx 0.0259\ eV$ at 300 K. [6 Marks]	[10]	2	2
4	a) Consider Silicon at $T = 300\ K$, contains an acceptor impurity concentration of $N_a = 10^{16} cm^{-3}$. Determine the concentration of donor impurity atoms (N_d) that must be added so that the silicon is $n-type$ and the Fermi energy is 0.20 eV below the conduction-band edge. For silicon at this temperature use, $N_c = 2.8 \times 10^{19}\ cm^{-3}$ and $k_B T \approx 0.0259\ eV$. [5 Marks] b) Using the result of part (a), calculate the electrical conductivity (σ) and resistivity (ρ) of the n-type silicon formed after compensated doping. Assume the mobilities at 300 K are, for electrons $\mu_n = 1350\ cm^2\ V^{-1} s^{-1}$ and $\mu_h = 480\ cm^2\ V^{-1} s^{-1}$ for holes. [5 Marks]	[10]	2	2
5	a) Suppose the cross-sectional area is fixed due to packaging constraints. What other parameters can be adjusted to achieve the required resistance and current handling, and what trade-offs would each involve? [2 Marks] b) In a GaAs semiconductor device, you observe that the electron diffusion current is much higher than the drift current despite applying a moderate electric field. Electron concentration decreases from $10^{17} cm^{-3}$ to $10^{16}\ cm^{-3}$ over $10\ \mu m$. If an electric field of 50 V/cm is applied: Given: - $\mu_n = 8500\ cm^2\ V^{-1} s^{-1}$ - $D_n = 220\ cm^2\ s^{-1}$ Calculate both drift and diffusion current densities. Then explain the physical significance and why diffusion dominates in this case. [8 Marks]	[10]	3	3

**********All the best *************