Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S3 (S,FE) (FT/WP) / S1 (PT) Examination November/December 2025 (2019 Scheme)

Course Code: ECT201

Course Name: SOLID STATE DEVICES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1	Draw the Fermi Dirac Distribution function of intrinsic, n-type and p-type semiconductors.	(3)
2	Explain the concept of effective mass.	(3)
3	What are the applications of hall effect ?	(3)
4	Why mobility varies with temperature ?	(3)
5	Draw the energy band diagram of a PN junction under: a) equilibrium, b) forward bias and c) reverse bias	(3)
6	What is meant by base width modulation?	(3)
7	Define the threshold voltage of an enhancement type MOSFET. What are the parameters that influence threshold voltage ?	(3)
8	Draw and explain transfer characteristics of an n-channel depletion type MOSFET.	(3)
9	Describe drain induced barrier lowering.	(3)
10	Explain hot carrier effect in MOSFETS.	(3)

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11

a). Derive the expression for equilibrium electron and hole concentrations in a semiconductor in terms of the effective density of states. Formulate the relation between these concentrations at equilibrium. (10)

b). A Si sample is doped with $4*10^{17}$ cm^{-3} Boron atoms. Find the Fermi level relative to intrinsic level at 300K. (At 300K, n_i of Si is $1.5*10^{10}$ cm^{-3} and kT=0.026eV.) (4)

12

a) Explain the generation and recombination mechanisms of excess carriers in a semiconductor. (10)

b) An n-type semiconductor with donor concentration $N_d=10^{19}$ cm^{-3} is steadily illuminated such that the excess electron concentration is $10^{15}cm^{-3}$. Find out the optical generation rate g_{op}. Life time of hole is 10μs. (4)

Module 2

13

a) Derive the expression for diffusion current density. (8)

b) A current of 3mA is flowing through a p-type Si bar of length 2 cm and thickness $2*10^{-3}$cm. A voltage of 3mV is developed across it when a magnetic field of $10*10^{-5}$ Wb/cm^2 is applied at 300K. Calculate hole concentration. If the resistivity of the sample is 0.1 Ω-cm, find hole mobility. (6)

14

a) With the help of necessary equations illustrate how the diffusion coefficient is related to mobility via Einstein's relation. (8)

b) Calculate the resistivity and conductivity of intrinsic Si at 300K. Electron and hole mobility's are 1350 cm^2/V-s and 480 cm^2/V-s respectively. (6)

Module 3

15

a) Derive ideal diode equation. (8)

b) The doping relation in an ideal Si p-n junction is Na = 50*Nd. The built-in potential barrier is 0.75V. Calculate the total width of depletion region of the junction when a reverse voltage of 10 V is applied. Permittivity of Si is $11.7*8.85*10^{-14}/cm^2$. (6)

16

a) With the help of necessary figures, differentiate between rectifying and ohmic contacts. (8)

b) For a pnp transistor, when emitter junction is forward biased and collector junction is reverse biased, it is observed that I_{EP} = 4mA, I_{EN} = 0.02mA and I_{CP} = 3.96mA. Neglecting leakage currents, determine a). Terminal currents I_E,I_C (6)

and I_B b). Emitter injection efficiency. c). base transportation factor and d) α and β

Module 4

17

a) Using energy band diagrams, illustrate accumulation, depletion and inversion processes in an n-channel enhancement MOSFET. (10)

b) A MOS capacitor formed on a p-type Si substrate doped with $Na=5*10^{16}/cm^3$. Calculate the surface potential required to make Si-SiO2 interface: a) intrinsic and b) strongly inverted. (4)

18

a) Derive the expression for the drain current of a MOSFET under linear and saturation regions. (10)

b) Find $I_D(sat)$ and $g_m(sat)$ of an n-channel MOSFET having the following parameters: channel length=2μm, thickness=30μm, electron mobility= $450cm^2/V\text{-}s$, threshold voltage =0.8V and V_{gs} =4V. (4)

Module 5

19 What is the need for scaling in MOSFET's? Differentiate between constant voltage scaling and constant field scaling. (14)

20

a) With the help of a diagram, explain the structure and operation of a Fin FET (10)

b) Describe velocity saturation in MOSFET's. (4)

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