QP Code:EC2T04-3 **(Pages:3)**

Reg No : .... Name : ....

MAR ATHANASIUS COLLEGE OF ENGINEERING, KOTHAMANGALAM

(Govt. Aided Autonomous Institution)

Fourth Semester B.Tech. Degree Examination, May, 2026

Course Code: B24EC2T04

Course Name: SOLID STATE DEVICES

Max. Marks: 100 Duration:3 Hours

PART - A: 30 Marks (10 Qns x 3 Marks)

Answer all questions

1. Distinguish between elemental and compound semiconductors with one example each ?
2. State any two differences between thermal equilibrium and steady-state conditions in a semiconductor ?
3. State and explain the continuity equation in semiconductors.
4. Define Poisson equation in semiconductors.?
5. Explain Ohmic contacts and Rectifying contacts with neat diagrams
6. Draw the energy band diagram of a p-n junction under reverse bias condition.
7. What is accumulation in a MOS capacitor?
8. What is meant by body effect in MOSFET? How does it affect the threshold voltage of the MOSFET?
9. Illustrate and explain negative resistance in a tunnel diode.
10. Why is MOSFET scaling required in VLSI technology?

PART - B: 70 Marks (5 Qns x 14 Marks)

Answer any One full question from each module.

Module 1

11. a. Explain the recombination mechanisms of excess carriers in semiconductors. Describe direct and indirect recombination with suitable energy band diagrams.? (7 marks)

    b. For a semiconductor under steady illumination, the excess carrier concentration is $\Delta n = 5\times10^{13} cm^{-3}$. If the recombination lifetime is 2μs, calculate the recombination rate.? (7 marks)

OR

12. a. Derive the expression for equilibrium hole concentration in the valence band.? (7 marks)

b. A semiconductor at 300 K has its Fermi level 0.30 eV above the valence band. Calculate the hole concentration. (Given: $N_v = 1.04 \times 10^{19} cm^{-3}$)? (7 marks)

Module 2

13. a. Explain the concept of quasi-Fermi levels. Explain their role under steady-state conditions. (7 marks)

b. A semiconductor under steady illumination has electron concentration = 1×10^{16} per cm^3 and hole concentration = 1×10^{14} per cm^3 at 300 K. Calculate the separation between electron and hole quasi-Fermi levels. (Given intrinsic carrier concentration = 1.5×10^{10} per cm^3) (7 marks)

OR

14. a. Explain the variation of mobility with temperature in semiconductors. Illustrate your answer using a neat graph. (7 marks)

b. At low temperature impurity scattering dominates, while at high temperature lattice scattering dominates. Explain how mobility varies with temperature in both regions.? (7 marks)

Module 3

15. a. Define and derive expressions for emitter injection efficiency and base transport factor. (7 marks)

b. For a transistor, I_{EP} = 4 mA, I_{EN} = 0.02 mA, I_{CP} = 3.96 mA. Calculate

(i) Emitter injection efficiency

(ii) Base transport factor

(iii) $\alpha$and β. (7 marks)

OR

16. a. Derive the expression for depletion width of an abrupt PN junction. (7 marks)

b. For a silicon PN junction at T = 300 K, $N_A = 10^{17}$ per cm^3 and $N_D = 10^{15}$ per cm^3. Given that the intrinsic carrier concentration $n_i = 1.5 \times 10^{10} cm^{-3}$ and the permittivity of silicon $\epsilon = 11.7\epsilon_0$, calculate the depletion width at equilibrium. ($\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$) (7 marks)

Module 4

17. a. Explain the concept of pinch-off in a MOSFET. Using this concept, justify why the drain current remains almost constant in the saturation region. (8 marks)

b. Draw and explain the transfer characteristics of an n-channel MOSFET. (6 marks)

OR

18. a. Classify MOSFETs based on mode of operation and channel type and explain enhancement and depletion type MOSFETs with suitable diagrams. (9 marks)

b. A Silicon n-channel MOSFET has μ_n= 600 cm ^{2}/V-sec, Cox= 1.2x10^{-7} F/cm^2, W=50 μm, L=10 μm and Vth = 0.8V. Find the drain current when (i) V_{GS} = 2V and V_{DS} = 1V, (ii) V_{GS} = 3V and V_{DS} = 5V (5 marks)

Module 5

19. a. Explain the structure and working principle of HEMT with a diagram. (7 marks)

b. Discuss the need for FinFET technology in modern VLSI design. How does it overcome the limitations of planar MOSFETs? (7 marks)

OR

20. a. What is channel length modulation in MOSFETs? How does it affect the output characteristics of the MOSFET? (7marks)

b. Explain the concepts of velocity saturation and hot carrier effects in a MOSFET. (7 marks)

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