

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

- | | | |
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| 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**

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|-----|--|------|
| 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 $4 \times 10^{17} \text{ cm}^{-3}$ Boron atoms. Find the Fermi level relative to intrinsic level at 300K. (At 300K, n_i of Si is $1.5 \times 10^{10} \text{ cm}^{-3}$ and $kT=0.026\text{eV}$.) | (4) |

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- a) Explain the generation and recombination mechanisms of excess carriers in a semiconductor. (10)
- b) An n-type semiconductor with donor concentration $N_d = 10^{19} \text{ cm}^{-3}$ 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 $10 \mu\text{s}$. (4)

Module 2

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- 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 $2 \times 10^{-3} \text{ cm}$. A voltage of 3mV is developed across it when a magnetic field of $10 \times 10^{-5} \text{ Wb/cm}^2$ is applied at 300K. Calculate hole concentration. If the resistivity of the sample is $0.1 \Omega\text{-cm}$, find hole mobility. (6)

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- 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 $1350 \text{ cm}^2/\text{V-s}$ and $480 \text{ cm}^2/\text{V-s}$ respectively. (6)

Module 3

15

- a) Derive ideal diode equation. (8)
- b) The doping relation in an ideal Si p-n junction is $N_a = 50 N_d$. 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 $11.7 \times 8.85 \times 10^{-14} / \text{cm}^2$. (6)

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- 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 $I_{EP} = 4 \text{ mA}$, $I_{EN} = 0.02 \text{ mA}$ and $I_{CP} = 3.96 \text{ mA}$. 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 $N_A = 5 \times 10^{16} \text{ cm}^{-3}$. Calculate the surface potential required to make Si-SiO₂ interface: a) intrinsic and b) strongly inverted. (4)

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

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

Module 5

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

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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)
