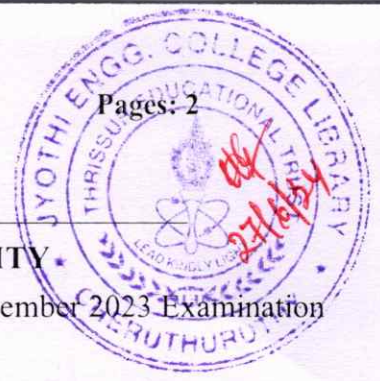


Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S3 (S,FE)/S1 (PT)(S) June 2024 (2019 Scheme)/S3 (WP)(R) December 2023 Examination

**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 | Explain the indirect recombination mechanism in semiconductors. | (3) |
| 2 | What are Quasi-Fermi levels? | (3) |
| 3 | How the mobility of carriers varies with temperature? | (3) |
| 4 | Derive Einstein relations. | (3) |
| 5 | An abrupt p-n junction made of Silicon has $N_A=10^{18} \text{ cm}^{-3}$ on the p-side and $N_D=5 \times 10^{15} \text{ cm}^{-3}$ on the n-side. At 300K, calculate built-in potential using its expression. | (3) |
| 6 | Describe the rectifying behaviour of a metal-n-type Semiconductor contact. | (3) |
| 7 | Draw the equilibrium energy band diagram of an ideal MOS capacitor. | (3) |
| 8 | Derive the expression for threshold voltage of a MOS capacitor. | (3) |
| 9 | Compare constant voltage scaling and constant field scaling | (3) |
| 10 | Explain DIBL. | (3) |

PART B*Answer any one full question from each module. Each question carries 14 marks***Module 1**

- | | | |
|-----|--|------|
| 11a | Derive the expression for electron, hole and intrinsic concentrations at equilibrium in terms of effective density of states. | (8) |
| b | A Silicon sample is doped with $10^{17} \text{ As atoms/cm}^3$. What is the equilibrium hole concentration p_0 at 300K? Where is E_f relative to E_i ? Draw the energy band diagram | (6) |
| 12a | Draw and explain Fermi-Dirac Distribution function and apply it to semiconductors. Also draw the plot of FDD and energy band diagram. | (10) |
| b | Explain the different excess carrier generation mechanisms. | (4) |

Module 2

- 13a Derive the expression for diffusion current density in a semiconductor. (9)
- b Explain Hall effect. (5)
- 14a Derive Continuity Equations and hence derive the steady state Diffusion equations for electrons and holes. (10)
- b An n-type silicon bar 0.1cm long and $100\mu\text{m}^2$ in cross sectional area has a majority carrier concentration of $5 \times 10^{20} \text{cm}^{-3}$ and electron mobility $0.13 \text{m}^2/\text{Vs}$ at 300K. What is the resistance of the bar? (4)

Module 3

- 15a Derive ideal diode equation. List out the various approximations used. (10)
- b An abrupt Silicon p-n junction has $N_A = 10^{17} \text{cm}^{-3}$ on the p-side and $N_D = 10^{15} \text{cm}^{-3}$ on the n-side. The area of cross-section of the diode is 10^{-4}cm^2 . The relative permittivity of Si is 11.8. Determine the following at 300K. (4)
- (a) the built-in voltage
- (b) the depletion layer width W_0, X_{p0}, X_{n0}
- (c) the maximum electric field
- 16 With the aid of energy band diagram, explain how a metal-N type junction functions as a rectifying and ohmic contact. (14)

Module 4

- 17a Starting from the fundamentals, derive the expression for drain current of a MOSFET in its two regions of operation. (10)
- b Draw the transfer characteristics of an n-channel enhancement MOSFET in linear and saturation regions. (4)
- 18a With the help of energy band diagrams, explain the three regions of operation of a MOS capacitor (8)
- b A Silicon MOS system with p-substrate having $N_A = 10^{15} \text{cm}^{-3}$ and oxide thickness 100\AA is at the onset of strong inversion. Determine (6)
- (a) width of the depletion layer.
- (b) the charge density in the depletion layer.
- (c) the threshold voltage.
- Given $\epsilon_{\text{rox}} = 3.9, \epsilon_{\text{rsi}} = 11.8$.

Module 5

- 19 Summarize the various short-channel effects in MOSFET. (14)
- 20 Draw and explain the structure and operation of FinFET. List out its advantages. (14)
