Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTER B. TECH DEGREE EXAMINATION (Regular), DECEMBER 2022
ELECTRONICS AND COMMUNICATION ENGINEERING
(2020 SCHEME)

Course Code : **20ECT201**

Course Name: **Solid State Devices**

Max. Marks : **100** **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. Sketch the energy band diagram of the following semiconductors in equilibrium condition i) intrinsic ii) n-type iii) p- type.
2. Distinguish between direct and indirect band gap semiconductors.
3. Describe the diffusion process in a semiconductor.
4. Explain the effect of temperature and doping on mobility.
5. Calculate the contact potential of a PN junction diode having $N_A = 2 \times 10^{16}/cm^3$ and $N_D = 5 \times 10^{13}/cm^3$ at T = 300K. Given $n_i = 1.5 \times 10^{10}/cm^3$.
6. Sketch the energy band diagram of a p-n junction at i) equilibrium ii) under forward biased.
7. Differentiate enhancement and depletion mode MOSFET.
8. Explain body effect in MOSFET.
9. Explain scaling in MOSFETs with advantages and disadvantages.
10. Describe sub-threshold conduction in MOSFET.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Derive mass action law in semiconductors. (7)

    b) A Silicon semiconductor sample doped with 2×10^{16} cm^{-3} of Boron atoms. Determine i. The equilibrium electron and hole concentrations, ii. Position of fermi energy level in the band gap, iii. Also plot the energy band diagram. Given $n_i = 1.5 \times 10^{10}$ cm^{-3} for Silicon at 300 K. (7)

OR

12. a) Explain Fermi Dirac Distribution function for an intrinsic semiconductor with necessary diagram. (6)

    b) An n-type Si sample with Nd = 10^{15} cm^{-3} is steadily illuminated such that $g_{op} = 10^{21}$ EHP/cm^3 S. If $\tau_n = \tau_p = 1\ \mu s$ for this excitation, calculate the $F_n - F_p$. Given $n_i = 1.5 \times 10^{10}$cm^{-3} for Silicon at 300 K. (8)

MODULE II

13. a) Derive Einstein's relation for the mobility of electrons in a semiconductor. (7)

b) Explain Hall effect in semiconductors. Derive the expression for carrier concentration and mobility in terms of Hall voltage. (7)

OR

14. a) Derive the continuity equations for holes and electrons in a semiconductor. (6)

b) Derive the expression for conductivity and mobility of carriers in a semiconductor subjected to an electric field. (8)

MODULE III

15. Derive the ideal diode current equation for a p-n junction and list out the assumptions used. (14)

OR

16. a) Explain the working of a p-n-p transistor with neat sketch. (7)

b) Describe ohmic metal-semiconductor contacts with band diagrams. (7)

MODULE IV

17. a) Derive the expression for the threshold voltage of a MOSFET. (8)

b) Describe the C-V characteristics of an ideal MOS capacitor. (6)

OR

18. a) For an n-channel MOSFET with a gate oxide thickness of 10 nm, $V_T = 0.6V$, and $Z = 25\ \mu m$, $L = 1\ \mu m$. Calculate the drain current at $V_G = 5V$ and $V_D = 0.1V$. Assume an electron channel mobility of $\bar{\mu}_n = 200\ cm^2/V\text{-}s$. (5)

b) Draw and explain the energy band diagram of a MOS capacitor in accumulation, depletion and inversion condition. (9)

MODULE V

19. a) Explain the concept of velocity saturation and hot carrier effect in MOSFET. (6)

b) Differentiate constant voltage scaling and constant field scaling. (8)

OR

20. a) Explain DIBL and its affects in MOSFET. (8)

b) Explain the operation of a FinFET with diagram. (6)

****