

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
Third Semester B.Tech Degree Examination December 2020 (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 | With suitable examples, distinguish between elemental and compound semiconductors. Give their applications. | (3) |
| 2 | Draw the energy band diagrams under equilibrium for the following semiconductors. i) intrinsic ii) n type iii) p type | (3) |
| 3 | Write down the current equations in a semiconductor. | (3) |
| 4 | What is the significance of quasi fermi level? If there is gradient in quasi fermi level, what does it indicates? | (3) |
| 5 | Draw the V-I characteristics of a P N junction diode & mark the regions of operation. Write down the ideal diode equation. | (3) |
| 6 | Draw the structure of a PNP transistor. Clearly Indicate the current components on the figure. | (3) |
| 7 | Plot the transfer characteristics of an n-channel MOSFET. Give the current equation. | (3) |
| 8 | An nMOS transistor has $W/L = 4/2$, gate oxide thickness 40 \AA , Mobility of electrons $180 \text{ cm}^2/\text{Vsec}$. The threshold voltage is 0.4 V , relative permittivity of gate oxide $\epsilon_{ox} = 3.9$. Calculate the drain current when $V_{gs} = 1.5 \text{ V}$, $V_{ds} = 1.8 \text{ V}$. | (3) |
| 9 | What is channel length modulation in MOSFETs? How does it affect the output characteristics of the MOSFET? | (3) |
| 10 | Explain the principle of operation and advantage of FinFET. | (3) |

PART B

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

Module 1

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| 11 | a) Derive the equation for hole concentration in a semiconductor under thermal equilibrium in terms of n_i , E_f and E_i . | (8) |
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- b) A silicon sample doped with $2 \times 10^{16} \text{ cm}^{-3}$ of Boron atoms. ($n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ for Silicon at 300 K) Determine,
- The equilibrium electron and hole concentrations
 - Position of fermi energy level in the band gap (6)
 - Plot the energy band diagram
- 12 a) Plot and explain the temperature dependence of intrinsic carrier concentration in semiconductors (4)
- b) With suitable sketches explain the indirect recombination mechanism via traps. (5)
- c) An n-type Si sample with $N_d = 10^{15} \text{ cm}^{-3}$ is steadily illuminated such that $g_{op} = 10^{21} \text{ EHP/cm}^3\text{s}$. If $\tau_n = \tau_p = 1 \mu\text{s}$ for this excitation, calculate the separation in the quasi-Fermi levels, $(F_n - F_p)$. ($n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ for Silicon at 300 K) (5)

Module 2

- 13 a) Explain the term mobility with respect to semiconductors. What are the factors on which the mobility depends on? Explain the variation of mobility with temperature and doping. (8)
- b) A potential of 100 mV is applied across a semiconductor bar, and the resulting current is 1 mA. A magnetic field of 10^{-4} Wb/cm^2 is applied perpendicular to this semiconductor bar. The hall voltage measured is -2 mV. The dimensions of the bar are width = 0.1 mm, length = 5 mm and thickness = 10 μm . Find (6)
- the type of the semiconductor bar
 - the concentration and the mobility of majority carriers
- 14 a) Derive continuity equation for holes. (4)
- b) Solve the continuity equation, under steady state conditions assuming the semiconductor is long and no drift current is present. Plot the solution. (6)
- c) A p type semiconductor injected at one end with minority carrier electrons, under steady state conditions. $N_a = 10^{15} \text{ cm}^{-3}$, $\tau_n = 0.1 \mu\text{s}$, $\mu_n = 700 \text{ cm}^2/\text{V Sec}$. Calculate the electron diffusion length. (4)

Module 3

- 15 a) With the help of energy band diagrams, explain the behaviour of the contact between a metal and an n -type semiconductor. Clearly distinguish between Schottky and ohmic contacts. (10)

- b) What is base width modulation? How does it affect the input and output characteristics of a BJT? (4)
- 16 a) Derive the equation for the built in potential of a PN junction under thermal equilibrium. (7)
- b) A PN junction, doped on one side with 10^{18} cm^{-3} Boron atoms and the other side with 10^{16} cm^{-3} of Arsenic atoms at 300 K. ($n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ at 300 K and $\epsilon_r = 11.9$ for Silicon). Calculate, the built in potential. (3)
- c) The following parameters are given for a PNP transistor. $I_{EP} = 2 \text{ mA}$, $I_{En} = 0.01 \text{ mA}$, $I_{cP} = 1.98 \text{ mA}$ and $I_{cn} = 0.001 \text{ mA}$. Determine
- The base transport factor
 - The emitter injection efficiency (4)
 - α and β

Module 4

- 17 a) Draw and explain the C-V Characteristics of an Ideal MOS capacitor. Derive the expression for threshold voltage. (8)
- b) Draw the energy band diagrams, of an ideal MOS capacitor under equilibrium, and strong inversion conditions. (6)
- 18 a) Draw the structure of n channel MOSFET. Derive the expression for drain current of a MOSFET in the two regions of operation. What are the assumptions made in deriving the expression? (10)
- b) What is meant by body effect in MOSFET? How does it affect the threshold voltage of the MOSFET? (4)

Module 5

- 19 a) What is meant by scaling in MOSFETs? Explain the challenges in device scaling? (7)
- b) Explain the concept of constant voltage scaling and its limitations. (7)
- 20 a) What is meant by DIBL in MOSFETs? How does it affect the threshold voltage of a MOSFET? (7)
- b) Explain the concepts of velocity saturation and hot carrier effects in a MOSFET. (7)
