Reg No.:_______________ Name:_______________

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

B.Tech Degree S3 (R,S) / S3 (WP) (R,S) / S1 (PT) (S,FE) Examination November 2024 (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

1 What is an extrinsic semiconductor? How is it produced from an intrinsic semiconductor? (3)

2 Write the expression for Fermi-Dirac distribution function. Plot the Fermi-Dirac distribution function verses the energy band diagram of n-type and p-type semiconductor. (3)

3 Distinguish between lattice scattering and ionized impurity scattering. (3)

4 The hole mobility of a semiconductor $\mu_p = 500\ cm^2/Vs$, $kT/q = 26mV$ and $\tau_p =$ 0.1 µs. Find the diffusion constant ($D_p$) and diffusion length ($L_p$) at 300K? (3)

5 Draw the energy band diagram of forward and reverse bias PN junction. (3)

6 What is meant by electron affinity and work function? (3)

7 What is the strong inversion with reference to a MOS capacitor (3)

8 What is the difference between enhancement and depletion MOSFET? (3)

9 Explain the need for scaling? (3)

10 How does channel length modulation affect the drain characteristics of a MOSFET? (3)

**PART B**

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

**Module 1**

11a. Derive the equation for electron and hole concentration in a semiconductor at equilibrium Find how these concentrations are related to intrinsic carrier concentration. (9)

b. A Si sample is doped with $10^{16}$ Phosphorous atoms/cm$^3$. Calculate the equilibrium hole concentration $p_0$ at 300K. Find the location of $E_F$ relative to (5)

$E_i$? Draw the energy band diagram of the same. What changes occur in energy band diagram if phosphorus doping is increased? What does this imply? (Take $n_i$ = 1.5 x $10^{10}$ $cm^{-3}$)

12a. Explain the different types of indirect recombination mechanisms in a semiconductors. How do they differ from direct recombination? (8)

b. Consider Si doped with 2 x $10^{15}$ donors/$cm^{-3}$, and assume that $\tau_n = \tau_p$ = 5 μs. Calculate the recombination coefficient, $\alpha_r$ for the low-level excitation, and find the steady state excess carrier concentration $\Delta n = \Delta p$, if the sample is uniformly exposed to a steady state optical generation rate $g_{op}$ = $10^{19}$ EHP/$cm^3$s. (6)

**Module 2**

13a. Derive the equation for the drift current in a semiconductor. (10)

b. Derive Poisson's equation. (4)

14a. What is Hall effect? Derive the expression for carrier concentration and mobility in terms of Hall voltage. (8)

b. A Ge sample is properly contacted and oriented in a 5 x $10^{-5}$ Wb/$cm^2$ magnetic field and the current is 4 mA. The sample dimensions are w = 0.25mm, t = 50 μm and L = 2.5mm and the measurements are $V_{AB}$ = -2.5 mV and $V_{CD}$ = 170 mV. Find the type and concentration of majority carriers and its mobility? (6)

**Module 3**

15a. Derive the expression for maximum value of electric field and depletion width an abrupt PN junction at equilibrium. Plot the electric field distribution and potential distribution across the depletion region. (10)

b. Draw the energy band diagram of metal n-type semiconductor Schottky contact. (4)

16a. With suitable assumptions derive the expression of the ideal diode equation. Plot the minority carrier distribution across the p-n junction in forward bias condition. (10)

b. What is base width modulation? How does it affect the terminal currents of a BJT.? (4)

**Module 4**

17 With the aid of necessary band diagrams, explain equilibrium, accumulation, depletion and inversion stages of a MOS capacitor. Find the expression for threshold voltage of an ideal MOS capacitor (14)

18a. Derive the expression for drain current in linear and saturation region. (10)

b. A Si n-channel MOSFET with $n^+$ polysilicon gate has $V_{GS} = 3$ V, $V_{DS} = 5$V, $V_T = 0.76$ V, $t_{ox} = 300A^0$, $\mu_n = 600$ $cm^2/Vs$, z = 50 μm, L = 10 μm, and $C_{ox} = 1.15 \times 10^{-7}$ $F/cm^2$. Calculate the drain current. (4)

## Module 5

19a. Explain the concept of constant field scaling. What are the advantages compared to constant voltage scaling? (8)

b. How does hot carrier effect affect the performance of a short channel MOSFET? (6)

20 With suitable diagram explain the working of FinFET? How does the structure help in enhancing MOSFET performance (14)

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