Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree Examination December 2021 (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	State and explain law of mass action.	(3)
2	Explain the concept of quasi Fermi level	(3)
3	State and explain the terms in Einstein's relation.	(3)
4	Distinguish between drift and diffusion mechanisms. Write the expression for the corresponding currents	(3)
5	Explain Early effect and its impact on collector and base currents.	(3)
6	Derive the expression for built in potential of a PN junction diode	(3)
7	Draw the energy band diagram of a MOS capacitor at equilibrium, accumulation and strong inversion condition.	(3)
8	Explain the transfer characteristics of a MOSFET.	(3)
9	Explain Drain induced barrier lowering?	(3)
10	Draw and label the structure of a FINFET	(3)

PART B

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

Module 1

11	(a)	Define Fermi Dirac distribution function. Explain with relevant figures Fermi Dirac distribution of carriers in intrinsic and extrinsic materials.	(10)
	(b)	The Fermi level in a Si sample at 300K is located at 0.3eV below the bottom of the conduction band. The effective density of states N_C=3.22x10^{19}cm^{-3} and N_V=1.83x10^{19}cm^{-3}. Determine (i) the electron and hole concentration at 300K (ii) the intrinsic carrier concentration at 300K	(4)
12	(a)	An n-type Si sample with $N_d = 10^{15}$ cm^{-3} is steadily illuminated such that	(7)

gop = 10^{21} EHP/cm^{3}s. If $\tau_n = \tau_p$ = 1μs for this excitation, calculate the separation in the quasi-Fermi levels, $(E_{Fn} - E_{Fp})$.

(b) Illustrate the direct and indirect recombination process of excess carriers in semiconductors (7)

Module 2

13 (a) Explain Hall effect? Derive the expression for determining carrier concentration in a semiconductor bar using Hall effect. . (7)

(b) (i) Show that the minimum conductivity of a semiconductor sample occurs when $n_0 = n_i\sqrt{\frac{\mu_p}{\mu_n}}$ (ii) What is the expression for the minimum conductivity σ_{min}? (iii) Calculate σ_{min} for Si at 300 K and compare with the intrinsic conductivity. (7)

14 (a) Derive the expression for drift current density, mobility of carriers and conductivity of a semiconductor. (8)

(b) A Si sample with 10^{15}/cm^3 donors is uniformly optically excited at room temperature such that 10^{19}/cm^3 electron-hole pairs are generated per second. Find the separation of the quasi-Fermi levels and the change of conductivity upon shining the light. Electron and hole lifetimes are both 10 μs. D_p = 12 cm^2/s. (6)

Module 3

15 (a) Draw the energy band diagram of a metal N type semiconductor with $\phi_m > \phi_s$ under equilibrium condition and on biasing. Is the contact rectifying or ohmic. Justify your answer. (9)

(b) Assume that a p-n-p transistor is doped such that the emitter doping is 20 times that in the base, the minority carrier mobility in the emitter is one-fourth that in the base, and the base width is one-tenth the minority carrier diffusion length. The carrier lifetimes are equal. Calculate α and β for this transistor. (5)

16 (a) Derive ideal diode equation. (8)

(b) A Schottky barrier diode is formed from n type Si of a doping 10^{16}cm^{-3} and area 10^{-3}cm^2. A Si PN junction has the same area and $N_A=10^{19}$cm^{-3}, $N_D=10^{16}$cm^{-3}, $\tau_n=\tau_p=1\mu s$. (i)Calculate the Schottky barrier diode current at 0.4V and 300K. (ii) Calculate the value of forward bias to obtain same (6) current for a PN junction.[R^*=110A/K^2, Electron affinity of Si=4.15eV, metal work function=4.9eV,Diffusion constant=12cm^2/s]

Module 4

17 (a) Draw and explain the CV characteristics of a MOS capacitor (8)

(b) For a long channel n-MOSFET with W = 1V, calculate the V_G required for an $I_{D(sat.)}$ of 0.1 mA and $V_{D(sat.)}$ of 5V. Calculate the small-signal output conductance g and the transconductance $g_{m(sat.)}$ at V_D = 10V. Recalculate the new I_D for V_G - V_T = 3V and V_D = 4V. (6)

18 (a) Draw and explain the drain characteristics and transfer characteristics of a MOSFET. (8)

(b) An Al-gate p-channel MOS transistor is made on an n-type Si substrate with $N_d = 5x10^{17}$ cm^{-3}. The SiO_2 thickness is 100 Å in the gate region, and the effective interface charge Q_i is 5 x 10^{10} q C/cm^2 and the work function difference between metal and semiconductor is -0.15V. Find W_{max} , V_{FB} , and V_T of the device. (6)

Module 5

19 (a) Distinguish between constant voltage scaling and constant field scaling (8)

(b) Illustrate the operation of FinFET (6)

20 Explain any four short channel effects in MOSFET (14)

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