Reg. No.														

B.Tech. DEGREE EXAMINATION, MAY 2024

Fourth Semester

18ECE203T – SEMICONDUCTOR DEVICE MODELING

(For the candidates admitted from the academic year 2018-2019 to 2021-2022)

Note:

(i) **Part - A** should be answered in OMR sheet within first 40 minutes and OMR sheet should be handed over to hall invigilator at the end of 40^{th} minute.

(ii) **Part - B & Part - C** should be answered in answer booklet.

Time: 3 hours | Max. Marks: 100

PART – A (20 × 1 = 20 Marks)

Answer **ALL** Questions

	Marks	BL	CO	PO
1. Which of the following is known as indirect band gap semiconductor? (A) Silicon and germanium (B) 3^{rd} group elements (C) Compound semiconductor (D) 5^{th} group elements	1	1	1	1
2. For velocity saturation phenomenon the charge particles lose kinetic energy by releasing (A) Optical phonon (B) Proton (C) Neutron (D) Electron	1	2	1	2
3. A hole in a semiconductor is defined as (A) Free electron (B) Half covalent bond (C) A free proton (D) A free neutron	1	1	1	1
4. Assume that in an N-type semi conductor at T = 300 K, the electron concentration varies linearly from 1×10^{18} to $7\times10^{17} cm^{-3}$ over a distance of 0.1 cm. Calculate the diffusion current density if the electron diffusion coefficient is 22.5 cm^2s. (A) 10.8 A/cm^2 (B) 11.8 A/cm^2 (C) 12.8 A/cm^2 (D) 13.8 A/cm^2	1	2	1	2
5. A PN junction diode act as a (A) Controlled switch (B) Bidirectional switch (C) Unidirectional switch (D) Voltage switch	1	1	2	1
6. In a linearly graded PN junction diode, the maximum electric field and potential barrier varies as __________ and __________ of the depletion width. (A) Square and cubic (B) Linear and cubic (C) Square and linear (D) Constant and linear	1	2	2	1
7. Which among the following does not has PN junction? (A) Diode (B) FET (C) BJT (D) Resistor	1	1	2	1

8. In a reverse biased PN diode, the charge flows due to 1 1 2 1

(A) Majority charge carrier
(B) Diffusion
(C) Drift
(D) Kinetic energy

9. The BJT can be represented as two diodes connected back to back through a simple wire 1 2 3 2

(A) False, because two diodes cannot form a BJT
(B) True, because both diode doping levels are different
(C) True, because both diodes are non-symmetrical
(D) False, because there will be no current gain

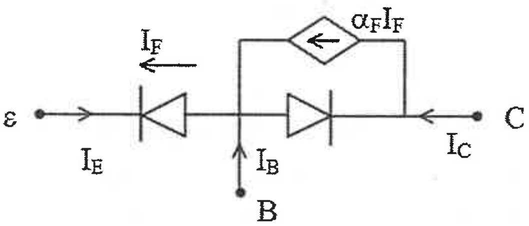
10. Which of the following in not an assumption in EBERS moll model and why? 1 2 3 1

(A) Uniform doping in all regions because non uniform doping causes drift component
(B) Narrow base width so that the current is constant in base region
(C) No generation and recombination as it help in solving the continuity-equation.
(D) Minority currents is non-diffusive and varies linearly so as to solve the equation

11. In a transistor, $I_C = 100mA$ and $I_E = 100, 2$mA, the value of β is 1 2 3 2

(A) 100
(B) 50
(C) 1
(D) 200

12. The below figures shown one part of the EBERS moll model. Which of the following statement is true? 1 2 3 1



(A) Forward active mode: B-E forward biased and B-C reverse biased
(B) Forward active mode: B-E reverse biased and B-C forward biased
(C) Forward active mode: B-E reverse biased and B-C reverse biased
(D) Forward active mode: B-E forward biased and B-C forward biased

13. The electrical equivalent component for MOS structure is 1 1 4 1

(A) Resistor
(B) Capacitor
(C) Inductor
(D) Switch

14. The threshold voltage is a condition at which surface electron concentration (n_s) is equal to 1 1 4 1

(A) Bulk doping (N_A)
(B) Intrinsic concentration (n_i)
(C) Surface potential
(D) Fermi potential

15. P channel MOSFET is made inside an — 1 1 4 1

(A) n well (B) p well
(C) Doesn't require any well (D) Both N and P well

16. In which region is the temporal response of an MOS capacitor the slowest? — 1 2 4 4

(A) Accumulation (B) Flat band
(C) Depletion (D) Inversion

17. The scaling factor of length and width of the channel are — 1 1 5 1

(A) 1, 1 (B) $1/\alpha, \alpha$
(C) $1/\alpha, 1/\alpha$ (D) α, α

18. The aspect ratio of the MOSFET has the units of — 1 1 5 1

(A) Unitless (B) m
(C) m^2 (D) m^{-1}

19. The ideal subthreshold slope for MOSFETs is in between — 1 2 5 4

(A) 60-80 m V/Decade (B) 40-50 m V/Decade
(C) 10-30 m V/Decade (D) 30-40 m V/Decade

20. The full form of DIBL is — 1 1 5 1

(A) Drain induced barrier lowering (B) Doping induced barrier lowering
(C) Drain induced bulk lowering (D) Drain inside barrier lowering

PART – B (5 × 4 = 20 Marks)

Answer **ANY FIVE** Questions

		Marks	BL	CO	PO
21.	Derive an expression for the electron concentration in the conduction band.	4	2	1	2
22.	Calculate the width of the depletion region at zero bias for an abrupt P-N junction with $N_A = 10^{19}\,per\,cm^3$ and $N_D = 10^{15}\,per\,cm^3$ at room temperature. (Use $n_i = 1.5\times10^{10}\,per\,cm^3$, $\varepsilon_r = 11.9$ for Si, $\varepsilon_0 = 8.85\times10^{-14}\,F/cm$)	4	3	2	2
23.	Explain emitter injection efficiency of a BJT with suitable mathematical expression in terms of doping and depletion width.	4	3	3	2
24.	Draw the energy band diagram of a MOS diode in depletion region. State the condition for the same.	4	3	4	1
25.	Explain in brief the MOSFET scaling.	4	3	5	1
26.	Determine the diffusion current in a semiconductor for a GaAs sample at T =300 K. the electron concentration varies linearly from 1×10^{18} to $7\times10^{17}\,cm^{-3}$ over a distance of 0.10 cm. Given $D_n = 225 cm^2/s$.	4	2	1	2
27.	Explain with diagram the base width modulation phenomenon in a BJT with needed equation.	4	2	3	2

PART – C (5 × 12 = 60 Marks)
Answer ALL Questions

	Question	Marks	BL	CO	PO
28. a.i.	Determine the drift current in a semiconductor for a given electric field of 10 V/cm for a GaAs sample at T =300 K with $N_D = 10^{16} cm^{-3}$ and $N_A = 0$. Assume complete ionization.	6	3	1	2
ii.	Determine the electron and hole concentration at thermal equilibrium for $N_D = 3\times10^{15} cm^{-3}$ and $N_A = 10^{16} cm^{-3}$ at T=300K in a compensated semiconductor.	6	3	1	2
	(OR)				
b.	Explain the different types of scattering phenomenon in a semiconductor with suitable expression and diagrams with mobility dependence on temperature and doping.	12	2	1	1
29. a.	Determine the space charge width and maximum electric field for a silicon PN junction diode at T = 300 K with doping densities of $N_a = 1\times10^{16}$ and $N_d = 1\times10^{15} cm^{-3}$. Assuming $V_{bi} = 0.635V$.	12	3	2	2
	(OR)				
b.	Derive the expression for the potential barrier as a function of doping on both sides of a PN junction diode using energy band diagram.	12	3	2	1
30. a.	Derive the expression for early voltage in terms of doping, depletion width and capacitance.	12	3	3	1
	(OR)				
b.	Explain the working of a NPN bipolar junction transistor with suitable diagram and expressions	12	2	3	1
31. a.	Derive the threshold voltage of a long-channel MOSFET.	12	2	4	1
	(OR)				
b.	Explain the low and high frequency capacitance-voltage characteristics of a MOS diode and highlight the different regions clearly. .	12	3	4	4
32. a.	Explain in detail any three critical short channel effects in a MOSFET with proper expression and diagrams.	12	3	5	4
	(OR)				
b.	Explain the advancement in semiconductor industry using Moore's law.	12	2	5	1

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