Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC, AE)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1 a) Define Hall effect. Derive the expressions for majority carrier concentration and mobility. (7)

b) Explain the variation in energy levels of a semiconductor when an electric field is applied? (3)

c) Consider a semiconductor bar with w=0.1mm, t=10μm and L=5mm. For B=10kg (1kg= 10^{-5}Wb/cm^2) and a current 1mA, we have V_{AB}=-2mV, V_{CD}=100mV, Find the type, concentration, and mobility of the majority carrier. (5)

2 a) Prove that $n_0p_0 = ni^2$. (7)

b) The Fermi level position in a Si sample at 300K is 0.29eV below E_c. Determine the carrier concentration and conductivity of the specimen. Given that n_i=1.5 x 10^{10}cm^{-3}, μ_n=1350cm^2/Vs, μ_p=480cm^2/Vs. (8)

3 a) Derive an expression for drift current density. (7)

b) Explain the effect of temperature on mobility. (3)

c) Calculate the thermal equilibrium electron and hole concentration in Si at T=300K, when the Fermi energy level is 0.27eV below the conduction band edge E_c. The effective densities of states in the conduction band and valance band are 2.8 x 10^{19} cm^{-3} & 1.04 x 10^{19} cm^{-3} respectively at 300K. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw the energy band diagram of a p-n junction at a) equilibrium b) Forward bias c) Reverse bias. (6)

b) Differentiate Ohmic contact and Rectifying contacts with neat diagram. (9)

5 a) Explain with neat diagrams (7)

(i) Zener breakdown.

(ii) Avalanche breakdown.

b) With appropriate energy band diagram explain the operation of a tunnel diode. (8)

6 a) Determine the junction capacitance of a silicon pn junction at T = 300 K when a reverse bias voltage of 5V is applied across the junction. The doping concentrations of p&n regions are $8x10^{21}$ m^{-3}& $3x10^{22}$ m^{-3} respectively & the cross-sectional area of the junction is $5x10^{-9}$ m^{2}. (Assume n_i for Si at 300K is $1.5x10^{10}cm^{-3}$ and ε_r=11.7) (7)

b) Derive the expression for open circuit contact potential of a p-n junction under equilibrium. (8)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Derive the expression for drain current at saturation for a MOSFET. (8)

b) Explain the basic performance parameters α, β & γ. (6)

c) Explain early effect and early voltage. (6)

8 a) Derive the expression for minority carrier distribution in a pnp transistor. (10)

b) Explain the principle of operation of MOS capacitor with suitable energy band diagram. (10)

9 a) Explain the principle of operation of FINFET with neat diagrams. (5)

b) Plot the sub-threshold characteristics of MOSFET and explain. (5)

c) Describe the C-V Characteristics of an Ideal MOS capacitor. Derive the expression for threshold voltage. (10)

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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC,AE)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1 a) Explain Fermi Dirac distribution function. Plot the Fermi Dirac distribution function for an intrinsic semiconductor. (4)

b) Explain diffusion. Derive an expression for diffusion current density for an n-type semiconductor. (7)

c) A Si sample is doped with 10^{17}As atoms/cm^3. What is the equilibrium hole concentration p_0 at 300K? Where is E_F relative to E_i? (4)

2 a) Draw the graph showing the distribution of excess carrierswith respect to time in an n-type semiconductor. (3)

b) Derive the expressions for equilibrium concentration of electrons and holes using Fermi Dirac distribution function. (6)

c) A direct bandgap semiconductor hasn_i = 10^{10} cm^{-3} donors. Its low level carrier lifetime τ is$\tau_n = \tau_p = 10^{-7}$s. (6)

i) If a sample of this material is uniformly exposed to a steady optical generation rate of $g_{op} = 2x10^{22}$ EHP/cm^2-s; Calculate the excess carrier concentration $\Delta_n = \Delta_p$

Note : The excitation rate is not low level but assume that α_r is the same.

ii) If the carrier lifetime (τ) is defined as the excess carrier concentration divided by the recombination rate, what is τ at this excitation level?

3 a) Explain High field effects. (4)

b) Derive and explain Einstein relations. (6)

c) A Ge sample is doped with 10^{17} Boron atoms/cm^3.Determine the carrier concentration & Fermi level position at room temperature.n_i for Ge = 2.5 x 10^{13} cm^{-3} at room temperature. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw and explain the VI characteristics of PN junction diode. (4)

b) Explain the different types of capacitances associated with a p-n junction. (6)

c) The following data are given for a Si abrupt pn junction at 300k, $A=1cm^2$, $V_o= 0.6V$. (5)

P- side	N-side
$N_A = 10^{18}\ cm^{-3}$ $\tau_n = 50\ \mu s$ $D_n = 34\ cm^2/s$	$N_D = 10^{16}\ cm^{-3}$ $\tau_p = 10\ \mu s$ $D_p = 13\ cm^2/s$

Calculate $I_p(x_n = 0)$; $I_n(x_p = 0)$ & the total diode current ; (Given kT/q = 0.026 V)

5 a) Derive the ideal diode equation. (10)

b) Differentiate between Zener and Avalanche breakdown mechanisms. (5)

6 a) Derive an expression for the contact potential of an open circuit p-n junction. (7)

b) Write short notes on metal semiconductor contacts. (8)

PART C

Answer any two full questions, each carries20 marks.

7 a) Explain the principle of operation of MOS capacitor with suitable energy band diagrams. (10)

b) Explain base width modulation with neat diagrams. (4)

c) Briefly explain (6)

i) MOSFET scaling.

ii) Hot electron effect.

8 a) Derive the expression for minority carrier distribution and terminal currents of a pnp transistor. (14)

b) Explain the capacitance – voltage relation for a MOS capacitor with neat diagram. (6)

9 a) Explain the principle of operation of FINFET. (7)

b) With neat diagrams, explain the flow of different current components in a pnp transistor under active mode of operation. (7)

c) Draw and explain the drain characteristics of an n-channel MOSFET. (6)

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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC,AE)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1	a)	Derive the expression for conductivity and mobility of carriers in a semiconductor subjected to an electric field.	(7)
	b)	Explain the temperature dependence of carrier concentration in extrinsic semiconductors.	(3)
	c)	Calculate the hole and intrinsic carrier concentrations. Sketch band diagram. $N_c=10^{19}/cm^3$, $N_v=5x10^{18}/cm^3$, Eg=2eV, T=900K, $n_0=10^{17}/cm^3$.	(5)
2	a)	Derive Einstein's relation.	(6)
	b)	Explain why indirect recombination is a slow process.	(4)
	c)	A Si sample is doped with $10^{16}/cm^3$ In atoms and a certain number of shallow donors. The In acceptor level is 0.16eV above E_V and E_f is 0.26eV above E_V at 300K.How many In atoms are un-ionised?	(5)
3	a)	Derive the expression for electron, hole and intrinsic concentrations at equilibrium in terms of effective density of states. Formulate the relation between these concentrations at equilibrium.	(8)
	b)	An n-type Si sample with $Nd = 10^{15}$ cm^{-3} is steadily illuminated such that gop = 10^{21} EHP/cm^3s. If $\tau_n = \tau_p$ = lμs for this excitation, calculate the separation in the quasi-Fermi levels, *(Fn - Fp).*	(7)

PART B

Answer any two full questions, each carries 15 marks.

4	a)	Derive ideal diode equation. State any two assumptions used.	(10)
	b)	Draw the potential, charge density and electric field distribution within the transition region of an abrupt pn junction with Nd<Na. Label the diagram.	(5)
5	a)	Illustrate how a metal – n type contact behave as rectifying contact and ohmic contact with supporting energy band diagram.	(10)
	b)	If a metal with a work function of 4.6 e V is deposited on Si (electron affinity of 4 eV) and acceptor doping level of 10^{18} cm^{-3}. Draw the equilibrium band diagram and mark off the Fermi level, the band edges, and the vacuum level. Is this a Schottky or ohmic contact, and why?	(5)
6	a)	Illustrate the operation of a tunnel diode with supporting diagrams and explain its VI characteristics	(10)

b) An abrupt Si p-n junction has $N_a = 10^{18} cm^{-3}$ on one side and $N_d = 5x\ 10^{15} cm^{-3}$ on the other. If the junction has a circular cross section with a diameter of 10µm, Calculate Vo, x_{no} , Q_+, and Ɛo for this junction at equilibrium (300 K). (5)

PART C

Answer any two full questions, each carries20 marks.

7 a) Derive the expression for minority carrier distribution and terminal currents in a BJT. State the assumptions used. (12)

b) Explain the basic performance parameters α, β & γ. (3)

c) Assume that a p-n-p transistor is doped such that the emitter doping is 10 times that in the base, the minority carrier mobility in the emitter is one-half 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)

8 a) Derive the expression for drain current at linear region and saturation for a MOSFET. (10)

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. Find W_m , V_{FB} , and V_T, if the gate to substrate work function difference Φms = -0.15V (5)

c) Draw and explain the transfer characteristics of an n-channel MOSFET. (5)

9 a) Explain the principle of operation of MOS capacitor with suitable energy band diagram. (10)

b) Explain base width modulation. Explain its effect on terminal currents. (5)

c) Draw and label the minority carrier distribution curve of a BJT in active mode. (5)

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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third semester B.Tech examinations (S) September 2020

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC,AE)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1	a)	Explain Hall effect? Derive the expression for carrier concentration and mobility in terms of Hall voltage.	(7)
	b)	Explain the effect of temperature on mobility.	(5)
	c)	A Si sample is doped with 10^{16} cm^{-3} boron atoms and a certain number of shallow donors. The Fermi level is 0.36 eV above *Ei*, at 300 K. What is the donor concentration N_d?	(3)
2	a)	Derive the expression for diffusion current density in a semiconductor.	(6)
	b)	Show that diffusion length is the average length a carrier diffuse before recombination.	(5)
	c)	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 .Electron and hole lifetimes are both 10 µs. Dp = 12 cm^2/s and μ_n=1300cm^2/Vs.	(4)
3	a)	Derive the law of mass action, starting from the fundamentals.	(10)
	b)	Consider Si doped with 2 x 10^{15}donors/cm^3.Assume that $\tau_n = \tau_p$ = 5 µs. Calculate the recombination coefficient α_r for the low-level excitation. Using this value of recombination coefficient α_r , 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	(5)

PART B

Answer any two full questions, each carries 15 marks.

4	a)	Derive the expression for contact potential and width of depletion region of an abrupt PN junction at equilibrium.	(10)
	b)	A Si p+-n junction has a donor doping of 5 x 10^{16} cm^{-3} on the n side and a cross sectional area of 10^{-3} cm^2. If τ_P = 1µs and Dp = 10 cm^2/s, calculate the current with a forward bias of 0.5 V at 300 K.	(5)
5	a)	Derive the expression for junction capacitance and storage capacitance of a step PN junction diode.	(8)
	b)	The work function of chromium is 4.5V. The dielectric constant and the electron affinity of Si are 12 and 4.01V respectively. If the density of states Nc=2.8x10^{19}	(7)

cm^{-3}, compute the maximum electric field in the case of a junction formed by these two materials at 300 K, when the applied reverse voltage is 5V. Compute the junction capacitance per unit area for this case. Assume that Si is doped with 10^{17}/cm^3 n type dopants.

6 a) With suitable energy band diagram explain a Schottky contact. (6)

b) Differentiate between Zener and avalanche breakdown mechanisms with supporting diagrams (4)

c) Draw the energy band diagram of a p-n junction at a) equilibrium b) Forward bias c) Reverse bias. (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Derive an expression for base transport factor of a BJT. (10)

b) Explain Early effect. (5)

c) A pnp BJT has emitter (N_E), base (N_B), and collector (Nc) doping of 10^{20}cm^{-3}, 10^{18} cm $^{-3}$ and 10^{17} cm^{-3} respectively, and a base width of 0.5 micron. Calculate the peak electric field at the CB junction, and the CB depletion capacitance per unit area for the normal active mode of operation with a V_{CB} = 50 V. (5)

8 a) Draw and explain the C-V Characteristics of an Ideal MOS capacitor. Derive the expression for threshold voltage. (10)

b) For a MOSFET with V_T = 1V and W = 50 µm, L = 2 µm, calculate the drain current at (5)

(i) V_G = 5 V, V_D = 0.1V

(ii) V_G = 3V, V_D = 5V.

Assume an electron channel mobility μ_n= 200 cm^2 /V-s, gate oxide thickness tox= 100Å, and the substrate is connected to the source.

c) Draw and explain the subthreshold characteristics of an n-channel MOSFET. (5)

9 a) With the aid of necessary band diagrams, explain equilibrium, accumulation, depletion and inversion stages of a MOS capacitor. (12)

b) Explain the effect of real surfaces in the threshold voltage of a MOS capacitor. (4)

c) Explain the terms emitter injection efficiency and base transport factor of a BJT. (4)

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