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Reg. No. _____

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, JULY 2017

EC203: SOLID STATE DEVICES (AE, EC)

Max. Marks:100.

Duration: 3 Hours

PART A

Answer any One from Qn. No.2 and 3. Qn. No. 1 is Compulsory.

1. a) Plot the Fermi Dirac distribution function versus Energy for different temperatures. Justify the plot using necessary equations. (5)
- b) Show that L_n is the average distance an electron diffuses before it recombines. (5)
- c) Derive the expression for conductivity of a Semiconductor. (5)
2. a) For the given data, calculate hole and intrinsic carrier concentrations. Also sketch the band diagram. $N_C = 10^{19} \text{cm}^{-3}$, $N_V = 5 \times 10^{18} \text{cm}^{-3}$, $E_g = 2 \text{eV}$, $T = 9000 \text{K}$, $n = 10^{17} \text{cm}^{-3}$ (5)
- b) Define Hall Effect. Derive the expressions for i) majority carrier concentration ii) mobility. (5)
- c) Prove that the minimum conductivity of a semiconductor occurs when $n_0 = n_i (\mu_p / \mu_n)^{0.5}$
Also find the expression for minimum conductivity. (5)

OR

3. a) A p-type Si with minority electron lifetime of $0.1 \mu\text{s}$, is uniformly illuminated by a light having photon energy of 2.5eV .
 - i) Determine the rate of excess carrier generation that is required to generate a uniform electron concentration of 10^{10}cm^{-3} . (2)
 - ii) What is the optical power (cm^{-3}) that should be absorbed to create the excess carrier population of part (i)? (2)
 - iii) How much optical power per cm^3 will be generated if the carriers recombine via photoemission?(2)
- b) Derive Steady state diffusion equations. (6)
- c) State and explain the different recombination mechanisms (3)

PART B

Answer any One from Qn. No.5 and 6. Qn. No. 4 is Compulsory.

4. a) Draw the energy band diagrams of a pn junction when it is i) under equilibrium ii) forward biased iii) reverse biased. (6)
- b) Draw the energy band diagram of a metal-n type semiconductor with $\phi_m > \phi_s$ when it is i) under equilibrium and ii) when it is biased. Is the contact rectifying or ohmic? Justify your answer. (6)
- c) What is the difference between depletion and diffusion capacitance in a diode? Which one dominates in forward bias? (3)
5. a) Derive the expressions for i) Contact potential ii) transition region width iii) maximum value of electric field. (8)
- b) A p+n Si diode has $N_A=10^{15}\text{cm}^{-3}$ and $N_D=10^{17}\text{cm}^{-3}$. area of cross section $A=10^{-3}\text{cm}^2$ and the lifetime in n and p regions be $1\ \mu\text{s}$ at 300K. Determine the diode current for applied voltage of i) $V = 0.1\text{V}$ ii) $V = 0.6\text{V}$. Given $D_p = 10\text{cm}^2/\text{s}$, $D_n = 36\text{cm}^2/\text{s}$. (4)
- c) What are the assumptions taken for the derivation of the general form of Diode equation?(3)

OR

6. a) A Schottky barrier diode is formed by depositing tungsten on n-type Si. If $N_D = 10^{15}\text{cm}^{-3}$, $\phi_m = 4.9\text{eV}$, $\chi_s = 4.15\text{eV}$ (electron affinity of silicon), at 300K, determine:
i) Built in Voltage ii) width of depletion region and iii) Maximum electric field. (6)
- b) Draw and explain the characteristics of a tunnel diode. (4)
- c) Derive the expression for the time variation of voltage across a p-n junction as it is switched from forward bias to reverse bias condition. (5)

PART C

Answer any One from Qn. No.8 and 9. Qn. No. 7 is Compulsory.

7. a) Illustrate the minority carrier distribution in a PNP transistor in the active mode of operation. Give values of minority carrier concentrations in the three region. (4)
- b) Define Early effect. What is its effects on I_c , I_B , α and β of a transistor? (4)
- c) Draw the band diagrams for ideal MOS structure at i) equilibrium ii) accumulation iii) depletion and iv) Inversion. (8)
- d) Draw the structure of a FINFET . Plot its output characteristics. (4)

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- 8. a)** Derive the terminal current equations of a npn transistor. List the assumptions made for the derivation. (12)
- b)** Define with expressions i) Base transport factor ii) Emitter injection efficiency iii) Current transfer ratio iv) Base to collector current amplification factor. (8)

OR

- 9. a)** Draw and explain the capacitance- voltage characteristics of an n-channel MOS capacitor. (5)
- b)** What are the effects of real surfaces on the threshold voltage of a MOS capacitor? Derive the threshold voltage equation of a real MOS capacitor? (10)
- c)** An n^+ -polysilicon gate n-channel MOS transistor is made on a p-type Si substrate with $N_a = 10^{15} \text{cm}^{-3}$. The SiO_2 thickness is 100Å in the gate region, at the onset of inversion. Find i) width of depletion layer and ii) V_T . Given ϵ_r of Si and SiO_2 are 11.8 and 3.9 respectively. (5)
