Registration no: | | | | | | | | | | |

Total Number of Pages: 02 **B.Tech**
BSCP1207

3rd Semester Back Examination 2016-17
PHYSICS OF SEMICONDUCTOR DEVICES
BRANCH(S): BIOTECH,EE, EEE
Time: 3 Hours
Max Marks: 70
Q.CODE: Y601

Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.

Q1 **Answer the following questions:** **(2 x 10)**

a) What is latch-up in CMOS circuits?
b) What is effective mass? Write the expression for it.
c) What do you mean by punch-through breakdown?
d) What is steep-retrograde body doping? Mention its advantages over the normal body doping.
e) Distinguish between Schottky barrier diode and Ohmic contact.
f) Sketch the curve showing the variation of Fermi-level (E_F) with doping concentration & absolute temperature for both n-type and p-type semiconductors.
g) Determine the total number of energy states in Si between E_C to $E_C + K_BT$ at T = 300K, where K_B is Boltzmann's constant, (Given that electron effective mass of GaAs, $m_n^* = 1.08m_0$ and Planck's constant, $h = 6.6 \times 10^{-34} Js.$).
h) Calculate the temperature at which there is a 10^{-3} probability that an energy state 0.53 eV above Fermi energy level is occupied by an electron.
i) What is the significance of Fermi energy level? Under what condition, Fermi Dirac distribution function changes to Boltzmann distribution?
j) Distinguish between degenerate and non-degenerate semiconductor.

Q2

a) Derive an expression for the thermal equilibrium concentration of electrons in the conduction band using density of states function and Fermi-Dirac distribution function. **(5)**
b) Calculate the intrinsic carrier concentration in GaAs at T = 400K. Given that $N_c = 4.7 \times 10^{17} cm^{-3}$; $N_v = 7 \times 10^{18} cm^{-3} at T = 300K. E_g = 1.42eV$. **(5)**

Q3

a) Derive an expression for the diode current in an ideal Schottky barrier diode and describe its I-V characteristics. **(5)**

b) Calculate the theoretical barrier height, built-in potential barrier and maximum electric field in a metal-semiconductor diode between tungsten and n-type silicon doped to N_d = $10^{16} cm^{-3}$ at T = 300K for zero applied bias if work function of metal is $\emptyset_m$ = 4.55 V and electron affinity of the semiconductor isχ = 4.01V. Given n_i = 1.5 × $10^{10} cm^{-3}$, ϵ_s = 11.7$\epsilon_0$withϵ_0 = 8.85 × $10^{-14} C^2 N^{-1} cm^{-2}$. **(5)**

Q4

a) Derive the expression for excess minority carrier electron concentration in the base region for the forward active mode of an npn BJT. **(5)**

b) Using Ebers-Moll model of a bipolar transistor, derive the expressions for emitter and collector currents with necessary equivalent circuit diagram. **(5)**

Q5

a) Derive an expression for built-in potential barrier of a uniformly doped abrupt pn junction in thermal equilibrium with necessary energy band diagram. **(5)**

b) For a Si pn junction, at T = 300K with zero applied bias has doping concentrations of N_d = 6 × $10^{16} cm^{-3}$and N_a = 4.5 × $10^{15} cm^{-3}$. Determine x_n, x_p and space charge width W. Given n_i = 1.5 × $10^{10} cm^{-3}$, ϵ_s = 11.7$\epsilon_0$withϵ_0 = 8.85 × $10^{-14} C^2 N^{-1} cm^{-2}$. **(5)**

Q6

a) What is threshold inversion in a MOS capacitor? Derive the expression for threshold voltage of a MOS capacitor with p – type semiconductor substrate. Express it in terms of Flat-band voltage. **(5)**

b) An MOS device has the parameters; aluminum gate, p-type substrate with N_a = 3 × $10^{16} cm^{-3}$, t_{ox} = 500$A^0 and Q_{ss}^{'}$ = $10^{11} eCoulomb\ .\ cm^{-2} and\ \emptyset_{ms}$ = −0.981. Determine the threshold voltage at T = 300 K if,n_i = 1.5 × $10^{10} cm^{-3}$, ϵ_s = 11.7$\epsilon_0 and \epsilon_{ox}$ = 3.9ϵ_0; ϵ_0 = 8.85 × $10^{-14} C^2 N^{-1} cm^{-2}$. **(5)**

Q7

a) Derive the expressionfor induced electric field for a non-uniformly doped n – type semiconductor and the Einstein's relation between diffusion co-efficient and mobility. **(5)**

b) The electron concentration in silicon is given by$n(x)$ = $10^{15} e^{-\left(\frac{x}{L_n}\right)} (x \geq 0)$ whereL_n = $10^{-4} cm$. The electron diffusion coefficient isD_n = 25 cm^2/s. Determine the electron diffusion current density at (i)x = $10^{-4} cm$, (ii) x = 0 and (iii)$x \rightarrow \infty$. **(5)**

Q8 **Write short notes on any two of the followings:** **(5 x 2)**

a) C-V Characteristics of MOS capacitor.

b) Breakdown mechanism in PN junction.

c) Complete ionization and freeze-out

d) JFET and HEMT