Registration No : | | | | | | | | | | |

Total Number of Pages : 02 **B.Tech**
PET3I001

3rs Semester Regular / Back Examination 2018-19
SEMICONDUCTOR DEVICES
BRANCH : ECE, ETC
Time : 3 Hours
Max Marks : 100
Q.CODE : E795

Answer Question No.1 (Part-1) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right hand margin indicate marks.

Part- I

Q1 **Short Answer Type Questions (Answer All-10)** **(2 x 10)**

a) What is the significance of Fermi energy level? Under what condition Fermi-Dirac distribution function changes to Boltzmann distribution
b) Determine the value of p_0 and $n_0$for silicon at T=300K if the Fermi energy is 0.22eV above the valence band energy.
c) What is lattice mobility? Give its significance in carrier transport phenomena in a semiconductor.
d) Why non-equilibrium excess carriers are generated in a semiconductor?
e) Show that the total space charge width increases as reverse bias voltage increases.
f) Draw the small signal equivalent circuit of a MOSFET and write the frequency limiting factors of MOSFET.
g) Write down the expression for critical electrical field and voltage at breakdown voltage and identify the factors involved in the expression.
h) What is meant by base width modulation?
i) In what type of application of BJT Eber's moll model is used?
j) With the help of suitable digrams, show the minority carrier distribution in an npn transistor for cut-off mode and saturation mode.

Part- II

Q2 **Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) What is Fermi energy? Discuss the variation of Fermi energy with temperature using suitable expression and plot.
b) The total current in a semiconductor is constant and is composed of electron drift current and hole diffusion current. The electron concentration is constant and is equal to $10^{16}cm^{-3}$.The hole concentration is given by $p(x)=10^{15}xexp(-x/L)cm^{-3}(x \geq 0)$where$L=12\ \mu m$.The total current density is $J=4.8A/cm^2$.Calculate (i) the hole diffusion current density versus x,and (ii)the electron current density versus x.
c) Derive Einstein relation showing relationship between diffusion constant and mobility.
d) Set up the ambipolar transport equation for charge carriers and write some of its applications.
e) Explain the effect of space charge width at p-n junction when(i) forward biased and (ii) reverse biased.
f) A silicon p-n junction at T=300K with zero applied bias has doping concentration of $N_d=5x10^{16}cm^{-3}$ and $N_a=5x10^{15}cm^{-3}$.Determine x_n,x_p,and W and $E_{max.}$
g) Explain the concept of junction breakdown in a p-n junction. Derive an expression for peak electric field of p-n junction at breakdown voltage.
h) With a neat and clean diagram explain the energy band diagram in MOS structure before and after contact.
i) What is CMOS technology? Sketch the cross section of an n-channel enhancement and depletion mode MOSFET.

j) Consider a MOS device with the following parameters: p^+ polysilicon gate, n-type substrate with $N_a=10^{15}cm^{-3}$, $t_{ox}=220A^0$ and $Q_{ss}=8x10^{10}cm^{-3}$. Given ϕ_{ms} =+1.1. Determine the threshold voltage at T=300K

k) Sketch a basic Eber's –Moll Equivalent Circuit and derive Eber's Moll equation

l) Consider a uniformly doped silicon bipolar transistor with a metallurgical base width of 0.5 μm and a base doping $N_B= 10^{16}cm^{-3}$. The punch through voltage is to be V_{pt}=25 V. Determine the collector doping and deletion region width in collector region to meet the given punch-through voltage specification

Part-III

Long Answer Type Questions (Answer Any Two out of Four)

Q3 **a)** Derive the ideal diode equation of the p-n junction. Draw V-I characteristics. **(8)**

b) Explain the C-V characteristics of accumulation region, depletion region and inversion region of a p-type substrate MOS capacitor **(8)**

Q4 **a)** Derive the expression for thermal equilibrium concentration of holes in the valency band using effective density of states function, Fermi energy and other terms. **(8)**

b) What is threshold voltage? What is its significance? Derive an expression for the flat band voltage in terms of the physical parameters. **(8)**

Q5 **a)** Derive an expression for excess minority carrier electron concentration in the base region in forward active mode for an npn bipolar transistor. Explain the condition of cutoff, saturation and inverse active modes. **(8)**

b) What are different types of MOSFET's? Explain the basic working of one of MOSFET's. Draw its current voltage characteristics. **(8)**

Q6 **a)** Distinguish between non-degenerate and degenerate semiconductor. Derive an expression for Fermi energy level position in an extrinsic semiconductor as a function of concentration and temperature. **(8)**

b) Derive an expression for the electric field and potential in the space charge region of a uniformly doped p-n junction. **(8)**