B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING EXAM 2019

FIRST YEAR FIRST SEMESTER

BASIC ELECTRONICS

Time: 3 hours (*All parts of the same question must be answered together*) **Full Marks: 100**

Module 1 (Answer **any TWO** questions)

1.a) Classify crystalline solids on the basis of their energy band diagram and explain their nature at room temperature. 7

b) What is Fermi-Dirac distribution function? Illustrate its variation with energy at both T=0K and T>0K. 6

c) When do Fermi-Dirac statistics and Maxwell-Boltzmann statistics converge? 2

2.a) Derive the expression for intrinsic carrier concentration of a semiconductor. 11

b) n_1 and n_2 are intrinsic carrier concentrations of two semiconductors at room temperature. If $n_1 > n_2$, which one should be preferred for semiconductor device applications? 1

c) Determine the position of Fermi level in an intrinsic semiconductor. 3

3.a) A *Si* sample is doped with $5\text{x}10^{15}$ Boron atoms/cm^3. How is E_F located relative to E_i? The sample is further doped with 10^{17} Phosphorus atoms/cm^3. For the resulting material, 7

i) Find position of the Fermi level,
ii) Determine equilibrium majority and minority carrier concentrations,
iii) Sketch the energy band diagram. Take $n_i = 1.5\text{x}10^{10} cm^{-3}$ and $k_B T = 26\ meV$.

b) What do you understand by diffusion length? Derive its expression in a semiconductor under steady state minority carrier injection. 2+6

Module 2 (Answer **any TWO** questions)

4.a) With the help of a neat band diagram, show the formation of a junction between an *n*-type semi-conductor and a metal of smaller work function. Explain the nature of the junction thus formed. 8

b) Derive an expression for the built-in potential of a *p-n* junction. 7

5.a) Draw and explain diode equivalent circuit. How is it modified under forward and reverse bias conditions? 4+3

b) Describe the *Avalanche breakdown* mechanism. What are the influences of doping and temperature on such breakdown? 6+2

6.a) Derive an expression for the width of depletion region in a *p-n* junction. How does this width get modified for one sided junction? 8+2

b) A *Si p-n* junction has doping densities $N_A = 5\text{x}10^{16} cm^{-3}$ and $N_D = 2\text{x}10^{17} cm^{-3}$. Calculate the width of depletion region on either side of the junction at 300 K. Assume $n_i = 1.5\text{x}10^{10} cm^{-3}$, $k_B T = 26\ meV$ and $\varepsilon_r = 11.7$ for *Si*. 5

[Turn over

Module 3 (Answer **any TWO** questions)

7.a) Sketch the *I-V* characteristics of Tunnel diode, indicating different current components on it. Explain the operation of such device with the help of adequate band diagrams. 4+10

b) What is the relative doping level in Backward diode with respect to that in Tunnel diode? 1

8.a) What is meant by *Emitter injection efficiency* and *Base transport factor* in connection to transistor operation? How are they related to common-emitter and common-base current gain? 2+4

b) Draw and explain the output characteristics of a BJT in common-base configuration. Label three regions clearly on the figure. 8+1

9.a) Explain the working principle of a Junction field effect transistor. 8

b) What are the FET parameters? How are they related? 7

10. Answer **any THREE**: 3x5

a) Explain the *Pinch-off* mechanism in MOSFET.

b) Describe Ebers-Moll model to prove that two diodes connected back to back is not a transistor.

c) What is Early effect? Name the features influenced by it in a transistor.

d) Briefly explain the working principle of a Photodiode.

e) Sketch a VMOS and point out why it is called power FET.

f) What is an Opto-coupler? Why it is used?

Module 4

11. Name the device most appropriate for the following operations (**any TEN**): 1x10

a) Rectification of line voltage,
b) Rectification of very small ac voltage,
c) Providing constant reference voltage,
d) Switching street lamp,
e) Signal amplification,
f) Providing voltage controlled current source,
g) Providing current controlled current source,
h) Display of information,
i) Sensing temperature variation.
j) Realizing a voltage controlled resistor in an IC,
k) Realizing a capacitor in integrated form,
l) Powering electronic equipment on board a satellite.
m) Tuning a specific channel in radio receiver,
n) Digital signal inversion