B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING SECOND YEAR FIRST SEMESTER - 2019

ELECTRONIC DEVICES

Time : **Three hours** Full Marks : **100**

Answer questions from all groups

Group A

Answer any **two** *questions.*

1. (i) Explain the formation of a periodic potential in a crystalline solid ?

(ii) What are the wave functions associated with Krönig-Penny model ?

(iii) Solve these wave equations and to show the formation of energy bands.

5+2+13=20

2. (i) Derive the expressions of effective mass for two different types of current carriers.

(ii) "Effective mass sometimes can be negative" - elucidate your opinion about this statement with the concept of crystal momentum.

(iii) The energy wave number relation for a one-dimensional crystal of lattice constant a is given by $E(k) = E_0 - \alpha - 2\beta \cos ka$, where E_0, α and β are constants. Obtain the effective mass of the electron at the bottom and at the top of the band.

(iv) "At thermal equilibrium, the Fermi level of a material varies with distance " - Is this true ? Give an analytical basis of your opinion.

(3+3)+4+(3+3)+4=20

3. (i) For a system in thermal equilibrium, consisting of N non-interacting indistinguishable particles possessing minute mass, find out their distribution function, considering that a maximum of one particle can be in one quantum state and their spin are half integral multiples of $\hbar$.

(ii) Consider two identical particles. Each particle can be in any of the three possible states - 0, E and $3E$. Find the number of arrangements of the particles of the system for Fermi-Dirac distribution. Also find the ratio of the probability that the two particles are found in the same state to the probability that the two particles are found in different states.

12+(4+4)=20

Group B

Answer any **one** *questions.*

4. An abrupt Silicon p-n junction, cylindrical in shape, has $N_a = 10^{17}$ cm^{-3} on one side and $N_a = 10^{14}$ cm^{-3} on the other. Consider the radius of the bar as 3μm and $kT = 0.0259$.

(i) What will the equilibrium band diagram of this junction look like ?

(ii) From the diagram find the contact potential and compare it with the theoretical value?

(iii) Calculate the the electric field of this junction at the edge of the depletion region.

(iv) What is the penetration of the space charge region into the p-material and n-material?

(v) Calculate the charge on the p side of the depletion region.

(vi) How does the variation of the electric field and the charge density look like ?

3+2+2+3+2+3=15

5. (i) In a very long p-type Silicon bar, holes are injected such that the steady state excess hole concentration is 5×10^{16} cm^{-3} at $x = 0$ and $T = 300$ K. The bar has a cross-sectional area of 0.35 cm^2. Consider the mobility of holes to be 500 cm^2/V-s and the carrier lifetime to be 10^{-10} seconds.

(a) What is the diffusion length of these holes ?

(b) Find out the hole current.

(ii) Why are the potential energy barriers for electrons and holes directed oppositely in a p-n junction ?

(iii) Describe the two types of current conduction mechanisms in a pn junction.

(4+4)+2+5= 15

Group C

Answer any **two** *questions.*

6. (i) Explain the current conduction mechanism of a p-n junction diode in both forward and reverse bias.

(ii) Can you measure the built in potential of the diode using a simple voltmeter ?

(iii) Describe the mechanisms of Zener breakdown and Avalanche breakdown.

5+1+(4+4)= 15

7. (i) In a diagram, indicate the current components in an n-p-n transistor connected in the common base configuration. Hence derive an expression for the collector current.

(ii) Why is this type of transistor known as 'bipolar junction transistor' ?

(iii) Can a BJT be used as a current amplifier in common base configuration ? Why ?

(iv) In a p-n-p transistor, 0.1% of the injected holes recombine in the base. What is the value of β for this transistor ?

(5+5)+1+2+2= 15

8. (i) What is major difference between a Bipolar Junction Transistor and a Field Effect Transistor ?

(ii) For an n-channel FET, why does increasing the potential difference between the drain and the source cause a sub-linear behaviour of the drain current ?

(iii) Can you relate the saturation drain-source voltage and the drain current to any standard function ? Give reasons for your answer.

(iv) Pinch-off voltage of a FET seems to play a very important role in the operation of the device. How does this voltage come to play in the device operation ?

(v) Drawing an analogy from BJT where the collector current is controlled by the base-emitter voltage, what can you say about the drain current and the gate-source voltage in FET ?

2+3+3+3+3 = 15

Group D

9. Write short notes on any two of the following -

(i) CCD
(ii) Solar Cell
(iii) SCR
(iv) Tunnel Diode

7.5 + 7.5= 15