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

Total number of printed pages – 2

B. Tech

BSCP 1207

Third Semester Examination – 2013

PHYSICS OF SEMICONDUCTOR DEVICES

BRANCH : EEE, ETC, EIE, IT, CSE, ELECTRICAL, BIOTECH, IEE, AEIE, EC

QUESTION CODE : C- 510

Full Marks – 70

Time : 3 Hours

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

1. Answer the following questions 2×10
   (a) Draw the E versus k diagram where the allowed energy bands and forbidden energy band gaps are indicated and E and k having the usual meaning.
   (b) Draw the k-space diagrams of Si and GaAs.
   (c) What is complete ionization and freeze out condition ?
   (d) The minority carrier life time in p-type material is 10^{-7} second. What is diffusion length ? Diffusion co-efficient is given by $3.88 \times 10^{-3}\ m^2 s^{-1}$.
   (e) What do you understand by
      (i) depletion region and
      (ii) potential barrier.
   (f) What is early effect ?
   (g) Explain about current flow mechanism in Ohmic contacts.
   (h) Explain about flat band condition.
   (i) What is CMOS technology ?
   (j) In a bipolar transistor biased in the forward active region, the base current is $I_B = 6\mu A$ and the collector current is $I_C = 500\mu A$. Determine α. (where α is common base current gain)
2. (a) What is electron effective mass ? Write the expression for it. 2
   (b) Prove that the concentration of holes in an intrinsic semiconductor is given by $P = N_V \exp[-(E_F - E_V)/KT]$ 4

P.T.O.

(c) If $E_F = E_C$ find the probability of a state being occupied at $E = E_C + KT$ and if $E_F = E_V$ find the probability of a state being empty at $E = E_V - KT$. 4

3. (a) Derive the expression for the built-in potential barrier when an electric field is created in the depletion region by the separation of positive and negative space charge densities in the p-n junction assuming uniform doping and assuming an abrupt junction approximation. 7

(b) Derive the expression for total depletion or space charge width for the above condition. 3

4. (a) Derive expression for junction capacitance of a p-n junction. 4

(b) An abrupt silicon p-n junction has dopant concentration of $N_a = 2 \times 10^{16}\ cm^3$ and $N_d = 2 \times 10^{15}\ cm^{-3}$ at T = 300 K. Calculate

(i) V_{bi}

(ii) W at $V_R = 0$ and $V_R = 8V$

(III) the maximum electric field in the space charge region at $V_R = 0$ and $V_R = 8V$. ($K = 1.38 \times 10^{-23} J/K$, $n_i = 1.5 \times 10^{10}$, $\varepsilon_s = 11.7 \varepsilon_0$, $\varepsilon_0 = 8.85 \times 10^{-12} C^2/N.m^2$)

(where V_{bi}, W, N_a, N_d, n_i, and ε_s having their usual meaning). 6

5. (a) Explain the basic operation of bipolar junction transistor. 4

(b) Derive the expression for the excess minority carrier concentration in the emitter region of the n-p-n transistor in the forward active mode. 6

6. (a) What do you mean by carrier diffusion ? Derive an expression for diffusion current density of electrons and holes. 4

(b) Derive the Einstein relation. 4

(c) Assume the mobility of a carrier at T = 300 K is $\mu = 925\ cm^2/Vs$. Calculate the carrier diffusion co-efficient. ($K = 1.38 \times 10^{-23} J/K$). 2

7. (a) Describe what is meant by an inversion layer of charge. Describe how an inversion layer of charge can be formed in an MOS capacitor with a p-type and n-type substrate. 6

(b) Define the threshold voltage. Derive expression for threshold voltage of a MOS capacitor. 4

8. (a) Give a comparative account of p-n junction diodes, Schottky barrier diodes. 4

(b) What are different types of MOSFETs ? Explain the basic working of one of MOSFETs. Draw its current voltage characteristics. 6
