The Open University of Sri Lanka
Department of Electrical and Computer Engineering
ECX5239 – Physical Electronics
Final Examination – 2015/2016

Date: 2016-12-06 Time:0930-1230

This paper has two sections. Answer **five questions** selecting **at least two question from each section.**
Adhere to the usual notations.

Note: $Charge\ of\ an\ electron = 1.602 \times 10^{-19}\ C$, $Boltzmann\ constant = 8.617 \times 10^{-5}\ eV\ K^{-1}$. For any missing parameters suitable values can be assumed.

Section A

Q1.

(a) Determine the probability of occupancy of a state that is located at $0.259eV$ above E_F at

i. $T = 0\ K$
ii. $T = 300\ K$
iii. $T = 600\ K$ [2X3]

(b) Determine the probability of vacancy of a state that is located at $0.4eV$ below E_F at $T = 300\ K$. [10]

(c) Repeat part (b) if the state is at $0.01\ eV$ above E_F at $T = 300K$. [4]

Q2.

(a) Explain what do you meant by Hall Effect in your own words. [5]

(b) Germanium is doped with 5×10^{15} donor atoms per cm^3 at 300 K. The dimensions of the Hall device are $d = 5 \times 10^{-3}\ cm, w = 2 \times 10^{-2}\ cm$ and $l = 0.1\ cm$. The current $I = 250\ \mu A$, the applied voltage is $V_x = 100\ mV$ and the magnetic flux is $B_z = 5 \times 10^{-2}\ Tesla$. Calculate

i. The Hall voltage
ii. The Hall field and
iii. The carrier mobility [5X3]

Q3.

(a) Briefly explain why the narrower the bang gap the higher is the intrinsic carrier density in a semiconductor. [10]

(b) Discuss why in an intrinsic semiconductor the Fermi energy level E_F does not lie exactly in the middle of the band gap. [10]

Q4.

(a) Explain the meaning of the term "mobility" and its dependence on the frequency of collisions. [6]

(b) Consider a uniformly doped silicon p-n junction with doping concentrations $N_A = 5 \times 10^{17}\ cm^{-3}$ and $N_D = 10^{17}\ cm^{-3}$.

i. Calculate the built in voltage V_0 at $T = 300\ K$. [8]

ii. Determine the temperature at which V_0 decreases by 1%. [6]

Section B

Q5.

(a) Explain the operation of a diode using the atomic level behavior under the three bias conditions. [8]

(b) What are the special features of a Schotkey diode? What physical construction has given it these characteristics? [6]

(c) Explain the operation of Schotkey diode with the help of energy band diagrams. [6]

Q6.

(a) LED is a special diode which uses *direct band gap* semiconductor materials. Explain what is meant by *direct band gap* materials. [4]

(b) Completely explain how light is emitted in a LED with the help of energy band diagrams. [6]

(c) In GaAs the most probable energy level for an electron is $\frac{kT}{2}$ above the conduction band edge. Similarly the most probable level for a hole is $\frac{kT}{2}$ below the valence band edge. The energy gap for GaAs is 1.4eV. Hence calculate the emitted frequency of a GaAs LED at 27^{0}C. [6]

(d) Plot the Emitted frequency Vs. Temperature curve for the above LED. [4]

Q7.

(a) Describe the special design features in a bipolar junction transistor. (You should state the doping concentrations and thickness of different sections in the BJT) [6]

(b) Explain the operation of a npn BJT at an atomic level highlighting how the amplification is achieved. [8]

(c) Draw a graph to show the minority carrier distribution in a npn transistor biased in the active region. [6]

Q8.

(a)

i. Completely explain the operation of an n-channel MOSFET. [5]

ii. Deduce I_D Vs. V_{DS} graph for the n-channel MOSFET from your answer to (i). [5]

iii. What is *pinch off* in JFET? [4]

(b) Briefly explain the hazards which are associated with the semiconductor industry. [6]