The Open University of Sri Lanka
Department of Electrical and Computer Engineering
ECX5239 – Physical Electronics
Final Examination – 2014/2015

Date: 2015-08-09 Time: 0930-1230

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

Section A

Q1.

(a) Explain the origin of different energy bands corresponding to the electrons in solids. **(5 Marks)**

(b) Compare and contrast the energy band diagrams of metals and semiconductors and insulators. **(6 Marks)**

(c) Diamond is having a density of states in the conduction band $2 \times 10^{24} m^{-3}$ and has a probability of occupancy of these states 5.85×10^{-47} at room temperature. Calculate the conductivity of Diamond at room temperature. $\mu_e = 4500\ cm^2V^{-1}s^{-1}, \mu_h = 3800\ cm^2V^{-1}s^{-1}$. **(9 Marks)**

Q2.

(a) Explain the term "mobility" and discuss its dependence on temperature. **(5 Marks)**

(b) Silicon is doped with 4×10^{16} donor atoms per cm^3 at room temperature. A Hall device is with dimensions of height 5×10^{-3} cm, width 3×10^{-2}cm and length 8×10^{-2}cm. The current and voltage applied are 250μA and 100 mV respectively. A magnetic field of 5×10^{-2} Tesla is applied. Calculate,

(i) Hall Voltage
(ii) Hall field and
(iii) Carrier mobility. **(5 x 3 Marks)**

Q3.

(a) With the use of an energy level diagram of an n-type semiconductor explain its ability to conduct a current. **(5 Marks)**

(b) The band-gap energy in a semiconductor is usually a function of temperature and can be modeled as $E_g = E_g(0) - \frac{k_1 T^2 + k_2 T}{k_2 + T}$. For an unknown semiconductor material $E_g(0) =$ 1.310 eV. The parameter values are given as $k_1 = 3.98 \times 10^{-4}\ {}^{eV}/_{K}$ and $k_2 = 541$ K. Find the band-gap energy of the given material for $0 \leq T \leq 1000$ K in 200 K intervals. **(10 Marks)**

(c) Discuss the conduction property of the above unknown material. **(5 Marks)**

Q4.

(a) Why does a capacitance exist in a reverse biased p-n junction and it decrease with increasing reverse bias voltage? **(5 Marks)**

(b) Calculate the built in voltage V_0 at room temperature in a uniformly doped silicon $p-n$ junction with doping concentrations $N_A = 5 \times 10^{17}\text{cm}^{-3}$ and $N_B = 2 \times 10^{17}\text{cm}^{-3}$. **(8 Marks)**

(c) Find the temperature which reduces the built in voltage by 2%. **(7 Marks)**

Section B

Q5.

(a) Discuss the assumptions which were made during the derivation of the Ideal Diode Equation. **(5 Marks)**

(b) Compare the I-V characteristics of an Ideal Diode and a Practical Diode? **(5 Marks)**

(c) What are the special features of a Tunnel Diode? **(5 Marks)**

(d) Explain the operation of a Tunnel Diode with the help of energy band diagrams. **(5 Marks)**

Q6.

(a) Explain the atomic level behaviour of a PNP bi-polar junction transistor (BJT). **(5 Marks)**

(b) What is saturation in a BJT? Clearly show this region in a $I_C vs\ V_{CE}$ graph. **(5 Marks)**

(c) To switch a PNP transistor from cutoff to saturation, what should happen to the hole density in the base and how is this accomplished? **(5 Marks)**

(d) Explain why the collector current decreases when the transistor is operated in the saturation region. **(5 Marks)**

Q7.

(a) Using atomic level behaviour, clearly explain the operation of a p-channel MOSFET. **(6 Marks)**

(b) Deduce I_D Vs. V_{DS} graph for the p-channel MOSFET from your answer to (a). **(5 Marks)**

(c) Comment on the effect of the temperature variation to the saturation point in a MOSFET. **(5 Marks)**

(d) Hence produce the $V_{DS,Sat}\ vs\ T$ graph for a p-channel MOSFET. **(4 Marks)**

Q8.

(a) List and explain three latest technological trends in the global semiconductor industry. **(6 Marks)**

(b) What is meant by *hazards* in the semiconductor industry? **(3 Marks)**

(c) How can you minimize these *hazards*? Explain. **(6 Marks)**

(d) *Greener Production* is a widely discussed topic which is relevant to the semiconductor industry too. How does this concept become relevant to the Sri Lankan semiconductor industry? **(5 Marks)**