# MACHAKOS UNIVERSITY

**University Examinations for 2017/2018**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF COMPUTING AND INFORMATION TECHNOLOGY**

**FIRST YEAR FIRST SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE (MATHEMATICS AND COMPUTER SCIENCE)**

**SMA 130: INTRODUCTION TO ELECTRONICS**

**DATE: 20/12/2017** **TIME: 8:30 – 10:30 AM**

**INSTRUCTIONS: Answer Question One and Any Other Two Questions**

**Physical constants**

Electronic charge, e = 1.6 x $10^{-19}$C

Mass of an electron, $m_e$=9.11x$10^{-31}$kg

Planck's Constant , h=6.625x$10^{-34}$JS

Permittivity of free space , $E_0$=8.854x$10^{-12}$ $FM^{-1}$

Permeability of free space, $\mu_0=4\pi x10^{-7}$ $Hm^{-1}$

Electron mobility $\mu_e=0.38m^2v^{-1}s^{-1}$ (intrinsic Ge)

Hole mobility, $\mu_n=0.18m^2v^{-1}s^{-1}$ (intrinsic Ge)

Boltzmann's constant , $k_B$=1.38x$10^{-23}JK^{-1}$

Rydberg constant , $R_H$=1.1x$10^7m^{-1}$

Electron volt (eV) =1.6 x$10^{-19}$J

Intrinsic carrier density for Germanium , $n_i = 2.5x10^{19}m^{-3}$

Intrinsic carrier density for silicon , $n_s = 1.5x10^{16}m^{-3}$ Z for hydrogen =1

Density of Germanium atoms density=$4.2x10^{28}$ atoms /$m^3$

**QUESTION ONE (20 MARKS)**

a) i State the successes of the Bohr's Atomic model (2 marks)

ii Explain the meaning of the Valence bard (4 marks)

iii Given that the distribution of electronics according to Fermi-Dirac's statistics into the available energy state is given by

$$P(E) = \frac{1}{1+e^{(E-E_r)/KT}}$$

Explain the case of $E = E_r$ (3 marks)

b) i Mobilities of electrons and holes in a sample of intrinsic Germanium are $0.36m^2v^{-1}s^{-1}$and $0.17m^2v^{-1}s^{-1}$respectively .If the electron and hole density are each equal to $2.5x10^{19}m^{-3}$, calculate the sample conductivity (4 marks)

ii) Explain how the depletion layer is formed in a P-N junction (3 marks)

c) i Differentiate between Forward and reverse biasing of a PN junction (1 mark)

ii Explain the meaning of the term Hall effect as used in semiconductors (1 mark)

iii Write down the disadvantages of Tunnel diodes (1 mark)

iv Draw the equivalent circuit of a properly biased PNP transistor (2 marks)

d) i Explain the common base configuration (1 mark)

ii The following readings were obtained from transistor connected in common Base configuration : $I_E = 2mA$ and $I_B = 20\mu A$.Compute the values of $\alpha$ and $Ic$ (3 marks)

iii Explain how the constant – current transfer characteristics are obtained (1 mark)

e) i Write down the method used in analyzing transistor circuits easily and rapidly (1 mark)

ii Explain the meaning of acronym 'FET' and write down the two types of FET'S (1 mark)

iii Explain the function of the following in FETS, source, Drain,Gates and Channel

iv FETS can be used in almost every application in which BJT's can be used . However they have certain application which are exclusive to them. Give any four of their uses (2 marks)

**QUESTION TWO (20 MARKS)**

a) State Bohr's postulates of the atomic Models (3 marks)

b) Show that the velocity of electrons around the nucleus in the $n^{th}$ orbit is given by

$$V = \frac{ze^2}{2E_0\, nh}$$

Where the symbols have their usual meaning (5 marks)

c) Show the kinetic energy of the revolving electrons in the $n^{th}$ orbit of the Bohr's atom is given by $ke = \frac{mz^2e^4}{8{E_0}^2\, n^2h^2}$

Evaluate the ionization energy for hydrogen atom (n=1) (6 marks)

d) Appling the Fermi-Dirac statistics for the distribution of electrons into the available energy states, show that an intrinsic semi-conductor, the Fermi-level lies midway between the conduction band and the valence band (6 marks)

**QUESTION THREE (20 MARKS)**

a) Explain how orbital quantum number, $l$ is used for the following

i) Helps to distinguish between different sub-orbits (2 marks)

ii) Helps to determine the shape of different sub-orbits (2 marks)

b) Deduce an expression for the electrical conductivity of an intrinsic semiconductor (5 marks)

c) Explain, in terms of the energy band theory, what happens when a donor impurity is added into an intrinsic semiconductor (3 marks)

d) A potential difference of 10V is applied longitudinally to a rectangular specimen of an intrinsic Germanium of length 2.5cm,width0.4cm and thickness 0.15cm .Calculate at room temperature

i) Electron and hole velocities (3 marks)

ii) The total current in the specimen (2 marks)

e) A specimen of pure Germanium at $300^0$k has a density charge carrier of $2.5x10^{19}m^{-3}$.It is doped with donor impurity atoms for every $10^{16}$atoms of Germanium .All impurity atoms may be supposed to be ionized .Find the resistivity of the doped Germanium (3 marks)

**QUESTION FOUR (20 MARKS)**

a) An N-type sample of Germanium contains $N_a=3.0x10^{18}Cm^{-3}$and $N_a=10^{16}Cm^{-3}$,A junction is formed by alloying with indium ,Assuming that $N_a$ in region are equal to $N_a$ at the n the alloying temperature

i. Calculate the Fermi –level position at $300^0$k in the p- and N- region (4 marks)

ii. Draw the equilibrium band diagram for the function and determine the barrier voltage from it (3 marks)

iii. Calculate the barrier voltage from the barrier voltage equation and comment on the results obtained in (ii)and (iii) (4 marks)

iv. If V is the voltage applied in the forward direction explain how this affects the depletion layer (2 marks)

b) Deduce the expression for the Boltzmann-Diode equation (7 marks)

**QUESTION FIVE (20 MARKS)**

a) Write down the application of the Hall Effect (2 marks)

b) State the advantages of transistor over vacuum tubes (3 marks)

c) Draw the common base (CB) test circuit used for the study of forward current voltage characteristics of a PNP transistor. Explain briefly (5 marks)

d) Show that for a properly biased transistor that $\alpha = \frac{\beta}{1+\beta}$ where symbols have their usual meaning. (4 marks)

e) Sketch a well labeled JFET drain characteristics and explain the main features present. (6 marks)