MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 205: PHYSICAL ELECTRONICS

DATE: **TIME:**

INSTRUCTIONS

Answer any other TWO questions

Planks constant=$6.626X10^{-34}$J-sec.
Electronic charge =$1.6X10^{-19}$C
1eV=$1.6X10^{-19}$ Joules
Mass of electron, m_e=$9.1X10^{-31}$kg
Permittivity of free space, ϵ_o=$8.854X10^{-12}$ F-m
K=$1.38X10^{-23}$

QUESTION ONE (COMPULSORY) (30 MARKS)

a) State mass action law and give its expression. (3 marks)

b) Briefly explain the operation of a light emitting diode. (3 marks)

c) A student observed that though an electron is negatively charged and the nucleus is positively charged, the electron does not fall into the nucleus due to forces of attraction. Briefly substantiate this observation. (4 marks)

d) Explain how the following semiconductor parameters vary with temperature:

   i. Intrinsic concentration.

   ii. Energy gap. (4 marks)

e) The radius of 2nd orbit of a given atom is $4.4262 \times 10^{-12}m$. Determine for the orbit:

   i. Velocity of electrons

   ii. Angular momentum of electrons

iii. Centrifugal force on the electrons. (6 marks)

f) A potential difference of 10 volts is applied longitudinally to a rectangular specimen of pure silicon of length 2.5cm, width 0.4cm and thickness 0.15cm. Calculate at 300^{o}K:

(i) Its conductivity if intrinsic carrier density is $2.5X10^{19}/m^3$.

(ii) Its resistivity

(iii) The total current.

Given electron mobility=$0.38m^2$/v-s, hole mobility=$0.18m^2$/v-s. (5 marks)

g) The Fermi energy level of a particular semiconductor material is 6.25eV at T=300K. assuming the electrons in the material follow Fermi Dirac distribution function, determine the following:

i. The probability of energy level at 6.25eV being occupied by an electron.

ii. Repeat part (i) if the temperature is increased to T=950K.

iii. The temperature where the probability that a state of 0.30eV above the Fermi level is 0.01. (5 marks)

QUESTION TWO (20 MARKS)

a) Explain the term free mean path with respect to collisions of electrons with stationery particles. (3 marks)

b) The kinetic energy possessed by an electron in certain orbit is 666.4 eV. The atomic number of the atom is 14. Determine:

i. Its total energy

ii. Its potential energy

iii. What will be the wavelength of the electromagnetic radiation emitted if the electron falls to the immediate adjacent orbit. (6 marks)

c) The circuit in fig.1 shows application of a given diode. Name the diode and explain the operation of the circuit. (6 marks)

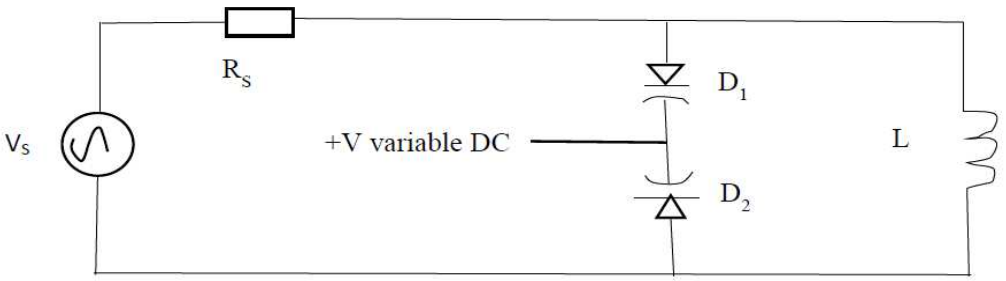


Fig. 1

d) Find the intrinsic carrier concentration and conductivity of germanium at 290°K for which constant N=3X10^{25}/m^3, energy gap Eg=1.2eV, electron mobility=0.14m^2/v-s, hole mobility=0.05m^2/v-s. (5 marks)

QUESTION THREE (20 MARKS)

a) State TWO applications of a tunnel diode. (2 marks)

b) Semiconductor materials form covalent bonds by sharing their outermost electrons. Briefly explain THREE characteristics of covalent bonds. (6 marks)

c) Every electron in an atom associated with four quantum numbers:

i. State the four quantum numbers

ii. State Pauli's exclusion principle

iii. Determine number of electrons in 2nd orbit using Pauli's exclusion principle. (6 marks)

d) A metallic wire of 5mm diameter with a resistivity of 2X10^{-8} Ohm-m and electron mobility of 0.003m^2/volt-sec is subjected to an electric field of 30mV/m. Find: -

i. Charge density of free electrons

ii. Current density

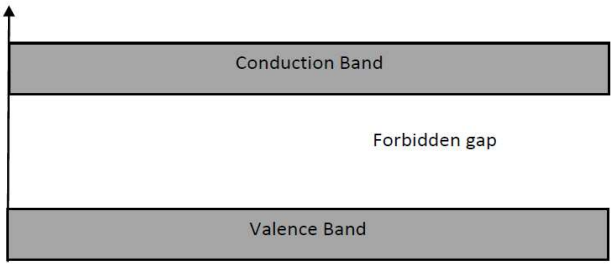
iii. Current flowing in the wire (6 marks)

QUESTION FOUR (20 MARKS)

a) For intrinsic semiconductors, Fermi energy level is given by $E_F = \frac{E_C+E_V}{2}$, where E_C is conduction band energy and E_V is valence band energy. Proof step by step. (6 marks)

b) A physicist preformed an experiment on a material and found the forbidden energy gap to be approximately 2.0×10^{-19} Joules as shown in fig. 2. With reasons, explain whether the material is a good conductor, semiconductor or a bad conductor. (5 marks)

Fig. 2



c) In a germanium sample, a donor type impurity is added to the extent of 1 atom per 10^8 germanium atoms. Show the resistivity of the sample drops to 3.7 ohm-cm. Given electron mobility=3800 cm^2/v-s, hole mobility=1800 cm^2/v-s, intrinsic carrier density is $2.5X10^{13}/cm^3$, germanium atoms per m^3 Nge=$4.41X10^{22}/cm^3$. (5 marks)

d) Determine the Germanium PN junction diode current for the forward biased voltage of 0.22 volts at 25°C with reverse saturation current equal to 1mA. Take η=1. (4 marks)

QUESTION FIVE (20 MARKS)

a) Derive expression for Schrodinger time dependent wave equation. (5 marks)

b) In an experiment to determine the wavelength of radiations from an excited atom, it was observed that the wavelength of the radiation was 6.21436×10^{-10} metres. Assuming this radiation was due to an atom falling from 2nd to 1st orbit, determine the atomic number of the atom involved. (5 marks)

c) An earth satellite has on board 12V battery which supplies a continuous current of 1A. Solar cells are used to keep the battery charged. The solar cells are illuminated by sun for 12 hours in every 24 hours. If the during exposure, each cell gives 0.5V at 100mA, determine the number of cells required. To charge the battery 13.0 volts are needed. (6 marks)

d) Differentiate between bulk resistance and junction resistance of a diode. (4 marks)