MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE ELECTRICAL AND ELECTRONIC ENGINEERING

EEE205: PHYSICAL ELECTRONICS

DATE: **TIME:**

INSTRUCTIONS

Answer Question One and 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) Sketch a well labelled diagram of a tunnel diode. (2 marks)

b) A current of 50 ampere is passed through a metal strip, which is subjected to magnetic flux density of $1.2\ Wb/m^2$. The magnetic field is directed at right angles to the current direction and the thickness of the strip in the direction of the magnetic field is 0.5 mm. The Hall voltage is found to be 100V. Calculate the number of conduction electrons per cubic meter in the metal. (4 marks)

c) Describe how the following semiconductor parameters vary with the temperature.

i. Intrinsic concentration
ii. Mobility
iii. Conductivity
iv. Energy gap (6 marks)

d) Using expressions of electron energies and momentum, proof that total energy of an electron is given by $-0.5mv^2$ and potential energy by $-mv^2$. (8 marks)

e) Given that pure silicon has 4.99×10^{22} atoms/m^3 and the extrinsic concentration $n_i = 1.5 \times 10^{10}/m^3$ at 300K. calculate the resistivity and number of holes and free electrons. (5 marks)

f) From the basic principles, proof that the current density in a good conductor is given by $J = qnv$ where q is the electronic charge, n is the concentration of electrons per unit volume and v is the electrons drift velocity. (5 marks)

QUESTION TWO (20 MARKS)

a) Describe how a varactor diode works as a voltage controlled capacitor. (3 marks)

b) Determine the germanium PN junction current for the forward bias voltage of 0.22V at room temperature of 25^0C with reverse saturation current of 1mA. Take η=1. (5 marks)

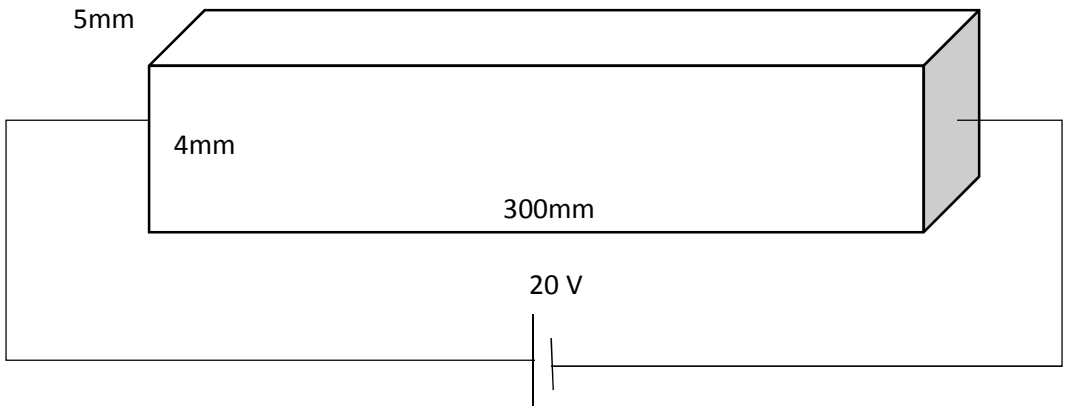
c) A silicon atom has atomic number Z=14. Determine:

i. Radius of the 2nd orbit n=2.
ii. Velocity of atom in the 2nd orbit. (6 marks)

d) For the good conductor specimen shown in fig.1, determine:

i. Electron drift velocity
ii. Conductivity
iii. Resistivity
iv. Total current
v. Current density

Assume free electron density of $2.5 \times 10^{24}/m^3$ and electron mobility of $0.8\ m^2/v - s$. (6 marks)



QUESTION THREE (20 MARKS)

a) State any THREE Bohr's postulates. (3 marks)

b) When an electron falls from a higher energy level to a lower energy level, the extra energy is released inform of electromagnetic radiation. Determine the wavelength of electromagnetic radiation after an electron falls from 2^{nd} orbit to 1^{st} orbit of an atom with atomic number Z=18. (6 marks)

c) A sample of germanium is doped to the extent of 10^{14} donor atoms/cm^3. At the temperature of the sample, the resistivity of the pure germanium is $60\Omega - cm$. If the applied electric field is 2 V/cm, find the current density. (6 marks)

d) A light emitting diode has a minimum voltage drop of 1.5V and a maximum voltage drop of 2.3 V. it is supplied from 10V supply with a series resistance of 0.47 Kilo-Ohms. Determine the maximum and minimum values of the light emitting diode current. (5 marks)

QUESTION FOUR (20 MARKS)

a) Briefly describe the four quantum numbers. (4 marks)

b) The Fermi energy level lies mid-way between the conduction and the valence band for an intrinsic semiconductor. Proof this statement by derivation. (6 marks)

c) Derive Schrodinger time independent wave equation. (6 marks)

d) With aid of well labelled diagram, briefly describe dark discharge, glow discharge and arc discharge. (4 marks)

QUESTION FIVE (20 MARKS)

a) Fill the tabulation in table 1. (7 marks)

Orbit	Total no. of electrons	No. of orbits	Name of sub-orbits	Distribution of electrons to sub-orbits
K (n=1)				
L (n=2)				
M (n=3)				
N (n=4)				

b) Using energy band diagrams, distinguish between good, semi and bad conductors. Give typical values of gap energy for the three materials. (6 marks)

c) Solar energy is available during the day when there is sunlight. For this energy to be used continuously to supply power to a security equipment, battery is used for storage purposes. The equipment uses a 15V battery which supplies a continuous current of 1A. solar cells are used to keep the battery charged are illuminated by sun for 10 hours in every 24 hours. If during exposure, each cell gives 0.2V at 100mA, determine the number of cells required:

i. In series
ii. In parallel
iii. Total number of cells

Assume to charge the battery, 16 volts are needed. (7 marks)