MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 205: PHYSICAL ELECTRONICS

DATE: 29/8/2022 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Question ONE is compulsory

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) The M-shell of an atom has three sub-orbits 3s, 3p and 3d. Determine the ratios of their semi-minor and semi-major axes and hence show the shape of the three sub-shell. (5 marks)

c) 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)

d) A group 4 element has 14 protons in its nucleus. Determine:

i. Energy possessed by the valence shell electrons in electron volts

ii. Energy possessed by conduction electrons, assuming energy gap 0f 1.5 eV,

iii. Fermi energy level. (6 marks)

e) What will be the resistivity of silicon, when it is doped with a penta-valent impurity to the extent of one impurity atom for each 40 million silicon atoms given: number of silicon atoms $=4.5X10^{22}/cm^3$, intrinsic carrier concentration$=1.5X10^{10}/cm^3$, Electron mobility$=0.14m^2$/volt-sec, hole mobility $= 0.040\ m^2$/volt-sec. (5 marks)

f) The resistance of copper wire of diameter 1.033mm is 6.51Ω per 333 meters. The concentration of copper is $8.4X10^{23}$ electrons per m^3. If the current is 2A, find:

i. Drift velocity

ii. Conductivity

iii. Mobility. (7 marks)

QUESTION TWO (20 MARKS)

a) Describe any TWO common uses of tunnel diode. (3 marks)

b) Briefly describe the quantum number which determines the number of sub-subshells in a given shell. (4 marks)

c) A sample of a good conductor of length L meters, cross-section A square meters has N total number of electrons. Derive the expression of current density of the sample when an electric field E is applied across it ends. (6 marks)

d) Determine the resistivity and the conductivity of an intrinsic sample of silicon at normal room temperature i.e. 300K. Assume electron mobility, $\mu_n=1350cm^2$/v-s, hole mobility, $\mu_h=0.048m^2$/v-s, intrinsic concentration at 300K$=1.52X10^{10}$ and charge of an electron or hole $=1.6X10^{-19}$ coulomb. (6 marks)

QUESTION THREE (20 MARKS)

a) State Pauli's exclusion principle. (3 marks)

b) Briefly describe how energy gap of intrinsic semi-conductors varies with variation in temperature and give the expression. (3 marks)

c) Determine radius of the 1st orbit of an atom whose atomic number is 12. Using the value of the radius, determine the velocity of electron in the orbit. Using the determined value of

velocity, determine the kinetic energy, potential and total energy possessed by the electron in the orbit. (7 marks)

d) With aid of a diagram, describe the three electric discharge regimes namely dark discharge, glow discharge and arc discharge. (7 marks)

QUESTION FOUR (20 MARKS

a) Explain any THREE Bohr atom postulates. (3 marks)

b) Determine the number of electrons in N-shell using Pauli's exclusion principle. (5 marks)

c) Determine the expression of time independent Schrodinger wave equation. (6 marks)

d) The dimensions of a metallic sample are length=30mm, width=5mm and thickness 4mm. A potential difference of 30 volts was applied longitudinally. Given free electron density is $2.5 \times 10^{24}/m^3$ and electron mobility is $8000 cm^2/v - s$ determine:

i. Electron drift velocity

ii. Conductivity of the sample

iii. The total current. (6 marks)

QUESTION FIVE (20 MARKS)

a) With aid of a diagram describe the formation of a depletion layer in Pn-junction. (4 marks)

b) Determine the PN junction diode current for the forward bias of 0.22V at 25°C with reverse saturation current of 1mA. Take η=1. (5 marks)

c) A semiconductor at 300K has intrinsic concentration, Ni=1.5x10^{16}/m^3 and resistivity of ρ=2x10^{13}ohm-meter. Donor impurity atoms N_D=1x10^{20} per m^3 were added as dopants. Determine the shift in Fermi energy level due to doping in electron-volts. (5 marks)

d) Proof that potential energy in an atom is given by mv^2 and total energy by $-\frac{1}{2}mv^2$ Joules. (6 marks)