KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCEAND BSc (Physics)

COURSE CODE: SPH 423

COURSE TITLE: SOLID STATE PHYSICS II

DURATION: 2 HOURS

DATE: 19/07/ 2021 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.

Start every question on a new page and make sure question's number is written on each page
This paper consists of **3** printed pages. Please Turn Over

QUESTION ONE (30 MARKS)

a) Distinguish between intrinsic semiconductor and extrinsic semiconductors. **(2 marks)**

b) In an extrinsic semiconductor, *majority carriers* and *minority carriers* play a major role in the electric conductivity. Let N_d be the donor impurity density, N_a the acceptor impurity density, p the density of holes and n the density of electrons in an extrinsic semiconducting material. Show that the density of holes and electrons in extrinsic semiconductor material is given by

$$n = \frac{(N_d - N_a) \pm \sqrt{(N_d - N_a)^2 + 4n_i^2}}{2}$$

(3 marks)

c) State some factors that influence conductivity of a semiconductor? **(3 marks)**

d) A superconducting tin has a critical temperature of 3.7 K at zero magnetic field and a critical field of 0.0306 Tesla at 0 K. Find the critical field at 2 K. **(4 marks)**

e) What are the functions of donor and acceptor impurities? **(2 marks)**

f) Define the following terms as used in superconductivity

i) Zero resistivity **(1 mark)**
ii) Transition temperature **(1 mark)**
iii) Critical magnetic field **(1 mark)**
iv) Critical current **(1 mark)**
v) Penetration depth **(1 mark)**
vi) Isotope effect **(1 mark)**

g) For a semiconductor the Hall Coefficient is given by $R_H = -\frac{1}{e}\frac{p\mu_p^2 - n\mu_n^2}{(p\mu_p - n\mu_n)^2}$ where μ_p and μ_n are the mobilities of holes and electrons respectively. Show that for an intrinsic semiconductor the above expression reduces to $R_H = -\frac{1}{n_i e}\left(\frac{\mu_n + \mu_p}{\mu_n - \mu_p}\right)$ **(4 marks)**

h) Differentiate between substitutional solid solutions and interstitial solid solutions. **(2 marks)**

i) Differentiate between paramagnetic materials and antiferromagnetic materials **(2 marks)**

j) What do understand by crystal imperfections? **(2 marks)**

QUESTION TWO (14 MARKS)

a) Differentiate between conductors, semiconductors and Insulators in terms of

i) electrical conductivity **(3 marks)**
ii) band gap width **(3 marks)**

b) Find the conductivity and resistivity of a pure silicon crystal at temperature 300°K. The density of electron hole pair per cc at 300°K for a pure silicon crystal is 1.072×10^{10} and the mobility of electron $\mu_n = 1350$ cm^2/volt-sec and hole mobility $\mu_h = 480$ cm^2/volt-sec **(4 marks)**

c) A silicon wafer is doped with phosphorus of concentration 10^{13} atoms/cm^3. If all the donor atoms are active, what is its resistivity at room temperature? The electron mobility is 1200 cm^2/Volt-sec charge on the electron is 1.6×10^{-19} Coulomb. **(4 marks)**

d) Define hall effect and explain five uses of hall effect **(6 marks)**

QUESTION THREE (20 MARKS)

a) Explain the following properties of superconductors

i) Energy gap **(4 marks)**

ii) Specific heat **(4 marks)**

b) The equation of motion of superconducting electrons is given by a transitory electric field E is

$$m\frac{dv_s}{dt} = -e\boldsymbol{E}$$

By defining current density of superconducting electrons derive London's first equation **(6 marks)**

c) By applying the Maxwell equations;

$$curl\ E = -\frac{\partial \boldsymbol{B}}{\partial t}$$

To the London's first equation show that;

$\frac{d}{dt}\left(\frac{m}{n_s e^2}(\nabla \times \boldsymbol{j}_s) + \boldsymbol{B}\right) = 0$ **(6 marks)**

QUESTION FOUR (20 MARKS)

a) Differentiate between magnetic permeability (μ) and magnetic susceptibility (χ_m) **(2 marks)**

b) State and explain the three types of magnetism. Illustrate the arrangement of their respective magnetic moments in presence and absence of applied magnetic field. **(12 marks)**

c) The magnetization with in a bar of some metal alloy is $1.2\text{x}10^6$ A/m at an H field of 200 A/m. Compute the following; (μ_0=$1.257\text{x}10^{-6}$ H/m)

i) The magnetic permeability **(2 marks)**

ii) The magnetic susceptibility **(2 marks)**

iii) The magnetic flux density with in this material **(2 marks)**

iv) What types of magnetism would you suggest as being displayed by this material? Why? **(2 marks)**

QUESTION FIVE (20 MARKS)

a) Write brief notes on each of the following types of dislocations; use diagrams to illustrate how each one of them is formed

i) Edge dislocation **(6 marks)**

ii) Screw dislocation **(6 marks)**

b) Briefly explain the following point defects **(8 marks)**

i) Vacancies

ii) Interstitial defect

iii) Frenkel defect

iv) Schottky Defect