KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE MASTERS OF SCIENCE (PHYSICS)

COURSE CODE: SPH 822E

COURSE TITLE: ENERGY BANDS, MAGNETISM & AMORPHOUS MATERIALS

DURATION: 2 HOURS

DATE: 5/10/2021 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES
- Answer any **three (3)** 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 (20 MARKS)

a) 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)**

b) Derive expressions for the shift in the Fermi level in the n and p type of semiconductor. **(6 marks)**

c) Show that the relative dielectric constant of a barium titanate crystal, which, when inserted in a parallel plate condenser of area 10 mm×10 mm and distance of separation of 2 mm, gives a capacitance of 10^{-9} F is 2259. **(4 marks)**

d) Explain the phenomenon of breakdown in dielectric materials **(6 marks)**

QUESTION TWO (20 MARKS)

a) What length of a round copper wire of diameter $1mm$ will have a resistance of $1k\Omega$ if copper conductivity is $60MS/m$. A cylindrical piece of silicon having diameter of $1mm$ is doped with $10^{20}m^{-3}$ atoms of phosphorus which are fully ionized. What length of this silicon would be required to give a resistance of $1k\Omega$ if electronic mobility of silicon is $0.1m^2/V-s$? **(6marks)**

b) Calculate the intrinsic carrier concentration of silicon at room temperature if $n = 1.41\times10^{16}m^{-3}, \mu_e = 0.145m^2/V-s, \mu_h = 0.05m^2/V-s$ and $e = 1.6\times10^{-19}C$. What are the individual contributions made by electrons and holes. **(4 marks)**

c) Calculate the donor concentration in N-type germanium having resistivity of $100\Omega-m$ Derive the formula you use. Take $e = 1.6\times10^{-19}C, \mu_e = 0.36m^2V^{-1}s^{-1}$. **(4 marks)**

d) How much donor impurity should be added to pure germanium so that its resistivity drops to 10% of its original value? Determine n and p in a p-type germanium sample whose resistivity is 0.01 ohm-cm, and also find n and p in a N-type silicon sample whose resistivity is 10 Ω-cm. Resistivity of pure Ge is 44.6 Ω-cm. **(6marks)**

QUESTION THREE (20 MARKS)

a) Differentiate between conductors, semiconductors and Insulators in terms of
   i) electrical conductivity **(4 marks)**
   ii) band gap width **(4 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 μ_n= 1350 cm²/volt-sec and hole mobility μ_h= 480 cm²/volt-sec **(6 marks)**

c) A silicon wafer is doped with phosphorus of concentration 10^{13} atoms/cm³. If all the donor atoms are active, what is its resistivity at room temperature? The electron mobility is 1200 cm²/Volt-sec charge on the electron is 1.6×10^{-19} Coulomb **(6 marks)**

QUESTION FOUR (20 MARKS)

a) Define the term 'Magnetization' and explain the circumstances that can make it go to zero

b) State and explain the three origins of magnetic moment of an atom **(3 marks)**

c) Briefly describe the following concepts basing on any of their three properties;

i) Diamagnetism **(3 marks)**

ii) Ferromagnetism **(3 marks)**

iii) Paramagnetism **(3 marks)**

d) Explain the hysteresis loop of a magnetic material **(5 marks)**

QUESTION FIVE (20 MARKS)

a) Explain four difference Between Crystalline and Amorphous Solids. **(4 marks)**

b) Describe the two techniques used for strengthening glass **(4 marks)**

c) In the context of amorphous inorganic compounds, name two network formers, two network modifiers, and one intermediate. **(3 marks)**

d) Briefly explain the following properties of amorphous glass

i) Conductivity **(3 marks)**

ii) Strength **(3 marks)**

iii) Chemical stability **(3 marks)**