# UNIVERSITY EXAMINATIONS
# 2022/2023 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: 25/04/2023** **TIME: 2:00-4:00PM**

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**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 $\mu_p$ and $\mu_n$ 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 $1.072 \times 10^{10}$ and the mobility of electron $\mu_n = 1350$ cm$^2$/volt-sec and hole mobility $\mu_h = 480$ cm$^2$/volt-sec **(6 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 $1.6\times10^{-19}$ Coulomb **(6 marks)**

## QUESTION FOUR (20 MARKS)

a) Define the term 'Magnetization' and explain the circumstances that can make it go to zero **(3 marks)**

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)**