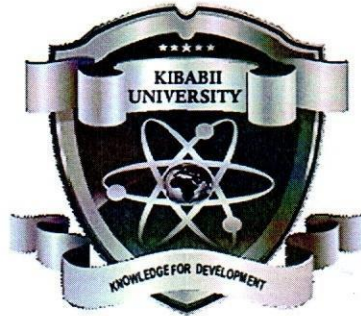


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KIBABII UNIVERSITY

**UNIVERSITY EXAMINATIONS
2021/2022 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: 10/05/2022

TIME: 2:00PM-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

KIBU observes ZERO tolerance to examination cheating

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 $10 \text{ mm} \times 10 \text{ mm}$ 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 1 mm will have a resistance of $1 \text{ k}\Omega$ if copper conductivity is 60 MS/m . A cylindrical piece of silicon having diameter of 1 mm 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 $1 \text{ k}\Omega$ if electronic mobility of silicon is $0.1 \text{ m}^2/\text{V-s}$? (6 marks)
- b) Calculate the intrinsic carrier concentration of silicon at room temperature if $n = 1.41 \times 10^{16} \text{ m}^{-3}$, $\mu_e = 0.145 \text{ m}^2/\text{V-s}$, $\mu_h = 0.05 \text{ m}^2/\text{V-s}$ and $e = 1.6 \times 10^{-19} \text{ C}$. What are the individual contributions made by electrons and holes. (4 marks)
- c) Calculate the donor concentration in N-type germanium having resistivity of $100 \Omega\text{-m}$. Derive the formula you use. Take $e = 1.6 \times 10^{-19} \text{ C}$, $\mu_e = 0.36 \text{ m}^2 \text{V}^{-1} \text{s}^{-1}$. (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 $10 \text{ }\Omega\text{-cm}$. Resistivity of pure Ge is $44.6 \text{ }\Omega\text{-cm}$. (6 marks)

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 $\mu_n = 1350 \text{ cm}^2/\text{volt-sec}$ and hole mobility $\mu_h = 480 \text{ cm}^2/\text{volt-sec}$ (6 marks)
- c) A silicon wafer is doped with phosphorus of concentration $10^{13} \text{ atoms/cm}^3$. If all the donor atoms are active, what is its resistivity at room temperature? The electron mobility is $1200 \text{ cm}^2/\text{Volt-sec}$ charge on the electron is $1.6 \times 10^{-19} \text{ Coulomb}$ (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; (3 marks)
- 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 (3 marks)
- i) Conductivity (3 marks)
 - ii) Strength (3 marks)
 - iii) Chemical stability (3 marks)