MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS

UNIVERSITY ORDINARY EXAMINATION

2023/2024 ACADEMIC YEAR

FIRST YEAR **SECOND** SEMESTER EXAMINATION FOR BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

EET 105 – MATERIAL SCIENCE

DURATION: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. Answer question one and any other two questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION

QUESTION ONE (30 MARKS)

a. State two factors affecting electrical conductivity (2marks)
b. Find the probability of occupancy of a quantum state whose energy is 0.05ev above the Fermi energy assuming a sample temperature of 450k. (2marks)
c. State and explain three factors affecting dielectric strength. (5marks)
d. A photon with a wavelength of 450nm strikes a semiconductor with band-gap energy of 1.8eV.
    i. Will this photon be absorbed by the semiconductors? Explain why or why not. (4marks)
    ii. If absorbed, what is the energy difference (ΔE) between the Photon's energy and the band-gap energy, expressed in electron volts (eV)
e. List three commonly used materials for solar energy conversion in solar cells.(3marks)
f. Giving two examples each, differentiate between amorphous and organic semiconductors. (2marks)
g. Briefly explain various classes of insulation based on temperature. (4marks)
h. A researcher is studying the properties of a new material. They measure a current of 0.5A flowing through a sample of the material with a cross-sectional area of 2 x $10^{-6}m^2$ and a length of 5m. The electric field strength within the material is measured to be 100v/m. Calculate:

i. The resistivity and the conductivity of the material.
ii. How does this material's conductivity compare to that of copper ($\delta = 5.96\ x\ 10^7$ s/m) (4marks)

i. Calculate the electrical conductivity of intrinsic silicon at 150^oc (423k) given the intrinsic concentration ($n_i = 4 \times 10^{19}\ m^{-3}$), electron mobility Type equation here. (2marks)
j. Differentiate between the following terms:
    i. Magnetic field intensity and magnetic flux density
    ii. Magnetic permeability and susceptibility (2marks)
k. Differentiate between Curie law and Curie-Weiss law. (2marks)

SECTION B – ANSWER ANY TWO QUESTIONS IN THIS SECTION

QUESTION TWO (20 MARKS)

a. With the aid of a well labelled diagram, describe the electron-energy band structure of a metallic conductor, semi-conductor and insulator. (4marks)
b. In a P-type semiconductor, n_i = 2.1 x $10^{19}m^{-3}$ and density of Boron is 4.5 x 10^{23} atoms/m^3. The electron and hole mobility are 0.4 and 0.2 m^2/vs respectively. Determine:
    i. Conductivity before addition of boron atoms
    ii. Conductivity after addition of boron atoms. (4marks)
c. Distinguish between the following types of magnetic materials based on their magnetic permeability (μ) and susceptibility (x) (6marks)
    i. Diamagnetic material
    ii. Paramagnetic material
    iii. Ferromagnetic material
d. Using a well-labelled diagram, briefly explain the hysteresis loop (B-H curve) for a magnetic material and hence identify the following from the curve. (6marks)
    i. Saturation
    ii. Remanence
    iii. Coercivity

QUESTION THREE (20 MARKS)

a. In a magnetic material, the field strength is 10^6 A/m and magnetic susceptibility of the material is 0.5 x 10^{-5}. Calculate the intensity of magnetization and the flux density of the material. (4marks)
b. State and explain four characteristics of dielectric materials. (8marks)
c. Using a suitable diagram, briefly describe polarization in dielectric materials. (4marks)
d. Illustrate the differences between hard and soft magnetic materials using a B-H curve and list two examples of each. (4marks)

QUESTION FOUR (20 MARKS)

a. State and explain four categories of insulating materials used in electrical apparatus. (4marks)
b. State and explain five classes of breakdown in solid dielectrics depending on voltage and time of application. (5marks)
c. State and explain three factors that affect the ageing of insulators and list two consequences of ageing in insulator. (5marks)

d. A parallel plate capacitor has an area of 7.45 x $10^{-4}m^2$ and its plates are separated by a distance of 0.0245m across with a potential of 10v applied. If a material with dielectric constant 6 is introduced between plates, determine:
   i. The capacitance
   ii. Charge stored in each plate
   iii. Dielectric displacement
   iv. Polarization (4marks)

e. Describe two applications of magnetic resonance techniques in materials characterization. (2marks)