



MACHAKOS UNIVERSITY

University Examinations 2019/2020

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR
BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)
EEE 304: ELECTRICAL ENGINEERING MATERIALS

DATE: _____

TIME: _____

INSTRUCTIONS TO STUDENTS

1. This paper contains **5 questions**.
2. Attempt **Question One** and **Any Other Two** questions
3. Show calculations where applicable

Constants

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m} \cdot \text{A}^{-1}$$

$$k = 1.38065 \times 10^{-23} \text{ J/K}$$

$$\text{Avogadro's number} = 6.023 \times 10^{23}$$

Atomic mass of copper is 63.54 g/mol

Atomic mass of Nickel is 58.69 g/mol

Atomic mass of Aluminium is 26.98 g/mol

Lattice parameter of diamond cubic germanium = $5.6575 \times 10^{-10} \text{ m}$.

Atomic number (Z) of germanium is 32.

Dielectric strength of mica is $40 \times 10^6 \text{ V/m}$

Dielectric constant of mica is 7

QUESTION ONE [30 MARKS]

- a) Briefly explain the following terms
- a) Unit cell
 - b) Crystalline Solids
 - c) Binding energy
 - d) Cation
- [4 marks]
- b) State and explain any four physical properties of metals. [8 marks]
- c) What is the mass in grams of one atom of copper? [2 marks]
- d) Derive the relationship between magnetic susceptibility and relative permeability. Given that a magnetic field 2000 A/m is applied to a material with a relative permeability of 4500. Calculate the magnetization and inductance. [7 marks]
- e) Calculate the loss of power in a copper transmission line 1800 m long when a current of 100 A is flowing. The wire has a diameter of 1.25 mm and the electrical resistivity is $1.67 \times 10^{-8} \Omega - m$ [4 marks]
- f) Xenon atom has $Z = 60$. Determine its electronic distribution. Also find out if it is chemically stable. What is the number of its valence electrons? [5 marks]

QUESTION TWO [20 MARKS]

- a) Calculate the energy in joules and electron volts (eV) of the photon whose wavelength is 121.6 nm. [4 marks]
- b) What do you understand by the term electronegativity? On electronegativity scale, an element which has a value of 0.1 is classified as being electronegative or electropositive. [4 marks]
- c) Since conduction occurs by the motion of electrical charge through a solid, the magnitude of conductivity (σ) depend on three factors. State these factors. [3 marks]
- d) The following data refers to copper: Density = $8.94 \text{ gm} / \text{cm}^3$; Resistivity = $1.73 \times 10^{-8} \Omega m$; Atomic weight=65.5. Calculate the mobility and average time of collision of the electrons in the copper. [9 marks]

QUESTION THREE [20 MARKS]

- (i) Since conduction occurs by the motion of electrical charge through a solid, the magnitude of conductivity depend on three factors. State and explain these factors. [6 marks]
- (ii) The resistance of a metal rod with conductivity $3.5 \times 10^8 (\Omega - m)^{-1}$ and length 10 m is measured to be 0.08Ω . Calculate the cross-sectional area of the rod. What voltage is required to produce a current of 3.2 A in this rod? [3 marks]
- (iii) By deriving an equation, show that the electrical conductivity of a material can be controlled by controlling the number of charge carriers in the material or by controlling the mobility of the charge carriers. [7 marks]
- (iv) Calculate the mobility of an electron in copper, assuming that all of the valence electrons contribute to the current flow. Take the lattice parameter of copper to be $3.6151 \times 10^{-10} m$ and assume that it has 4 atoms/unit cell. [4 marks]

QUESTION FOUR [20 MARKS]

- a) Discuss any three applications of semiconductors [6 marks]
- b) With the aid of a diagram, explain how ionic polarization occurs. [5 marks]
- c) A mica capacitor $250 mm^2$ and $2.5 \mu m$ thick is to have a capacitance of $0.0252 \mu F$.
i) How many plates are needed?
ii) What is the maximum allowable voltage? [5 marks]
- d) Explain the following terms:
i) Diamagnetism
ii) Paramagnetism [4 marks]

QUESTION FIVE [20 MARKS]

- (i) For germanium at $25^\circ C$, estimate (a) the number of charge carriers, (b) the fraction of the total electrons in the valence band that are excited into the conduction band, and (c) the constant n_0 . Take that $\sigma = 2 \Omega^{-1} \cdot m^{-1}$, $E_g = 0.67 eV$, $\mu_e = 0.38 m^2 V^{-1} \cdot s^{-1}$ and $\mu_h = 0.18 m^2 V^{-1} \cdot s^{-1}$. Also take that there are 8 atoms per unit cell of germanium. [9 marks]
- (ii) State the two types of extrinsic semiconductors. [2 marks]
- (iii) A mica capacitor $250 mm^2$ and $2.5 \mu m$ thick is to have a capacitance of $0.0252 \mu F$ (a) How many plates are needed? (b) What is the maximum allowable voltage? [6 marks]
- (iv) State any three characteristics of soft magnets. [3 marks]