



# MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 304: ELECTRICAL ENGINEERING MATERIALS

DATE:

TIME:

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**INSTRUCTIONS:** This examination paper contains five questions. Answer **Question ONE** and any other **TWO Questions**. Question ONE carries 30 Marks and ALL the other questions carry 20 Marks each.

*Important constants*

Take  $\epsilon_0 = 8.854 \times 10^{-12} \text{F/m}$ ,  $\mu_0 = 4\pi \times 10^{-10} \text{H/m}$ , one Bohr magneton  $= 9.27 \times 10^{-24} \text{A}\cdot\text{m}^2$ ,

Avogadro's Constant  $N_A = 6.023 \times 10^{23} \text{atoms/mol}$

Electron mass  $m_e = 9.1 \times 10^{-31} \text{kg}$ , electronic charge  $e = 1.6 \times 10^{-19} \text{C}$

Plank's Constant  $h = 6.625 \times 10^{-34} \text{Js}$ , Boltzmann's constant  $k = 1.38 \times 10^{-23} \text{JK}^{-1}$

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**QUESTION ONE (COMPULSORY) (30 MARKS)**

- a) Name and briefly explain three factors which affects hysteresis losses in a ferromagnetic material **(6 marks)**
- b) The electrical resistivity of pure silicon is  $3.0 \times 10^{-16} \Omega\cdot\text{m}$  at room temperature  $27^\circ\text{C}$ . The conductivity is  $2.67 \Omega^{-1}\text{m}^{-1}$  at  $250^\circ\text{C}$ . Estimate the size of the energy gap.

**(5 marks]**

- c) With well labelled diagrams of energy band structures, explain the differences in electrical conductivities of conductors, semiconductors and insulators. **[9Marks]**
- d) A  $2\mu\text{F}$  capacitor is connected across a 500 volts dc supply. If it contains mica as the dielectric material having relative dielectric constant  $\epsilon_r = 5$ ; find:
- The energy stored in the capacitor and **[2Marks]**
  - The energy stored in polarizing the dielectric material, **[2Marks]**
  - Repeat (ii) if the dielectric material is titanium oxide with  $\epsilon_r = 95$  **[1Marks]**
- e) A uniform silver wire has a resistivity of  $1.54 \times 10^{-16}\Omega\text{-cm}$  at room temperature. An electric field of  $45\text{V/cm}$  exists along the length of the wire. If the number of free electrons is  $5.8 \times 10^{28}/\text{m}^3$ . Calculate the drift velocity of electrons, their mobility and relaxation time. **[5 Marks]**

### QUESTION TWO (20 MARKS)

- a) List two families of adhesives and highlight their properties **[4 Marks]**
- b) An alloy of metal is found to have resistivity of  $2.5 \times 10^{-16}\Omega\text{-cm}$  at 400k. When it is heated to a room temperature of  $800^\circ\text{C}$ , the resistivity is found to increase by 25%. Assuming Matthiessen's rule to hold good for the alloy, find the allow resistivity due to impurity scattering alone at its temperature coefficient of resistivity. **[6 Marks]**
- c) A uniform copper wire has a resistivity of  $1.6 \times 10^{-16}\Omega\text{-cm}$  at room temperature. An electric field of  $2\text{V/m}$  is applied along the length of the wire. If the number of conduction electrons is  $5.6 \times 10^{28}/\text{m}^3$ . Calculate the electron mobility, drift velocity of electrons and their relaxation time. **[10 Marks]**

### QUESTION THREE (20 MARKS)

- a) With the aid of a well labelled diagram(s), discuss the concept of magnetic anisotropy in iron and nickel elements. **[10Marks]**
- b) State the different original sources if magnetic behaviour in atoms. **[3Marks]**
- c) Highlight the various practical applications of dielectric materials **[7Marks]**
- d) State the different original sources of magnetic behaviour in atoms. **[3Marks]**

**QUESTION FOUR [20 Marks]**

- a) Explain why current transformers and power transformers cores are made from cold rolled grain-oriented silicon steel (CRGOSS) alloys. **[8Marks]**
- b) Define the following terms as used in material science
- i) Dielectric loss angle **[6Marks]**
  - ii) Magnetic Susceptibility
  - iii) Superconductor material
- c) Explain with the aid of diagrams how doping modulates the energy gap in p-type and N-type semiconductor materials. **[6Marks]**

**QUESTION FIVE [20 Marks]**

- a) An intrinsic semiconductor material has a conductivity of  $400\Omega^{-1}m^{-1}$  at  $10^{\circ}C$  and  $1000\Omega^{-1}m^{-1}$  at  $30^{\circ}C$ .
- i) What is the size of energy gap in eV? **[7Marks]**
  - ii) What is the conductivity at  $20^{\circ}C$ ? **[3Marks]**
- b) Name five important characteristics of epoxy materials used for plotting of electronics devices and components. **[5Marks]**
- c) Enumerate the non-electrical factors to be considered when selecting polymers or polymeric composite materials used as printed circuit mother boards substrate materials. **[5Marks]**