

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF BACHELOR OF SCIENCE IN ELECTRICAL  
AND ELECTRONIC ENGINEERING

EENG 231: ELECTRICAL ENGINEERING MATERIALS

STREAMS: BSC EENG

TIME: 2 HOURS

DAY/DATE: TUESDAY 17/12/2024

11.30 P.M. – 1.30 P.M

INSTRUCTIONS:

Answer question ONE and any other TWO questions

Do not write on the question paper

Take:  $c = 3 \times 10^8$  m/s,  $h = 6.6261 \times 10^{-34}$  J/s,  $k = 1.3806 \times 10^{-23}$  J/k,  $e = 1.602 \times 10^{-19}$  C,  $\epsilon_0 = 8.85 \times 10^{-12}$  F/m,  $\mu_0 = 4\pi \times 10^{-7}$  H/m

QUESTION ONE

- Explain the concept of superconductivity, its discovery, and potential applications in electrical engineering (3 Marks).
- Why are ferromagnetic materials important in electrical engineering, and how are they used in transformers and electric motors (4 Marks)?
- Ultraviolet light of wavelength 250 nm is incident on a metal with a work function of 4.5 eV. Calculate the energy of the photons and the kinetic energy of the ejected electrons. (4 Marks)
- Describe the phenomenon of dielectric breakdown and its significance in the design of electrical equipment. (4 Marks).
- With the help of a well labeled diagram explain the working of a phototube. (4 Marks)

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- f. Aluminum is most commonly used in transportation. Discuss why. (3 marks)
- g. When an insulation is designed every attempt is made to avoid the existence of air spaces in it. Discuss why. (4 Marks)
- h. Explain two characteristics of the fuse material that ensure it operates correctly under overload conditions (4 Marks)?

### QUESTION TWO

- a.
- Derive an expression for the energy stored in a capacitor (5 Marks).
  - How is this related to the charge and voltage across the capacitor (2 Marks)?
  - What is the purpose of a capacitor in an AC circuit (1 Marks)?
  - Use the formula to calculate the energy stored in a 20  $\mu\text{F}$  capacitor charged to 5 V (2 Marks).
- b. In a photoelectric experiment, the stopping potential for electrons is measured to be 2.0 V when light of wavelength 300 nm is used. Calculate the energy of the incident photons, the work function of the metal, and the cut-off frequency. (4 Marks)
- c. The electronic polarizability of the Ar atom is  $1.7 \times 10^{-40} \text{ F m}^2$ . What is the static dielectric constant of Ar gas if  $N=2.44 \times 10^{25} \text{ atoms m}^{-3}$  (4 Marks)?
- d. If a watch glass containing a small quantity of paramagnetic liquid is placed on two dissimilar magnetic poles, the liquid shows an elevation in the middle. Explain why . (2 Marks)**

### QUESTION THREE

- a. Considering a dielectric with number density  $N$  (number of particles per unit volume) in an external electric field  $E$ . If the sum of  $E$  and an internal field  $E_{\text{int}}$  induces a dipole  $p_{\text{ind}}$  on each particle. Derive the [Clausius-Mossotti](#) Equation. Take the polarization vector to be  $P$ . (5 Marks)
- b. The refractive index of a medium is 1.8, and its relative permeability is 1.2. Find the relative permittivity of the medium (2 Marks).
- c. The maximum magnetic field strength in a solenoid is 0.9 T, and the cross-sectional area of the solenoid's coil is circular. If the total magnetic flux through the coil is 113 mWb, calculate the radius of the coil's cross-section. (4 Marks)

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- d. Compare the mechanical properties of ceramics and polymers in the context of their application in electrical insulation (4 Marks).
- e. The susceptibility of magnesium at 400K is  $1.5 \times 10^{-5}$ . At what temperature will the susceptibility increase to  $1.8 \times 10^{-5}$  (3 Marks)
- f. A certain paramagnetic material has a magnetic field strength of 1200 A/m. If the magnetic susceptibility is  $5 \times 10^{-6}$ , find the magnetization of the material. (2 Marks)

### QUESTION FOUR

- a. State the Paschen's law (1 Marks)
- b. Discuss the importance of the dielectric constant in capacitor design and provide an example of a dielectric material (4 Marks).
- c. A coil of 300 turns is wound uniformly on a ring of non-magnetic material. The ring has a mean circumference of 40 cm and a uniform cross sectional area of  $4 \text{ cm}^2$ . If the current in the coil is 5 A, calculate
- the magnetic field strength (2 Marks),
  - the flux density and (2 Marks)
  - the total magnetic flux in the ring (2 Marks).
- d. An iron ring of mean diameter 10 cm is uniformly wound with 2000 turns of wire. When a current of 0.25 A is passed through the coil a flux density of 0.4 T is set up in the iron. Find
- the magnetizing force and (3 Marks)
  - the relative permeability of the iron under these conditions (2 Marks).
- e. A waxed paper capacitor has two parallel plates, each of effective area  $800 \text{ cm}^2$ . If the capacitance of the capacitor is 4425 pF determine the effective thickness of the paper if its relative permittivity is 2.5 (4 Marks)
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