



UNIVERSITY OF GHANA

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FACULTY OF ENGINEERING SCIENCES

BSc. (ENG) MATERIALS SCIENCE AND ENGINEERING

END OF FIRST SEMESTER EXAMINATIONS: 2012/2013

MTEN 313: ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES OF
MATERIALS (3 CREDITS)

TIME ALLOWED: 3 HOURS

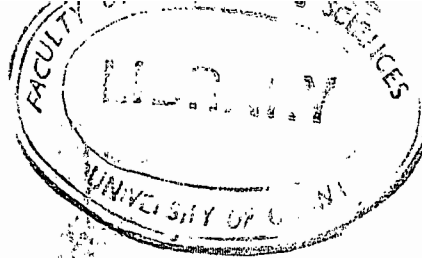
Take $\epsilon_0 = 8.85 \times 10^{-12}$ F/m, $|e| = 1.6 \times 10^{-19}$ C, $h = 4.13 \times 10^{-15}$ eV.s, $c = 3 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ H/m.

Answer all questions

SECTION A

(40 Marks)

1. Describe the phenomena of ferroelectricity and piezoelectricity.
2. State the two Ohm's law equations and prove that they are equivalent.
3. Differentiate between soft and hard magnets.
4. Explain the two sources of magnetic moments for electrons.
5. Briefly explain why metallic materials are opaque to visible light.
6. State the equation that relates the electromagnetic constant c and the electrical and magnetic constants.
7. Visible light having a wavelength of 6×10^{-7} m appears orange. Compute the frequency and energy of a photon of this light.
8. Mention the types of polarization of dielectric materials and explain one of them.
9. What is MOSFET?
10. Explain the Hall effect as applied under semiconductivity.



SECTION B

(60 Marks)

11. As a Materials Engineer in company X, you analysed a magnetic material in a laboratory. The magnetization of that ceramic material was 3.2×10^5 A/m at an H field of 50 A/m. Calculate,

- the magnetic susceptibility of that material
- the permeability and
- the magnetic flux density within the material.

What type(s) of magnetism is being displayed by the ceramic material and why?

12. A charge of 3.5×10^{-11} C is to be stored on each plate of a parallel-plate capacitor having an area of 160 mm^2 and a plate separation of 3.5 mm.

- What voltage is required if a material having a dielectric constant of 5.0 is positioned within the plates?
- What voltage would be required if a vacuum were used?
- What are the capacitances for parts (a) and (b)?
- Compute the dielectric displacement for part (a).
- Compute the polarization for part (a).

13. a) Calculate the resistance of a copper wire 3 mm in diameter and 2 m long.

b) What would be the current flow if the potential drop across the ends of the wire is 0.05 V?

c) What is the current density?

d) What is the magnitude of the electric field across the ends of the wire? [Take $\sigma_{\text{Cu}} = 6 \times 10^7 (\Omega \cdot \text{m})^{-1}$].

14. a) Prove that the maximum and minimum band gap energies for E_g (max) and E_g (min) are 3.1 eV and 1.8 eV respectively provided that the wavelengths are 0.7 μm minimum and 0.4 μm maximum.

b) Compute the velocity of light in calcium fluoride, which has a dielectric constant ϵ_r of 2.056 (at frequencies within the visible range) and a magnetic susceptibility of -1.43×10^{-5} .

What is the refractive index of this material?