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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

UNIVERSITY EXAMINATIONS 2021/2022 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF

MASTER OF SCIENCE IN PHYSICS

COURSE CODE: SPH 842 E

COURSE TITLE: ELECTRICAL, MAGNETIC AND OPTICAL PROPERTIES OF SOLIDS

DATE: MONDAY 1ST AUGUST, 2022 **TIME:** 2 PM - 5 PM

INSTRUCTIONS TO CANDIDATES

TIME: 3 Hours

Answer any five questions.

Symbols used bear the usual meanings.

YOU MAY USE THE FOLLOWING CONSTANTS

Atomic mass unit (u) = $1.6605 \times 10^{-27} kg$
Boltzmann constant $K = 1.38 \times 10^{-23} J/k$
Gravitational acceleration of the earth = 9.8m/s^2.
Planck's constant h = $6.625 \times 10^{-34}\ JS$
Avogadro number $N_A = 6.023 \times 10^{23}$ mole^{-1}
Molar gas constant R $= 8.3144 J/mole$
Mass of electron m =$9.1 \times 10^{-31} kg$
Speed of light $c = 3 \times 10^{8} m/s$
Charge of electron $e = 1.6 \times 10^{-19} C$
Permittivity in free space μo = 4Π x 10^{-7} Wb/A-m

QUESTION ONE (14 MARKS)

a) Derive the dispersion relation for transverse and longitudinal modes in plasma. Hence explain why alkali metals are transparent to ultraviolet light. (6 marks)

b) Show that the nearly free electron states in a linear lattice of parameter a are degenerate, and derive the first order perturbation results for these states. (6 marks)

c) Estimate the electron specific heat of Aluminum and copper at 600 K, given $\varepsilon_f = 11.7$ eV for Al and $\varepsilon_f = 7$ eV for copper (2marks)

QUESTION TWO (14 MARKS)

a) Distinguish between normal and inverse spinels (2 marks)

Explain with the aid of suitable diagrams, the extended states in a regular crystal structure (single crystal of silicon) and show how extended states gradually change into localized states in amorphous silicon. (4 marks)

b) Define dielectric function $\in(\omega, k)$. For long wavelengths region obtain an expression

$$\in(\omega) = 1 - \frac{\omega_p^2}{\omega^2}$$

Where symbols carry usual meaning. Plot this equation graphically and hence explain attenuation of the wave. (8 marks)

QUESTION THREE (14 MARKS)

a) Describe how nearly free electron model leads to the formation of forbidden gap and band structure (8 marks)

b) Discuss the properties of Bloch function. (4marks)

c) Explain why ferrites are used in high frequency transformers (2 marks)

QUESTION FOUR (14 MARKS)

a) Define ferrimagnetism? Describe lattice structure of ferrimagnetic materials (5 marks)

b) Distinguish between soft and hard ferrites, hence explain their applications (4 marks)

c) Obtain Curie -Weiss law for magnetic susceptibility of ferromagnetic materials (5 marks)

d) Describe the term coercivity in magnetic materials, hence explain why low coercivity is desired in transformer cores and high coercivity is desired in permanent magnets ? (4 marks)

QUESTION FIVE (14 MARKS)

a) With the aid of suitable illustrations, discuss hysteris in a magnetic material. (3 marks)

b) Obtain Langevin theory of diamagnetic material, hence show that diamagnetic susceptibility is negative. (8 marks)

c) Distinguish between ferromagnetism, ferrimagnetism and antiferromagnetism (3 marks)

QUESTION SIX (14 MARKS)

a) With the aid of a suitable diagrams, distinguish between diamagnetism and paramagnetism (2 marks)

b) Explain why hard ferromagnetic materials are used to make permanent magnets. (1 mark)

c) Obtain Langevin equation for paramagnetic susceptibility (8 marks)

d) The magnetic moment of an electron in the ground state of hydrogen atom is 1 Bohr magneton. Calculate the induced magnetic moment in a field of 1 Wb/m^2. (3 marks)