20

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

UNIVERSITY EXAMINATIONS 2021/2022 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER MAIN 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: WEDNESDAY 20TH APRIL, 2022 **TIME:** 2:00 PM - 5:00 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 $\mu o = 4\Pi \times 10^{-7}$ Wb/A-m

QUESTION ONE (14 MARKS)

a) Distinguish between Frenkel exciton and Mott-wannier excitons (2 marks)

b) What is anisotropy energy? hence explain the term magnetostriction (2 marks)

c) Explain different ways in which crystals may be coloured, hence define colour centre. (2 marks)

d) Explain the term dielectric function $\in (\omega, k)$. Hence 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 TWO (14 MARKS)

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

b) What are ferrites? Give their applications. (2 marks)

c) Explain why it is desirable to use hard ferromagnetic materials to make permanent magnets (2 marks)

d) With the aid of suitable diagrams, describe the temperature dependence of magnetic susceptibility for paramagnet, ferromagnet and antiferromagnet. (6 marks)

e) explain why alkali metals are transparent to ultraviolet light. (2 marks)

f) Discuss the properties of Bloch functions (3marks)

QUESTION THREE (14 MARKS)

a) Discuss the formation of forbidden gap and band structure by nearly free electron model (8 marks)

b) With the aid of relevant diagrams, explain the extended states in a single crystal of silicon and show how extended states gradually change into localized states in amorphous silicon. (4 marks)

c) Write short notes on normal and inverse spinels. Hence explain why ferrites are used in high frequency transformers (2 marks)

QUESTION FOUR (14 MARKS)

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

b) Show that Curie -Weiss law for magnetic susceptibility of ferromagnetic materials is given by

$$x = \frac{C}{T - T_C}$$

Symbols bear their usual meanings. (6 marks)

QUESTION FIVE (14 MARKS)

a) Describe hysteris in a magnetic material with the aid of suitable diagram (4 marks)

b) Discuss the domain structure in a ferromagnetic material (4 marks)

c) Distinguish between ferromagnetic, ferrimagnetic and antiferromagnetic using suitable diagrams (3 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? (3 marks)

QUESTION SIX (14 MARKS)

a) Deduce Kramers-Kronig relations. (8 marks)

b) Describe the origin of energy gap (2 marks)

c) A paramagnetic substance has 10^{28} atoms /m^3. The magnetic moment of each atom is 1.79×10^{-23} A-m^2. Calculate the paramagnetic susceptibility of the material at temperature of 320 K. What would be the dipole moment of the rod of this material 0.1 m long and 1 cm^2 cross-sectional area placed in a field of 7×10^4 A/m? (4 marks)