THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

SEPTEMBER – DECEMBER 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 308: INTRODUCTION TO SOLID STATE PHYSICS

Date: DECEMBER 2019	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and ANY other TWO Questions	

Q1. a) What do you understand by crystalline and amorphous solids? **(2 marks)**

b) Define packing fraction and find the value for a simple cubic structure **(3 marks)**

c) Write the reciprocal lattice if $\vec{a},\vec{b},\vec{c}$ are the basis vectors of a cubic crystal **(3 marks)**

d) State the Dulong-Petit law and give its importance in solids **(4 marks)**

e) Considering the reciprocal lattice vector G for two parallel planes of atoms, derive the Braggs condition $2d\sin\theta=\lambda$

(4 marks)

f) Show that the primitive of a B.C.C lattice is an F.C.C lattice **(3 marks)**

g) Sketch the (112), (111) and (101) planes in simple cubic cell. **(3 marks)**

h) Obtain the relationship between the atomic radius (r) and the lattice constant (a) for the simple cubic, the face centered and the body centered cubic structures. **(8 marks)**

Q2. a) Discuss why the Laue's method of X-ray diffraction is not preferred in determining the structure of a crystal

(4 marks)

b) Describe the powder method of x-ray diffraction and why it is the most preferred. **(6 marks)**

c) Of what importance are Miller indices in the rotating crystal method of X-ray diffraction **(4 marks)**

d) Discuss the free electron model and its failures **(6 marks)**

Q3. a) Proof that the length of reciprocal vector d_{hkl} is equal to the reciprocal of the interplanar spacing of the direct lattice. **(7 marks)**

b) Consider a triangular plane in the reciprocal lattice in 3D with point O being the origin. A point P on the plane is chosen such that OP is perpendicular to the plane. Proof that the reciprocal vector is perpendicular to the plane. **(7 marks)**

c) Show how the average energy in a Fermi gas can be expressed in terms of Ef_0 **(6 marks)**

Q4. a) Show that $\omega = \pm\sqrt{\frac{4\beta}{m}\sin^2\left(\frac{ka}{2}\right)}$ for a linear monoatomic lattice. **(8 marks)**

b) Explain the causes of lattice vibration and explain the curve for the linear monoatomic lattice

(6 marks)

c) Give a detailed description of optical and acoustical frequency of vibration of a linear diatomic lattice **(6 marks)**

Q5. a) What is the physical meaning of band effective mass of an electron?

(2 marks)

b) Gallium arsenide has a dielectric constant $\varepsilon_r = 13.13$, an effective mass $m_e = 0.07m_0$, and effective hole mass $m_h = 0.09m_0$. Calculate the donor and acceptor ionization energies, the Bohr orbit radius of a bound donor electron and a bound acceptor hole.

(6 marks)

c) Basing on the Fermi-Dirac statistics, show that the probability of finding electrons anywhere in an energy level is given by, $n = \frac{1}{3\pi}\frac{\left(\frac{2m}{\hbar^2}Ef_0\right)^3}{2}$

(6 marks)

d) Discuss the Weidmann Franz law and sketch variation of thermal conductivity in metals verses temperature

(6 marks)

END