KIBABII UNIVERSITY

MAIN UNIVERSITY EXAMINATIONS

ACADEMIC YEAR 2022/2023

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

BACHELOR OF SCIENCE

COURSE CODE: SPH 417

COURSE TITLE: SOLID STATE PHYSICS

DATE: 24/05/2022   TIME: 9:00AM-11:00AM

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any TWO of the remaining.

Time: 2 hours

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

a) Distinguish between crystalline and amorphous solids   (2 marks)

b) Explain briefly the following terms:
   i)   Lattice   (2 marks)
   ii)   Basis   (2 marks)
   iii)   Crystal structure   (2 marks)
   iv)   Unit cell   (2 marks)
   v)   Primitive unit cell   (2 marks)
   vi)   Bravais lattice   (2 marks)
   vii)   Wigner-sietz cell   (2 marks)

c) Sketch the following planes in a simple cubic cell:
   i)   (1 0 0)   (2 marks)
   ii)   (1 1 0)   (2 marks)
   iii)   (1 1 1)   (2 marks)

d) State and explain Bragg's diffraction law   (2 marks)

e) X rays with wavelength of $1.54\mathring{A}$ are used to calculate the spacing of (200) planes in aluminum. The Bragg angle for the first order reflection is $22.4\mathring{A}$. What is the size of the unit cell of Aluminum crystal?   (3 marks)

f) Name any one type of bonding that exists in crystals   (1 mark)

g) Using a well labelled diagram, define a face-centred cubic (fcc) unit cell.
                                                                                  (2 marks)

QUESTION TWO (20 MARKS)

(a) State the Wiedemann-Franz law and state its limitation   (3 marks)

(b) A beam of electrons with kinetic energy 1 KeV is diffracted and passes through a polycrystalline metal foil. The metal has a cubic crystal structure with spacing of $1\ \mathring{A}$. Given m, q, h, c,

   i)   Calculate the wavelength of the electrons.   (4 marks)
   ii)   Calculate the Bragg angle for the first order diffraction maximum.   (4 marks)

(c) Explain Phonon momentum; hence illustrate the normal process and Umklapp process?
                                                                                  (4 marks)

(d) State any five assumptions of 1-D monoatomic lattice   (5 marks)

QUESTION THREE (20 MARKS)

(a) State any four assumptions of classical free electron model   (4 marks)

(b) Explain the Laue method as one of the principal method of crystal structure analysis.

(8 marks)

(c) Write the dispersion relation for 1-D diatomic lattice and use it to explain optical mode and acoustic mode? (8 marks)

QUESTION FOUR (20 MARKS)

(a) What is Hall effect? Calculate the Hall coefficient of sodium based on free electron model. Sodium has BCC structure and the side of the cube is $4.2\mathring{A}$ (Given charge of electron is $1.6 \times 10^{-19}C$). (8 marks)

(b) Diffraction studies involving X-rays, electrons or neutrons give information about the crystallographic properties of solids. Compare these three techniques with reference to particle energies and type of information that can be obtained. Which technique is the most appropriate for studying surface crystallography? Which technique is used to determine magnetic structure? (12 marks)

QUESTION FIVE (20 MARKS)

(a) i) What is a 1-D diatomic lattice? (2 marks)
     ii) Explain the assumptions applied in 1-d diatomic lattice. (5 marks)
(b) Discuss the free electron gas in 3-D and show that its energy is quantized (10 marks)

(c) What is a lattice vibration? Explain how it occurs? (3 marks)