MAIN UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER FOR THE DEGREE OF

BACHELOR OF SCIENCE IN PHYSICS

COURSE CODE: SPC 311

COURSE TITLE: SOLID STATE PHYSICS

DATE: 6/12/2023 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any TWO of the remaining.

Time: 2 hours

QUESTION ONE (30 MARKS)

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

b) Explain briefly the following terms:

i) Lattice (1 mark)

ii) Basis (1 mark)

iii) Crystal structure (1 mark)

iv) Unit cell (1 mark)

v)Primitive unit cell (1 mark)

vi)Bravais lattice (1 mark)

vii)Wigner-sietz cell (1 mark)

c) Name any three experimental diffraction methods (3 marks)

d) 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)

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

f) 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^o. What is the size of the unit cell of Aluminum crystal? (3 marks)

g) Illustrate using proper diagrams, Simple cubic (SC), Body centred cubic (BCC) and face centred cubic (FCC) structures (6 marks)

QUESTION TWO (20 MARKS)

(a) 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 Å. (Given mass m = 9.11 x 10-31kg, Plancks constant h = 6.63 x 10-34Js and speed of electrons c = 3.0 x 108m/s)

i)Calculate the wavelength of the electrons. (6 marks)

ii) Calculate the Bragg angle for the first order diffraction maximum. (4 marks)

(b) Explain Phonon momentum; hence illustrate the normal process and Umklapp process? (10 marks)

QUESTION THREE (20 MARKS)

a) Discuss the dispersion relation for 1-D diatomic lattice and use it to explain optical mode and acoustic mode? (10 marks)

b) Neutron diffraction may be used to measure ω vs. κ for an excitation in a crystalline solid. To describe this, assume the crystal symmetry is known, write down the energy and momentum conservation laws for the diffraction and then indicate what parameters must be measured in order to obtain ω vs. κ (6 marks)

c) State any four assumptions of a 1-D monoatomic lattice (4 marks)

QUESTION FOUR (20 MARKS)

a) 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? (10 marks)

b) Explain the Laue method as one of the principal method of crystal structure analysis (10 marks)

QUESTION FIVE (20 MARKS)

While sitting in front of a colour Television with 25kV picture tube potential, you have an excellent chance of being irradiated with X-rays.

a) What process produces most of the X-ray flux? (5 marks)

b) For the resulting continuous distribution, calculate the shortest wavelength (maximum energy) X-ray. ($h= 6.6 \times 10^{-34}$Js, $c=3 \times 10^{8}$ m/s, $1eV=1.6 \times 10^{-19}$ J). (5 marks)

c) For a rock salt (NaCl) crystal placed in front of the tube potential, calculate the Bragg angle for a first order reflection maximum at $\lambda= 0.5$ Å ($\rho NaCl = 2.165$ g/cm^3) (10 marks)