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MAIN EXAMINATION

JANUARY – APRIL 2018 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

PART TIME PROGRAMME

PHY 408: SOLID STATE PHYSICS

Date: APRIL 2018	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Physical Constants
Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg
Speed of light, $c = 3 \times 10^{8}$ m/s
Boltzmann constant, $k_B = 1.38 \times 10^{-23}$ J/K
Planck's constant, $h = 6.63 \times 10^{-34}$ Js
Avogadro's number, $N_A = 6.023 \times 10^{23}$ mol^{-1}

Q1 a) Distinguish between the following terms
- (i) Phonon and photon **(2 marks)**
- (ii) phase and group velocity **(2 marks)**
- (iii) primitive and non-primitive cells **(2 marks)**
- (iv) diamagnetic and paramagnetic materials **(2 marks)**

b) Define the following terms
- (i) Lattice vibration **(1 mark)**
- (ii) Crystallography **(1 mark)**
- (iii) Packing efficiency **(1 mark)**

c) The lattice spacing of one dimensional lattice atom of mass 3.7×10^{-27} kg is 3 Ă and the effective spring constant is 1.5×10^{-3} N/m. Calculate the maximum angular frequency of waves which can be propagated in the lattice **(3 marks)**

d) The lattice constant of a simple cubic lattice is 5.63 Ă. Calculate the distance between the nearest (110) planes. **(3 marks)**

e) (i) Draw a plane at 2**a**, 5**b**, 2**c** **(3 marks)**
(ii) Determine the miller indices in e(i) above **(3 marks)**
(iii) State the crystal direction and plane **(2 marks)**

f) Obtain a relationship between the cell edge and the atomic radius in the case of a BCC cubic unit cell **(3 marks)**

g) State the differerences and similarity between Einstein and Debye's models **(4 marks)**

Q2 a) A simple cubic structure has (100) plane spaced 5 x 10^{-10} m apart. Calculate
(i) Wavelength **(3 marks)**
(ii) wave number **(3 marks)**
(iii) energy in MeV of the lowest energy electrons which would diffract from these planes at normal incident **(4 marks)**

b) Prove that superconductors are diamagnetic in nature **(5 marks)**

c) Using Drude's theory show that

$$\rho = \frac{m_e \langle v \rangle}{ne^2\lambda}$$

Where ρ is the resistivity of a metal and λis the mean free path. **(5 marks)**

Q3 a) The atomic radius of a silver (atomic weight 107.9g) atom is 0.144 nm. Silver crystallizes in an FCC cubic structure. Calculate the density (g/cm3) for silver **(5 marks)**

b) Derive the relationship between the frequency of vibration, ω and the wave vector **q** for a linear lattice with a monatomic unit cell **(10 marks)**

c) An X ray diffractometer recorder chart for an element that has either BCC or FCC crystal structure showed diffraction peaks at the following 2θ angles 40.663, 47.314 and 83.448. Given that the wavelength of the incoming radiation was 0.1505 nm, determine the crystal structure **(5 marks)**

Q4 a) Calculate the atomic packing factor for a
(i) simple cubic lattice **(5 marks)**

(ii) body centred cubic lattice **(5 marks)**
(iii) face centred cubic lattice **(5 marks)**

b) Derive an expression for the magnetic susceptibility χ for s spherically symmetric charge distribution having N atoms per unit volume. **(5 marks)**

Q5 State the factors that need to be considered when calculating the internal energy of a solid and hence show how each of the factors can be determined **(20 marks)**

END