(d)(i) Explain briefly the empty lattice approximation of band theory and draw the first three bands for simple cubic lattice along [110] according to empty lattice approximation.

(ii) What is De Haas Van Alphen Effect? What are the conditions required to observe this effect? [5+(1+2)]

(All the symbols have their usual meaning)

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Internal Assessment-10

PKC/PG/IIIS/PHS-303/22

2022

M.Sc.

3rd Semester Examination

PHYSICS

PAPER – PHS-303A

Full Marks : 50

Time : 2 Hours

(PHS 303A-Solid State Physics-I)

1. Answer any ***four*** bits: 2×4 = 8

a) Write down the consequences of the substitutional defects.

b) For copper $n_o = 8.5 \times 10^{22}$ cm^{-3}, $E_{Fo} = 3.2$eV. Calculate the Thomas Screening length.

c) What is meant by reduced Zone scheme and extended zone scheme?

d) What are the essential conditions of material to be ferroelectric?

e) What is Mott's metal-insulator transition?

f)The energy of an electron in a crystalline solid is related to the wave number k by the relation $= \frac{10\hbar^2k^2}{m}$, calculate its velocity and effective mass.

g) What is a colour centre?

h) What is the basis of nearly free electron model in band theory?

2. Answer any ***four*** bits: 4×4 = 16

a) Derive the expression the concentration of Frenkel defect in ionic solid at any temperature T. 4

(Turn over)

b) The energy-wavenumber relationship for an electron in some material is given by $E = E_0 + 2Acos(ka)$, where symbols have their usual meaning. Determine the group velocity and find the electron's position as a function of time. Ignore scattering. 4

c) Describe the crystal structure of the $BaTiO_3$ and explain how spontaneous polarization appears in this material. 4

d) If a copper rod is heated from *0 K* to *1250 K* and there is an increase in length of *2%* of original length. What fraction of this increase in length is due to formation of the vacancies? Given activation energy for vacancy formation is $E_V = 1.2 \times 10^5$ J/mole and $R = 8.314$ *J/mole/K*, Copper is an FCC structured crystal. 4

e) Explain flux quantization and landau levels in case of metal placed in a magnetic field at low temperature. 4

f) Discuss ionic conductivity and derive Einstein relation for ionic conduction in a solid. 4

g) A *2-D* square lattice has side *2.5 Å*. What will be the momentum of an electron whose wave terminates at the boundary of first Brillouin zone? Also calculate the energy of the electron. 4

h) i) Find the electron plasma frequency considering the motions of positive ions imbedded in an electron sea. ii) A conductor has been

found by optical studies to have $\omega_p = 1.80 \times 10^{15} s^{-1}$ for the plasma frequency, and $\tau = 2.83 \times 10^{-15}\ s$ for the electron relaxation time at room temperature. Calculate the electrical conductivity from these data.

3. Answer any ***two*** from the following $2 \times 8 = 16$

(a) What are the basic assumptions of tight binding model? Derive the energy dispersion relation of electron in an fcc solid in 3-dimension according to the tight binding approximation (TBA). What is the band width of the system? [2 +5+1]

(b) (i) Find an estimation of critical shear stress in perfect solid according to Frenkel. Why this value of the critical shear stress is much higher than the experimentally observed value?

(ii) What do you mean by screw and edge dislocation? Draw Burgers circuit for these dislocations.

(iii)Which direction of slip plane is favourable in case of an fcc crystal? [3+4+1]

(c) (i) Justify the different terms in Boltzmann transport equation.

(ii) What is relaxation time approximation? Find the expression for electrical conductivity of a metal using the Boltzmann transport equation under relaxation time approximation. [3+(1+4)]