M.Sc.-III/Physics-301C/18

M.Sc. 3rd Semester Examination, 2018

PHYSICS

Course Title: Solid State Physics

Paper : PHY 301C

Course ID : 32451

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

1. Answer *any five* questions: 2×5=10

(a) If the energy wave number relation for an electron in some material is $E = E_0 + 2A\,cos\,(Ka)$. Show that electron's positions is a function of time (ignore scattering). 2

(b) The relative permittivity of Ge is 16. The edge length of the convertial cubic cell for Ge lattice is $5{\cdot}65 \times 10^{-10}m$. Calculate the electronic polarisability of Ge atoms. 2

(c) Calculate the frequency of radiation which must be incident on a substance placed in a magnetic field of strength $\left(5 \times \frac{10^5}{\pi}\right)$ ampere/ metre, so that the electrons can absorb energy. 2

(d) A paramagnetic material is subjected to a homogeneous field of 10^6 ampere/ metre at 37°C. Calculate the average magnetic moment along the field direction per spin in Bohr magneton. 2

(e) Draw (010), (110), (111) planes for a cubic crystal of Lattice constant '*a*'. 2

(f) Write down Widemann Franz's law related with the free electron theory of solid. 2

(g) Write down the dispersion relation for the One dimensional monoatomic lattice. Draw the dispersion curve form within the range $-\frac{\pi}{a} < q < \frac{\pi}{a}$. 1+1=2

2. Answer *any four* questions: 5×4=20

(a) In the one-dimensional Kroning-Penney (KP) model derive the following energy-momentum relation.

$$Cos\,Ka = Cos\,(\alpha a) + \frac{P sin\alpha a}{\alpha a}$$

Where $\alpha = \sqrt{\frac{2mE}{n^2}}$, *a* is the lattice constant and K is the wave number. 5

(b) (i) 'Zero resistivity and perfect diamagnetism' are two independent criteria for an ideal superconductor'.— Explain the statement.

(ii) How does entropy change for a material from normal state to superconducting state?

3+2=5

(c) (i) Show that Hall coefficient for free electron in solid $R_H = -\frac{1}{ne}$ ($n \rightarrow$ electron density)

(ii) Write down the Hall coefficient for a impure semiconductor containing n, p, number of electrons and holes per m^3 respectively. 4+1=5

(d) (i) Prove that the close packing of atoms in the Hexagonal close packed (hcp) structure demands an axial ratio, $\frac{c}{a} = \sqrt{\frac{8}{3}}$.

(ii) Calculate packing factor of hcp structure. 3+2=5

(e) (i) Draw two dispersion branches of a diatomic lattice $(M_1 < M_2)$, showing the frequency gap.

(ii) Discuss acoustic mode and optical mode at infinite wavelength ($q = 0$). 2+3=5

(f) From the aspect of free electron theory for a fermi gas in alkali metals and in nobel metals, discuss Pauli paramagnetism. Derive also Pauli paramagnetic susceptibility. 2+3=5

3. Answer *any one* question: 10×1=10

(a) For a ferromagnetic substance:

(i) Write down its basic features.

(ii) Discuss Weiss theory of ferromagnetism under $T>T_C$, $T<T_C$, $T=T_C$.

(iii) Derive Curie-Weiss law.

(iv) Discuss the ground state of free iron atom by using Hund rules. 2+3+3+2=10

(b) (i) 'Transition from normal state to superconducting state is a second order phase transition'— Explain.

(ii) What is Josephson's effect? Show mathematically that an alternating current is produced in a Josephson junction by applying a dc voltage.

(iii) Write down London equation, which describe the electrodynamics of the supercurrent. Define London penetration depth. 2½+5+2½=10