[4922]-202
M.Sc.
PHYSICS
PHY UT-602 : Solid State Physics
(2013 Pattern) (5 Credits) (Semester-II)

Time : 3 Hours]   *[Max. Marks : 50*

Instructions to the candidates:

   1)   Attempt any five questions.

   2)   Draw neat and labelled diagram wherever necessary.

   3)   Figures to the right indicate full marks.

   4)   Use of logarithmic table and calculators is allowed.

Constants:

   1.   Boltzmann constant = k_B = 1.38×10^{-23} J/K

   2.   Planck's constant = h = 6.623×10^{-34} J-s

   3.   Avogadro's number = N_A = 6.023×10^{26} kg mole^{-1}

   4.   Mass of electron = m = 9.1×10^{-31} kg

   5.   Electronic charge = e = 1.6×10^{-19} C

   6.   Bohr magneton = μ_B = 9.27×10^{-24} A-m^2

   7.   Permeability of free space = μ_0 = $4\pi \times 10^{-7}$ A/m

   8.   Universal gas constant = R = 8.31×10^{3} J/K-mole

   9.   Velocity of light = C = 3×10^{8} m/s

Q1) a)   Derive an expression for the geometrical structure factor for a BCC structure. Discuss its values for various planes.   **[4]**

   b)   Explain Meisner effect in superconductivity.   **[3]**

c) The saturation value of magnetisation of iron is 1.74×10^6 A/m. Iron has a BCC structure with an elementary cube edge of 0.286 nm. Calculate average number of Bohr magnetons contributed to the magnetisation per atom. **[3]**

Q2) a) Using equation $m\left[\dfrac{dv}{dt} + \dfrac{v}{\tau}\right] = -eE$ for electron drift velocity v, show that

the electrical conductivity ω is: $\sigma(\omega) = \sigma(0)\left[\dfrac{1 + i\sigma\omega\tau}{1 + \omega^2\tau^2}\right]$, where symbols have usual meaning. **[4]**

b) What is meant by hysteresi's in magnetic materials. **[3]**

c) A paramagnetic salt contains 10^{28} ions per m^3 with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptebility and the magnetisation produced in a uniform magnetic field of 10^6 A/m when temperature is 27°C. **[3]**

Q3) a) Derive Langevin's diamagnetism formula for diamagnetic susceptebility. Write its physical interpretation. **[4]**

b) What are normal and Umklapp processes. **[3]**

c) Calculate the Debye specific heat of copper at 300 K. Given: Debye characteristic frequency is 6.55×10^{12} sec^{-1}. **[3]**

Q4) a) Derive Curie-Weiss law on the basis of Weiss molecular field theory of ferromagnetism. **[4]**

b) Explain the concept of Block wall with reference to magnetism. **[3]**

c) Calculate the critical current which can flow through a long thin superconducting wire of aluminium of diameter 10^{-3} m. The critical magnetic field for aluminium is 7.9×10^3 A/m. **[3]**

Q5) a) Explain the following terms with suitable diagrams in case of ferromagnetic materials: **[4]**

i) Exchange energy

ii) Anisotropy energy and

iii) Block wall energy.

b) Explain Type I and Type II superconductors with appropriate examples. **[3]**

c) Explain isotope effect for a superconducting material. **[3]**

Q6) a) Derive the London equation for superconducting state and obtain an expression for penetration depth. **[4]**

b) A superconducting lead has a critical temperature of 7.26K at zero magnetic field and a critical field of 8×10^5 A/m at 0 K. Find the critical field at 5 K. **[3]**

c) For copper, the lattice specific heat at low temperature has the behaviour of $[C_V]_{La} = 4.6 \times 10^{-12} \times T^3$ J/k mol K. Estimate the Debye temperature for copper. **[3]**

Q7) a) Discuss the vibrational modes in a finite one dimensional lattice of identical atoms. Hence derive the dispersion formula. **[5]**

b) Derive an expression for paramagnetic susceptibility using Langenvin's theory. **[5]**

Q8) a) On the basis of Kronig-Penny model, show that the energy spectrum of an electron consists of allowed and forbidden bands. **[5]**

b) Describe the motion of electron in I-D Periodic potential. Explain the concept of effective mass m*. Draw E-K, V-K and m*-K diagrams. **[5]**

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