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MANIPAL UNIVERSITY, MANIPAL

SECOND SEMESTER M.SC (Physics) END SEMESTER EXAMINATION, MAY 2016

SUB: INTRODUCTION TO CONDENSED MATTER PHYSICS (PHY 602)
(REVISED CREDIT SYSTEM)

Time: 3 Hrs. **Max. Marks : 50**

Note: (a) Answer any FIVE full questions.

CONSTANTS

Elementary charge = 1.60×10^{-19}C
Electric constant [permittivity], $\varepsilon_0 = 8.85 \times 10^{-12}$F/m
Magnetic constant [permeability], $\mu_0 = 1.26 \times 10^{-6}$H/m
Electron mass, $m_e = 9.11 \times 10^{-31}$kg
Avogadro constant = 6.02×10^{23}mol^{-1}
Electron magnetic moment = 9.28×10^{-24}J/T
Proton magnetic moment = 1.41×10^{-26}J/T
Bohr magneton = 9.27×10^{-24}J/T
Planck's constant = 6.63×10^{-34} J.s
Boltzmann constant = 1.38×10^{-23} J/K

1A. The expression for allowed states for electrons in a metal for the range E and E + dE is given by, $Z(E)dE = (4\pi V / h^3)(2m)^{3/2}\ E^{1/2}dE$, where the symbols have their usual meaning. Calculate the (i) Fermi energy at 0K (ii) Average energy of electrons at 0K in terms of $E_F(0)$ (iii) Average energy of electrons at a temperature T > 0K in terms of average energy of electrons at 0K.

1B. What are the assumptions of Dulong and Petit's law of lattice heat capacity? What are the drawbacks of Dulong and Petit's theory of lattice heat capacity?

1C. The density of zinc is 7.13×10^3 kg/m^3 and its molar mass is 0.0654 kg/mol. Calculate (a) the Fermi energy (b) Fermi temperature and (c) mean energy at 0 K. The effective mass of the electron in zinc is 0.85 times the free electron mass

(5+2+3)

2A. Define atomic scattering factor? Derive the general expression for the atomic scattering factor using spherical polar coordinates.

2B. Show that fivefold rotational axis is not permissible in the case of lattices.

2C. Calculate the value of Born exponent 'n' for NaCl crystal whose lattice parameter is 5.63 Å, binding energy is 1.83 kcal/mol (or 7.95 eV/molecule) and Madelung constant $\alpha = 1.75$ respectively.

(5+2+3)

3A. Explain Born–Haber cycle for the experimental determination of lattice energy in NaCl crystal.

3B. Plot the dispersion curve for a linear one-dimensional diatomic lattice ($m_1 > m_2$).

3C. A diffractometer data of a cubic crystal of an element show peaks at 2θ angles of 38.60°, 55.71°, 69.70°, 82.55°, 95.00° and 107.67°. If the wavelength of the X rays used is 0.1543 nm, determine the crystal structure and lattice parameter.

(4+3+3)

4A. Obtain an expression density of electrons in the conduction band of an intrinsic semiconductor.

4B. Based on the band theory of solids, write the expression for velocity and effective mass of the electron. Show the graphical variation of energy versus k, velocity versus k, effective mass versus k.

4C. In a Hall effect experiment on silver, a potential of 59 μV is developed across a foil of thickness 0.05 mm when a current of 28 mA is passed in a direction perpendicular to a magnetic field of 1.25 tesla. Calculate the Hall coefficient and density of charge carriers.

(5+2+3)

5A. Describe the Lengevin's classical theory of paramagnetism and obtain the expression for susceptibilty.

5B. With a graph, explain the frequency dependence of the several contributions to the polarizability in a dielectric.

5C. Determine the percentage of ionic polarizability in the sodium chloride crystal which has the optical index of refraction and the static dielectric constant 1.5 and 5.6 respectively.

(5+2+3)

6A. Give the BCS theory (qualitative) of superconductivity.

6B. Explain FCC and HCP close packed structures.

6C. A magnetic material has a magnetization of 3200 A/m and flux density of $14\pi \times 10^{-4}$ weber/m^2. Determine the magnetizing force and the relative permeability of the material.

6D. Determine the temperature at which the probability that an energy state with an energy 0.1 eV above the Fermi level will be occupied by an electron is 5%.

(3+3+2+2)