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MANIPAL UNIVERSITY

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DEPARTMENT OF SCIENCES, M.Sc PHYSICS
II SEMESTER END SEMESTER EXAMINATIONS, JUNE 2017

SUBJECT: Introduction to Condensed Matter Physics [PHY 602] Make up

(REVISED CREDIT SYSTEM)

Time: 3 Hours   Date: 13-06-2017   MAX. MARKS: 50

Note: (i) Answer any FIVE FULL questions.
(ii) Missing data, if any, may suitably be assumed.

PHYSICAL 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 = 9.11×10^{-31}kg Avogadro constant = 6.02×10^{23}mol^{-1}
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. Obtain an expression for the lattice energy/binding energy of ionic crystal like NaCl in terms of Madelung constant, repulsive force exponent and equilibrium separation. Draw the potential energy versus interatomic distance curve.

1B. Calculate the potential energy of CsCl at equilibrium, if the separation between cesium and Chlorine atoms is 0.356 nm, Madelung constant = 1.76 and Born exponent, n = 11.5.

1C. Calculate the atomic packing factor for fcc crystal assuming hard sphere model.

[5+3+2]

2A. Obtain Laue's equations for x-ray diffraction by crystals. Show that these are consistent with the Bragg's law.

2B. A powder pattern is obtained for lead (fcc) with X radiations of 0.145 nm. The (220) reflection is obtained at Bragg angle of 32°. Calculate the lattice parameter of lead and the radius of the atom.

2C. Explain Bragg's law of diffraction of X-rays by the crystal.

[5+3+2]

3A. Derive the dispersion relationship for vibrations of a one-dimensional monoatomic lattice.

3B. In a drop of water of radius 10^{-3} m, the molecular dipoles are pointed in the same direction. If the dipole moment of water molecules is 6 x 10^{-30} C-m, calculate the polarization. Density of water is 1000 kg/m^3.

3C. The saturation magnetization of BCC iron is 1750 kAm–1. Calculate the net magnetic moment per iron atom in the crystal. Given: The lattice parameter of BCC iron = 0.287 nm.

[5+3+2]

4A. Describe the Einstein's theory of lattice heat capacity of solids.

4B. 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.

4C. 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%.

[5+3+2]

5A. Obtain an expression for density of electrons in the conduction band of an intrinsic semiconductor.

5B. How do you distinguish metal, semiconductor and insulator based on band theory of solids?

5C. A flat copper ribbon 0.330 mm thick carries a steady current 50.0 A and is located in a uniform 1.30-T magnetic field directed perpendicular to the plane of the ribbon. Hall voltage of 9.60 μV is measured across the width of the ribbon. Calculate is the charge density of the free electrons.

[5+3+2]

6A. Describe the Lengevin's classical theory of paramagnetism and obtain the expression for susceptibility.

6B. With a neat diagram, explain the occurrence of hysteresis in ferromagnetic materials.

6C. Explain Meissner effect in superconductors. Mention any two applications of superconductors.

[5+3+2]