MANIPAL ACADEMY of HIGHER EDUCATION
(Deemed to be University under Section 3 of the UGC Act, 1956)

Reg. No.									

DEPARTMENT OF SCIENCES, II SEMESTER M.Sc PHYSICS
END SEMESTER EXAMINATIONS, JUNE 2019

SUBJECT: Introduction to condensed matter physics [PHY 4202]
(REVISED CREDIT SYSTEM-2017)

Time: 3 Hours   Date: 08-06-2018   MAX. MARKS: 50

Note: (i) Answer **ALL** questions
(ii) Draw diagrams, and write equations wherever necessary

PHYSICAL CONSTANTS

Elementary charge = 1.60×10^{-19} C; Electric constant [permittivity], $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Magnetic constant [permeability], $\mu_0 = 4\pi \times 10^{-6}$ 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 Laue's equations for x-ray diffraction by crystals. Show that these are consistent with the Bragg's law.
1B. Derive an expression for binding energy of an ionic crystal.
1C. 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.

(5 + 3 + 2)

2A. Explain different types of polarization. Derive an expression for frequency dependence of electronic polarizability using the classical theory.
2B. Explain briefly BCS theory of superconductivity.
2C. Sodium metal has BCC structure. The radius of the sodium atom is 0.185 nm. Estimate the order of the diamagnetic susceptibility in sodium.

(5 + 2 + 3)

3A. Calculate the average energy of electrons at absolute zero in terms of Fermi energy. Explain the following (i) Fermi level (ii) Fermi temperature (iii) Fermi velocity. With necessary diagrams [Energy versus F(E)], discuss the FD statistics as applied to free electrons in a metal at (iv) T = OK (v) T > 0K.
3B. Discuss the classical theory of thermal conductivity in conductors.
3C. Calculate the c/a ratio for an ideally close packed HCP crystal and show that it is equal to $\sqrt{\frac{8}{3}}$ or 1.63.

(5 + 3 + 2)

4A. **(a)** Describe the Debye theory of lattice heat capacity. Given: The total number of vibrational modes in the frequency range $d\vartheta$ is expressed as, $Z(\vartheta)d\vartheta = 4\pi V\left[\frac{2}{v_t^3} + \frac{1}{v_l^3}\right]\vartheta^2 d\vartheta$, where symbols have their usual meaning.
4B. (i) Show the position of Fermi level in intrinsic and extrinsic semiconductors.
(ii) The effective mass of hole and electron in GaAs are respectively 0.48 and 0.068 times the free electron mass. The band gap energy is 1.43. How much above is its Fermi level from the top of the valence band at 300 K? Given that Fermi level of an intrinsic semiconductor : $E_F = \frac{E_c+E_v}{2} + \frac{3}{4}kT\,ln\left(\frac{m_p}{m_n}\right)$, where m_p and m_n are effective masses of hole and electron respectively.
4C. Determine the percentage of ionic polarizability in the sodium crystal which has the optical index of refraction and static dielectric constant as 1.5 and 5.6 respectively.

(5 + 3 + 2)

5A. With relevant figures, explain the occurrence of hysteresis in ferromagnetic materials. Distinguish between ferromagnetic, antiferromagnetic and ferromagnetic materials.
5B. Based on band theory, obtain expressions for (i) Effective mass of the electrons, (ii) Effective number of electrons in the band, N_{eff} , in terms of slope of E versus k curve.
5C. Calculate the Fermi energy of a monovalent bcc solid whose lattice constant is 0.534 nm.

(5 + 3 + 2)