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, APRIL 2018

Subject: Introduction to condensed matter physics
Subject code: PHY 4202
(REVISED CREDIT SYSTEM-2017)

Time: 3 Hours | Date: 16-04-2018 | 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], $\mu_0 = 1.26 \times 10^{-6}$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

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1. **(a)** Determine the inter-planar spacing between the two parallel planes with Miller indices ($h\ k\ l$) in a cubic crystal of side 'a'.

(b) Explain Laue method for x-ray diffraction and explain the origin of Laue spots.

(c) Explain with suitable examples the covalent and molecular type of bonding in solids.

(d) From a powder camera of diameter 114.6 mm, using an x-ray beam of wavelength 0.154 nm, the following S values in mm are obtained for a material: 86, 100, 148, 180, 188, 232, and 272. Determine the structure and lattice parameter of the material.

(3+2+2+3)

2. **(a)** Sketch the dispersion relations for linear monoatomic and diatomic lattices (ω vs k graph). Highlight the differences between the two.

(b) Determine the natural cut-off frequency in the long wavelength limit ($k \rightarrow 0$) for a linear monoatomic lattice if the velocity of sound and the interatomic spacing in the lattice are 3×10^3 m/s and 3 Å, respectively.

(c) Explain BCS theory of superconductivity.

(d) Calculate the wavelength of photon, which will be required to break a Cooper pair in a superconductor like aluminium whose critical temperature is 1.2 K.

(3+2+3+2)

3. **(a)** Describe the Debye theory of lattice heat capacity. Given: The total number of vibrational modes in the frequency range dν is expressed as, $z(\upsilon)d\upsilon = 4\pi V\left[\frac{2}{v_t^3}+\frac{1}{v_l^3}\right]\upsilon^2 d\upsilon$,where symbols have their usual meaning.

(b) Explain the thermal conductivity in metals based on classical theory.

(c) Calculate the number of free electrons /m^3 in monovalent copper (fcc). Hence, calculate electrical conductivity. The relaxation time for the electron is 2.7×10^{-4}s. Atomic radius of Cu is 0.128 nm.

(5+3+2)

4. **(a)** Using the slope of E vs k graph, explain how solids are classified based on band theory.

(b) Explain Hall effect in semiconductors and obtain the expression for Hall coefficient. How Hall coefficient of the specimen can be determined experimentally?

(c) In a Hall effect experiment, a current of 3.2 A lengthwise in a conductor of 9.5 μm thick produces a transverse Hall voltage of 40 μV when a magnetic field of 1.4 T acts perpendicular to the thin conductor. From these data, find the Hall coefficient and number density of charge carriers. If the width the conductor is 1.2 cm, calculate the drift velocity and Hall field generated inside the conductor.

(d) What are the failures of free electron theory? State Bloch theorem.

(2+3+3+2)

5. **(a)** Explain the sources of polarizabilities in dielectric materials and derive the Clausius-Mossotti relation expressing the relationship between dielectric constant and atomic polarizability.

(b) Compare Ferromagnetic, antiferromagnetic and ferrimagntic materials with examples.

(c)A 0.50-T magnetic field is applied to a paramagnetic gas whose atoms have an intrinsic dipole moment of 1.29 Bohr magneton. At what temperature will the mean kinetic energy of translation of the gas atoms be equal to the energy required to reverse such a dipole end for end in this magnetic field?

(5+3+2)