MANIPAL ACADEMY of HIGHER EDUCATION
(Institution of Eminence Deemed to be University)

Reg.No. | | | | | | | | | |

DEPARTMENT OF SCIENCES, IV SEMESTER M.Sc. (Physics)
END SEMESTER EXAMINATIONS, MAY 2023
BASIC CONDENSED MATTER PHYSICS [PHY 5251]
(CHOICE BASED CREDIT SYSTEM - 2020)

Time: 3 Hours Date: 22-05-2023 MAX. MARKS: 50

Note (i) Answer ALL questions

(ii) Draw diagrams, and write equations wherever necessary

		Marks	CO	BL
1A	Obtain von Laue's equations for x-ray diffraction by crystals. Show that these are consistent with the Bragg's law.	5	1	2
1B	A diffractometer data of a cubic crystal of an element show peaks at 2θ angles 44.66°, 51.64°, 75.78° and 93.22°. If the wavelength of X ray used is 0.1543 nm, determine the crystal structure and lattice parameter.	3	1	3
1C	What is reciprocal lattice? Describe how to construct a reciprocal lattice for a direct lattice. Mention the different properties of reciprocal lattice.	2	1	2
2A	Obtain the expression for lattice energy in case of ionic crystals in terms of Madelung constant and other parameters.	5	1	2
2B	Calculate the Debye specific heat of copper at (i) 10 K and (ii) 300 K, given that the Debye characteristic frequency is 6.55 × 1012 Hz.	3	2	3
2C	Give the dispersion relation and plot the dispersion curve for the vibrations of one-dimensional monoatomic lattice.	2	2	2
3A	Derive the dispersion relation for the vibration of a one-dimensional diatomic lattice. Show the graph of dispersion relation.	5	2	2
3B	Explain BCS theory (qualitative) of superconductors.	3	4	2
3C	A superconducting lead has a critical temperature of 7.26 K at zero magnetic field and a critical field of 8 × 105 A/m at 0 K. Find the critical field at 5 K.	2	4	3
4A	(i) Explain classical theory of thermal conductivity in metals.	3	3	2
	(ii) With suitable sketches, distinguish between type I and type II superconductors.	2	4	2
4B	Sodium metal with bcc structure has two atoms per unit cell. The radius of the sodium atom is 0.185 nm. Calculate (i) Fermi energy (ii) the electrical resistivity if the classical value of mean free time at this temperature is 3 × 10–14 seconds.	3	3	3
4C	With relevant diagrams, discuss the following cases with regard to Fermi function. (a) T = 0K, E < EF (b) T = 0K, E > EF (c) T > 0K, EF – E > kT (d) T > 0K, E – EF > kT.	2	3	3
5A	State and prove Bloch theorem for periodic potential.	5	3	2
5B	Show the typical variation of conductivity with temperature for an extrinsic semiconductor and explain different regions.	3	4	3
5C	A semiconducting crystal with 12 mm long, 5 mm wide and 1 mm thick has a magnetic density of 0.5 T applied from front to back perpendicular to largest faces. When a current of 20 mA flows length wise through the specimen, the voltage measured across its width is found to be 37 μV . What is the Hall coefficient of this semiconductor? Calculate the charge carrier density.	2	4	3

CONSTANTS

Elementary charge = 1.60×10^{-19} C

Electric constant [permittivity], $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

Electron mass = 9.11×10^{-31} kg

Avogadro constant = 6.023×10^{23} mol^{-1}

Planck's constant = 6.63×10^{-34} J.s

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