MPH-012

ASSIGNMENT BOOKLET

M.Sc. (Physics) Programme
(MSCPH)

CONDENSED MATTER PHYSICS

Valid from 1st January, 2026 to 31st December, 2026

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2026)

Dear Student,

Please read the section on assignments in the Programme Guide for M.Sc. (Physics). A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, **which would consist of one tutor-marked assignment** for this course. The assignment is in this booklet. The total marks for this assignment is 100, of which 40 marks are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

1) On top of the first page of your answer sheet, please write the details exactly in the following format:

ENROLMENT NO.: ……

NAME: ……

ADDRESS: ……

COURSE CODE:…….

COURSE TITLE: ……

ASSIGNMENT CODE: ……..

STUDY CENTRE: …….. **DATE:** …….

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.

3) Leave 4 cm margin on the left, top and bottom of your answer sheet.

4) Your answers should be precise.

5) **Submit the complete assignment answer sheets containing Part A and Part B, within the due date.**

6) The assignment answer sheets are to be submitted to your Study Centre as per the schedule. **Answer sheets received after the due date shall not be accepted. We strongly suggest that you retain a copy of your answer sheets.**

7) This assignment is **valid from 1st January, 2026 to 31st December, 2026**. If you have failed in this assignment or fail to submit it by 31st December, 2026, then you need to get the assignment for the year 2027, and submit it as per the instructions given in the Programme Guide.

8) **You cannot fill the examination form for this course** until you have submitted this assignment. For any queries, please contact: mbnewmai@ignou.ac.in, slamba@ignou.ac.in

We wish you good luck.

Tutor Marked Assignment
CONDENSED MATTER PHYSICS

Course Code: MPH-012
Assignment Code: MPH-012/TMA/2026
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

PART A

1. a) A metallic element has a density of 2.70 g cm^{-3}, a lattice constant of 4.0495 Å and an atomic weight 26.9815g mol^{-1}. Calculate the number of atoms per unit cell of this element and predict its lattice crystal structure. (5)

   b) Show that the reciprocal lattice of a *bcc* lattice is an *fcc* lattice. Calculate the magnitude of the shortest non-zero reciprocal lattice vector. (5)

   c) A metallic crystal has an *fcc* lattice with a lattice constant 0.4 nm. Explain whether the following planes are allowed or forbidden for X-ray diffraction:

   (100), (111), (210), (220)

   Calculate the X-ray diffraction angles for the allowed planes. Assume that diffraction occurs in the first order and the X-ray wavelength is 0.154 nm. (5)

2. a) Calculate the inter-atomic equilibrium distance r_e for KCl for which the equilibrium lattice energy is 163.0 kcal mol^{-1}, n=8.6 and the Madelung constant is 1.75. (5)

   b) For a linear chain of identical atoms of mass 10^{-26} kg calculate the maximum value of the angular frequency of the longitudinal wave and the group velocity at k=0, given that the inter-atomic distance is 2.0 Å and the spring constant is 20 Nm^{-1}. (5)

   c) Calculate the temperature at which the lattice contribution to the specifc heat and the electronic contribution to the specific heat become equal in a metal which has a Debye temperature of 390 K and a Fermi energy 11.7 eV. (5)

3. a) A divalent metal crystallizes in an *fcc* structure with a lattice constant of 4.5 Å . Calculate the number density of conduction electrons and the Fermi velocity. (5)

   b) In Sommerfeld free electron theory, show that at a temperature T

   (i) $\mu = \varepsilon_F\left[1-\frac{1}{3}\left(\frac{\pi k_B T}{2\varepsilon_F}\right)^2\right]$ and (ii) $c_V = \frac{\pi^2}{2}\left(\frac{k_B T}{\varepsilon_F}\right) n k_B$ (5)

   c) For the energy dispersion relation:

   $$\varepsilon(\vec{k}) = 2t_x\cos(k_x a_x) - 2t_y\cos(k_y a_y) - 2t_z\cos(k_z a_z)$$

   calculate the inverse mass tensor . (5)

   d) Calculate the energy dispersion for *s*-band in the *bcc* lattice for the tight binding approximation.
   Note: For the central atom located at (0,0,0) in the bcc unit cell, the nearest neighbours are located at $\frac{a}{2}(\pm1,\pm1,\pm1)$, where a is the lattice constant. (5)

PART B

4 a) Calculate the resistivity of Silicon at 60° C given that its resistivity at 30° C is 2.5 Ωm. (5)

b) In an *n*-type semiconductor the Fermi level lies 0.4 eV below the conduction band at T=300 K. Calculate the position of the Fermi level when the temperature is raised to 330 K. (5)

5. a) The susceptibility of O_2 is 0.39×10^{-3} and its density is 1.43 kgm^{-3}. Calculate its total polarisability. Assume that the mass number for O_2 is 32. (5)

b) For Chromium (J = 3, S = 3, Z=24) vapour at 1800 K with a number density of atoms $\frac{N}{V}=5.0\times10^{25}\,\mathrm{m}^{-3}$ calculate:

i) The Larmor diamagnetic susceptibility assuming the atomic radius to be 1.2 Å.

ii) The Curie paramagnetic susceptibility.

(2+3)

c) For the hydrogen molecule which has two hydrogen atoms each with one electron occupying the 1s energy level, write the two particle wave functions for the singlet and triplet states. Determine the eigenvalues of the effective Hamiltonian $\hat{H}_{eff}=\frac{1}{4}(E_S+3E_T)-\frac{(E_S-E_T)}{\hbar^2}\hat{S}_1.\hat{S}_2$, in the singlet and triplet states (4+6)

6. a) For a superconducting specimen, the critical fields are 1.5×10^5 Am^{-1} and 4.0×10^5 Am^{-1} at 14 K and 13 K respectively. Calculate the critical temperature and critical field at 0 K (5)

b) Show that for the superconducting transition in the absence of magnetic field, there is a discontinuity in the specific heat of a superconductor at T_c which can be written as:

$$C_n - C_s = -\mu_0 T_c\left(\frac{dH_c}{dT}\right)^2 \quad (5)$$

c) The critical temperature of lead (Pb) of average atomic mass 207.2 amu is 7.20 K. Calculate the critical temperature of a specimen of lead isotope with mass 206 amu using the normal isotope effect. (5)

d) Explain the significance of the pseudogap phase in cuprates. (5)

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