

ASSIGNMENT BOOKLET
Bachelor's Degree Programme (B.Sc.)

PHYSICS OF SOLIDS

Valid from January 1, 2025 to December 31, 2025

**It is compulsory to submit the Assignment before filling in the
Term-End Examination Form.**

Please Note

- You can take electives (56 or 64 credits) from a minimum of TWO and a maximum of FOUR science disciplines, viz. Physics, Chemistry, Life Sciences and Mathematics.
- You can opt for elective courses worth a MINIMUM OF 8 CREDITS and a MAXIMUM OF 48 CREDITS from any of these four disciplines.
- At least 25% of the total credits that you register for in the elective courses from Life Sciences, Chemistry and Physics disciplines must be from the laboratory courses. For example, if you opt for a total of 64 credits of electives in these 3 disciplines, at least 16 credits out of those 64 credits should be from lab courses.
- You cannot appear in the Term-End Examination of any course without registering for the course. Otherwise, your result will not be declared and the responsibility will be yours.



School of Sciences
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2025

Dear Student,

We hope you are familiar with the system of evaluation to be followed for the Bachelor's Degree Programme. At this stage you may probably like to re-read the section on assignments for Elective Courses in the Programme Guide that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation which would consist of **one tutor-marked assignment (TMA)** for this course.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully.

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

ENROLMENT NO. :

NAME :

ADDRESS :

.....

.....

COURSE CODE :

COURSE TITLE :

ASSIGNMENT NO. :

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 and in your own words. Do not copy answers from study material.
- 5) While solving problems, clearly indicate the question number along with the part being solved. Write units at each step of your calculations as done in the text because marks will be deducted for such mistakes. Take care of significant digits in your work. Recheck your work before submitting it.
- 6) **This assignment will remain valid from January 1, 2025 to December 31, 2025.** However, you are advised to submit it within **12 weeks** of receiving this booklet to accomplish its purpose as a teaching-tool.

Answer sheets received after the due date shall not be accepted. **We strongly feel that you should retain a copy of your assignment response to avoid any unforeseen situation and append, if possible, a photocopy of this booklet with your response.** If you have any problems or queries related to the course, you can write to us on the e-mail slamba@ignou.ac.in.

We wish you good luck.

Tutor Marked Assignment

PHYSICS OF SOLIDS

Course Code: PHE-13
Assignment Code: PHE-13/TMA/2025
Max. Marks: 100

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

1. Answer in brief: (2×10=20)
 - i) List the symmetries of the H₂O molecule.
 - ii) Determine the interplanar spacing of the (110) planes in Cu given that its lattice constant is 3.61Å.
 - iii) NaCl has a melting point of 800 °C and MgO has a melting point of 2800 °C. How would you explain these facts?
 - iv) Explain the significance of the linear and shear strain components of a crystal.
 - v) Explain how a monoatomic linear chain behaves as a low pass filter.
 - vi) List the limitations of the free electron theory.
 - vii) Draw the energy band diagram for an *n*- type and *p*- type semiconductor.
 - viii) What are Type I and Type II superconductors?
 - ix) Among the melt growth processes which method is the cleanest? Give reasons.
 - x) Distinguish between piezoelectric and pyroelectric materials with an example of each.

2.
 - a) A metallic element has a density of 10.22 g cm⁻³, an atomic weight of 95.94 u and an atomic radius of 0.136nm. Determine whether its lattice structure is bcc or fcc.
 - b) Show that an arbitrary reciprocal lattice vector $\vec{G} = h\vec{a}_1^* + k\vec{a}_2^* + l\vec{a}_3^*$ is perpendicular to the family of planes denoted by (*h,k,l*) in the direct lattice space.
 - c) Prove that the volume of a unit cell of the reciprocal lattice of a bcc structure is inversely proportional to the volume of the unit cell of its direct lattice.
 - d) Determine the conditions governing geometrical structure factor for an *fcc* lattice. Is reflection observed from the (111) and (211) planes of the *fcc* structure? (5×4=20)

3.
 - a) The interaction energy between two atoms is given by $E(r) = \left(-\frac{A}{r} + \frac{B}{r^7} \right)$ where *r* is the inter-atomic separation. Show that for the particles to be in equilibrium, $r = r_e = \left(\frac{7B}{A} \right)^{1/6}$ and show that in stable equilibrium the energy of attraction is seven times the energy of repulsion.
 - b) In a linear chain of two different types of atoms of masses *M* and *m* the displacement of the two atoms in the *k* = 0 optical branch are *u* and *v* respectively. Show that

$$\frac{u}{v} = -\frac{m}{M}$$

- c) Copper has a Debye temperature of 340 K and a Fermi temperature of 81000 K. At what temperature will the contribution of the vibrations of the crystal lattice (within the Debye theory) and that of the conduction electrons (within the free electron theory) to the specific heat become equal?
- d) Derive an expression for the bulk modulus of a cubic crystal. (5×4=20)
4. a) Calculate the relaxation time of electrons in silver assuming that each silver atom contributes one free electron for conduction. The density of silver is $10.5 \times 10^3 \text{ kg m}^{-3}$, conductivity of silver is $6.8 \times 10^7 \Omega^{-1} \text{ m}^{-1}$ and the atomic weight of silver is 107.9 u.
- b) When 1.5 A of current is passed through a zinc specimen under a magnetic field of 2.0 T, the Hall voltage is 4.45 μV . The width of the specimen is 0.03mm. Calculate the carrier concentration.
- c) For an intrinsic semiconductor with a band gap of 0.75eV, determine the position of the Fermi level at T=300 K if $m_h^* = 6m_e^*$.
- d) Given that the maximum wavelength of the photon required to break up a Cooper pair in tin is $1.08 \times 10^{-3} \text{ m}$, calculate the energy gap. (5×4=20)
5. a) Determine the mean radius of the He atom given that its molar diamagnetic susceptibility is $-1.9 \times 10^{-6} \text{ cm}^3 \text{ mol}^{-1}$.
- b) With the help of diagrams explain the different types of point defects in crystals.
- c) Describe how photolithography is used for production of nanostructures.
- d) What are transducers? Explain how a polymer capacitor is used as a humidity transducer. (5×4=20)
