PHE-13

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

PHYSICS OF SOLIDS

Valid from January 1, 2022 to December 31, 2022

It is compulsory to submit the Assignment before filling up 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
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068

2022

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 : ……

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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, 2022 to December 31, 2022**. 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/2022
Max. Marks: 100

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

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1. Answer in brief: (2×10=20)

   i) List the symmetries of the CH_3OH molecule.

   ii) Calculate the Miller indices of a crystal plane that intersects the three axes along the basis vectors $\vec{\mathbf{a}}_1$, $\vec{\mathbf{a}}_2$ and $\vec{\mathbf{a}}_3$ at $2a_1$, $3a_2$ and a_3 respectively.

   iii) In an *fcc* lattice, explain from which of the following plane/planes x-ray diffraction may be observed: (0,2,1), (0,0,1), (0,1,1).

   iv) The melting point of potassium is 63.5°C and that of potassium chloride is 770°C. How do you explain this?

   v) To study the elastic properties of a cubic crystal we need to determine three elastic stiffness constants, whereas to study the elastic properties of a orthorhombic crystal we need to determine nine elastic stiffness constants. Explain.

   vi) What are the shortcomings of the classical theory of heat capacity?

   vii) Explain why there is no difference between the electrical conductivity of a semiconductor and an insulator at T =0 K.

   viii) Explain what are super electrons and normal electrons in the two fluid model of superconductivity.

   ix) Can a LCD display be used in a car? Explain.

   x) Can a pyroelectric material be used as a transducer? Explain

2. a) The primitive lattice vectors of a lattice are given by

$$\vec{\mathbf{a}}_1 = 3\hat{\mathbf{i}}; \quad \vec{\mathbf{a}}_2 = \frac{3}{2}\hat{\mathbf{i}} + \frac{3\sqrt{3}}{2}\hat{\mathbf{j}}; \quad \vec{\mathbf{a}}_3 = 6\hat{\mathbf{k}}$$

   Determine the volume of the primitive cell and the reciprocal lattice vectors.

   b) Calculate the atomic packing fraction for the Magnesium crystal.

   c) A metallic element has a density of 10.5 g/cm^3, a molecular weight of 108.0 u and a lattice constant of 4.09Å. Determine the number of atoms in a unit cell of this element and predict its crystal structure.

   d) Determine the first order Bragg reflection angle from the (111) planes in a cubic crystal with lattice constant 4.2 Å for an *x*-ray beam with λ = 1.54 Å. (5×4=20)

3. a) Calculate the lattice energy per mole of CsCl given that the value of the Madelung constant, repulsive exponent (*n*) and inter-ionic separation for CsCl are 1.763, 10.7 and 3.5 Å respectively.

   b) The elastic stiffness constants for a material are $C_{11} = 1.075 \times 10^{12}\,\mathrm{Nm}^{-2}$, $C_{12} = 1.39 \times 10^{11}\,\mathrm{Nm}^{-2}$ and $C_{44} = 5.67 \times 10^{11}\,\mathrm{Nm}^{-2}$. If the density of the material is

$3510\,\text{kg m}^{-3}$, calculate the velocity of the longitudinal elastic waves propagating in the [110] direction.

c) The Debye frequency of aluminium is 9.66×10^{13} Hz. Calculate its molar heat capacity at 10K.

d) In a chain of two different types of atoms show that the group velocity at $k = 0$ is zero for the optical branch. (5×4=20)

4. a) The atomic weight is of a monovalent metal is 197u and it's density is $19.32\,\text{g cm}^{-3}$. Calculate the density of conduction electrons. Given that the Fermi energy of the metal is 5.53eV calculate the electronic thermal conductivity at 300 K.

b) The effective mass of the electron and hole in Si are 0.26 m_e and 0.39 m_e respectively. Calculate the effective density of states in the valence band and conduction band and the intrinsic carrier concentration at 300 K, given that the band-gap is $E_g = 1.12$ eV.

c) In a Hall experiment, in a silver specimen of width 2.0 cm, the current value is 100 A and the magnetic field is 1.5 T. For a carrier concentration of 6.0×10^{28} electrons per m^3, calculate the Hall voltage.

d) Calculate the limiting value of the magnetic field for which lead will act as a superconductor at 4 K. Take $B_{ac}(0) = 80.0$ mT and $T_c = 8.0$ K for lead. (5×4=20)

5. a) Determine the magnetic moment of $Co^{2+}Fe^{3+}O_4$.

b) Describe the method used to grow crystals of the compound semiconductor GaAs.

c) Explain addition and condensation polymerization with an example of each.

d) Why are the properties of thin films different from their bulk counterparts? Explain how they are used as interference filters. . (5×4=20)

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