PHE-13

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

PHYSICS OF SOLIDS

Valid from January 1, 2021 to December 31, 2021

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

2021

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, 2021 to December 31, 2021**. 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/2021
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) Formaldehyde (CH_20) is a planar trigonal molecule with C at the centre. List its symmetries.

   ii) Calculate the inter-planar distance between the (211) planes for a lattice with lattice constant 3.2 Å.

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

   iv) State the degeneracy of the second excited state for an electron in a cubical box of side *L*.

   v) Calculate the effective mass of an electron in a crystalline solid whose energy is given by the relation

   $$E = 5\hbar^2 k^2 / m$$

   vi) Describe the structure of a spinel ferrite.

   vii) Explain, with the help of a diagram, the depletion region in a *p*-*n* junction.

   viii) Explain with the help of diagrams the magnetism in a superconductor when it is cooled in the presence of a magnetic field.

   ix) Does a substitutional impurity alter the density of a crystal? Explain.

   x) Explain why plastic beads are used in a Xerox toner?

2. a) Niobium with an atomic weight of 92.90 u is characterized by a bcc lattice structure with a lattice constant of 3.30 Å. Calculate the density.

   b) The primitive lattice vectors of a lattice are given by

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

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

   c) Calculate the atomic packing fraction for a *bcc* lattice.

   d) The first order Bragg reflection angle from the (111) planes in an fcc metal is 19.2° for an *x*-ray beam with λ = 1.54 Å. Calculate the density of the metal if its atomic weight is 26.98 u. (5×4=20)

3. a) The lattice energy for an ion is given by

   $$u\ (r) = -\frac{\alpha q^2}{4\pi\varepsilon_0 r} + 6\lambda e^{-r/\rho}$$

where λ and ρ are constants and α is the Madelung constant. Find an expression for the cohesive energy.

b) Derive an expression for the velocity of the transverse wave in the [100] direction in a cubic crystal.

c) Calculate the heat capacity of Hf at 200 K, given that its Debye temperature is 242 K.

d) The unit cell size of KCl is 6.3 Å and the Young's modulus in the [100] direction is 3.8×10^{10} Nm^{-2}. Estimate the wavelength at which electromagnetic radiation is strongly reflected by a crystal [Atomic weight of K = 39 and Cl = 37]. (5×4=20)

4. a) The density of copper is 8.92×10^3 kg m^{-3} and its atomic weight is 63.5. Assuming that each copper atom provides one conduction (free) electron, calculate the density of conduction electrons. Also estimate the relaxation time for free electrons applying classical free electron theory. What is the corresponding mean free path? Take the electrical conductivity of copper to be 6.8×10^7 Ω^{-1} m^{-1}.

b) For an intrinsic semiconductor with energy gap E_g = 0.85 eV, determine the position of the Fermi level at 300 K if $m_h^* = 6m_e^*$. Also calculate the density of electrons and holes at 300 K.

c) In Hall experiment, the current density due to the applied electric field is 2A m^{-2} and Hall constant is measured to be -1.5×10^{-10} Vm^3 A^{-1} $Tesla^{-1}$. Calculate drift velocity of the change carriers.

d) A superconducting material has a critical temperature of 4.1 K at zero magnetic field. The critical field at 0 K is 0.04 Tesla. Determine the critical field at 2 K. (5×4=20)

5. a) What are the features of magnetic hysterisis loop? Explain how the shape of the loop determines the application of a magnetic material.

b) A germanium crystal with doping of 10^{18} arsenic atoms per cm^3 is required. For initial Ge load of 20 kg, calculate the mass of arsenic to be added. Assume that the value of k_0 remains constant throughout the growth process. Consider the density of molten germanium to be 5.7 g cm^{-3} and atomic weight of arsenic 74.934u.

c) Describe the different types of polymerization processes with an example of each.

d) Explain with the help of a diagram, the operation of a photovoltaic solar cell. (5×4=20)

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