M.Sc. PHYSICS
SECOND SEMESTER
CONDENSED MATTER PHYSICS
MPH-203

Duration: 3 Hrs. **Marks: 70**

{Part : A (Objective) = 20
Part : B (Descriptive) = 50}

[PART-B : Descriptive]

Duration: 2 Hrs. 40 Mins. **Marks: 50**

[Answer question no. One (1) & any four (4) from the rest]

1. Obtain the dispersion relation for the lattice waves in a monatomic linear lattice of mass 'm', spacing 'a' and lattice constant 'β'. Show that in monatomic lattice system, the phase velocity is equal to group velocity at low frequency regime. (6+4=10)

2. Enlist the various contributions to the total polarizability. Derive an expression for electronic polarizability using the classical theory. How is dielectric constant (ε_r) related to electric susceptibility (χ)? (3+6+1=10)

3. a) Show that the molecular polarizability, $\alpha = \frac{3\varepsilon_0}{n}\left(\frac{\varepsilon_r - 1}{\varepsilon_r + 2}\right)$, where symbols have their usual meanings. (6+4=10)
   b) Consider a CCl_4 molecule, which relative permittivity $\varepsilon_r = 2.24$, density $\rho = 1.60$ gm/cm^3, molecular weight M_w=156. If an electric field of 10^7 V/m is applied to the molecule, then calculate its dipole moment.

4. Discuss the formation of allowed and forbidden energy bands on the basis of Kronig-Penney model. (10)

5. a) What is reciprocal lattice? Derive the relationships for the primitive translation vectors of the reciprocal lattice in terms of those of the direct lattice. (2+6+2=10)
   b) Copper (Cu) has fcc structure and atomic radius of Cu is 0.1278 nm. Calculate the interplanar spacings for (111) and (321) planes of Cu crystal.

6. a) Describe briefly Drude's model of free electron theory of metals and hence derive an expression for electrical conductivity in metals. (6+4=10)
   b) If the conductivity of silver at 20 °C is $6.8 \times 10^7\ \Omega^{-1}m^{-1}$ and its density is 10.5×10^3 kg/m^3, calculate the density of electrons, assuming that each silver atom provides one conduction electron. Also calculate the mobility and mean free path of the electrons in silver. The atomic weight of silver is 107.9.

7. (a) Explain Hall effect? Show that for an n-type semiconductor the Hall coefficient R_H is given by $R_H = -\frac{1}{ne}$. (3+5+2=10)

   (b) Explain how Hall coefficient is used to determine the mobility of charge carriers.

8. (a) Give an account of Weiss theory of ferromagnetism and hence derive the Curie-Weiss law. (8+2=10)

   (b) Draw a typical B-H loop for a ferromagnetic material and identify retentivity and coercivity in the curve.

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[PART-A : Objective]

Choose the correct answer from the following: **1X20=20**

1. With increase in the 'M/m' ratio, width of the forbidden frequency band in atomic lattice:
   a. increase b. decrease
   c. remain constant d. none of above

2. The force exerted by a spring on an atom in lattice can be expressed by:
   a. Coulomb's Law b. Hooke's Law
   c. Van der Waals force d. none of above

3. The quantum of energy in lattice vibration is called:
   a. photon b. soliton
   c. phonon d. gluon

4. The first Brillouin zone in crystal lattice is defined by k-values lies within:
   a. $-\frac{\pi}{2} < k < \frac{\pi}{2}$ b. $-\frac{\pi}{a} < k < \frac{\pi}{a}$
   c. $-\frac{\pi}{2a} < k < \frac{\pi}{2a}$ d. $-\pi < k < \pi$

5. Phonon, being indistinguishable particle, requires ..... statistics to describe their distribution in energy states.
   a. Maxwell-Boltzman b. Fermi-Dirac
   c. Bose-Einstein d. All of above

6. The relation between relative permittivity (ε_r) and susceptibility (χ) is:
   a. $\varepsilon_r = \sqrt{1+\chi}$ b. $\varepsilon_r = \chi - 1$
   c. $\varepsilon_r = (\chi - 1)^2$ d. $\varepsilon_r = 1 + \chi$

7. The polarization (P), electric field (E) and dielectric displacement (D) is given by:
   a. $E = \varepsilon_0 D + P$ b. $D = \varepsilon_0 P + E$
   c. $D = \varepsilon_0 E + P$ d. $D = \varepsilon_0 (E + P)$

8. The dipolar polarizability per molecule is given by:
   a. $\frac{p}{3kT^2}$ b. $\frac{p}{3kT}$ c. $\frac{p^2}{kT}$ d. $\frac{p^2}{3kT}$

9. Unit of dipole moment per unit volume is:
   a. Coulomb
   b. Coulomb/meter
   c. Coulomb/(meter)^2
   d. Coulomb/(meter)^3

10. According to Band Theory, the potential experienced by an electron in a crystal is:
   a. constant
   b. periodic
   c. exponential
   d. all of above

11. The width of allowed energy band increases with:
   a. total energy
   b. binding energy
   c. Fermi energy
   d. none of above

12. The nearest neighbor distance in case of bcc structure is:
   a. $(a\sqrt{3})/2$
   b. $(a\sqrt{2})/2$
   c. $2a/\sqrt{3}$
   d. $2a/\sqrt{2}$

13. A plane intercepts at a, $b/2$, $3c$ in a simple cubic unit cell. The Miller indices of the plane are:
   a. (132)
   b. (261)
   c. (361)
   d. (123)

14. The average drift velocity v_d of electron in a metal is related to the electric field E and collision time τ as:
   a. $\sqrt{\frac{eE\tau}{m}}$
   b. $\frac{eE\tau}{m}$
   c. $\sqrt{\frac{m}{eE\tau}}$
   d. $\frac{m}{eE\tau}$

15. The total binding energy of an ionic crystal is given by (where symbols have their usual meanings)

a. $U_{tot} = \left(\frac{N\alpha q^2}{R_0}\right)\left[1 + \frac{\rho}{R_0}\right]$

b. $U_{tot} = -\left(\frac{N\alpha q^2}{R_0}\right)\frac{\rho}{R_0}$

c. $U_{tot} = -\left(\frac{N\alpha q^2}{R_0}\right)\left[1 - \frac{\rho}{R_0}\right]$

d. $U_{tot} = \left(\frac{R_0}{N\alpha q^2}\right)\left[1 - \frac{\rho}{R_0}\right]$

16. Intrinsic concentration of charge carriers in a semiconductor varies as:

a. T

b. T^2

c. $T^{3/2}$

d. T^{-1}

17. The unit of Hall coefficient is:

a. $Vm^2A^{-1}\omega b^{-1}$

b. $Vm^2A\omega b^{-1}$

c. $Vm^2A\omega b^{-1}$

d. $Vm^2A^{-2}\omega b$

18. The Fermi level in an n-type semiconductor at 0 K lies:

a. below the donor level

b. half way between the conduction band and donor level

c. coincides with intrinsic Fermi level

d. none of the above.

19. The magnetic susceptibility has the dimension of:

a. $\omega b/m^2$

b. $\omega b/m$

c. amp/m

d. dimensionless

20. At Curie temperature, the spontaneous magnetization for ferromagnetic material is:

a. infinity

b. 1

c. -1

d. zero

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UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

Question Paper CUM Answer Sheet

[PART (A) : OBJECTIVE]

Serial no. of the main Answer sheet

Course : .....

Semester : ..... Roll No : .....

Enrollment No : ..... Course code : .....

Course Title : .....

Session : 2016-17 Date : .....

Instructions / Guidelines

- The paper contains twenty (20) / ten (10) questions.
- The student shall write the answer in the box where it is provided.
- The student shall not overwrite / erase any answer and no mark shall be given for such act.
- Hand over the question paper cum answer sheet (Objective) within the allotted time (20 minutes / 10 minutes) to the invigilator.

Full Marks	Marks Obtained	Remarks
20		

Scrutinizer's Signature *Examiner's Signature* *Invigilator's Signature*