Roll No. ………………………..

Name of Department:	**Physics and Astrophysics**
Name of Course:	**B.Sc. (Hons) Physics - Core**
Semester:	**V**
Name of Paper:	**Solid State Physics**
Unique Paper Code:	**32221502**
Question paper Set No:	**A**

Duration**: 3 Hours** Maximum Marks: **75**

(*Write your Roll No. on the top immediately on receipt of this question paper*)
Answer ***any four*** *of the six questions. All questions carry equal marks.*

Q 1. Give an account of Laue's theory of X-ray diffraction for a simple cubic lattice. How does it lead to the Bragg's law of crystal diffraction? Iron changes from BCC to FCC lattice at 914°C. The atomic radii of the iron atoms in the two structures are 0.125 nm and 0.130 nm, respectively. Calculate the percentage of volume change as the structure changes.

Q 2. Starting from its assumptions, discuss Einstein's theory of lattice heat capacity and explain why it does not give correct behavior at low temperature? What would be the effect on the specific heat of solids at room temperature, if the Plank's constant were increased four times? Why does Einstein's theory give an approximately correct picture of lattice vibrations for optical phonons, but not for acoustic phonons?

Q 3. Find the expression for the Hall coefficient of a semiconductor in which both electrons and holes are present in appreciable concentrations. What is the sign of the Hall coefficient of a material in which the concentration of holes is twice the electron concentration, but their mobility is half of electron mobility?

Q 4. Derive the precession frequency of the dipole moment on an atomic orbital in a magnetic field. Use the expression for induced magnetic field from this precession to find the value of relative permeability and magnetic susceptibility of a material due to this precession. The flux of the magnetic field and magnetic field intensity of a certain magnetic material are 1.8 T and 1000 A/m, respectively. Find the relative permeability and magnetic susceptibility of the material.

Q 5. Explain the reason for the use of hypothetical spherical cavity for determining the local field of a dielectric in Lorentz procedure, and deduce the expression for the local field using this cavity. A sphere of dielectric constant ϵ is placed in uniform external electric field E_0. Find the volume average electric field E of the sphere and show that the polarization in the sphere is

$P = \frac{\chi E_0}{[1+(4\pi\chi/3)]}$ where $\chi = \frac{(\epsilon-1)}{4\pi}$ (in CGS) or $P = \frac{\chi E_0}{[1+(\chi/3)]}$ where $\chi = \epsilon - 1$ (in SI).

Q 6. What is ferroelectricity? Derive an expression for Curie-Weiss law of ferroelectric materials. Calculate the superconducting transition temperature of a specimen whose critical fields are 1.5 x 10^5 T and 4.5 x 10^5 T at 15°K and 12°K, respectively. Discuss the concept of Cooper pair as per BCS theory. Does the Cooper pair follow F-D statistics or B-E Statistics? Give reasons for your answer.

Values of Constants

k_B = 1.3807 x 10^{-23} JK^{-1}
N_A = 6.022 x 10^{23} mol^{-1},
h = 6.63 x 10^{-34} Js
μ_o = 4 π x 10^{-7} Hm^{-1}
μ_B = 9.2732 x 10^{-24} Am^2
ε_o = 8.854 x 10^{-12} Fm^{-1}
m_e = 9.1 x 10^{-31} Kg
e = 1.6 x 10^{-19} C