Name: Enrolment No:	

UPES

End Semester Examination, May 2025

Course: Solid State Physics **Semester : IV**
Program: B.Sc. (H) Physics **Time : 03 hrs.**
Course Code: PHYS 3057 **Max. Marks: 100**

Instructions: 1) Mention your Roll No. at the top of the question paper.
2) Attempt all the parts of a question at one place only.
3) Use of non-programmable scientific calculator is allowed.

SECTION A
(All questions are compulsory)

S. No.		Marks	CO
Q 1	(i) Piezoelectricity is a result of: **a.** Asymmetry in the crystal structure **b.** Ferromagnetic alignment **c.** Ionic conduction **d.** Thermal expansion (ii) Pyroelectric materials are most sensitive to: **a.** Electric fields **b.** Sound waves **c.** Changes in temperature **d.** Mechanical vibrations (iii) What is a necessary condition for a material to exhibit pyroelectricity? a. It must be an insulator b. It must be a metal c. It must have a permanent electric dipole d. It must be heated above its melting point (iv) Which of the following statements about ferroelectric domains is correct? **a.** Domain walls are highly conductive **b.** Domains are separated by grain boundaries **c.** Domain orientation can be changed by applying an external electric field	**4**	**CO2**

	d. Domains are permanent and unchangeable		
Q 2	Why do crystalline materials have sharp melting points?	**4**	**CO2**
Q 3	Draw the fermi-energy diagram for intrinsic and extrinsic semiconductors.	**4**	**CO3**
Q 4	In terms of magnetic susceptibility, how do paramagnetic materials compare to ferromagnetic materials?	**4**	**CO2**
Q 5	What are quasi-particles? Give some examples.	**4**	**CO1**
	SECTION B **(All questions are compulsory)**		
Q 6	Show that the interplanar spacing for orthorhombic crystals is given by $$d_{hkl} = \frac{1}{\sqrt{\left(\frac{h}{a}\right)^2 + \left(\frac{k}{b}\right)^2 + \left(\frac{l}{c}\right)^2}}$$ where the symbols have their usual meanings.	**10**	**CO1**
Q 7	Derive Curie-Weiss law for ferroelectric materials.	**10**	**CO1**
Q 8	Derive the expression for magnetic susceptibility of a diamagnetic material and show that all electrons contribute towards diamagnetism.	**10**	**CO3**
Q 9	The London penetration depths for a superconducting material are 45 nm at 2 K and 190 nm at 6.8 K. Calculate the critical temperature T_c and the penetration depth at 0 K. OR The critical temperature of a certain superconductor drops from 5.5 K to 5.3 K due to an isotopic substitution. If the original mass was 100 u, find the new isotopic mass.	**10**	**CO4**
	SECTION-C **(Q10 is compulsory while Q 11 has internal choice)**		
Q 10	(a) Show that the Langevin-Debye equation in dielectrics is $$\boldsymbol{P} = NE\left\{4\pi\varepsilon_o R^3 + \frac{e^2}{\omega_o^2}\left(\frac{1}{m} + \frac{1}{M}\right) + \frac{\mu^2}{3kT}\right\}$$ where, the symbols have their usual meanings. (b) A paramagnetic material has a BCC structure with a unit cell edge of 2.8 Å. If the saturation value of the magnetization is 1.5 x 10^6 A/m, calculate the average magnetization contribution per atom in Bohr magnetron.	**10** **10**	**CO3**

Q 11	(a) What are the key assumptions of Einstein's theory of specific heat for solids, and how can one derive the temperature-dependent expression for specific heat based on this model? (b) What is the Meissner effect, and how does it occur when a material transitions into the superconducting state? OR (a) Explain why replacing an element in a superconductor with its heavier isotope typically leads to a lower critical temperature. What does this suggest about the mechanism of superconductivity? (b) Show that in case of 1D lattice vibrations the angular frequency is given by $$\omega = \sqrt{\frac{4\beta}{m}}\left|\sin\frac{ka}{2}\right|$$ where the symbols have their usual meanings	**10** **10** **10** **10**	**CO2**

Values of some physical constants:

Planck's constant, $h = 6.6 \times 10^{-34}$ J.s
Boltzmann's constant, $k = 1.38 \times 10^{-23}$ J/K
Mass of electron, $m_e = 9.1 \times 10^{-31}$ Kg
Mass of proton, $m_p = 1.67 \times 10^{-27}$ Kg
Velocity of light, $c = 3 \times 10^{8}$ m/s
Rydberg Constant, $R = 1.097 \times 10^{7}$ m^{-1}
Avogadro's number = 6.023×10^{23}
Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m
Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ H/m