Q.P. Code: 16340

(Time: 3 HOURS) **[Total Marks: 75]**

N.B. (1) Attempt any six questions.
(2) Note the internal options.
(3) Marks assigned to each question are written against the question.

1. Describe in detail the orthogonalized plane-wave method of electronic band structure calculation. Show how it leads to pseudopotentials. Interpret them and explain their significance **13**

OR

2. (a) Show that the exchange energy of an electron in state $(\vec{k})$ of an electron gas in jellium model is, $\epsilon_x(\vec{k}) = -\frac{2e^2 k_F}{\pi} F(k/k_F)$, $F(x) = \frac{1}{2} + \frac{1-x^2}{4x} \ln\left|\frac{1+x}{1-x}\right|$. Plot *F(x)*.
(b) Given $\epsilon_x(\vec{k})$, what is the average exchange energy per particle? (No calculations).
(c) What is the total energy per particle? **13**

3. Find the eigenvalues of an electron in a magnetic field. What are Landau levels? Obtain an expression for the degeneracy of the levels. Calculate it for a sample of size 1 cm^3 in a magnetic field of 1 Tesla. **12**

OR

4. (a) Compare and contrast the band structures and Fermi surfaces of alkali and noble metals.
(b) Write a short note on cyclotron resonance. **12**

5. (a) Obtain the phonon dispersion relation w(**k**) for a one-dimensional vibrating lattice with two atoms per primitive cell.
(b) Describe the lattice diffraction pattern of a vibrating lattice. **12**

OR

6. In neutron scattering from a crystal, explain zero-, one- and two-phonon scattering processes. What is the information obtained from each of them? **12**

7. Explain the phenomenon of hysteresis in magnetic materials. Define the terms saturation magnetization, remanence and coercivity and identify these points on the hysteresis curve. Describe hard and soft magnets with suitable examples. List some of their applications. **12**

OR

8. Write in brief on the Stoner Criterion for ferromagnetism. Give suitable examples of elemental ferromagnets. **12**

9. Briefly describe the phenomenon of superconductivity highlighting the important characteristics. Trace the history of superconductors since its discovery by Kamerlingh Onnes to the high Tc superconductors discovered by Bednorz and Muller in terms of the compounds and their Tc. How do the high Tc superconductors differ from the conventional ones? **13**

OR

10. Write short notes on any two: **13**
(a) Cooper pairs
(b) Flux Quantization
(c) London equations for Superconductors

11. Write in brief about your self-study project. Explain the significance of the study. **13**

OR

12. What were the various topics discussed for the in-depth self-study? Discuss any one of them in detail. **13**

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