

PG/Phy/3rd Sem/21(CBCS)

2021

PHYSICS

Paper : PHY - 301

[Condensed Matter Physics]

(CBCS)

Full Marks : 40

Time : Two Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

(Answer should be to the point and concise)

Answer any *four* questions from the following : 10×4=40

1. (a) Show that the wave function, $\Psi(\vec{r}) = \sum_{j=1}^N \exp(i\vec{k} \cdot \vec{r}_j) \Psi_0(\vec{r} - \vec{r}_j)$ used in the tight binding (TB) approximation can be expressed as a Bloch function.
- (b) Determine the width of the energy band of 's' electron (s-band) for an BCC crystal in the TB approximation i.e., considering only the overlap of nearest neighbour wave functions. 3+7
2. (a) Estimate the mean free path of an electron based on the concept of quantum free electron theory. Compare the result with the classical one.
- (b) Calculate the value of Madelung Constant for 3-dimensional (3D) NaCl crystal. Establish the relation between Bulk Modulus (K) and range of the short repulsive interaction (ρ) for an ionic crystal.

- (c) In a band structure calculation, the dispersion relation for an electron is found to be $\epsilon_k = \beta(\cos k_x a + \cos k_y a + \cos k_z a)$ Calculate the effective mass at the boundary of 1st Brillouin Zone. 'β' is a constant. 3+(2+3)+2
3. (a) Briefly explain Heisenberg's theory of ferromagnetism and set up the relation between exchange integral and exchange field constant.
- (b) The saturation magnetization of iron is 1.75×10^6 A/m. Assuming iron is bcc structure with $a = 2.925$ Å. Find the average number of Bohr magneton contributed to the saturation magnetisation per atom. Explain, why the non integral value is obtained though Fe has integral unpaired spin. 5+5
4. (a) Discuss A.C Josephson's effect. Show that the current oscillate with frequency $\omega = \frac{2eV}{\hbar}$.
- (b) What are the basic differences between energy gap of a semiconductor and superconductor? Calculate the energy gap of a superconducting Sn and the minimum frequency that can be absorbed given that critical temperature of tin is 3.72 K. Comments on your result. 5+(2+2+1)
5. (a) What is meant by the geometrical structure factor? In a powder diffraction experiment using $\text{Cu-K}\alpha$ radiation, the first five lines are observed from mono-atomic cubic crystal when 2θ is 38.0° , 44.2° , 64.4° , 77.2° and 81.4° . Determine the crystal structure and lattice constant of the sample.
- (b) What is Umklapp process? Show that infinite chain of identical atoms behaves as low pass filter. (2+3)+(2+3)
-