Dr Vimal Sharma 6/12/2022 (m) (128)

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR

SOLID STATE PHYSICS, PH-224 (3RD SEMESTER)

B. TECH. (ENGINEERING PHYSICS)

END SEMESTER EXAMINATION (DEC-2022)

Time: 3 Hrs. **Max. Marks: 50**

Note: Attempt all the 12 question in the same sequence as given.

Q 1 What is the essential difference between the classical theory and the quantum theory of paramagnetism? (3)

Q 2 Give the Curie law of paramagnetism. What is the Curie temperature? (3)

Q 3 Explain the concepts of lattice, basis and crystal structure. How are they related? (3)

Q 4 Write the expression for the Fermi-Dirac distribution function and discuss its behaviour with change in temperature. (3)

Q 5 Show (111) and (222) planes in a cubic unit cell of side 'a'. Compute the distances of these planes from a parallel plane passing through the origin. (3)

Q 6 What is the reciprocal lattice and why is it named so? Derive the relationships for the primitive translation vectors of the reciprocal lattice in terms of those of the direct lattice. (3)

Q 7 Find out reciprocal lattice for a space lattice defined by the following primitive translation vectors:

$\vec{a} = 5\hat{i} + 5\hat{j} - 5\hat{k}, \vec{b} = -5\hat{i} + 5\hat{j} + 5\hat{k}, \vec{c} = 5\hat{i} - 5\hat{j} + 5\hat{k}$ where i, j and k are the unit vectors along x, y and z axes. Also find out the volume of the primitive cell. (4)

Q 8 What is Madelung constant? How is it expressed mathematically? What is the significance of the Madelung constant? (4)

Q 9 Consider a line of alternate positive and negative ions each carrying a charge q. the repulsive potential energy between the nearest neighbours is given by A/r^n. Show that, for a total of 2N ions, the equilibrium energy of the system is (6)

$$U_0 = -\left[2Nq^2 ln\left(\frac{2}{r_0}\right)\right]\left(1 - \frac{1}{n}\right)$$

Q 10 Derive an expression for the lattice heat capacity of a solid following Einstein's model. Discuss the assumptions and predictions of this model and compare it with experimental observations. (6)

Q 11 Discuss the formation of allowed and forbidden energy bands on the basis of the Kronig-Penney model. Discuss the extreme conditions when energy levels are discrete or continuous. What is the effect of changing the binding energy of electron on the energy bands? (6)

Q 12 Explain the origin of diamagnetism in materials. Obtain an expression for diamagnetic susceptibility using the Langevin's theory. What is the significance of negative susceptibility? (6)