K20P 1120

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Suppl./Imp.) Examination, October 2020
(2014 Admission Onwards)
PHYSICS
PHY3C11 : Solid State Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (Either **a)** or **b)**) : **(2×12=24)**

I. a) Define reciprocal lattice and reciprocal lattice vectors. Determine the reciprocal lattice vectors of simple cubic, body centred and face centred cubic lattices.

OR

b) Explain Bloch theorem. Discuss the formation of energy bands in a one dimensional lattice based on Kronig-Penney model.

II. a) What is an intrinsic semiconductor ? Obtain the expression for carrier concentration in an intrinsic semiconductor. Show that the Fermi energy level of an intrinsic semiconductor lies nearly midway between top of the valence band and bottom of the conduction band.

OR

b) What are paramagnetic materials ? Discuss the quantum theory of paramagnetism and hence derive Curie's law.

SECTION – B

Answer **any four** questions. **1** mark for part **a)**, **3** marks for part **b)** and **5** marks for part **c)** : **(4×9=36)**

III. a) What are quasi crystals ?

b) Explain the geometric structure factor of a crystal lattice.

c) Show that the X-ray diffraction spectrum of a body centred cubic crystal lattice does not contain diffraction lines corresponding to reflection from (3 0 0) Miller crystal planes.

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IV. a) What is a phonon ?

b) Explain the Einstein's model of lattice heat capacity of solids.

c) The Debye temperatures of gold and copper are $-103^{\circ}C$ and $75^{\circ}C$ respectively. Determine the Debye cut-off frequency of elastic waves in gold. (Given, Debye cut-off frequency of copper is 1.27×10^{13} Hz).

V. a) Define Fermi energy.

b) Explain the effect of temperature on the Fermi-Dirac distribution function of a free electron gas.

c) Determine the temperature at which there is 2% probability that a state with an energy 0.25 eV above the Fermi energy will be occupied by an electron.

VI. a) Sketch the diagram representing the indirect optical absorption process associated with semiconductors.

b) Explain the concept of effective mass of an electron.

c) The energy (E) near the valence band edge of a crystal is $E = -10^{-39} K^2 Jm^2$ where K is the wave vector associated with the electron. An electron with wave vector $10^9 \hat{x} m^{-1}$ is removed from an orbital in the completely filled valence band ($\hat{x}$ is the unit vector along x direction). Calculate the effective mass and momentum of the electron ?

VII. a) Define coherence length.

b) Briefly explain the BCS theory of superconductivity.

c) The critical temperature of Mercury with average mass 200.59 amu is 4.15 K. Using BCS theory, determine the critical temperature of one of the isotopes of mercury with average mass 204 amu.

VIII. a) What are ferroelectric crystals ?

b) Explain ferromagnetic domains.

c) The carbon atoms form a regular hexagon of side 1.39 Å in benzene having 6 relevant electrons per molecule. Determine the diamagnetic susceptibility per unit volume of benzene due to these electrons. (Given, mass of benzene is 78.11 g/mol and density of benzene is 880 kg/m^3).