MP 3.3

Third Semester M.Sc. in Physics Examination, September 2016
CONDENSED MATTER PHYSICS

Time : 3 Hours Max. Marks : 80

Instruction : *Answer **all** questions.*

1. a) Write a note on Bravais lattices listing all the types. **10**

   b) Show that lattices cannot have five fold symmetry under translation. **5**

   OR

2. a) Discuss elastic scattering of X-rays from a perfect lattice. **5**

   b) Find reciprocal lattice of fcc lattice. **5**

   c) Mention the applications of synchrotron radiations. **5**

3. a) Explain the principles of electron diffraction technique. **4**

   b) Compare neutron diffraction with X-ray diffraction. **5**

   c) Explain diamagnetism, paramagnetism and ferromagnetism on the basis of magnetic dipoles of the atoms. **6**

   OR

4. a) What is gyromagnetic ratio ? Calculate the g – factor for Cr^{2+} ion. **5**

   b) Give the Neel theory of antiferromagnetism based on two-sublattice model. **10**

5. a) What is the difference between type I and type II superconductors ? **5**

   b) Derive an expression for the London penetration depth. **10**

   OR

6. a) Discuss the thermodynamics of superconducting transition and derive Rutger's formula. **8**

   b) Explain superconductivity on the basis of BCS theory. **7**

7. a) Derive an expression for the carrier concentration in an intrinsic semiconductor. **10**

   b) Derive an expression for electrical conductivity of an intrinsic semiconductor and explain how it helps to determine its energy gap. **5**

   OR

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8. a) Obtain an expression for impurity concentration for a doped semiconductor. **10**

   b) Derive an expression for the ionization energy of donors in an extrinsic semiconductor. **5**

9. Answer **any four** of the following : **(4×5=20)**

   a) Obtain Miller indices for (100), (010) and (111) planes.

   b) In a cubic crystal, using X-rays of wavelength 1.6 Å, a first order (100) reflection is observed at glancing angle of 18°. Calculate the distance between the (100) planes and (111) planes of the crystal.

   c) A paramagnetic substance has 10^{28} atoms per cubic meter. The magnetic moment of each atom is 1.8×10^{-23} ampere per square meter. Calculate paramagnetic susceptibility at 310 K.

   d) Calculate the change in susceptibility from its maximum value of MnO crystal at 300 K using the following data.

   $T_N = 116\,K$, $\chi_{T=T_C} = 57.9 \times 10^{-4}$, $\Theta = 610$, $N = 0.57 \times 10^{28}\,m^{-3}$, $\mu_J = 5.7\mu_B$ and $\mu_B = 9.27 \times 10^{-24}\ JT^{-1}$.

   e) Estimate the magnetic field strength necessary to destroy superconductivity in a sample of lead at 4.2 K. Given : $T_C = 7.2$ K and $H_C(0) = 0.080$ T.

   f) On the basis of BCS theory calculate the energy gap in eV of lead at 0 K and at 6.8 K. Given: $T_C = 7.2K$ and $k_B = 1.38 \times 10^{-23}\,JK^{-1}$.

   g) Determine the Fermi level at 310 K for the intrinsic semiconductor materials with

   i) $\frac{m_p^*}{m_n^*} = 2$

   ii) $\frac{m_p^*}{m_n^*} = 1.5$. Given: $k_B = 1.38 \times 10^{-23}\,JK^{-1}$.

   h) Calculate the ionization energy of a donor atom in a semiconductor with $m_n^* = 0.25m_0$ and $\varepsilon = 16$. Ionization energy of hydrogen atom is 13.6 eV.