Seat No. : _______________

ZQ-112

May-2014

M.Sc., Sem.-II

409 : Physics

(Solid State Properties and Physics of Semiconductor)

Time : 3 Hours] [Max. Marks : 70

Instructions : (1) Attempt **all** questions.
(2) Symbols used have their usual meanings.
(3) Assume data when necessary.

1. (a) Write note on Electron Spin Resonance and Nuclear Spin Resonance. **7**

OR

Discuss the Neel model of anti-ferromagnetism and deduce expression for the magnetic susceptibility for that.

(b) Derive Curie-Weiss law for ferromagnetism. **7**

OR

(b) (i) Obtain expression of magnetic susceptibility in the case of ferrimagnetism. **4**

(ii) The curie temperature of Fe is 770 °C. For Fe, $\mu = 2\mu_B$ and $N = 8 \times 10^{28}\ m^{-3}$ are given. Calculate Weiss constant. **3**

2. (a) Explain Meissner effect for bulk specimen and multiply connected specimen ? **7**

OR

Using thermodynamics of the superconducting transition show that the superconducting state of a conductor is more stable than its normal state.

(b) Obtain an expression of superconducting current for macroscopic quantum interference. **7**

OR

(b) (i) What is Coherence length ?
Obtain necessary expression for Coherence length. **4**

(ii) For Nb : Z = 5 and Tc = 9.26 K.
For Pb : Z = 4 and Tc = 7.20 K. Estimate T_c for Hg (Z = 2). **3**

3. (a) Define generation and recombination. Show that during the recombination process excess charge carrier density in a p-type semiconductor decays exponentially with time. **7**

OR

Describe the concept of mobility. Show that

$\sigma = n_i \, e(\mu_n + \mu_p)$

Graphically illustrate the effect of carrier density on μ_n & μ_p for *p*-type Si at 300K

(b) (i) A silicon bar 0.1 cm long and 100 μm^2 in cross sectional area is doped with 10^{17} cm^{-3} phosphorous atoms. Find the current passing through the bar at 300 K when 10 V is applied. Given : $\mu_n = 700\ cm^2$ / volt-sec. **3**

(ii) Prove that in an intrinsic semiconductor the Fermi level lies at the centre of the firbidden gap. **4**

OR

(b) What is density of states ? Obtain an expression of density of states for a metal and extend it to find a similar equation for a semiconductor. **7**

4. (a) Draw the charge carrier profiles across an abrupt p-n junctions. Derive the rectifier equation for p-n junction. **7**

OR

Considering an abrupt p-n junction, obtain an expression of depletion layer width when no external bias is applied.

(b) Draw energy band diagram when two metals are joined. Explain the concept of contact potential. State the physical significance of such potential. **7**

OR

Draw the band diagram of an abrupt p-n junction, derive an expression of the junction capacitance when an external bias, V is applied to the junction.

5. Answer the following : (each carry **1** mark) **14**

(1) The magnetism of atomic magnet is due to

(a) Only spin motion of electrons

(b) Only orbital motion of electrons

(c) Both spin and orbital motion of electrons

(d) Proton-neutron interaction in the nucleus

(2) Magnetic susceptibility is negative in case of

(a) Paramagnetic materials (b) Ferromagentic materials

(c) Diamagnetic materials (d) For (a) & (b) both

(3) In ferrimagnetism

(a) The number of atoms with opposite spins is unequal

(b) The number of atoms with opposite spins is equal

(c) The number of atoms with opposite spins is zero

(d) There is zero magnetic moment

(4) The quantized unit of spin wave energy is called a _______

(a) megneton (b) megnon

(c) spintron (d) photon

(5) The critical field for the superconductor is calculated by

(a) $B_C = \left[\frac{B_0}{1 - (T / T_C)^4}\right]$

(b) $B_C = \left[\frac{B_0}{1 - (T / T_C)^2}\right]$

(c) $B_C = B_0[1 - (T / T_C)^2]$

(d) $B_C = B_0[1 - (T / T_C)^4]$

(6) A theoretical explanation of Meissner effect can be obtained from the

(a) Maxwell's equations

(b) Cooper pair

(c) Quantization of magnetic flux

(d) London equation

(7) A mixed state of normal and superconducting region is observed

(a) only in Type I superconductors

(b) only in Type II superconductors

(c) in both Type I and Type II superconductors

(d) neither in Type I nor in Type II superconductors

(8) Draw the energy band diagram of a metal and insulator.

(9) Draw a schematic Fermi level diagram of a n-type semiconductor kept at 30° and 90° C.

(10) What is the law of mass action ?

(11) Draw the mobility versus temperature curves for pure and doped silicon.

(12) What do you mean by thermo-ionic emission ?

(13) Why "trap" is required for recombination process in semiconductor ?

(14) Define avalanche breakdown.