Seat No. : _____

TA-115

April-2013

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.

1. (a) What is Curie-Weiss law ? Derive it. Also derive the equations for energy density and heat capacity of the ferromagnetic substance on the basis of the mean field theory. **7**

OR

Obtain the dispersion relation of Magnons in Ferromagnets.

(b) Differentiate between ferromagnet and ferrimagnet substances. Discuss the Neel model of ferrimagnetism. **7**

OR

Obtain the necessary expression for the Bloch $T^{3/2}$ law.

2. (a) (i) Explain Meissner effect. How superconductors are classified in to Type I and Type II ? **4**

(ii) For Nb : Z = 5 and T_c = 9.26 K.

For Pb : Z = 4 and T_c = 7.20 K. Estimate T_c for Hg (Z = 2). **3**

OR

(a) By deriving the necessary expression, explain current-voltage characteristics of the DC Josehpson effect. **7**

(b) Obtain expressions for London penetration depth and coherence length. **7**

OR

(b) (i) Write the underlying assumptions in BCS theory. **4**

(ii) Find the angle θ at which the B_c (T) – T curve meets the T-axis. **3**

3. (a) Discuss Hall effect. Using necessary equations, explain how it is used for determination of mobility of a semiconductor ? **7**

OR

(a) (i) Explain how and why Fermi level changes with temperature. **4**

(ii) A silicon bar 0.1 cm long and 100 μm^2 in cross sectional area is doped with 10^{17} cm^{-3} phosphoros atoms. Find the current at 300 K with 10 V applied. The electron mobility in silicon is 700 cm^2 V^{-1} Sec^{-1}. **3**

(b) Define density of states. Use momentum diagram to obtain an expression for density of states in a semiconductors. State its importance. **7**

OR

State and prove the law of mass action. Mention at least two applications of it.

4. (a) For a semiconductor *p-n* junction, derive an expression of depletion layer width when suitable external bias is applied to the junction. **7**

OR

Derive an equation of diode rectification and explain the *I-V* curve from it.

(b) Draw energy band diagram when two metals are joined. Explain the concept of contact potential. How it can be extended to semiconductor junctions ? **7**

OR

(b) Explain the terms :

(i) Abrupt *p-n* junction. **4**

(ii) Contact potential. **3**

5. Answer the following in brief : (each carry **one** mark) **14**

(1) The quantized unit of spin wave energy is called a _____.

(a) megneton (b) megnon

(c) spintron (d) photon

(2) The Curie law is valid for

(a) diamagnet (b) paramagnet

(c) ferromagnet (d) all substances

(3) In the long wave length limit, the magnon dispersion relation reduces to

(a) $\omega = \frac{4J_{ex}S}{\hbar}|ka|$ (b) $\omega = \frac{4J_{ex}S}{\hbar}\cos(ka)$

(c) $\omega = \frac{4J_{ex}S}{\hbar}\sin(ka)$ (d) $\omega = \frac{4J_{ex}S}{\hbar}$

(4) The isotope effect coefficient is

(a) zero (b) 1/2

(c) 2 (d) infinite

(5) In the ac Josephon effect, the current has an oscillatory component of angular frequency ω = _____

(a) 2eV/ħ (b) 2eV/(ħc)

(c) eV/(2ħ) (d) 2ħc/(eV)

(6) In the macroscopic quantum interference the current is maximum when _____.

(a) eφ/ħc = sπ with s = integer

(b) 2eφ/ħc = sπ with s = integer

(c) φħ/c = sπ with s = integer

(d) ħc/eφ = sπ with s = integer

(7) In the BCS theory

(a) $T_C = 114\theta_D \exp[-1/UD(E_F)]$

(b) $T_C = 114\theta_D \exp[-UD(E_F)]$

(c) $T_C = 1.14\theta_D \exp[-1/UD(E_F)]$

(d) $T_C = 1.14\theta_D \exp[-UD(E_F)]$

(8) Plot a graph of excess charge carrier density versus time for recombination process in a *p*-type semiconductor.

(9) Why the location of acceptor state is close to top of the valance band ?

(10) Draw the charge carrier density profile of an abrupt *p-n* junction.

(11) State the importance of metal work function.

(12) Plot the mobility versus donor density (N_d) of *n*-type silicon.

(13) Define Fermi factor. Give its unit.

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

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