Seat No. : _____

AD-152

April-2019

M.Sc., Sem.-II

409 : Physics
(Solid State Properties and Physics of Semi-conductor)
(New)

Time : 2:30 Hours] **[Max. Marks : 70**

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

1. (A) Write the following :

(i) Give the detailed analysis of the propagation of spin waves in a linear chain. Show that the corresponding excitation energy can be quantized leading to a concept of magnon. **7**

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

OR

(i) Explain in detail the exchange interaction and Heisenberg model to understand the magnetism.

(ii) Obtain the dispersion relation for magnons in ferromagnet.

(B) Answer in brief : (any **four**) **4**

(i) Define exchange energy.

(ii) What do you mean by magnon ?

(iii) What is closure domain ?

(iv) Define coercivity.

(v) The magnetic state of a material depends on pressure. (TRUE / FALSE)

(vi) Define Curie temperature.

2. (A) Write the following :

(i) Write down the London equation and show that the magnetic field decays exponentially. Also using the concept of coherence length, derive the dirty superconductor limit. **7**

(ii) What do you mean by tunnelling ? Explain in details DC Josephson effect. **7**

OR

(i) (1) State underlying assumptions in BCS theory. **4**

(2) Obtain the angle θ at which the $\Delta(T) - T$ curve meets the T-axis. **3**

(ii) Obtain necessary condition for quantization of the magnetic flux in a superconducting ring. **7**

(B) Answer in brief : (any **four**) **4**

(i) Define Meissner effect.

(ii) State the difference between type-I and type-II superconductors.

(iii) Define coherence length.

(iv) In AC Josephson effect, a DC voltage applied across the junction causes _____ current oscillations across junction. [AC, DC, RF, No]

(v) Superconductor exhibits _____ conductivity.

[ZERO, FINITE, INFINITE]

(vi) What do you mean by London penetration depth ?

3. (A) Answer the following :

(i) Explain how the energy bands are formed. Discuss the energy band formation in case of a silicon crystal. **7**

(ii) For a non-degenerate p-type semi-conductor, prove the following **7**

$$p = n_i \exp\left[\frac{E_i - E_F}{kT}\right]$$

OR

(i) Explain band diagram of an intrinsic semi-conductor. Show that at any temperature, the Fermi level lies at the centre of the band gap in such material.

(ii) Write brief notes on : (a) Degenerate semi-conductors (b) Effect of temperature on Fermi level.

(B) Answer in brief : (any **three**) **3**

(i) Differentiate between direct and indirect band gap semi-conductors.

(ii) At any temperature, for pure semi-conductor, the $\mu_n > \mu_p$ why ?

(iii) Draw the energy band diagram for metal.

(iv) Draw the location of Fermi level for a p-type semi-conductor kept at 25 °C and 75 °C.

(v) State any two applications of Hall effect.

4. (A) Answer the following :

(i) What is abrupt p-n junction ? For such junction, obtain following expression for built-in potential. **7**

$$V_{bi} = \frac{kT}{q} \ln\left[\frac{N_A N_D}{n_i^2}\right]$$

(ii) Obtain rectifier equation and draw the I-V characteristics of an ideal p-n junction diode. **7**

OR

(i) For an abrupt p-n junction assume a rectangular depletion region at thermal equilibrium. Draw the electric field distribution of such junction and prove that the area under the field triangle corresponds to the built-in potential of the p-n junction.

(ii) Explain depletion capacitance and capacitance-voltage characteristics of a p-n junction.

(B) Answer in brief : (any **three**) **3**

(i) State the difference between abrupt and graded p-n junction.

(ii) Draw the space charge distribution of an abrupt p-n junction.

(iii) On which factors does the width of the depletion region of a p-n junction depend ?

(iv) Give any two assumptions of ideal p-n junction diode.

(v) Give the unit of depletion capacitance.

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(iii) Define coherence length.

(iv) In AC Josephson effect, a DC voltage applied across the junction causes _____ current oscillations across junction. [AC,DC,RF, None]

(v) Superconductor exhibits _____ conductivity.

[ZERO, FINITE, INFINITE, None]

(vi) What do you mean by London penetration depth ?

3. (A) Answer the following :

(i) Explain the mobility of a semi-conductor. Establish a relationship between conductivity and mobility. **7**

(ii) Define density of states. Use momentum diagram to obtain an expression for density of states in a semi-conductors. State its importance. **7**

OR

(i) Using neat diagram, discuss the Hall effect.

(ii) Explain the process of generation and recombination. Obtain an expression for the decay of excess hole concentration in p-type semi-conductor.

(B) Answer in brief : (any **three**) **3**

(i) On which factor does the mobility of charge carrier depend ?

(ii) Give the unit of Hall co-efficient R_H.

(iii) Draw the energy band diagram for metal.

(iv) Draw the location of Fermi level for an n-type semi-conductor kept at 20 °C and 70 °C.

(v) Why traps are required for recombination process in semi-conductor ?

4. (A) Answer the following :

(i) Use neat diagram to explain the junction between two metals. Explain contact potential. **7**

(ii) For a semi-conductor p-n junction, derive an expression of depletion layer width when no external bias is applied to the junction. **7**

OR

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

(ii) Explain the concepts of (1) contact potential (2) Graded p-n junction.

(B) Answer in brief : (any **three**) **3**

(i) State the difference between abrupt and graded p-n junction.

(ii) On which factors does the contact potential of p-n junction depend ?

(iii) On which factors does the width of the depletion region of a p-n junction depend ?

(iv) Draw the energy band diagram of reverse biased p-n junction.

(v) State the importance of metal work function.

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