* B B G - 0 0 3 - 1 0 1 6 0 3 2 *

BBG-003-1016032 Seat No. _____

B. Sc. (Sem. VI) (CBCS) (W.I.F. 2016) Examination

July - 2021

Physics : P - 602

(Statistical Mechanics & Solid State Physics)

(New Course)

Faculty Code : 003

Subject Code : 1016032

Time : $2\frac{1}{2}$ Hours] [Total Marks : **70**

Instructions : (1) Attempt any five questions out of following ten questions.
(2) Symbols have their usual meanings.
(3) Figures on right side indicate marks.

1 (a) Give answer to the following questions : **4**
(1) For the particles like photons, B-E statistics is applicable. Do you agree ?
(2) Minimum volume of a cell in phase space is of the order of _____.
(3) In M-B statistics, internal energy of particles at absolute zero temperature is taken as _____. (infinite / zero)
(4) At high temperature, Fermi-Dirac distribution reduces to Bose-Einstein distribution. Is it true or false ?

(b) If an energy level having degeneracy $g_i = 4$ is to be occupied by 3 particles. Find the number of ways to arrange them in case of B-E statistics. **2**

(c) Discuss : The Sterling's theorem. **3**

(d) Derive the most probable distribution formula for F-D statistics. **5**

2 (a) Give answer to the following questions : **4**
(1) F-D statistics is applicable to particles which are having zero spin. Is it true or false ?
(2) Phase space is a _____ dimensional space.
(3) M-B statistics is applicable to identical and distinguishable particles. Do you agree ?
(4) Change of phase points between two cell in a phase space give rise to new macrostate. Is it true or false ?

(b) The Fermi energy for a substance is 9.1 eV. Find the velocity of an electron in this Fermi level. Mass of electron is 9.1×10^{-31} kg. **2**

(c) Derive equation of volume in Phase space in terms of momentum. **3**

(d) Derive the distribution law for M-B statistics. **5**

3 (a) Give answer to the following questions : **4**

(1) Define Miller indices.

(2) Which cubic structure has the minimum packing fraction ?

(3) The alkali metals like Na, Li have a fcc crystal structure. Is it True or false ?

(4) The co-ordination number in case of hcp crystal structure is _____.

(b) Draw the plane in cubic crystal having Miller indices (010) and (110). **2**

(c) Show that the packing fraction in case of simple cubic structure is 52%. **3**

(d) Discuss Body Centered Cubic (bcc) crystal in detail. **5**

4 (a) Give answer to the following questions : **4**

(1) Elements from group-IV (semiconductors) forms covalent bonds. Do you agree ?

(2) Melting point for NaCI crystal is _____ °C.

(3) According to Einstein, the solid containing N atoms is considered to be equivalent to 3N harmonic oscillator. Is it true or false ?

(4) According to Dulong and Pettit law, the specific heat C_v = _____.

(b) If Debye temperature for carbon is 1850 K, find the molar specific heat for diamond at 185 K. **2**

R = 8.4 J/mol^{-K}.

(c) Write a note on Hydrogen bonding crystals. **3**

(d) Discuss in detail : Ionic crystal. **5**

5 (a) Give answer to the following questions : **4**

(1) Metals have very low electrical and thermal conductivities. Do you agree ?

(2) What is Wiedemann-Frantz law ?

(3) According to Sommerfeld model, the work function ϕ = _____.

(4) Write Pauli's exclusion principle.

(b) Find the concentration of conduction electrons at room temperature in case of Copper which has mass density 8.95 gm/m^3. 1 mole of Cu weighs 64 grams. **2**

(c) Explain Density of states in one dimension. **3**

(d) Discuss free electron gas in one dimensional box and derive the equation of normalized wave function. **5**

6 (a) Give answer to the following questions : **4**

(1) Define "Density of states".

(2) According to Drude-Lorentz, the heat capacity of free electron should be 3NK. Do you agree ?

(3) The Hall resistance depends on the sample thickness t. Is it true or false ?

(4) In Hall effect, magnetic field is applied _____ to the current. (parallel / perpendicular)

(b) Explain free electron model in brief. **2**

(c) Show that the Fermi wavelength associated with an electron having an energy equal to Fermi energy is given by $\lambda_F = 2(\pi/3N)^{1/3}$. **3**

(d) Discuss in detail : Hall effect. **5**

7 (a) Give answer to the following questions : **4**

(1) What is Fermy energy ?

(2) The _____ point in the conduction band is called the conduction band edge. (lowest / highest)

(3) The low electrical conductivity in insulators is due to binding electrons. Is it true or false ?

(4) Where is the Fermi level exactly located in the band structure of insulators ?

(b) The band gap of an alloy semiconductor is 1.98 eV. What is the wavelength of radiation emitted due to recombination of holes and electrons ? **2**
h = 6.626×10^{-34} J/s, 1 eV = 1.6×10^{-19} J

(c) Explain effect of impurities in semiconductor. **3**

(d) Discuss : Electron-hole carrier concentration in intrinsic semiconductor. **5**

8 (a) Give answer to the following questions : **4**

(1) At absolute zero temperature, pure and perfect crystal of semiconductor is an insulator. Is it true or false ?

(2) The _____ point in the valence band is called the valence band edge. (lowest / highest)

(3) Band gap energy (E_g) for Germanium is _____ eV.

(4) What is electron-hole recombination process ?

(b) Draw the band structure model of an insulator. **2**

(c) Explain bonding in semiconductors. **3**

(d) Discuss donor states in extrinsic semiconductor. **5**

9 (a) Give answer to the following questions : **4**

(1) Kammerlingh found that the resistance of mercury drops suddenly to almost zero when the temperature falls below _____ K .

(2) In case of superconductors, if atomic mass of isotopes increases, its critical temperature decreases. Is it true or false ?

(3) When the dimension of a superconductor increases due to stress, its transition temperature T_c _____. (increases / decreases)

(4) Superconductor behaves like a perfect paramagnetic material. Do you agree ?

(b) Hg has isotopic mass 199 amu and critical temperature 4.185 K. If isotopic mass changes to 202 amu, determine its new critical temperature. **2**

(c) Explain Meissner effect. **3**

(d) Discuss : Applications of superconductors. **5**

10 (a) Give answer to the following questions : **4**

(1) When size of superconductor is reduced, What happens to critical magnetic field ?

(2) Define "critical field" for super conductor.

(3) What is weak junction in Josephson's effect ?

(4) For alloys, the transition temperature is extremely _____. (high / low)

(b) For a superconducting specimen, if critical field at temperature 4.2 K is 20.7×10^5 A/m, calculate critical field at critical temperature 14.5 K. **2**

(c) Discuss properties which changes in superconducting transition. **3**

(d) Describe : The London's theory for superconductivity. **5**