Seat No. _____

# HA-003-1016032

## B. Sc. (Sem. VI) (CBCS) Examination

**April - 2023**

**Physics : 602**

***(Statistical Mechanics & Solid State Physics) (Old Course)***

**Faculty Code : 003**

**Subject Code : 2016032**

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

**Instructions :** (1) All questions are compulsory.
(2) Symbols have their usual meanings.
(3) Figures to the right indicate marks.

**Physical Constants :**

$h = 6.62 \times 10^{-34}$ Js, $\hbar = 1.055 \times 10^{-34}$ Js,
Boltzmann constant $k = 1.38 \times 10^{-23}$ J/k, $R = 8.3$ J $mol^{-1}$ $K^{-1}$,
Mass of an electron = $9.1 \times 10^{-31}$ Kg.

**1** (a) Answer the following objective questions : **4**

(1) Electrons are Bosons. True or false?

(2) In phase space, the minimum volume of a phase cell is _____.

(3) Write Fermi Dirac distribution law.

(4) Photons are Fermions. True or false?

(b) Answer any **one** question : **2**

(1) Find the thermodynamic probabilities for a system of 3 particles in 2 cells.

(2) If 3 particles are arranged in an energy level having a degeneracy $g_i = 4$, find the number of ways the distributions are possible if the particle are (a) Fermions (b) Bosons.

(c) Answer any **one** question : **3**

(1) Derive an expression for the volume in phase space.

(2) Distinguish between Maxwell Boltzmann distribution, Bose Einstein distribution and Fermi Dirac distribution (any five).

(d) Answer any **one** in detail : **5**

(1) Starting with the basic postulates derive Maxwell Boltzmann distribution law.

(2) Starting with the basic postulates derive Fermi Dirac distribution law.

**2** (a) Answer the following objective questions : **4**

(1) $a = b = c$ and $\alpha = \beta = \gamma = 90°$ defines a _____ crystal.

(2) What is hydrogen bonding?

(3) According to Dulong and Petit's law the molar specific heat of a solid, $C_V$ = _____.

(4) Define unit cell.

(b) Answer any **one** question : **2**

(1) Debye's temperature of carbon (diamond) structure is 1850 K. Calculate the molar specific heat at constant volume for diamond at 20 K.

(2) Find the ratio of intercepts on the three axes by (123) plane in a simple cubic crystal.

(c) Answer any **one** question : **3**

(1) Write a note on metallic bonding.

(2) Explain simple cubic structure with necessary diagrams.

(d) Answer any **one** in detail : **5**

(1) Write a note on Miller indices with an example.

(2) Derive Einstein's equation for the specific heat of a solid.

**3** (a) Answer the following objective questions : **4**

(1) Define density of states.

(2) Define mobility.

(3) The relation $\vec{J} = \sigma \vec{E}$ is known as _____.

(4) Define Fermi energy.

(b) Answer any **one** question : **2**

(1) Calculate the emf generated in sodium when a current of 100mA passes along a sample of 5 mm wide and 1 mm thick in a field of 0.1 T. Hall coefficient for sodium, $R_H = 2.45 \times 10^{-10}\ m^2 / C$.

(2) Show that the wavelength associated with an electron having an energy equal to Fermi energy is given by, $\lambda_F = 2\left[\frac{\pi}{3N}\right]^{\frac{1}{3}}$.

(c) Answer any **one** question : **3**

(1) Define Hall effect and derive an expression for Hall resistance $R_H$.

(2) Distinguish between metals, semiconductors and insulators based on the band theory.

(d) Answer any **one** in detail : **5**

(1) Explain free electron gas in one dimension.

(2) Explain density of states D(E) in three dimensions.

**4** (a) Answer the following objective questions : **4**

(1) What are acceptors?

(2) In an extrinsic semiconductor $n_e = n_h$. True or false.

(3) Define direct band gap semiconductors.

(4) What is the atomic number of silicon?

(b) Answer any **one** question : **2**

(1) The resistivity of *n*-type semiconductor of germanium is $0.01\,\Omega - m$ at room temperature. Calculate the donor concentration if the mobility of electrons is 0.39 $m^2$/volt-sec.

(2) The mobilities of electrons and holes in a sample of intrinsic germanium at 300 K are $0.36\,m^2V^{-1}s^{-1}$ and $0.17\,m^2V^{-1}s^{-1}$ respectively.If the conductivity of the specimen is $2.12\,\Omega^{-1}m^{-1}$, calculate the intrinsic carrier density of germanium.

(c) Answer any **one** question : **3**

(1) Explain conductivity in a *p* type semiconductor.

(2) What is the effect of impurity on semiconductors?

(d) Answer any **one** in detail : **5**

(1) Prove that the Fermi level is halfway between valence band and conduction band in intrinsic semiconductors.

(2) Explain the electrical conductivity and bonding in semiconductors.

**5** (a) Answer the following objective questions : **4**

(1) Define critical magnetic field.

(2) What is transition temperature?

(3) Superconductors are perfect diamagnetic materials. True or false?

(4) What is a Type II superconductor?

(b) Answer any **one** question : **2**

(1) Hg has an isotopic mass 199 and $Tc$ = 4.185K. If the isotopic mass changes to 202, calculate its $Tc$?

(2) Calculate the London penetration depth for lead at 0K whose density is $11.3x10^3$ kg / $m^3$. Atomic weight of lead is 207.19.

(c) Answer any **one** question : **3**

(1) Write the applications of superconductivity.

(2) Explain Meissner effect.

(d) Answer any **one** in detail : **5**

(1) Derive London equation.

(2) Explain the thermodynamics of superconducting transition.

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