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PA-003-1016032 Seat No. _____

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

March / April - 2020

Physics : Paper - 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) All questions are compulsory.
(2) Symbols have their usual meanings.
(2) 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 Fermions. True or false?

(2) The six dimensional space consisting three position coordinates and three momentum coordinates is known as _____.

(3) Write the equation giving Maxwell Boltzmann distribution law.

(4) Fermi Dirac distribution is applicable to particles with spin equal to $\frac{1}{2}\hbar, \frac{3}{2}\hbar_{etc}$. True or false?

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

(1) 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 particles are (a) Fermions (b) Bosons.

(2) The Fermi level for potassium is 2.1 eV. Calculate the velocity of an electron at the Fermi level.

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

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

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

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

(1) Derive Maxwell-Boltzmann distribution law.

(2) Starting with the basic postulates, derive Bose-Einstein distribution law.

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

(1) Define unit cell.

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

(3) According to Dulong and Petit's law, the molar specific heat of a solid $C_v = 3R$. True or false?

(4) What is hydrogen bonding ?

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

(1) What would be the effect on the specific heat of solids at room temperature if Planck's constant were increased by ten fold ?

(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 crystals.

(2) What are the criticisms against Debye's theory?

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

(1) Write a note on Miller indices giving one example.

(2) Derive the classical equation (Dulong and Petit's law) for the specific heat of solids.

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

(1) Define density of states.

(2) At absolute zero the Fermi function $f(E) = 1$ for $E < E_F$. True or false?

(3) Define Fermi energy.

(4) Write Ohm's law in vector form.

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

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

(2) Calculate the number of energy states available for electrons in cubical box of side $1\,cm$ lying below an energy of $1eV$.

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

(1) Derive Boltzmann equation.

(2) What is Hall effect? Derive an expression for Hall coefficient.

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

(1) Explain free electron gas in one dimension.

(2) Explain density of states $D(E)$ in one dimension.

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

(1) In an intrinsic semiconductor, $n = p$. True or false?

(2) In an n-type semiconductor the donor level is just above the valence band. True or false?

(3) Define band gap.

(4) Define extrinsic semiconductors.

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

(1) In an n type semiconductor, the Fermi level lies $0.3\,eV$ below the conduction band at $300K$. If the temperature is increased to $330K$, find the new position of the Fermi level.

(2) The mobilities of electrons and holes in a sample of intrinsic germanium at $300K$ 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 donor states in an extrinsic semiconductor.

(2) Write a note on intrinsic semiconductor.

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

(1) Explain electron-hole carrier concentration in semiconductors.

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

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

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

(2) The minimum magnetic field necessary to destroy superconductivity is known as _____.

(3) What are Cooper pair of electrons ?

(4) In a type I superconductor there are two critical magnetic fields. True or false?

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

(1) For a specimen of V_3G_a, the critical fields are respectively 1.4×10^5 A/m and 4.2×10^5 A/m for 14 K and 13K. Find the transition temperature.

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

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

(1) Write five properties which change during superconducting transition.

(2) Explain Meissner effect.

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

(1) Explain the thermodynamics of superconducting transition.

(2) Explain the BCS theory.
