**DQ-003-2016032** Seat No. _____

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

**April - 2022**

## Physics - 602

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

***(New 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) Particles which obey Bose-Einstein statistics are known as Bosons. True or false?

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

(3) The minimum volume of a phase cell is $h^3$. True or false?

(4) Fermi Dirac distribution is applicable to particles with spin equal to 0, $\hbar$, $2\hbar$, $3\hbar$..... 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 particles are

(i) Fermions

(ii) Bosons.

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

(1) Write a note on phase space.

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

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

(1) Derive Bose-Einstein distribution law.

(2) Derive Fermi-Dirac distribution law.

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

(1) According to Debye's theory, at low temperature $C_V$ is proportional to $T^3$. True or false?

(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) NaCl is an example for _____ crystal.

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

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

(2) Show that the density or the packing fraction in the case of simple cubic is about 0,5.

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

(1) Write a note on hydrogen bonding.

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

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

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

(2) Derive Einstein's equation for the specific heat of solids,

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

(1) State Wiedemann and Franz's law.

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

(3) State Pau1i's exclusion principle.

(4) Define relaxation time.

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

(1) The number of free electrons per cubic metre of sodium is $2.5 \times 10^{28}$. Calculate the Fermi energy.

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

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

(1) What are the outstanding properties of metals?

(2) Derive the expression for the thermal conductivity of metals.

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

(1) Explain Sommerfeld's theory of electrical conductivity.

(2) Explain quantum theory of free electron in a box (free electron gas in three dimensions).

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

(1) In a semiconductor, $np = n_i^2$ True or false?

(2) In a $p$-type semiconductor the acceptor level is just above the valence band. True or false?

(3) In an n type semiconductor holes are the majority carriers. True or false?

(4) What are acceptors ?

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

(1) The resistivity of n-type semiconductor of germanium is $0.01\ \Omega - \text{m}$ 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) What are the applications of semiconductors?

(2) Write a note on n-type semiconductor and donor state.

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

(1) Explain Hall effect and derive an expression for Hall coefficient.

(2) What are semiconductors? What are intrinsic and extrinsic semiconductors? Derive the expression for the electrical conductivity of semiconductors.

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

(1) Cooper pair of electrons effectively attract each other. True or false?

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

(3) Define transition temperature Tc.

(4) In a type II superconductor there is only one critical magnetic field. True or false?

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

(1) Calculate the London penetration depth at 0 K for lead whose density is 11.3 kg/m$^3$ and the atomic weight is 207.19. $N_A$ = 6.02×10$^{26}$/kmol.

(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 the applications of superconductors?

(2) Explain Meissner effect.

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

(1) Derive London equation.

(2) Explain the BCS theory.

_____