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MSCPH-504

Statistical Mechanics

M.Sc. PHYSICS (MSCPH-21)

Ist Semester Examination, 2022 (June)

Time : 2 Hours] **Max. Marks : 80**

Note : This paper is of Eighty (80) marks divided into two (02) Sections A and B. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION–A

(Long Answer Type Questions)

Note : Section 'A' contains Five (05) long answer type questions of Twenty (20) marks each. Learners are required to answer any Two (02) questions only.

(2×20=40)

1. What is partition function? Obtain it for a monoatomic perfect gas represented by the canonical ensemble. Find expressions for free energy, entropy and internal energy of the gas in terms of its partition function.

2. Show that a system of classical harmonic oscillators Helmholtz free energy is $NkTln(\hbar\omega)/kT)$and also show its complete agreement with the equipartition theorem.

3. Explain Bose-Einstein condensation. How does it differ from ordinary condensation? Derive the critical temperature at which this phenomenon sets in.

4. What are the phase transitions of first and second kind? Discuss Ising model for phase transitions of second kind.

5. (a) Show that the molar specific heat of a strongly degenerate boson gas is given as $C_v = 1.92\ R(T/T_C)^{3/2}$, Represent it graphically.

(b) Show that electron gas in a white Dwarf Star is strongly degenerate and relativistic in nature.

SECTION–B

(Short Answer Type Questions)

Note : Section 'B' contains Eight (08) short answer type questions of Ten (10) marks each. Learners are required to answer any Four (04) questions only. (4×10=40)

1. Explain the meaning of :

(a) Microstate.

(b) Macrostate.

(c) Ensemble in statistical mechanics.

2. Consider a system of two particles each having only 3 quantum states of energy 0, ε, 2ε system is in contact with a heat reservoir at temperature T. Write down the partition function for the system obeys

(a) Fermi Dirac statistics.

(b) Bose Einstein statistics.

3. Derive Sackur Tetrode equation for the entropy of an ideal monoatomic gas. How does it resolve the Gibb's Paradox?

4. A system consisting of 3 independent particles localized in space. Each particle has two states of energy 0 and ε. When the system is in thermal equilibrium with a heat reservoir at temperature T, calculate its partition function?

5. Compare the three statistics Bose- Einstein, Fermi-Dirac and Maxwell Boltzmann Statistics.

6. What do you mean by phase space? Using this concept find the number of phase cells for one dimensional simple harmonic oscillator.

7. Show that the mean speed of an electron in an electron gas at T = oK $\bar{v} = \frac{3v_F}{4}$, where v_F is the speed of an electron at the Fermi energy.

8. Define phase transition? Distinguish between first and second order phase transitions with suitable examples.
