LOYOLA COLLEGE (AUTONOMOUS) CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **PHYSICS**

THIRD SEMESTER – **NOVEMBER 2024**

PPH 3501 – STATISTICAL MECHANICS

Date: 07-11-2024 Dept. No. Max. : 100 Marks

Time: 01:00 pm-04:00 pm

SECTION A

Answer ANY FOUR of the following **4 x 10 = 40 marks**

1. Consider a system of N non-interacting indistinguishable particles of integral spin distributed over all possible quantum energy levels. What is the total number of microstates the system can have?
2. Describe λ-transition. Using two fluid model, explain the peculiar properties of liquid Helium below 2.18 K.
3. Show that the probability distribution $P_{m,N}$ where m is the number of directed steps in a total of N steps in a one dimensional random walk problem, is a Gaussian distribution.
4. Bring out the conditions for the thermodynamical equilibrium between two systems.
5. Consider a system of N non-interacting linear harmonic oscillators in contact with a heat reservoir. Calculate the partition function and the thermodynamic properties of the system if the oscillators are classical.
6. Describe an ensemble. What is meant by a stationary ensemble? Using Liouville's theorem show that the ensemble average of a physical quantity is a constant.
7. Derive the total partition function of a system of N non-interacting diatomic molecules with rotational and vibrational degrees of freedom.
8. Apply BE distribution law to a black body and derive Planck's law of black body radiation. Show how the law reduces to classical laws of black body radiation and appropriate limits.

SECTION B

Answer ANY THREE of the following **3 x 20 = 60 Marks**

9. Point out the failure of Einstein's theory of specific heat capacity of an ideal monoatomic crystalline solid. Treating phonons as an ideal Bose gas derive the Debye's law of specific heat capacity due to lattice vibration.
10. Show that the free electron gas in q white dwarf as a fully degenerate Fermi gas and formulate a theory to show that the size of the star becomes smaller as the mass becomes larger.
11. With suitable theory establish why free electrons in metals exhibit a temperature independent paramagnetic susceptibility.
12. Considering the free electron gas in a white dwarf to be a fully degenerate relativistic Fermi gas, estimate Chandrasekhar limit.
13. Write down the classical theory of specific heat capacity of a crystalline monoatomic solid. Point out its shortcomings and introduce Einstein's theory.
14. Determine the thermodynamic properties of an ideal degenerate Fermi gas.

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