LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

THIRD SEMESTER – **APRIL 2023**

PPH 3501 – STATISTICAL MECHANICS

Date: 02-05-2023 Dept. No. Max. : 100 Marks

Time: 09:00 AM - 12:00 NOON

PART A		
Q. No	**Answer all questions**	**(10 x 2 = 20 Marks)**
1	Define the term equal-e-priori probability. If the equal-e-priori probability associated with a system is 1.25×10^{-10}, calculate the number of microstates of the system.	
2	What is Gibb's paradox?	
3	Show that the expression $S = -k \sum_i P_i \ln P_i$ reduces to $S = k \ln \Omega$ for a system in microcanonical ensemble.	
4	Explain negative temperature. If two systems, one in negative temperature and the other in normal temperature are kept in thermal contact, what would be direction of energy flow?	
5	Define grand canonical potential. Express the entropy of the system in terms of it.	
6	Distinguish between pure state and mixed state.	
7	If five particles occupy a 5-fold degenerate energy levels calculate the number of microstates possible if they were i) classical particles ii) bosons iii) fermions.	
8	If the critical temperature of a system of N electrons enclosed in a volume V is 3 K, calculate the critical temperature of same number of protons enclosed in the same volume.	
9	Why do free electrons in metals exhibit paramagnetic property?	
10	Ten non-interacting spin $\frac{3}{2}$ particles exist in a one dimensional box. If E_1 is the lowest possible energy level of the system calculate the Fermi energy of the system.	

PART – B		
Answer any four questions		**(4 x 7.5 = 30 Marks)**
11	Establish that two different ideal gases when separated are more highly ordered than when they are mixed.	
12	Using the method of canonical ensemble, derive Einstein's law for specific heat capacity of a monoatomic crystalline solid.	

13	Derive the canonical partition function and from that the thermodynamical parameters of N non-interacting classical harmonic oscillators.
14	Obtain an expression for the fractional fluctuation in the number of particles of a system in grand canonical ensemble.
15	Discuss BE condensation. What causes a Bose gas to condense? Plot the temperature dependence of the number of condensed particles.
16	Determine the thermodynamical parameters of a fully degenerate Fermi gas.
PART – C	
Answer any four questions	**(4 x 12.5 = 50 Marks)**
17	Establish the connection between statistical mechanics and thermodynamics.
18	Discuss the concept of negative temperature in connection with a system of N non-interacting magnetic dipoles under the canonical ensemble formalism.
19	i) State and prove equipartition theorem.ii) Applying BE statistics to black body radiation, derive Planck's law. Show that it reduces to Rayleigh's law and Wien's law at appropriate limiting conditions.
20	Consider an ideal gas system immersed in a reservoir with which it exchanges both energy and particles. Obtain its equation of states.
21	Obtain the specific heat capacity of an ideal Bose gas and plot its variation against temperature. What is the significance of the kink in the plot?
22	Treating the white dwarf as an ideal relativistic Fermi gas system, apply FD statistics to estimate the upper limit in the mass of a star for it to become a white dwarf.

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