STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2023 – 2024 & thereafter)

M.Sc. DEGREE EXAMINATION NOVEMBER 2024
PHYSICS
FIRST SEMESTER

COURSE : MAJOR CORE
PAPER : STATISTICAL MECHANICS
SUBJECT CODE : 23PH/PC/SM14
TIME : 3 HOURS **MAX. MARKS : 100**

Q. No.	SECTION A **Answer ALL the Questions (10 x 3 = 30 marks)**	CO	KL
1	What is phase space?	**1**	**1**
2	Define Fermi energy.	**1**	**1**
3	Outline the concept of negative temperature.	**1**	**1**
4	Why do free electrons in metals exhibit paramagnetic property?	**2**	**2**
5	Clarify the role of statistics in the study of thermodynamic systems.	**2**	**2**
6	Why fermions do not condense like bosons?	**2**	**2**
7	Explain the concept of statistical equilibrium.	**2**	**2**
8	Give the significance of critical temperature of an ideal boson gas.	**3**	**3**
9	Classify the following particles based on the statistics that they obey i) Protons ii) Phonons iii) Oxygen molecule.	**3**	**3**
10	What is a density matrix used for?	**3**	**3**
Q. No.	**SECTION B (30 marks)**	**CO**	**KL**
	PART A **Answer any TWO Questions: (2 x 5 = 10 marks)**		
11	Two particles are to be distributed in two cells. How many microstates are possible if the particles are, i) boltzons ii) bosons iii) fermions.	**3**	**3**
12	For lithium the Fermi energy is 4.7 eV and the density of electrons is $4.6x10^{28}$ /m^3. Calculate the electron density for a metal with Fermi energy 2.35 Ev.	**3**	**3**
13	Using the canonical partition function for the ideal gas, show that $(\delta E)^2 = k_B T^2 C_v$	**3**	**3**
	PART B **Answer any FOUR Questions: (4 x 5 = 20 marks)**		
14	Compare the canonical, micro canonical and grand canonical ensembles.	**4**	**4**
15	Obtain an expression for the concentration fluctuation in a grand canonical ensemble.	**4**	**4**
16	Discuss Liouville's theorem and explain its consequences.	**4**	**4**
17	Treating the white dwarf as an ideal relativistic Fermi gas system, estimate the upper limit in the mass of a star for it to become a white dwarf.	**4**	**4**
18	Apply the Bose Einstein statistics to investigate the equilibrium properties of black body radiation.	**4**	**4**
Q. No.	**SECTION C** **Answer the following: (2 x 20 = 40 marks)**	**CO**	**KL**
19	a) Derive the formula for specific heat of a solid using the Debye theory.	**5**	**5**
	b) Formulate the expression for partition function of a linear harmonic oscillator in Canonical ensemble.	**5**	**5**
	(OR)		

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	c) What is Gibbs paradox? How it can be resolved?		
	d) Discuss the theory of electrons in metals and obtain an expression for electronic heat capacity of metals.		
20	a) Explain the phenomenon of Bose-Einstein condensation and its application to liquid helium II.	**5**	**5**
	b)State and prove equipartition theorem.	**5**	**5**
	(OR)		
	c) Discuss the properties of density operator and obtain density operator expression for micro canonical and canonical ensembles.		
	d) Discuss the Einstein theory of specific heat capacity and mention its limitations.		

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