Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2023

Course: Statistical Mechanics **Semester: II**
Program: MSc (Physics) **Time: 03 hours**
Course Code: PHYS 7017 **Max. Marks: 100**

Instructions:

- All questions are compulsory (**Q9** and **Q11** have an internal choice).
- Scientific calculators can be used for calculations.

SECTION A

(5Q x 4M = 20 Marks)

S. No.		Marks	CO
Q1	What do you understand by phase space?	**4**	**CO1**
Q2	If three identical particles are distributed over three single particle states, how many possibilities are allowed if the particles are (a) spin-zero pions, and (b) electrons?	**4**	**CO1**
Q3	For fermions, plot $D(\varepsilon)$ and $n(\varepsilon)$ in the low-T and high-T limits.	**4**	**CO3**
Q4	What is meant by scaling behavior?	**4**	**CO4**
Q5	What do you understand by spontaneous symmetry breaking?	**4**	**CO4**

SECTION B

(4Qx10M= 40 Marks)

Q6	Explain the terms most probable value, ensemble average and the most probable distribution.	**10**	**CO1**
Q7	For an ideal Bose gas with continuous energy spectrum write expressions for number N and internal energy U, and show that $N = 2.315 \frac{V}{4\pi^2}\left(\frac{2m}{\hbar^2}\right)^{3/2}(k_B T_E)^{3/2}$	**10**	**CO3**
Q8	Discuss the Landau theory of phase transition.	**10**	**CO4**

Q9	Discuss the quantization of vibrational motion and obtain expressions for vibrational partition function and vibrational energy. **OR** Discuss the properties of grand canonical ensemble, its partition function and density distribution function.	**10** **10**	**CO2**
	SECTION-C **(2Qx20M=40 Marks)**		
Q10	a) Discuss the Langevin model of paramagnetism. b) Consider a system of N particles and a phase space consisting of only two states having energies 0 and ε. Calculate partition function, internal energy, and heat capacity of the system.	**10** **10**	**CO2**
Q11	a) For an ideal quantum gas discuss the particle distribution and internal energy. For a system of Fermions having continuous energy spectrum, write down the expressions for number N and internal energy U in terms of density of states. b) The Fermi energy of lithium is 4.72 eV at $T = 0$. Calculate the number of conduction electrons per unit volume. Determine the values of Fermi momentum and Fermi temperature. **OR** a) Find the most probable state for Bose-Einstein distribution and show that the equilibrium state is given by: $n_i = g_i/[\exp(\alpha+\beta\varepsilon_i) - 1]$ b) Calculate the Fermi wavelength and Fermi energy for 4.2×10^{21} electrons in a box of volume 1 cm^3.	**10** **10** **10** **10**	**CO3**

Planck constant h = 6.62 x 10^{-34} J-s

Mass of electron m_e = 9.31 x 10^{-31} kg

Boltzmann constant k_B = 1.38 10^{-23} J/K

Universal gas constant R = 8.314 J/K mol