M.Sc. Physics Semester – 3 Examination - NOV- 2017
Phys-C-302 - {Statistical Mechanics}
Paper Code: 4704

Time: 2 Hours 30 Min | Maximum Marks: 70

Note: Answer all questions. Figures to the right indicate marks allotted.
All symbols have their usual meaning.

1	a) Discuss the Gibb's paradox and explain how is it resolved?	07
	b) Explain – Ensemble in classical statistical mechanics and Ergodic hypothesis.	05
	c) A classical harmonic oscillator of mass m and force constant k has definite total energy E, but its initial time is completely uncertain. Find the probability density function.	02
	OR	
1	a) Derive and discuss the classical Liouville's theorem.	08
	b) Explain microstates and macrostates in statistical mechanics.	04
	c) Estimate the magnitude of volume Ω if the entropy of a system is of the order of Nk_B.	02
2	a) Write significance of postulate of equal a priory probabilities and postulate of random phase in quantum statistical mechanics. Derive and explain density matrix.	08
	b) Describe the concept of *entropy* using quantum mechanical microcanonical ensemble.	04
	c) The total energy of a black body radiation in a cavity of a volume V at temperature T is given by $u = aVT^4$, where a is a constant ($4\sigma/c$). Obtain an expression for entropy in terms T, V and a.	02
	OR	
2	a) Using quantum mechanical concept for microcanonical ensemble, discuss in details the case of ideal quantum gas. Explain why fermions have antisymmetric wave functions.	10
	b) For canonical ensemble, discuss density matrix. Derive thermodynamic relations.	04
3	a) For the case of photons, derive an expression for partition function. And hence obtain an equation for internal energy per unit volume – Planck's law.	07
	b) Briefly describe Bose-Einstein condensation.	04
	c) Why Helium does not solidify? – give qualitative assessment.	03
	OR	
3	a) For the case of phonons (quantized lattice vibrations), derive an expression for partition function. And hence obtain an equation for specific heat using Debye theory.	10
	b) What is the role of partition function in statistical mechanics. What is its unit? Give expression for calculating energy in terms of partition function.	03
	c) Calculate the atomic or lattice constant volume specific heat at 1 K for copper. The Debye temperature of Cu is 315 K.	01
4	a) What is Pauli's paramagnetism? For nonrelativistic free electron in presence of external magnetic field $\boldsymbol{B}$, derive an expression for magnetization per unit volume.	10
	b) Explain the mechanism responsible for stability of a white dwarf star.	04

	OR	
4	a) Derive thermodynamic quantities for ideal Fermi gas. Assuming valance electrons in copper obeys perfect F-D gas, calculate the electronic constant volume specific heats of Cu at T = 300 K. The Fermi energy for Cu is 7 eV.	10
	b) Consider a rigid lattice of distinguishable spin-½ atoms in a uniform magnetic field *H*. Let two spin states have energies $-\mu_0 H$ and $+\mu_0 H$ for spin-up and spin-down states relative to applied field *H*. If the system is at temperature *T*, determine (i) the canonical partition function, and (ii) total magnetic moment of the system.	03
	c) White dwarf star to a good approximation can be considered as _______. Write the correct option from below. (i) degenerate Fermi gas (ii) nondegenerate Fermi gas (iii) degenerate Boson gas (iv) nondegenerate Boson gas	01
5	a) Derive relation between critical pressure, volume and temperature for ideal gas and real gas.	07
	b) Derive Clausius-Clapeyron equation.	05
	c) Define triple point and critical point.	02
	OR	
5	a) Write note on one dimensional Ising model.	10
	b) A solid contains *N* magnetic atoms with spin-½. At sufficiently high temperature spin states are completely randomly oriented. At sufficiently low temperature all the spins are oriented along specific direction – *ferromagnetic*. If the heat capacity (*C*) as a function of temperature *T* is given by following expression, find the maximum value of constant c_1. Here, T_1 is a constant. Given: $C(T) = \begin{cases} c_1\left(\frac{2T}{T_1} - 1\right) & \text{if } \frac{T_1}{2} < T < T_1 \\ 0 & \text{otherwise} \end{cases}$.	02
	c) Give two differences between first-order and second-order phase transition.	02