P227 **Reg.No:** .... **Name:** ....

M SC DEGREE END SEMESTER EXAMINATION APRIL/MAY 2015
SEMESTER - 2: M SC PHYSICS
COURSE CODE: P2PHYT07- THERMODYNAMICS AND STATISTICAL PHYSICS

Time: 3 Hours **Max. Marks: 75**

Part A(Objective Type)

(Answer **all** questions)Each question carries 1 Mark

1. Under equilibrium conditions, the thermodynamic quantity associated with black body radiation at temperature T which reduces to zero is
   (a) Entropy
   (b) Helmoholtz free energy
   (c) Gibbs free energy
   (d) Enthalpy

2. If F is Helmholtz free energy, then which of the equation hold true
   (a) $C_v = -T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$
   (b) $C_v = T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$
   (c) $C_v = -T\left(\frac{\partial^2 F}{\partial V^2}\right)_T$
   (d) $C_v = T\left(\frac{\partial^2 F}{\partial V^2}\right)_T$

3. Consider a fluid which is in equilibrium with its vapour at a given temperature. The total system(heat bath+fluid+vapour) could be described by
   (a) Canonical ensemble
   (b) Microcanonical ensemble
   (c) Grand canonical ensemble
   (d) None of these

4. Which of the following is an example of first order phase transition
   (a) Paramagnetic to ferromagnetic transition
   (b) Liquid gas transition at the critical point.
   (c) Normal metal to superconductor transition
   (d) Liquid gas transition away from the critical point

5. The wave functions of two identical particles in a state n and r is $\phi_n(r_1)$ and $\phi_s(r_2)$ respectively. Assume these particles obey MB statistics, the wave function of this two particle system is given by

(a) $\phi_n(r_1) \pm \phi_s(r_2)$

(b) $\frac{1}{\sqrt{2}}(\phi_n(r_1)\phi_s(r_2) + \phi_s(r_1)\phi_n(r_2))$

(c) $\frac{1}{\sqrt{2}}(\phi_n(r_1)\phi_s(r_2) - \phi_s(r_1)\phi_n(r_2))$

(d) $\phi_n(r_1)\phi_s(r_2)$

$(5 \times 1 = 5)$

Part B(Short answer)

(Answer any **five** questions)Each question carries 2 Marks

6. Discuss the thermodynamic and statistical definition of entropy.

7. Three similar dice marked A, B, C each having six equally likely faces marked 1, 2, 3, 4, 5, 6 are thrown simultaneously. Calculate the probability of getting the faces of all the dice uppermost marked as 1.

8. "The ensemble average of any physical quantity f is identical to the value one expects to obtain on making an appropriate measurement on the given system". Justify this statement.

9. Write a short note on "equipartition theorem".

10. Discuss the Maxwell-Boltzmann law of distribution of velocities.

11. Describe the Einstein model of specific heat.

12. What is order parameter. What is the order parameter for a liquid-gas transition?

13. What do you mean by critical exponents?

$(5 \times 2 = 10)$

Part C(Problems/short essay)

(Answer any **three** questions)Each question carries 4 Marks

14. Show that chemical potential is the Gibbs free energy per particle ($\mu = G/N$).

15. Obtain Stefan's law and Wien's displacement law from Plank's law.

16. Consider a rigid lattice of distinguishable spin 1/2 atoms in a magnetic field. The spins have two states, with energies $-\mu_0 B$ and $\mu_0 B$ for spin up and down respectively. The system is at a temperature T. Obtain the heat capacity C_V and schematically plot it as a function of T.

17. Derive the density of states $D(\epsilon)$ as function of energy ϵ for free electron gas in one dimension(confine it in a length L). Calculate the Fermi energy ϵ_F at zero temperature for an N electron system.

18. Derive Clapeyron equation by assuming the Gibbs potential or the chemical potential is same at the phase boundary.

$(3 \times 4 = 12)$

Part D(Essay)

(Answer **all** questions)Each question carries 12 Marks

19. (a) Give an account of various thermodynamic potentials and obtain Maxwell's thermodynamic relations.

OR

(b) Explain Carnot cycle using a $P - V$ diagram and find the efficiency of a Carnot engine in terms of the temperature.

20. (a) Obtain the probability distribution for a system in a canonical ensemble in terms of the canonical partition function. Express various thermodynamic quantities using partition function.

OR

(b) The energy a particle trapped in a 3-dimensional cubic box of side L is $\epsilon_i = \frac{\hbar^2\pi^2}{2mL^2}(n_1^2 + n_2^2 + n_3^2)$. Obtain the equation of state, entropy and specific heat capacity for this system. Comment on the expression for entropy you have obtained.

21. (a) Discuss the Debye theory of specific heat and explain its limitations.

OR

(b) Obtain the probability distribution for a system in grand canonical ensemble. Establish the connection between grand potential and thermodynamics.

22. (a) Discuss the thermodynamic properties of Fermi gas and obtain its high temperature behavior.

OR

(b) Discuss the mechanism of phase separation and explain phase separation for a liquid-gas system.

$(4 \times 12 = 48)$