Q.Code: ..... Reg.No: ..... Name: .....

M A 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. In the region of co-existence of liquid and vapour phases of a material
   (a) C_p and C_v are both finite.
   (b) C_V and $\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$ are both finite.
   (c) C_V and $K = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$ are both finite.
   (d) C_p, β and K are all infinite.
2. Which of the thermodynamic relation hold true
   (a) $(\frac{\partial S}{\partial V})_{U,N} = -\frac{P}{T}$
   (b) $(\frac{\partial S}{\partial V})_{U,N} = \frac{P}{T}$
   (c) $(\frac{\partial S}{\partial U})_{U,N} = -\frac{P}{T}$
   (d) $(\frac{\partial S}{\partial U})_{U,N} = \frac{P}{T}$
3. Two particles are said to be distinguishable when
   (a) They have overlapping wave functions
   (b) Wave function is symmetric under the exchange of particles
   (c) Wave functions are antisymmetric under the exchange of particle.
   (d) Average distance between the particle is greater than their de Broglie wavelength.
4. The energy density of black body radiation in 1-dimension depends on the temperature as T^{α}. Value of α is
   (a) 1
   (b) 2
   (c) 3
   (d) 4
5. If Z is the partition function of a system, the average pressure P is
   (a) $\frac{\partial Z}{\partial \beta}$
   (b) $\frac{1}{\beta}\frac{\partial \ln Z}{\partial V}$

(c) $-\frac{1}{\beta}\frac{\partial \ln Z}{\partial V}$

(d) $\frac{1}{\beta^2}\frac{\partial \ln Z}{\partial V}$

$(5 \times 1 = 5)$

Part B(Short answer)

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

6. Thermodynamically establish the formulae

$$V\left(\frac{\partial P}{\partial T}\right)_{\mu} = S \text{ and } \mathrm{V}\left(\frac{\partial \mathrm{P}}{\partial \mu}\right)_{\mathrm{T}} = \mathrm{N}\ .$$

7. Distinguish between microstate and macrostate with an example.

8. "In 1-dimension the number of microstates per unit energy interval(density of states) become more populated as the energy decreases." Comment on this statement.

9. Find the average energy of a system of N classical harmonic oscillators.

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

11. Describe properties of Fermi gas at absolute zero.

12. Discuss the liquid -gas transition with the help of a $P - V$ diagram.

13. Write a short note on Ising model. $(5 \times 2 = 10)$

Part C(Problems/short essay)

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

14. Obtain Maxwells thermodynamic relations.

15. The partition function of a system is given as $Z = e^{aT^4V}$, where a is a constant. Calculate pressure and entropy of this system.

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. A cubically shaped vessel 20 cm on side contains diatomic H_2 gas at a temperature 300K. Each H_2 molecule consists of two hydrogen atoms with mass of 1.66×10^{-24}g each, separated by 10^{-8}cm. (Assuming an ideal gas behavior and ignoring the vibrational degree of freedom)

    (a) What is the average velocity of molecules?

    (b) What is the average velocity of rotation of the molecules around an axis which is the perpendicular bisector of the line joining the two atoms?

18. Generally the specific volume of a liquid is much smaller than that of its vapour. Assuming the vapour to obey the perfect gas equation, prove that $P = P_0 e^{-L/RT}$.

$(3 \times 4 = 12)$

Part D(Essay)

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

19. (a) Consider a system of N non-interacting particles, each is fixed in position having a spin of $1/2$ with an associated magnetic moment μ. Find the entropy of the system and simplify it using stirling approximation. Find the magnetization M and schematically plot it as a function of $1/T$.

OR

(b) i. Discuss the relation between probability and second law of thermodynamics
ii. What is meant by equal a priori probability?
iii. State the limitations of classical probability.
iv. Bring out the salient features of statistical probability.

20. (a) Discuss the Maxwells distribution of molecular speeds.

OR

(b) Obtain the partition function, Free energy and entropy of a diatomic molecule undergoing rotational motion. Describe high and low temperature behavior of energy U and specific heat C_V.

21. (a) Explain various methods of measuring chemical potential.

OR

(b) i. Derive Planks distribution function.
ii. Discuss Einstein model of specific heat.

22. (a) Explain the Landau theory of phase transition.

OR

(b) Discuss the thermodynamic properties of a non interacting Bose gas.

$(4 \times 12 = 48)$