Reg. No ..... Name **19P2044**

MSc DEGREE END SEMESTER EXAMINATION - MARCH/APRIL 2019

SEMESTER 2 : PHYSICS

COURSE : **16P2PHYT08 : THERMODYNAMICS AND STATISTICAL MECHANICS**

(For Regular - 2018 Admission and Supplementary - 2017/2016 Admissions)

Time : Three Hours Max. Marks: 75

Section A

Answer all the following (1 marks each)

1. Total number of arrangements of 10 sticks of chalk is
   (a) 10! (b) 9! (c) 11! (d) none of these
2. At low temperatures for a diatomic molecule having only vibrational motion will have heat capacity
   (a) k_B (b) exponentially decreasing (c) linearly decreasing (d) Constant
3. What is the microscopic definition of the temperature parameter β?
   (a) $\beta(E) = \partial \ln \Omega / \partial E$ (b) $\beta(E) = k\partial \ln \Omega / \partial E$
   (c) $\beta(E) = k\partial\Omega / \partial E$ (d) none of these
4. What is the thermodynamic quantity whose value is related to the magnitude of fluctuations of energy?
   (a) The pressure.
   (b) The heat capacity at constant volume.
   (c) Temperature.
   (d) none of these
5. Chemical potential of phonon is
   (a) 0 (b) 1 (c) T (d) EF

(1 x 5 = 5)

Section B

Answer any 7 (2 marks each)

6. Show that for a single mole of an ideal gas $C_P = C_V + R$.
7. What is meant by micro-canonical ensemble? Explain with example.
8. Write down the expression for Enthalpy.
9. What is Stirling's approximation.
10. Write down Schrodinger wave equation for a free particle in 1 dimension.
11. Obtain Cp for a triatomic gas.
12. Obtain the partition function for a diatomic having vibrational motion alone.
13. What is meant by Fermi Surface?
14. Obtain the grand partition function of a Fermi and bose system for a particular 'k'.
15. Discuss one method of calculating chemical potentials.

(2 x 7 = 14)

Section C

Answer any 4 (5 marks each)

16. A kilogram of water has a constant heat capacity of 4.2 $KJKg^{-1}K^{-1}$ over the temperature range 0^0C to 100^0C. The water starts at 0^0C and is brought into contact with a heat bath at 100^0C. When the water has just thermalized at 100^0C what is the change in the entropy of the water and that of the universe.

17. A current of 0.5A flows through a 2Ω resistor for 100sec. The system whose initial temperature is 300K is thermally isolated. The heat capacity of the resistor is $0.24JK^{-1}$; for a wide range of temperatures. The temperature of the resistor changes appreciably. What is the entropy change of the system?

18. A system of particles occupying single-particles states and obeying Boltzmann statistics is in thermal contact with a heat bath at temperature T. The populations are 3.1% for 0.0281 eV; 8.5% for 0.0195 eV; 23% for 0.0109 eV; 63% for 0.0023 eV. What is the temperature of the system?

19. Calculate the probability that a harmonic oscillator $e_n = (n + \frac{1}{2})\hbar\omega$ is a state with n an odd if the oscillator is in contact with a heat bath at temperature T.

20. Obtain the Fermi wave vector for conduction electrons in lithium having a number density of $4.6 \times 10^{28} m^{-3}$.

21. Give Bose derivation of Plank's law. Using this, show that the Stefan's constant is given by $\sigma = 2\pi^6 k^4 / (15c^2 h^3)$

(5 x 4 = 20)

Section D

Answer any 3 (12 marks each)

22.1. Derive the equation of state for a spin system

OR

2. Derive Equation of State for an ideal gas. Show that absolute Entropy will be user depended while Change in entropy will be user independent.

23.1. Show that the Translation motion of a single particle in 3 dimension gives a heat capacity of $3k_B/2$.

OR

2. Obtain the general expression for entropy for a diatomic molecule possessing vibrational motion alone.

24.1. Discuss the conditions for chemical equilibrium in terms of chemical potentials by taking an example.

OR

2. Discuss the conditions for chemical equilibrium in terms of Gibbs free energy by taking an example

(12 x 3 = 36)