

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/Int.PBIR(CH)/SEM-3/CH-511/2009-10  
2009**

**EQUILIBRIUM & NON-EQUILIBRIUM  
STATISTICAL MECHANICS**

Time Allotted : 3 Hours

Full Marks : 50

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words  
as far as practicable.*

**GROUP – A**

Answer any *five* questions.

5 × 5 = 25

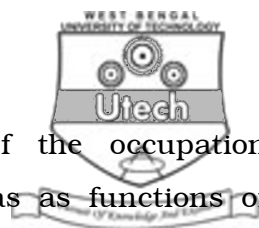
1. Maxwell probability densities for momentum are given by the following formulae :

$$\omega_{p_i} dp_i = \frac{1}{(2\pi mkT)^{1/2}} e^{-p_i^2 / 2 mkT} dp_i$$

where  $i = x, y, z$ .

Find the dispersion in  $p_x$ ,  $p_y$ ,  $p_z$  and  $p$ . What is the value of  $\langle p_x^{2n} \rangle$  ?

2. Find the free energy ( $F$ ) of an ideal monatomic gas using classical Gibbs distribution and hence obtain (a) an expression for the work done in an isothermal expansion from volume  $V_1$  to  $V_2$ , (b) entropy of the gas.
3. Find out the average energy  $\langle \epsilon \rangle$  of an ideal electron gas at  $T = 0$  K, given  $g_\epsilon = A \epsilon^{1/2}$  ( $A = \text{constant}$ ).



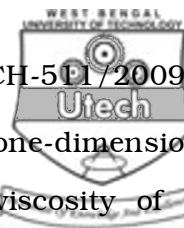
4. Plot and compare different features of the occupation function for a Bose gas and a Fermi gas as functions of energy. How does the occupation function for a Fermi gas behave around energy  $\varepsilon = \mu$ ,  $\mu$  being the chemical potential. Compare the distribution functions for the Bose gas and the Fermi gas.
5. What is Bose-Einstein condensation ? Show that the BEC temperature  $T_c \propto n^{2/3}$  where  $n$  is the particle density.
6. Obtain an expression for the cut-off frequency  $\omega_{max}$  of a crystal of  $N$  atoms and calculate the Omega potential ( $\Omega^*$ ) for the longitudinal mode in the limit  $\omega_{max} \gg KT/\hbar$ . How does  $C_v$  vary with  $T$  in this limit ?
7. Use the grand canonical formulation to obtain an expression for the Omega potential ( $\Omega^*$ ) of an ideal photon gas and hence obtain the pressure ( $P$ ) exerted by it. What is the special feature, if any, that you note in the expression for pressure ?

5

### GROUP – B

Answer any *three* of the following.  $3 \times 8 = 24$

8. Show that the rate constant of a diffusion controlled bimolecular reaction depends linearly on the sum of diffusion coefficients of the two reaction components.
9. Derive the relation between viscosity coefficient of a liquid and diffusion coefficient of a Brownian particle.



10. Show that the flux of reactants crossing an one-dimensional energy barrier depends inversely on the viscosity of the medium under overdamped condition.
11. Set up the Langevin equation for a Brownian particle under the action of a constant external force  $G$ . Explain all the terms of the equation.

Write down the corresponding equation for probability distribution function for the position variable of the particle for large friction.

***For clarity and presentation 1 mark.***

=====