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 $< p_x^{2n} >$?

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 < □ > of an ideal electron gas at T = 0 K, given $g_\varepsilon = A\, \varepsilon^{1/2}$ (A = 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 $\varepsilon = \mu$, μ 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 ω_{max} of a crystal of N atoms and calculate the Omega potential (Ω^*) for the longitudinal mode in the limit $\omega_{max} >> KT/\hbar$. How does C_v vary with T in this limit ?

7. Use the grand canonical formulation to obtain an expression for the Omega potential (Ω^*) 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.