RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2017

THIRD YEAR [BATCH 2014-17]

Date : 08/05/2017 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VII (Gr. B) Full Marks : 30

Answer **any three** questions : [3×10]

1. a) For a microcanonical ensemble find out the expression of temperature (T), pressure (P) and chemical potential (μ) in terms of Ω (number of accessible states).

   For an ideal non-relativistic gas of N molecules confined in a volume V, $\Omega \propto E^{3N/2} \cdot V^N$. Show that for reversible adiabatic process $PV^{5/3}$ = constant. 3+3

   b) Obtain the expression for the partition function and internal energy for a system of distinguishable particles in thermal equilibrium, distributed in three states with energy E, 2E and 3E, each having degeneracy g. 4

2. Using quantum statistics, derive Maxwell-Boltzmann energy distribution law. Find out the expression of chemical potential.

   Show that dispersion of energy according to M–B distribution is given by

   $$\left\langle (\Delta \in)^2 \right\rangle = \left\langle \in^2 \right\rangle - \left\langle \in \right\rangle^2 = \frac{3}{2}(k_B T)^2$$ (4+2)+4

3. a) Sow that one dimensional random walk problem can be treated as a diffusion phenomena. Find its diffusion coefficient. 4

   b) Set up Langevin's equation for one dimensional Brownian motion. Solve the equation with the help of reasonable approximations. Find the mean square displacement of the Brownian particle. 6

4. a) The energy levels of one free particle of mass m in a three dimensional rigid cube of side L is

   $$\mathrm{E}(\mathrm{n}_1, \mathrm{n}_2, \mathrm{n}_3) = \frac{\pi^2 \hbar^2}{2\mathrm{mL}^2}(\mathrm{n}_1^2 + \mathrm{n}_2^2 + \mathrm{n}_3^2)$$

   where n_1, n_2 and n_3 are quantum numbers.

   What is the lowest energy of a system consisting of 10 free particles in this box if the particles obey the (i) F-D statistics and (ii) B-E statistics. 4

   b) Give a brief explanation of B-E condensation. Explain why a Fermi gas never undergoes such a condensation. 1+2

   c) Find out which gas exerts maximum pressure at a constant temperature, an ideal gas obeying M-B statistics, an ideal gas obeying B-E statistics or an ideal gas obeying F-D statistics. 3

5. a) Sketch the Fermi-Dirac distribution function f_{FD} for T = OK and T > OK.

   Show that $-\left(\partial f_{FD} / \partial E\right)$ is a maximum and symmetric about the Fermi level. 1+5

   b) Consider a non-interacting Fermi gas at T = OK. Derive expressions of Fermi energy $(\in_F)$ and the degeneracy pressure of the Fermi gas. 4

———— × ————