RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2018

THIRD YEAR [BATCH 2015-18]

Date : 07/05/2018 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VII [Gr-B] Full Marks : 30

Answer <u>any three</u> questions of the following : [3×10]

1. a) What is phase space and phase trajectory? Obtain the phase trajectory of a 1-D harmonic oscillator with a constant energy. [2+1]

   b) Consider a free particle confined in a one-dimensional box of length L, having energy between E to E + dE. With the help of a diagram, show the allowed regions in the phase space. Calculate the number of associated microstates. [3]

   c) A very light torsion pendulum consisting of a thin wire and a tiny mirror is suspended inside a glass-walled vessel containing gas at temperature T. A light beam is reflected by the mirror on to a scale at a distance D from the mirror. What is the r.m.s amplitude of the vibration of the light spot on the scale? The moment of inertia of the pendulum about the axis of suspension is I and the time period is τ. [4]

2. a) A system consisting of a single particle is in thermal equilibrium at temperature T. It has two energy levels at energy 0 and $\in$ with degree of degeneracy g_0 and g_1 respectively. Calculate the partition function (Z), average energy <E> and specific heat C. Show that the specific heat tends to zero at very low and at very high temperature. [6]

   b) Obtain the density of states of a 2-D system of free electrons contained in an enclosure of area A and dimensions L_x and L_y. Write down the postulate of equal a priori probability. [3+1]

3. a) Distinguish between bosons and fermions with suitable examples. Plot B-E and F-D distribution functions on the same graph as a function of $\left(\frac{\in -\mu}{kT}\right)$, where symbols are of usual significances. Comment on the important differences between the two distributions. [2+3]

   b) In the domain of quantum statistics, derive the validity criterion of classical approximation. At the centre of the sun temperature $T \sim 10^7 K$, and concentration of electrons $n \sim 10^{32} m^{-3}$. Would it be valid to treat those electrons as a classical ideal gas? [3+2]

   [Given : rest mass of electron = $9\cdot11\times10^{-31}$ Kg, Planck's constant (h) $= 6\cdot62\times10^{-34}$ Js, Boltzmann constant (k) = $1\cdot38\times10^{-23} JK^{-1}$.

4. a) Write down the expression of grand canonical partition function $\mathbb{Z}$. Find the expression of the mean energy <E>. [1+2]

   b) Show that the dispersion in the particle number (N) is given by $\left\langle (\Delta N)^2 \right\rangle = \left\langle N^2 \right\rangle - \left\langle N \right\rangle^2 = \frac{1}{\beta}\frac{\partial \langle N \rangle}{\partial \mu}$. [3]

   c) Show that for Fermi-Dirac gas, dispersion in single particle occupancy (n_i) is given by, $\left\langle (\Delta n_i)^2 \right\rangle = \langle n_i \rangle \left(1 - \langle n_i \rangle\right)$. [3+1]

   [Symbols are of usual significances]. Physically explain the consequences of the result.

5. a) State the law of equipartition of energy. When is the law not applicable? [1+1]
   b) Write down Planck's law of energy distribution of photons and obtain Rayleigh Jeans Law from it.[1+2]
   c) What is Bose-Einstein Condensation? Explain why Fermions don't condense. [1+1]
   d) What is Gibb's paradox? How is it resolved? [1+2]

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