WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

PHSACOR14T-PHYSICS (CC14)

STATISTICAL MECHANICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) Draw the phase space trajectory of 1-D simple harmonic oscillator.

(b) State Ergodic hypothesis in statistical mechanics.

(c) What do you mean by ultraviolet catastrophe?

(d) In how many ways can two identical bosons be distributed in two energy states? Show the distribution diagrammatically.

(e) State Kirchoff's law and Stefan Boltzmann law.

(f) How does Sackur Tetrode equation resolve Gibbs paradox?

(g) How chemical equilibrium is defined?

(h) State the principle of equipartition of energy.

(i) Define microstates and macrostates.

(j) Explain the statistical idea of entropy.

(k) A spherical black body with radius R and at the temperature T (K) emits an energy E J/S. Another similar black body with radius $2R$ is at temperature $2T$ (K). What is the energy emitted by the second black body?

(l) State Saha ionization formula. What is its significance?

(m) Distinguish between canonical and grand-canonical ensembles.

(n) Two dices are rolled simultaneously. Enumerate the microstates and the macrostates.

(o) Assuming a typical white dwarf star comprises a strongly degenerate electron gas, calculate the Fermi temperature of a typical white dwarf star.
(Given $m_e = 9.1\times10^{-31}$ kg, $k_B = 1.38\times10^{-23}$ JK^{-1}, $h = 6.627\times10^{-34}$ J.s and number density $N/V = 10^{36}$)

2. (a) Consider N independent, distinguishable, one dimensional quantum harmonic oscillators having energy spectrum $\varepsilon_n = \left(n + \frac{1}{2}\right)\hbar\omega$. Calculate the single particle partition function. Show that N oscillator partition function is given by $z = e^{-\frac{N}{2}\beta\hbar\omega}\{1 - e^{-\beta\hbar\omega}\}^{-N}$. 3

(b) Calculate internal energy U and C_V for the above system. 2+2

(c) Two states with energy difference 4.83×10^{-7} J occur with relative probability e^2. Calculate the temperature. Given $k = 1.38\times10^{-23}$ J.K^{-1}. 3

3. (a) State Liouville's theorem of ensemble theory. What information does it carry regarding the reversibility of a macroscopic process? 2+1

(b) A system has two energy states E and $3E$, the lower level is 6 fold degenerate and the upper level is 2 fold degenerate. If there are N particles, calculate the fraction of molecules at the upper level. 3

(c) Show that the density of state g for molecules obeying Maxwell Boltzmann distribution is 4

$$g(p)dp = \frac{4\pi p^2 dp}{h^3}$$

4. (a) Starting from Fermi-Dirac distribution law derive the expression for energy distribution of free electrons in metal. 4

(b) Calculate the Fermi energy at absolute zero. 3

(c) Evaluate the temperature at which there is one percent probability that a state with an energy 0.5V above the Fermi Energy will be occupied by an electron. 3

5. (a) Write the chemical potential in terms of energy, Helmholtz's free energy and Gibb's free energy. 3+4+3

(b) Calculate the chemical potential for ideal gas.

(c) State law of mass action and Saha Ionization formula.

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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