6 SEM TDC PHYH (CBCS) C 14

2025

(May)

PHYSICS

(Core)

Paper : C–14

(Statistical Mechanics)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the following (any *five*) : 1×5=5

(a) In the equilibrium state, the thermodynamic probability of a system is

(i) zero

(ii) maximum

(iii) minimum but not 1

(iv) one

(b) Gibbs' paradox arises due to

(i) indistinguishability of classical particles

(ii) distinguishability of classical particles

(iii) omittance of quantum nature of the particles

(iv) absence of inter-particle interaction

(c) Rayleigh-Jeans law agrees well with the experimental result at

(i) low frequency

(ii) infinity

(iii) high frequency

(iv) None of the above

(d) At high temperature, Bose-Einstein distribution approaches Maxwell-Boltzmann distribution.

(i) False

(ii) True

(iii) Can't say

(iv) Sometimes true sometimes false

(e) From Fermi-Dirac statistics, $n_i =$

(i) $\frac{g_i}{e^{\alpha+\beta\varepsilon_i}+1}$ (ii) $\frac{2g_i}{e^{\alpha+\beta\varepsilon_i}+1}$

(iii) $\frac{g_i}{e^{\alpha+\beta\varepsilon_i}-1}$ (iv) $\frac{2g_i}{e^{\alpha+\beta\varepsilon_i}-1}$

(f) Bosons have spin value

(i) 0 (ii) 1

(iii) ½ (iv) 0 or 1

2. *(a)* Define and explain in brief the terms 'macrostate' and 'microstate' with the help of example. 2+2=4

(b) Define entropy. Deduce Boltzmann's entropy relation. 1+3=4

(c) Treating the ideal gas as a system governed by classical mechanics, derive the Maxwell-Boltzmann distribution law. 6

Or

Derive the partition function for an ideal monatomic gas.

3. *(a)* What do you mean by 'thermal radiation'? 2

Or

If the sun emits maximum energy at wavelength 4753 Å, calculate the temperature of its surface. (Given : Wien's constant $b = 0{\cdot}288$ cm °C)

(b) State and prove Kirchhoff's law of black-body radiation. 4

(c) State and derive Planck's law of black-body radiation. 1+4=5

Or

State Stefan-Boltzmann law of radiation. Deduce this law on thermo-dynamic consideration.

4. *(a)* What is photon gas? What is the difference between photon gas and ideal gas? 1+2=3

(b) What is Bose-Einstein statistics? Derive an expression

$$n_i = \frac{g_i}{e^{\alpha+\beta\varepsilon_i} - 1}$$ 1+3=4

Or

Explain why behavior of liquid helium cannot be explained by classical statistics. How is it be overcome by quantum mechanics? 4

(c) Bosons may condense at very low temperature. Discuss on the basis of statistical mechanics. 4

5. *(a)* At absolute zero temperature ($T = 0$ K) all the energy levels up to ε_f are completely filled. Calculate the total number of fermions in a Fermi gas at $T = 0$ K and express ε_f in terms of number density (N/V). 6

Or

Derive an expression for Fermi-Dirac law of energy distribution for free electrons in a metal.

(b) What is the cause of degeneracy pressure inside a white dwarf star? Explain the limit depending on which some stars become white dwarf and other become neutron star or black hole. 1+5=6

Or

A system has 7 particles arranged in two compartments. The first compartment has 8 cells and the second has 10 cells. All cells are of equal size. Calculate the number of microstates in the microstate (3, 4) when the particles obey F-D statistics. 6

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