

April 2025
B.A./B.Sc.
Sixth Semester
CORE – 14
PHYSICS
Course Code: PHC 6.21
(Statistical Mechanics)

Total Mark: 70
Time: 3 hours

Pass Mark: 28

I. Answer five questions, taking one from each unit.

UNIT-I

1. (a) Write the postulates of statistical mechanics. Explain the postulate of equal a priori probability with examples. 7
- (b) Consider N identical quantum oscillator which can occupy the energy levels with $E_n = (n + 1/2)\hbar\omega$, where $n = 0, 1, 2, \dots$. Find the partition function and find the average energy and entropy. 5
- (c) Define macrostate and microstate. 2
2. (a) Show that the partition function distribution of a perfect gas is $Z = \frac{V}{h^3} (2\pi mKT)^{3/2}$. 5
- (b) Define entropy and probability. Show that the entropy of the system is proportional to the logarithm of probability of that system. 5
- (c) Prove that the internal energy U of a system is given by $U = NkT^2 \frac{\partial}{\partial T} (\log Z)$ 4

UNIT-II

3. (a) State and prove Kirchoff's law of radiation and discuss its importance. 7
- (b) A black body at 500 °C has a surface area of 0.5 m² and radiates heat at the rate of 1.02×10^4 J/s. Calculate Stefan's constant. 2

- (c) State briefly the importance of theoretical and experimental investigation of black body radiations. How far the effort of Jeans and Wien succeeded in explaining the experimental results? 5
4. (a) Show that the radiation in an isothermal enclosure depends only on the temperature and not on the nature of the walls of the enclosure or on the bodies present inside it. 7
- (b) State Wien's displacement law and prove it thermodynamically. 5
- (c) Deduce the temperature at which a black body loses thermal energy at the rate of 1 watt/cm². Given $\sigma = 5.6 \times 10^{-8}$ watt/m²K⁴. 2

UNIT-III

5. (a) Discuss the distribution of energy in the spectrum of a black body on the basis of experiment performed by Lummer and Pringsheim. What are the salient features of black body radiation? 8
- (b) Show that the number of photons in black body radiation at a temperature T is equal to $N = \frac{V}{\pi^2} \left(\frac{KT}{\hbar C} \right)^3 \int_0^\infty \frac{x^2}{e^x - 1} dx$. 6
6. (a) What is quantum theory of radiation? Derive Planck's formula for distribution of energy in the spectrum of a black body. 7
- (b) Obtain the expression for the wavelength corresponding to maximum energy of emission using Planck's law. 7

UNIT-IV

7. (a) Derive the equation for the most probable distribution of a particle among various levels for a system obeying Bose-Einstein statistics. 7
- (b) Three particles are to be distributed in four energy states $a, b, c,$ and d . Write down all the possible ways for such a distribution, if the particles are fermions, bosons, and classical particles. 5
- (c) Define emissive and absorptive power. 2

8. (a) Write a short note on radiation as a photon gas. Derive the expression for entropy and find the average number of a photon gas in a cavity. 7
- (b) Derive the relation between total particles and energy for Bose-Einstein gas. 7

UNIT-V

9. (a) What is Fermi-Dirac gas? Show that a strongly degenerate Fermi-Dirac gas possesses energy and exerts a pressure even at 0 K. 7
- (b) The density of zinc is 7.13 g/cm^3 and its atomic weight is 65.4. Calculate its Fermi energy. Given, the effective mass of a free electron in zinc crystal is $7.7 \times 10^{-31} \text{ kg}$ and N is $6.02 \times 10^{23} \text{ atoms/gram-atom}$. 5
- (c) How do the Bose and Fermi distributions tend to classical distribution? 2
10. (a) Obtain the Chandrasekhar mass limit for a white dwarf star. 7
- (b) What is the fundamental difference between the assumptions of Einstein and Debye's theory of specific heat of solids? Derive Debye T^3 law and interpret the result. 7
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