3 (Sem–6/CBCS) PHY HC 2

2024

PHYSICS

(Honours Core)

Paper : PHY–HC–6026

(Statistical Mechanics)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×7=7

(a) What is the degeneracy of each quantum state for photon ?

(b) Find the possible number of arrangements of 5 bosons in 3 cells.

(c) If N_i is the identical, independent particles in the ith energy state with degeneracy g_i, then classical statistics can be applied if

(i) $\frac{N_i}{g_i} \approx 1$

(ii) $\frac{N_i}{g_i} << 1$

(iii) $\frac{N_i}{g_i} >> 1$

(iv) $g_i \approx 0$

(d) Fill in the blanks :

Quantum statistics tends to classical one when temperature is _____ and particle density is _____.

(e) Which law in thermodynamics is used to explain Fraunhofer lines in solar spectrum ?

(f) Name the statistics obeyed by phonons.

(g) Write the relationship between radiation pressure and radiation energy density.

2. Answer the following questions : 2×4=8

(a) What is partition function ? State its significance.

(b) Mention *any two* characteristics of blackbody radiation.

(c) Give the basic concepts of canonical and microcanonical ensemble.

(d) Give *two* examples of fermions.

3. Answer ***any three*** questions from the following : 5×3=15

(a) Deduce Stefan-Boltzmann law from Planck's law of blackbody radiation.

(b) Differentiate M–B, B–E and F–D statistics mentioning the wave function, distribution function and nature of particles in each of the *three* cases.

(c) What do you mean by ultraviolet catastrophe ? Explain.

(d) Deduce the expression for Maxwell's distribution of speeds in case of an ideal classical gas.

(e) Mention the important postulates of Planck's theory of blackbody radiation. Deduce Wien's distribution law from the expression for energy distribution in blackbody spectrum.

4. Answer ***any three*** questions : 10×3=30

(a) Mention Gibbs paradox. Deduce Sackur-Tetrode formula and explain its significance. 2+(6+2)=10

(b) Discuss statistically the case of two-level energy system for a paramagnetic substance in an external magnetic field and explain negative temperature. 7+3=10

(c) Derive an expression showing temperature dependance of Fermi energy. Show that the probability of occupation for an electron state at Fermi energy is equal to 50% for all finite temperature. 8+2=10

(d) Using B-E statistics, derive an expression of pressure of a perfect gas. Under what condition, does Bose-Einstein condensation occur? 8+2=10

(e) Derive Fermi-Dirac distribution law.

(f) Write short notes on : 5+5=10

(i) White dwarf stars

(ii) Macrostate and microstate
