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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 : $1 \times 7 = 7$

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

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

Contd.

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

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

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

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

(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 : $2 \times 4 = 8$

- (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 : $5 \times 3 = 15$

- (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 : $10 \times 3 = 30$

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

(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