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3 (Sem-6/CBCS) PHY HC 2

2025

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 minimum volume of the phase cell in quantum statistics ?

(b) Write one limitation of Maxwell-Boltzmann statistics.

(c) In how many ways, 2 particles can be distributed in 2 energy states according to F-D statistics ?

(d) A blackened platinum wire, when gradually heated, appears first dull red, then blue and finally white, why ?

(e) Name the statistics, which is used to study the density of electrons in copper at room temperature.

(f) If n_i are the number of particles in the i th energy state with degeneracy g_i , then B-E statistics can be applied if—

(i) $\frac{n_i}{g_i} \geq 1$

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

(iii) $\frac{n_i}{g_i^2} \ll 1$

(iv) None of the above

(Choose the correct answer)

(g) Under what condition, quantum statistics approaches to classical statistics?

2. Answer the following questions : $2 \times 4 = 8$

(a) Define phase space and phase line.

(b) The wavelength of maximum emissive power of heat radiation of Sun is $4750 \text{ \AA}$. Find the surface temperature of the Sun.

[Wien's displacement constant = 0.2892 cm-K]

- (c) What is generate Bose gas ?
- (d) Write *one* similarity and *one* difference between Bose-Einstein and Fermi-Dirac statistics.

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

- (a) Define microstate and macrostate. Three distinguishable particles, each of which can be in one of the ϵ , 2ϵ , 3ϵ , 4ϵ energy states, have total energy 6ϵ . Find all possible number of distributions of all the particles in the energy states. Also find the number of microstates in each case. 2+3=5
- (b) Write statistical definition of entropy and derive the relation between entropy and thermodynamic probability. 1+4=5
- (c) Deduce Sackur-Tetrode formula and explain its significance. 4+1=5
- (d) Write a note on Bose-Einstein condensation.
- (e) What is Fermi energy ? For copper, $n = 8.48 \times 10^{28}$ electrons/ m^3 . Estimate the value of Fermi energy (E_F) in eV. 1+4=5

4. Answer **any three** questions : $10 \times 3 = 30$

(a) Derive Maxwell-Boltzmann energy distribution law for on ideal gas.

(b) What is radiation pressure ? Prove that the diffuse radiation exerts a pressure on the walls of the container, equal to $\frac{1}{3}$ rd of the energy density. $2+8=10$

(c) Write the differences between photon gas and ideal gas. Starting from B-E statistics distribution law, derive Planck's law. $3+7=10$

(d) What is electron gas ? Derive the expression of energy distribution of free electrons in a metal using Fermi-Dirac statistics. $2+8=10$

(e) From Planck's law of black-body radiation, derive— $4+6=10$

(i) Wien's displacement law

(ii) Stefan-Boltzmann law

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

(i) White dwarf stars

(ii) Ensemble