2026

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Acc. No.
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PHYSICS

(Major)

Paper : PHY0600404

(Statistical Mechanics)

Full Marks : 60

Time : 2½ hours

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

1. Answer the following questions as directed : 1×8=8

(a) Define phase space.

(b) If one system is composed of N identical and indistinguishable fermions, then write down the expression of total number of microstates corresponding to a macrostate specified by the set of occupation numbers $\{n_1, n_2, \cdots\}$.

(c) Give one example of fermions.

(d) According to which statistics, the energy at absolute zero cannot be zero?

(i) Maxwell-Boltzmann statistics

(ii) Bose-Einstein statistics

(iii) Fermi-Dirac statistics

(iv) None of the above

(Choose the correct option)

(e) What is ultraviolet catastrophe?

(f) Bose-Einstein condensates have

(i) very low kinetic energy

(ii) low kinetic energy

(iii) high kinetic energy

(iv) highest kinetic energy

(Choose the correct option)

(g) Name the statistics where Pauli exclusion principle is used.

(h) Under what condition quantum statistics approaches the classical statistics?

2. Answer any *six* questions from the following : 2×6=12

(a) Explain the meaning of ensemble in statistical mechanics.

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(b) Calculate the radiant energy by a black-body at a temperature of 4000 K in MKS system.

(c) Write one similarity and one difference between Bose-Einstein and Fermi-Dirac statistics.

(d) What is degenerate Bose gas?

(e) Fermions are distributed in three energy states having energies $-E$, 0 and $+E$ respectively. Determine the value of energy of the macrostate (7, 8, 5).

(f) Explain the significance of partition function in statistical thermodynamics.

(g) Mention the characteristics of the particle upon which Bose-Einstein statistics is applicable.

(h) Calculate the temperature of a star when it radiates maximum energy at a wavelength 550 nm. Given Wien's constant $b = 2 \cdot 90 \times 10^{-3}$ mK.

(i) What is the minimum size of a phase space cell in classical and quantum mechanical system?

(j) Give one example of Bose gas and state its behaviour at temperature near zero Kelvin (~ 2·17 *K*).

3. Answer any *four* of the following : 5×4=20

(a) Discuss the term 'microstate'. Consider that two particles are to be distributed in an energy level which is 3-fold degenerate. Find the possible microstates if the particles are—

(i) distinguishable;

(ii) indistinguishable bosons;

(iii) indistinguishable fermions. 2+3=5

(Continued)

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(b) Derive the Sackur-Tetrode equation for the entropy of an ideal monoatomic gas. How does it resolve the Gibbs paradox? 4+1=5

(c) What is radiation pressure? Derive an expression of diffused radiation pressure. 1+4=5

(d) Write statistical definition of entropy. Derive the relation between entropy and thermodynamic probability. 1+4=5

(e) What is degenerate Fermi gas? Give one example of a highly degenerate Fermi system. What is the Fermi energy for copper, given density = 9 g cm^{-3}, atomic weight = 63·5 and valency equal to one? 1+1+3=5

(f) Using Maxwell-Boltzmann statistics, prove the law of equipartition of energy. 5

(g) What is blackbody radiation? Discuss the experimental curve of blackbody radiation. 5

(Turn Over)

(h) What do you mean by occupation index for each state in F-D statistics? An ideal Fermi gas is confined inside a container that is connected to particle reservoir. Each particle can occupy discrete set of single particle quantum states. If the probability that a particle quantum state is unoccupied is 0·1, then what is the average number of fermions in that state? 2+3=5

4. Answer any *two* questions of the following : 10×2=20

(a) Derive Maxwell-Boltzmann law of energy distribution.

(b) What is Fermi energy? Derive the expression of Fermi energy. Discuss the effect of temperature on Fermi distribution function. 1+4+5=10

(c) Using Bose-Einstein statistics, derive an expression of pressure of a perfect gas. Is Maxwell-Boltzmann distribution a limiting case of Bose-Einstein's distribution? If yes, explain. 8+2=10

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

(i) White dwarf stars

(ii) Rayleigh-Jeans law

(e) Write the difference between photon and ideal gas. Starting from B-E statistics distribution law, derive Planck's law. 2+8=10

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