Govt. P. G. College, Ambala Cantt

Course File: (Session 2023-24)
Name of Professor: Dr. Priyanka
Class: B.Sc.-II (NM), Semester – IVth
Subject code and Name: Physics- PH-401, Paper VII: Statistical Physics

Max.Marks:40
Internal assessment: 10
Time: 3 Hours

Note: 1. The syllabus is divided into 4 units. 9 questions will be set. 2. Question no 1 will be compulsory, it contains 6 parts (form all the four units) and answer should be brief but not in yes / no. 3. Four more questions are to be attempted, selecting one question from each unit. Questions 2-9 may contain two or more parts. All questions carry equal marks. 4. 20% numerical problems are to be set. 5. Use of scientific (non-programmable) calculator is allowed

Unit –I: Statistical Physics I Microscopic and Macroscopic systems, events-mutually exclusive, dependent and independent. Probability, statistical probability, A- priori Probability and relation between them, probability theorems, some probability considerations, combinations possessing maximum probability, combination possessing minimum probability, Tossing of 2,3 and any number of Coins, Permutations and combinations, distributions of N (for N= 2,3,4) distinguishable and indistinguishable particles in two boxes of equal size, Micro and Macro states, Thermodynamical probability, Constraints and Accessible states, Statistical fluctuations, general distribution of distinguishable particles in compartments of different sizes, Condition of equilibrium between two systems in thermal contact-- β parameter, Entropy and Probability (Boltzman's relation).

Unit –II: Statistical Physics II Postulates of statistical physics, Phase space, Division of Phase space into cells, three kinds of statistics, basic approach in three statistics. M. B. statistics applied to an ideal gas in equilibrium- energy distribution law (including evaluation of σ and β) , speed distribution law & velocity distribution law. Expression for average speed, r.m.s. speed, average velocity, r. m. s. velocity, most probable energy & mean energy for Maxwellian distribution.

Unit-III: Quantum Statistics Need for Quantum Statistics: Bose-Einstein energy distribution law, Application of B.E. statistics to Planck's radiation law B.E. gas, Degeneracy and B.E. Condensation, Fermi Dirac energy distribution law, F.D. gas and Degeneracy, Fermi energy and Fermi temperature, Fermi Dirac energy distribution law, Fermi Dirac gas and degeneracy, Fermi energy and Fermi temperature, Fermi Dirac energy distribution law for electron gas in metals, Zero point energy, Zero point pressure and average speed (at 0 K) of electron gas, Specific heat anomaly of metals and its solution. M.B. distribution as a limiting case of B.E. and F.D. distributions, Comparison of three statistics.

Unit-IV: Theory of Specific Heat of Solids: Dulong and Petit law, Derivation of Dulong and Petit law from classical physics. Specific heat at low temperature, Einstein theory of specific heat, Criticism of Einstein theory, Debye model of specific heat of solids, success and shortcomings of Debye theory, comparison of Einstein and Debye theories.

References: 1. Prakash S and Agarwal J P, Statistical Mechanics, Kedar Nath Ram Nath & co, Meerut.
2. Reiff. Statistical Physics, Berleley Physics Course Volume 5, Mc Graw Hill Book Co Ltd, New Delhi
3. Mc Quarrie D A. Statistical Mechanics, Viva Books Pvt Ltd, New Delhi.
4. Ashley Cmter (August 1999), Classical and Statistical Thermodynamics.

Course Objectives:

This course in statistical mechanics provides the basic idea of probability to the students.

1. There are ways of calculating probability for various statistical systems of particles.
2. Students will study basic ideology of phase space, microstate, macrostate.
3. The objective is to apply the principles of probability in distribution of particles in various systems and to calculate thermodynamic probability.
4. The course gives the insight of postulates of statistical physics.
5. Students will learn the different types of statistics distribution and particles. They will learn which particles follow which statistics and why.

Course Outcomes:

CO-1 Understand the concepts of microstate, macrostate, thermodynamic probability and also understand the studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles.
CO-2 Learn the basic Postulates of statistical physics, Phase space, Division of Phase space into cells and be able to derive the expression for average speed, r.m.s. speed, average velocity, r. m. s. velocity, most probable energy & mean energy for Maxwellian distribution.
CO-3 Understand the need and application of Quantum Statistics: Bose-Einstein & Fermi Dirac statistics and be able to articulate the connection as well as dichotomy between classical statistical mechanics and quantum statistical mechanics.
CO-4 Learn and understand the different law's and theory of specific heat of solids and their significance.

Lesson Plan

S. No.	Date	Topic
1.	8th Jan 2024-13th Jan2024	**Unit –I: Statistical Physics I -** Microscopic and Macroscopic systems, events-mutually exclusive, dependent and independent. Probability, statistical probability, A- priori Probability and relation between them, probability theorems, some probability considerations, combinations possessing maximum probability,

		combination possessing minimum probability.
2.	15th Jan 2024-20th Jan2024	Tossing of 2, 3 and any number of Coins, Permutations and combinations, distributions of N (for N= 2,3,4) distinguishable and indistinguishable particles in two boxes of equal size. **Related Problems and Discussions.**
3.	22th Jan 2024-27th Jan2024	Micro and Macro states, Thermodynamical probability, Constraints and Accessible states, Statistical fluctuations, general distribution of distinguishable particles in compartments of different sizes. **Test & Assignment**
4.	29th Jan 2024-3rd Feb2024	Condition of equilibrium between two systems in thermal contact—β parameter, Entropy and Probability (Boltzman's relation). **Unit –II: Statistical Physics II,** Postulates of statistical physics Phase space.
5.	5th Feb 2024- 10th Feb 2024	Division of Phase space into cells, three kinds of statistics, Basic approach in three statistics. M. B. statistics applied to an ideal gas in equilibrium- energy distribution law (including evaluation of σ and β).
6.	12th Feb 2024- 17th Feb 2024	Speed distribution law & velocity distribution law. Expression for average speed, r.m.s. speed, average velocity, r. m. s. velocity, most probable energy & mean energy for Maxwellian distribution. **Related Problems, Discussion & Test**
7.	19th Feb 2024- 24th Feb 2024	**Unit-III: Quantum Statistics** Need for Quantum Statistics: Bose-Einstein energy distribution law, Application of B.E. statistics to Planck's radiation law B.E. gas.
8.	26th Feb 2024- 2nd March 2024	Degeneracy and B.E. Condensation, Fermi-Dirac energy distribution law.**Doubts**
9.	4th March 2024-9th March 2024	Fermi Dirac gas and degeneracy, Fermi energy and Fermi temperature. **Related Problems & Discussion**
10.	11th March 2024-16th March 2024	Fermi Dirac energy distribution law for electron gas inmetals, Zero point energy, Zero point pressure and average speed (at 0 K) of electron gas.

		Related Problems & Discussion
11.	18th March 2024-22nd March 2024	Specific heat anomaly of metals and its solution. M.B. distribution as a limiting case of B.E. and F.D. distributions, Comparison of three statistics. **Test & Assignment**
	23rd March 2024 to 31st March 2024	**HOLI BREAK**
12.	1st April 2024 to 6th April 2024	**Unit-IV: Theory of Specific Heat of Solids** Dulong and Petit law. Derivation of Dulong and Petit law from classical physics. Specific heat at low temperature.
13.	8th April 2024 to 13th April 2024	Einstein theory of specific heat, Criticism of Einstein theory, **Test and Discussion**.
14.	15th April 2024 to 20th April 2024	Debye model of specific heat of solids, success and shortcomings of Debye theory, comparison of Einstein and Debye theories. **Revision**
15.	22th April 2024 to 27th April 2024	Revision: Doubts and Discussion.
16.	29th April 2024 to 30th April 2024	Revision: Doubts and Discussion.