Semester-VI

Paper Name: Statistical Mechanics

Course Code - PHY060404

Total Lectures: 60 (45 L + 15 T); Credit: 04 (Total Marks 100: Internal-40+External-60)

Course objective:

- *To provide basic concepts of statistical mechanics*
- *Describing various thermodynamical phenomena using probability theory*
- *To learn classical and quantum statistics*

Course outcome: Upon completion of the course, students will get accustomed to the microscopic origin of thermodynamic processes. After successful completion of the course, students will be able to perceive classical and quantum pictures of physical and chemical events.

Unit I: Classical Statistics (Lectures 15)

Microstate and macrostate, distributions of particles in compartments, principle of equal a priori probability. Phase space, volume of phase space. Elementary concept of ensembles, Types of ensembles. Ergodic hypothesis. Entropy and thermodynamic probability, Stirling's approximation, Maxwell-Boltzmann distribution function, Partition functions. Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to specific heat and its limitations. Thermodynamic parameters (internal energy, entropy, free energy, enthalpy) using partition functions.

Unit II: Classical and Quantum Theory of Radiation (Lectures 12)

Properties of thermal radiation. Blackbody radiation. Spectral distribution of Blackbody radiation, Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation pressure (for Normal and diffused case). Wien's Displacement law. Wien's Distribution Law. Saha's ionization formula. Rayleigh-Jean's Law (with proof). Ultraviolet catastrophe.

Need of quantum statistics. Planck's quantum postulates. Planck's law of blackbody radiation: Experimental verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan- Boltzmann Law, (4) Wien's Displacement law from Planck's blackbody radiation formula.

Unit III: Bose-Einstein Statistics (Lectures 8)

Bose-Einstein (BE) distribution, Pressure of a Bose gas, Bose Einstein Condensation

(qualitative description only), Properties of liquid Helium (qualitative discussion only), Radiation as a photon gas and Bose's derivation of Planck's blackbody radiation formula, Thermodynamic functions of photon gas – energy, entropy, and free energy.

Unit IV: Fermi-Dirac Statistics (Lectures 10)

Fermi-Dirac (FD) distribution, FD function and Fermi Energy, Degenerate Fermi gas, strongly degenerate case (qualitative discussion only), Thermodynamic functions - energy and pressure of a completely degenerate Fermi gas, Heat capacity at low temperature, Free electron gas in metals and electronic specific heat, Relativistic Fermi gas, thermodynamics of white dwarf star (qualitative discussion only).

Suggested books

[1] Statistical Mechanics, R K Pathria and P D Beale, Elsevier Science, 2021.

[2] Statistical Physics, F. Reif, McGraw-Hill Education India, 2008.

[3] Statistical and Thermal Physics, S. Lokanathan and R. S. Gambhir, PHI Learning, 1991.

[4] Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, Springer, 2009.

[5] An Introduction to Statistical Mechanics & Thermodynamics, R. H. Swendsen, Oxford University Press, 2012.

[6] A Primer of Statistical Mechanics, R. B. Singh, New Age International Publishers, 2006.