

Chapter 1: The Statistical Basis of Thermodynamics

- 1.1 The macroscopic and the microscopic states
- 1.2 Contact between statistics and thermodynamics: physical significance of the number $\Omega(N, V, E)$
- 1.3 Further contact between statistics and thermodynamics
- 1.4 The classical ideal gas
- 1.5 The entropy of mixing and the Gibbs paradox
- 1.6 The “correct” enumeration of the microstates

Chapter 2: Elements of Ensemble Theory

- 2.1 Phase space of a classical system
- 2.2 Liouville’s theorem and its consequences
- 2.3 The microcanonical ensemble
- 2.4 Examples
- 2.5 Quantum states and the phase space

Chapter 3: The Canonical Ensemble

- 3.1 Equilibrium between a system and a heat reservoir
- 3.2 A system in the canonical ensemble
- 3.3 Physical significance of the various statistical quantities in the canonical ensemble
- 3.4 Alternative expressions for the partition function
- 3.5 The classical systems
- 3.6 Energy fluctuations in the canonical ensemble: correspondence with the microcanonical ensemble
- 3.7 Two theorems — the “equipartition” and the “virial”
- 3.8 A system of harmonic oscillators
- 3.9 The statistics of paramagnetism
- 3.10 Thermodynamics of magnetic systems: negative temperatures

Chapter 4: The Grand Canonical Ensemble

- 4.1 Equilibrium between a system and a particle-energy reservoir
- 4.2 A system in the grand canonical ensemble
- 4.3 Physical significance of the various statistical quantities
- 4.4 Examples
- 4.5 Density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles
- 4.6 Thermodynamic phase diagrams
- 4.7 Phase equilibrium and the Clausius–Clapeyron equation

Chapter 5: Formulation of Quantum Statistics

- 5.1 Quantum-mechanical ensemble theory: the density matrix
- 5.2 Statistics of the various ensembles
- 5.3 Examples
- 5.4 Systems composed of indistinguishable particles
- 5.5 The density matrix and the partition function of a system of free particles

Chapter 6: The Theory of Simple Gases

- 6.1 An ideal gas in a quantum-mechanical microcanonical ensemble
- 6.2 An ideal gas in other quantum-mechanical ensembles
- 6.3 Statistics of the occupation numbers
- 6.4 Kinetic considerations
- 6.5 Gaseous systems composed of molecules with internal motion
- 6.6 Chemical equilibrium

Chapter 7: Ideal Bose Systems

- 7.1 Thermodynamic behavior of an ideal Bose gas
- 7.2 Bose-Einstein condensation in ultracold atomic gases
- 7.3 Thermodynamics of the blackbody radiation
- 7.4 The field of sound waves
- 7.5 Inertial density of the sound field
- 7.6 Elementary excitations in liquid helium II

Chapter 8: Ideal Fermi Systems

- 8.1 Thermodynamic behavior of an ideal Fermi gas
- 8.2 Magnetic behavior of an ideal Fermi gas
- 8.3 The electron gas in metals
- 8.4 Ultracold atomic Fermi gases
- 8.5 Statistical equilibrium of white dwarf stars
- 8.6 Statistical model of the atom

Chapter 9: Thermodynamics of the Early Universe

- 9.1 Observational evidence of the Big Bang
- 9.2 Evolution of the temperature of the universe
- 9.3 Relativistic electrons, positrons, and neutrinos
- 9.4 Neutron fraction
- 9.5 Annihilation of the positrons and electrons
- 9.6 Neutrino temperature
- 9.7 Primordial nucleosynthesis
- 9.8 Recombination
- 9.9 Epilogue

Chapter 10: Statistical Mechanics of Interacting Systems: The Method of Cluster Expansions

- 10.1 Cluster expansion for a classical gas
- 10.2 Virial expansion of the equation of state
- 10.3 Evaluation of the virial coefficients
- 10.4 General remarks on cluster expansions
- 10.5 Exact treatment of the second virial coefficient
- 10.6 Cluster expansion for a quantum-mechanical system
- 10.7 Correlations and scattering

Chapter 11: Statistical Mechanics of Interacting Systems: The Method of Quantized Fields

- 11.1 The formalism of second quantization
- 11.2 Low-temperature behavior of an imperfect Bose gas
- 11.3 Low-lying states of an imperfect Bose gas
- 11.4 Energy spectrum of a Bose liquid
- 11.5 States with quantized circulation
- 11.6 Quantized vortex rings and the breakdown of superfluidity
- 11.7 Low-lying states of an imperfect Fermi gas
- 11.8 Energy spectrum of a Fermi liquid: Landau's phenomenological theory²¹
- 11.9 Condensation in Fermi systems

Chapter 12: Phase Transitions: Criticality, Universality, and Scaling

- 12.1 General remarks on the problem of condensation
- 12.2 Condensation of a van der Waals gas
- 12.3 A dynamical model of phase transitions
- 12.4 The lattice gas and the binary alloy
- 12.5 Ising model in the zeroth approximation

- 12.6 Ising model in the first approximation
- 12.7 The critical exponents
- 12.8 Thermodynamic inequalities
- 12.9 Landau's phenomenological theory
- 12.10 Scaling hypothesis for thermodynamic functions
- 12.11 The role of correlations and fluctuations
- 12.12 The critical exponents ν and η
- 12.13 A final look at the mean field theory

Chapter 13: Phase Transitions: Exact (or Almost Exact) Results for Various Models

- 13.1 One-dimensional fluid models
- 13.2 The Ising model in one dimension
- 13.3 The n-vector models in one dimension
- 13.4 The Ising model in two dimensions
- 13.5 The spherical model in arbitrary dimensions
- 13.6 The ideal Bose gas in arbitrary dimensions
- 13.7 Other models

Chapter 14: Phase Transitions: The Renormalization Group Approach

- 14.1 The conceptual basis of scaling
- 14.2 Some simple examples of renormalization
- 14.3 The renormalization group: general formulation
- 14.4 Applications of the renormalization group
- 14.5 Finite-size scaling

Chapter 15: Fluctuations and Nonequilibrium Statistical Mechanics

- 15.1 Equilibrium thermodynamic fluctuations
- 15.2 The Einstein–Smoluchowski theory of the Brownian motion
- 15.3 The Langevin theory of the Brownian motion
- 15.4 Approach to equilibrium: the Fokker–Planck equation
- 15.5 Spectral analysis of fluctuations: the Wiener–Khinchine theorem
- 15.6 The fluctuation–dissipation theorem
- 15.7 The Onsager relations

Chapter 16: Computer Simulations

- 16.1 Introduction and statistics
- 16.2 Monte Carlo simulations
- 16.3 Molecular dynamics
- 16.4 Particle simulations
- 16.5 Computer simulation caveats