Statistical Physics

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1. Basics of thermodynamics

I. Preliminaries
II. Ideal gas
III. Laws of thermodynamics
IV. Consequences of first law
V. Consequences of second law
VI. Thermodynamics potentials

2. From random walk to probability distributions

I. A simple probabilistic system : random walk
II. Random walk and mean values
III. Probability distribution at large N
IV. Gaussian probability distribution
V. Poisson probability distribution

3. Statistical thermodynamics

I. Statistical formulation of a system

II. Thermal vs mechanical interaction

III. Thermal interaction between macroscopic systems

IV. Mecanical interaction between macroscopic systems

V. Microscopic description of the ideal gas

4. Statistical ensembles

I. Isolated systems $(E, N, V = \text{fixed})$: Microcanonical ensemble

II. System with specified $\bar{E}$ $(N, V = \text{fixed})$: Canonical ensemble

III. Simple applications of the canonical ensemble

IV. Mean values in a canonical ensemble

V. Canonical ensemble and connection with thermodynamics

VI. Mathematical derivation of canonical ensemble

VII. System with specified $\bar{E}$ and $\bar{N}$ $(v = \text{fixed})$: Grand canonical ensemble

VIII. Grand canonical ensemble and connection with thermodynamics

Appendix : Constrained systems and Lagrange multipliers

5. Applications of canonical ensemble

I. Ideal monatonic gas and Gibbs paradox

II. Real monatomic gas

III. Equipartition theorem and simple applications

IV. Specific heat of solids

V. Paramagnetism for arbitrary spin

VI. Interaction between spins and ferromagnetism

VII. Kinetic theory of diluted gases

Appendix: Debye theory of phonons

6. Applications of grand canonical ensemble: quantum gases

I. Identical particles, symmetry and statistical problem

II. Maxwell-Boltzmann statistics

III. Photon statistics

IV. Bose-Einstein statistics

V. Fermi-Dirac statistics

VI. Regimes of quantum BE and FD gases

VII. Black body radiation

References:

- K. Huang. Statistical Mechanics
- F. Reif. Fundamentals of Statistical and Thermal Physics
- D. Tong. Lectures on Statistical Physics

"Ludwig Boltzmann, who spent much of his life studying statistical mechanics, died in 1906 by his own hand. Paul Ehrenfest, carrying on the work, died similarly in 1933. Now it is our turn to study statistical mechanics."

— David Goodstein