

Topics in Callen's Thermodynamics and an Introduction to Thermostatistics

Thermodynamics

1. Postulates of Thermodynamics

- (1) Equilibrium states exist as function of (U, V, N)
- (2) Entropy $S(U, V, N)$. If remove constraint, external parameters adjust to maximize S
- (3) S additive, differential, increasing function of U
- (4) $S=0$ when $(\partial U / \partial S)_{V, N} = 0$, or $T=0$

2. Conditions of Equilibrium

Thermal, mechanical, chemical; Maximize S for given U

3. Sample Systems

Ideal gas, van der Waal's fluid, EM radiation, Rubber Band

4. Reversible processes; Engines

Maximum work theorem; Carnot cycle

5. Alternative formulations; Legendre transf.

$U(S, V, N) \rightarrow U(S, P, N), U(T, V, N), U(T, P, N)$
Minimize U for given S

6. Extremum principles in Legendre trans. reps.

7. Maxwell relations; reduction of derivatives

8. Stability: $\partial^2 S / \partial U^2 < 0$

9. First order phase transitions

10. Critical phenomena; second order trans.

11. Nernst postulate

12. Summary of principles of thermodynamics

13. Materials properties; various systems

14. Irreversible thermodynamics

Statistical Mechanics

15. Microcanonical formulation (isolated system, $U, V, N = \text{constant}$)

$$S = k_B \ln W$$

16. Canonical formulation (system contacting energy reservoir)

17. Grand canonical formulation (system contacting energy and particle reservoirs)

18. Quantum fluids

19. Fluctuations

20. Mean Field Theory

21. Conceptual foundations of thermostatistics

Kinetic Theory

Boltzmann Equation; Diffusion