

Contents

Part I Correlation Functions and Kinetic Equations

1. Introduction	3
2. General Equations of Motion of Statistical Physics	6
2.1 Quantum Statistics	6
2.2 Classical Statistics	10
2.3 Approximations	12
Problems	13
3. Small Amplitude Perturbation Theory (Linear Response)	14
Problems	20
4. Brownian Motion (Relaxator)*	22
Problems	27
5. Brownian Motion (Oscillator)*	29
Problems	32
6. Dispersion Relations and Spectral Representations	33
Problems	36
7. Symmetry Properties of Correlation Functions	37
Problems	41
8. Detailed Balance, Fluctuations and Dissipation	42
Problems	44
9. Scattering of Particles and Light**	45
Problems	50
10. Energy Dissipation, Detailed Balance and Passivity	52
10.1 The Response of Conserved Quantities to External Forces ..	52
10.2 Energy Dissipation and Passivity	53
Problems	55
11. The High-Frequency Behaviour of Response Functions	56
Problems	58
12. The Low-Frequency Behaviour of Response Functions	59
Problems	62
13. Stochastic Forces, Langevin Equation	63
13.1 The Subtraction Method (Langevin)	63

13.2	The Projection Method (Zwanzig and Mori)	66
	Problems	68
14.	Brownian Motion: Langevin Equation*	69
	Problems	72
15.	Nonlinear Response Theory	73
15.1	The General Initial Value Case	73
15.2	Low-Frequency Perturbation Theory	75
	Problems	77
16.	The Increase of Entropy and Irreversibility	78
16.1	General	78
16.2	Linear Response	79
16.3	Low-Frequency Response	81
	Problems	81
17.	The Increase of Entropy: A Critical Discussion**	82
17.1	Maxwell's Demon	82
17.2	Gibbs' Ink Parable	83
17.3	Zermélo's Recurrence Paradox	84
17.4	Loschmidt's Reversibility Objection	86
	Problems	87

Part II Irreversible Thermodynamics

18.	The Nyquist Formula	90
	Problems	92
19.	Thermomechanical Effects	93
19.1	Diffusion and the Mechanocaloric Effect ($\Delta T = 0$)	95
19.2	Heat Diffusion and Thermomechanical Pressure Difference ($\dot{N} = 0$)	95
	Problems	98
20.	Diffusion and Thermodiffusion	99
	Problems	103
21.	Thermoelectric Effects	104
	Problems	107
22.	Chemical Reactions	108
	Problems	111
23.	Typical Time Evolutions of Simple Chemical Reactions	112
23.1	Zero-Order Reactions	112
23.2	First-Order Reactions	113
23.3	Second-Order Reactions	113
23.4	Third-Order Reactions	114
	Problems	115

24. Coupled Nonlinear Reactions	116
24.1 Nonequilibrium Phase Transitions	116
24.2 Kinetic Oscillations	117
24.3 "Chaos"	120
Problems	121
25. Chemical Fluctuations	123
Problems	126
26. Sticking, Desorption, Condensation and Evaporation	127
Problems	130
27. Nucleation	131
Problems	136
28. The Oscillator with Mechanical and Thermal Attenuation* ...	137
Problems	141
29. Hydrodynamics	142
Problems	148
30. Hydrodynamic Long-Time Tails	149
Problems	151
31. Matter in Electromagnetic Fields	152
Problems	157
32. Rate Equations (Master Equation, Stosszahlansatz)	158
Problems	163
33. Kinetic Transport Equations	164
Problems	168
34. The Dynamic Conductivity in the Relaxation Time Model	169
34.1 Longitudinal Excitations	169
34.2 Transverse Excitations	170
34.3 Discussion of $\sigma^l(k, \omega)$ and $\sigma^t(k, \omega)$	171
34.4 Quantum Corrections	174
Problems	176
35. Zero Sound	177
Problems	179
36. The Fokker-Planck Approximation	180
Problems	183
37. Brownian Motion and Diffusion*	184
Problems	187
38. Fokker-Planck and Langevin Equations	188
39. Transport Equations in the Hydrodynamic Regime	193
39.1 The Hydrodynamic Approximation	193
39.2 Diffusion of Particles and Heat	195
39.3 The Viscosities	198
Problems	200

40. The Minimum Entropy Production Variational Principle	201
40.1 The Principle of Minimum Entropy Production	201
40.2 The Classical Boltzmann Gas	202
40.3 The Electron-Phonon System	206
40.4 Fermi Liquids	210
Problems	211

Part III Calculation of Kinetic Coefficients

41. Approximation Methods	214
42. Correlation Functions for Single-Particle Problems	217
42.1 General	217
42.2 Impurity Conduction (Greenwood Formula)	219
Problems	220
43. Perturbation Theory for Impurity Conduction	221
Problems	226
44. Electron-Phonon Conduction	227
Problems	229
45. Mode-Coupling Theory for Impurity Conduction	230
45.1 Particle Diffusion and Current Relaxation	230
45.2 Backscattering Effects	231
45.3 Self-Consistency Relations	234
Problems	236
46. Electron Localization	237
46.1 Breakdown of Perturbation Theory	239
46.2 Localization and Nonergodicity	239
46.3 Critical Behaviour and Scaling Laws	241
Problems	242
47. Localization and Quantum Interference*	244
48. Scaling Laws for Dynamic Critical Phenomena	247
48.1 General	247
48.2 The Lambda Transition in Liquid Helium	250
Problems	252
49. Applications of Dynamic Scaling Laws	254
49.1 Isotropic Ferromagnets	254
49.2 Uniaxial Antiferromagnets, Structural Phase Transitions	257
49.3 Anisotropic Ferromagnets	258
49.4 Liquid-Gas Transition	259
50. Mode-Coupling Theory for Dynamic Critical Phenomena	260
51. Broken Symmetry and Low-Frequency Modes**	264

52. Collision Rates	269
52.1 Perturbation Theory	269
52.2 Impurity Scattering	270
52.3 Chemical Reaction Rates	271
Problems	273
53. Many-Body Effects in Collision Rates	274
Problems	276
References	277
Subject Index	287