CONTENTS

Preface to the third Russian edition	xili
Prom the prefaces to previous Russian editions	xv
Notation	xvii
1. THE FUNDAMENTAL PRINCIPLES OF STATISTICAL PHYSICS	
 1. Statistical distributions 2. Statistical independence 3. Liouville's theorem 4. The significance of energy 5. The statistical matrix 6. Statistical distributions in quantum statistics 7. Entropy 8. The law of increase of entropy 	<i>I</i> 6 9 11 14 21 23 29
II. THERMODYNAMIC QUANTITIES	
 9 Y. Temperature 10. Macroscopic motion 11. Adiabatic processes 12. Pressure Work and quantity of heat 14. The heat function The free energy and the thermodynamic potential Relations between the derivatives of thermodynamic quantities 17. The thermodynamic scale of temperature 18. The Joule-Thomson process 19. Maximum work Maximum work done by a body in an external medium 	34 36 38 41 44 47 48 51 55 56 57
 21 Thermodynamic inequalities 22. Let Chatelier's principle 23. Nernst's theorem 24. The dependence of the thermodynamic quantities on the number of particles 25. Equilibrium of a body in an external field 26. Rotating bodies 27. Thermodynamic relations in the relativistic region 	63 65 68 70 73 74 76

26. Rotating bodies

J. 1.	otuting	0000100					
27.	Thermod	ynamic	relations	in	the	relativistic	region

III. THE GIBBS DISTRIBUTION

28. The Gibbs distribution	79
29. The Maxwellian distribution	82
30. The probability distribution for an oscillator	87
311 The free energy in the Gibbs distribution	91
32. Thermodynamic perturbation theory	95
33. Expansion in powers of I	98

Contents

ŝ	34. Min distribution for bodies	
	35. The Gibbs distribution for a variable number of particles	104 106
	35. The Gibbs distribution for a rotatingle number of particles 36. The derivation of the thermodynamic relations from the Gibbs distribution	109
	IV. IDEAL GASES	
3	7. The Boltzmann distribution	111
	38. The Boltzmann distribution in classical statistics	113
3	39. Molecular collisions	115
2	40. Ideal gases not in equilibrium	118
	41. The free energy of an ideal Boltzmann gas	120
	42. The equation of state of an ideal gas	121
2	43. Ideal gases with constant specific heat	125
4	44. The law of equipartition	129
45	5. Monatomic ideal gases	132
	46. Monatomic gases. The effect of the electronic angular momentum	135
	47. Diatomic gases with molecules of unlike atoms. Rotation of molecules	137
	48 Diatomic gases with molecules of like atoms. Rotation of molecules	141
49	9. Diatomic gases. Vibrations of atoms	143
	50 Diatomic gases. The effect of the electronic angular momentum	146
51	1. Polyatomic gases	148
52	2. Magnetism of gases	152
	V. THE FERMI AND BOSE DISTRIBUTIONS	

53. The Fermi distribution	158
54. The Bose distribution	159
55. Fermi and Bose gases not in equilibrium	160
56. Fermi and Bose gases of elementary particles	162
57. A degenerate electron gas	166
58. The specific heat of a degenerate electron gas	168
59. Magnetism of an electron gas. Weak fields	171
60. Magnetism of an electron gas. Strong fields	175
61. A relativistic degenerate electron gas	178
62. A degenerate Bose gas	180
63. Black-body radiation	183

VI. SOLIDS

64. Solids at low temperatures	191
65. Solids at high temperatures	195
66. Debye's interpolation formula	198
67. Thermal expansion of solids	201
68. Highly anisotropic crystals	203
69. Crystal lattice vibrations	207
1 . Number density of vibrations	211
71. Phonons	215
72. Phonon creation and annihilation operators	218
73. Negative temperatures	221

VII. NON-IDEAL GASES

74. Deviations of gases from the ideal state	225
75. Expansion in powers of the density	230
76. Van der Waals formula	232
77. Relationship of the virial coefficient and the scattering amplitude	236
78. Thermodynamic quantities for a classical plasma	239

vi

	vii	
thod of correlation	functions	243

79. The method of correlation functions24380. Thermodynamic quantities for a degenerate plasma245

VIII. PHASE EQUILIBRIUM

81. Conditions of phase equilibrium	251
82. The Clapeyron-Clausius formula	255
83. The critical point	257
84. The law of corresponding states	260

IX. SOLUTIONS

263
264
265
267
268
271
274
277
279
281
283
286
289
295
300
301

X. CHEMICAL REACTIONS

101. The condition for chemical equilibrium	305
102. The law of mass action	306
103. Heat of reaction	310
104. Ionisation equilibrium	313
105. Equilibrium with respect to pair production	315

XI. PROPERTIES OF MATTER AT VERY HIGH DENSITY

106. The equation of state of matter at high density	317
107. Equilibrium of bodies of large mass	320
108. The energy of a gravitating body	327
109. Equilibrium of a neutron sphere	329

XII. FLUCTUATIONS

110. The Gaussian distribution	333
111. The Gaussian distribution for more than one variable	335
112. Fluctuations of the fundamental thermodynamic quantities	338
113. Fluctuations in an ideal gas	345
114. Poisson's formula	347
115. Fluctuations in solutions	349
116. Spatial correlation of density fluctuations	350
117. Correlation of density fluctuations in a degenerate gas	354
118. Correlations of fluctuations in time	359
119. Time correlations of the fluctuations of more than one variable	363

Contents

65
68
71
77
84
89
93
96
(

XIII. THE SYMMETRY OF CRYSTALS

128. Symmetry elements of a crystal lattice	401
129. The Bravais lattice	403
130. Crystal systems	405
131. Crystal classes	409
132. Space groups	411
133. The reciprocal lattice	413
134. Irreducible representations of space groups	416
135. Symmetry under time reversal	422
136. Symmetry properties of normal vibrations of a crystal lattice	427
137. Structures periodic in one and two dimensions	432
138. The correlation function in two-dimensional systems	436
139. Symmetry with respect to orientation of molecules	438
140 Nematic and cholesteric liquid crystals	440
141. Fluctuations in liquid crystals	442

XIV. PHASE TRANSITIONS OF THE SECOND KIND AND CRITICAL PHENOMENA

142. Phase transitions of the second kind	446
143. The discontinuity of specific heat	451
144. Effect of an external field on a phase transition	456
145. Change in symmetry in a phase transition of the second kind	459
146. Fluctuations of the order parameter	471
147. The effective Hamiltonian	478
148. Critical indices	483
149. Scale invariance	489
150. Isolated and critical points of continuous transition	493
151. Phase transitions of the second kind in a two-dimensional lattice	498
152. Van der Waals theory of the critical point	506
153. Fluctuation theory of the critical point	511

V. SURFACES

154. Surface tension	517
155. Surface tension of crystals	520
156. Surface pressure	522
157. Surface tension of solutions	524
158. Surface tension of solutions of strong electrolytes	526
159. Adsorption	527
160. Wetting	529
161. The angle of contact	531
162. Nucleation in phase transitions	533
163. The impossibility of the existence of phases in one-dimensional systems	537

V111

CONTENTS OF PART 2

Preface

Notation

I. THE NORMAL FERMI LIQUID

- 1. Elementary excitations in a quantum Fermi liquid
- 2. Interaction of quasi-particles
- 3. Magnetic susceptibility of a Fermi liquid
- 4. Zero sound
- 5. Spin waves in a Fermi liquid
- 6. A degenerate almost ideal Fermi gas with repulsion between the particles

III GREEN'S FUNCTIONS IN A FERMI SYSTEM AT T = 0

- 7. Green's functions in a macroscopic system
- 8. Determination of the energy spectrum from the Green's function
- 9. Green's function of an ideal Fermi gas
- 10. Particle momentum distribution in a Fermi liquid
- I I. Calculation of thermodynamic quantities from the Green's function
- 12. Ψ operators in the interaction representation
- 13. The diagram technique for Fermi systems
- 14. The self-energy function
- 15. The two-particle Green's function
- 16. The relation of the vertex function to the quasi-particle scattering amplitude
- 17. The vertex function for small momentum transfers

18. The relation of the vertex function to the quasi-particle interaction function 19. Identities for derivatives of the Green's function

20. Derivation of the relation between the limiting momentum and the density 21 Green's function of an almost ideal Fermi gas

III. SUPERFLUIDITY

22. Elementary excitations in a quantum Bose liquid

- 23. Superfluidity
- 24. Phonons in a liquid
 - 25. A degenerate almost ideal Bose gas
 - 26. The wave function of the condensate
- § 27. Temperature dependence of the condensate density
- § 28. Behaviour of the superfluid density near the *l*-point
- § 29. Quantized vortex filaments
- § 30. A vortex filament in an almost ideal Bose gas
- § 31. Green's functions in a Bose liquid
- § 32. The diagram technique for a Bose liquid
- § 33. Self-energy functions
- § 34. Disintegration of quasi-particles
- § 3 5. Properties of the. spectrum near its termination point

Contents of part 2

IV. GREEN'S FUNCTIONS AT NON-ZERO TEMPERATURE.

36. Green's functions at non-zero temperatures

37. Temperature Green's functions

38. The diagram technique for temperature Green's functions

V. SUPERCONDUCTIVITY

- 39. A superfluid Fermi gas. The energy spectrum
- 40. A superfluid Fermi gas. Thermodynamic properties
- 41. Green's functions in a superfluid Fermi gas
- 42. Temperature Green's functions in a superfluid Fermi gas

43. Superconductivity in metals

- 44. The superconductivity current
- 45. The Ginzburg-Landau equations
 - 46. Surface tension at the boundary of superconducting and normal phases
 - 47. The two types of superconductor
 - 48. The structure of the mixed state
 - 49. Diamagnetic susceptibility above the transition point
- 50. The Josephson effect
 - 51. Relation between current and magnetic field in a superconductor
- 52. Depth of penetration of a magnetic field into a superconductor
- 53. Superconducting alloys

§ 54. The Cooper effect for non-zero orbital angular momenta of the pair

VI. ELECTRONS IN THE CRYSTAL LATTICE

- 55. An electron in a periodic field
- 56. Effect of an external field on electron motion in a lattice
- 57. Quasi-classical trajectories
- 58. Quasi-classical energy levels
- 59. The electron effective mass tensor in the lattice
- 60. Symmetry of electron states in a lattice in a magnetic field
- 61. Electron spectra of normal metals
- 62. Green's function of electrons in a metal
- 63. The de Haas-van Alphen effect
- 64. Electron-phonon interaction
- 65. Effect of electron-phonon interaction on the electron spectrum in a metal
- 66. The electron spectrum of solid insulators
- 67. Electrons and holes in semiconductors
- 68. The electron spectrum near the degeneracy point

VII. MAGNETISM

69. Equation of motion of the magnetic moment in a ferromagnet

- 70. Magnons in a ferromagnet. The spectrum
- 71. Magnons in a ferromagnet. Thermodynamic quantities
- 72. The spin Hamiltonian
- 73. Interaction of magnons
- 74. Magnons in an antiferromagnet

VIII. ELECTROMAGNETIC FLUCI-UATIONS

75. Green's function of a photon in a medium

76. Electromagnetic field fluctuations

77. Electromagnetic fluctuations in an infinite medium

son (st. i

Contents of part 2

this course, now being prepared by Pitacvskil and myself, which will also

- § 78. Current fluctuations in linear circuits
- § 79. Temperature Green's function of a photon in a medium
- § 80. The van der Waals stress tensor
- § 81. Forces of molecular interaction between solid bodies. The general formula
- § 82. Forces of molecular interaction between solid bodies. Limiting cases
- § 83. Asymptotic behaviour of the correlation function in a liquid
- § 84. Operator expression for the permittivity
- § 85. A degenerate plasma

IX. HYDRODYNAMIC FLUCTUATIONS

- § 86. Dynamic form factor of a liquid
- § 87. Summation rules for the form factor
- § 88. Hydrodynamic fluctuations
- § 89. Hydrodynamic fluctuations in an infinite medium
- § 90. Operator expressions for the transport coefficients
- § 91. Dynamic form factor of a Fermi liquid

Index