

Contents

<i>Preface</i>	<i>page xi</i>
<i>Acknowledgements</i>	xv
1 The laws of thermodynamics	1
1.1 The thermodynamic system and processes	1
1.2 The zeroth law of thermodynamics	1
1.3 The thermal equation of state	2
1.4 The classical ideal gas	4
1.5 The quasistatic and reversible processes	7
1.6 The first law of thermodynamics	7
1.7 The heat capacity	8
1.8 The isothermal and adiabatic processes	10
1.9 The enthalpy	12
1.10 The second law of thermodynamics	12
1.11 The Carnot cycle	14
1.12 The thermodynamic temperature	15
1.13 The Carnot cycle of an ideal gas	19
1.14 The Clausius inequality	22
1.15 The entropy	24
1.16 General integrating factors	26
1.17 The integrating factor and cyclic processes	28
1.18 Hausen's cycle	30
1.19 Employment of the second law of thermodynamics	31
1.20 The universal integrating factor	32
Exercises	34
2 Thermodynamic relations	38
2.1 Thermodynamic potentials	38
2.2 Maxwell relations	41

2.3	The open system	42
2.4	The Clausius–Clapeyron equation	44
2.5	The van der Waals equation	46
2.6	The grand potential	48
	Exercises	48
3	The ensemble theory	50
3.1	Microstate and macrostate	50
3.2	Assumption of equal <i>a priori</i> probabilities	52
3.3	The number of microstates	52
3.4	The most probable distribution	53
3.5	The Gibbs paradox	55
3.6	Resolution of the Gibbs paradox: quantum ideal gases	56
3.7	Canonical ensemble	58
3.8	Thermodynamic relations	61
3.9	Open systems	63
3.10	The grand canonical distribution	63
3.11	The grand partition function	64
3.12	The ideal quantum gases	66
	Exercises	67
4	System Hamiltonians	69
4.1	Representations of the state vectors	69
4.2	The unitary transformation	76
4.3	Representations of operators	77
4.4	Number representation for the harmonic oscillator	78
4.5	Coupled oscillators: the linear chain	82
4.6	The second quantization for bosons	84
4.7	The system of interacting fermions	88
4.8	Some examples exhibiting the effect of Fermi–Dirac statistics	91
4.9	The Heisenberg exchange Hamiltonian	94
4.10	The electron–phonon interaction in a metal	95
4.11	The dilute Bose gas	99
4.12	The spin-wave Hamiltonian	101
	Exercises	105
5	The density matrix	106
5.1	The canonical partition function	106
5.2	The trace invariance	107
5.3	The perturbation expansion	108
5.4	Reduced density matrices	110
5.5	One-site and two-site density matrices	111

5.6	The four-site reduced density matrix	114
5.7	The probability distribution functions for the Ising model	121
	Exercises	125
6	The cluster variation method	127
6.1	The variational principle	127
6.2	The cumulant expansion	128
6.3	The cluster variation method	130
6.4	The mean-field approximation	131
6.5	The Bethe approximation	134
6.6	Four-site approximation	137
6.7	Simplified cluster variation methods	141
6.8	Correlation function formulation	144
6.9	The point and pair approximations in the CFF	145
6.10	The tetrahedron approximation in the CFF	147
	Exercises	152
7	Infinite-series representations of correlation functions	153
7.1	Singularity of the correlation functions	153
7.2	The classical values of the critical exponent	154
7.3	An infinite-series representation of the partition function	156
7.4	The method of Padé approximants	158
7.5	Infinite-series solutions of the cluster variation method	161
7.6	High temperature specific heat	165
7.7	High temperature susceptibility	167
7.8	Low temperature specific heat	169
7.9	Infinite series for other correlation functions	172
	Exercises	173
8	The extended mean-field approximation	175
8.1	The Wentzel criterion	175
8.2	The BCS Hamiltonian	178
8.3	The s - d interaction	184
8.4	The ground state of the Anderson model	190
8.5	The Hubbard model	197
8.6	The first-order transition in cubic ice	203
	Exercises	209
9	The exact Ising lattice identities	212
9.1	The basic generating equations	212
9.2	Linear identities for odd-number correlations	213
9.3	Star-triangle-type relationships	216
9.4	Exact solution on the triangular lattice	218

9.5	Identities for diamond and simple cubic lattices	221
9.6	Systematic naming of correlation functions on the lattice	221
	Exercises	227
10	Propagation of short range order	230
10.1	The radial distribution function	230
10.2	Lattice structure of the superionic conductor αAgI	232
10.3	The mean-field approximation	234
10.4	The pair approximation	235
10.5	Higher order correlation functions	237
10.6	Oscillatory behavior of the radial distribution function	240
10.7	Summary	244
11	Phase transition of the two-dimensional Ising model	246
11.1	The high temperature series expansion of the partition function	246
11.2	The Pfaffian for the Ising partition function	248
11.3	Exact partition function	253
11.4	Critical exponents	259
	Exercises	260
<i>Appendix 1</i>	The gamma function	261
<i>Appendix 2</i>	The critical exponent in the tetrahedron approximation	265
<i>Appendix 3</i>	Programming organization of the cluster variation method	269
<i>Appendix 4</i>	A unitary transformation applied to the Hubbard Hamiltonian	278
<i>Appendix 5</i>	Exact Ising identities on the diamond lattice	281
<i>References</i>		285
<i>Bibliography</i>		289
<i>Index</i>		291