

Contents

1	Back to Basics	1
1.1	The Role of Statistical Mechanics	1
1.2	Introduction to Coin Tossing	2
1.3	Heads I Win, Tails You Lose	2
1.4	Stirling's Theorem	5
1.5	More Flipping Coins	6
1.6	Distinguishable Particles	8
1.7	Summary	11
1.8	Problems	12
2	The Statistics of Distinguishable Particles	14
2.1	The Boltzmann Distribution for Distinguishable Particles	14
2.2	Lagrange's Method of Undetermined Multipliers	15
2.3	The Single-Particle Partition Function	21
2.4	Degeneracy	22
2.5	The Partition Function of a System	23
2.6	Summary	25
2.7	Problems	26
3	Paramagnets and Oscillators	29
3.1	A Spin-1/2 Paramagnet	29
3.2	Paramagnets with Angular Momentum \mathbf{J}	34
3.3	The Simple Harmonic Oscillator	36
3.3.1	An Array of 1-D Simple Harmonic Oscillators	36
3.3.2	An Array of 3-D Simple Harmonic Oscillators	38
3.4	Summary	40
3.5	Problems	41
4	Indistinguishable Particles and Monatomic Ideal Gases	43
4.1	Distinguishable and Indistinguishable States	43
4.2	Identical Gas Particles – Counting the States	45
4.3	The Partition Function of a Monatomic Ideal Gas	51
4.4	Properties of the Monatomic Ideal Gas	52
4.5	More about Adiabatic Expansions	53

4.6	Maxwell–Boltzmann Distribution of Speeds	56
4.7	Gibbs Paradox	56
4.8	Summary	59
4.9	Problems	61
5	Diatomic Ideal Gases	62
5.1	Other Degrees of Freedom	62
5.2	Rotational Heat Capacities for Diatomic Gases	63
5.3	The Vibrational Partition Function of a Diatomic Gas	65
5.4	Putting it All Together for an Ideal Gas	66
5.5	Summary	67
5.6	Problems	68
6	Quantum Statistics	69
6.1	Indistinguishable Particles and Quantum Statistics	69
6.2	Bose–Einstein Statistics	71
6.3	Fermi–Dirac Statistics	73
6.4	More on the Quantum Distribution Functions	73
6.5	Summary	76
6.6	Problems	76
7	Electrons in Metals	77
7.1	Fermi–Dirac Statistics: Electrons in Metals	77
7.2	The Heat Capacity of a Fermi Gas	79
7.3	The Quantum–Classical Transition	82
7.4	Summary	85
7.5	Problems	86
8	Photons and Phonons	88
8.1	The Photon Gas	88
8.2	Generalized Derivation of the Density of States	89
8.3	Blackbody Radiation	90
8.4	Phonons	92
8.5	Summary	93
8.6	Problems	94
9	Bose–Einstein Condensation	97
9.1	Introduction	97
9.2	The Phenomenon of Bose–Einstein Condensation	97
9.3	The Quantum–Classical Transition Revisited	102
9.4	Summary	102
9.5	Problems	103
10	Ensembles	104
10.1	Introduction	104
10.2	The Chemical Potential	106

10.3	Ensembles and Probabilities	107
10.4	The Fermi–Dirac and Bose–Einstein Distributions Revisited	110
10.5	Fermi–Dirac Distribution Revisited	110
10.6	Bose–Einstein Distribution Revisited	111
10.7	Summary	111
10.8	Problems	112
11	The End is in Sight	113
11.1	Phase Space	113
11.2	Equipartition of Energy	115
11.3	Route Map through Statistical Mechanics	116
11.4	Summary	118
11.5	Problems	118
A	Worked Answers to Problems	119
A.1	Chapter 1	119
A.2	Chapter 2	120
A.3	Chapter 3	122
A.4	Chapter 4	124
A.5	Chapter 5	125
A.6	Chapter 6	126
A.7	Chapter 7	126
A.8	Chapter 8	128
A.9	Chapter 9	132
A.10	Chapter 10	133
A.11	Chapter 11	134
B	Useful Integrals	137
C	Physical Constants	138
D	Bibliography	139
	Index	140