Contents

Preface *page* ix

1 Thermodynamic entropy 1
1.1 Thermodynamics and entropy 1
1.2 Reversible and irreversible processes 2
1.3 The second law of thermodynamics 5
1.4 Entropy and irreversibility 7
1.5 Quantifying irreversibility 9
1.6 The Carnot efficiency and Carnot's theorem 13
1.7 Absolute or thermodynamic temperature 15
1.8 Consequences of the second law 18
1.9 Equations of state 21
1.10 The third law of thermodynamics 27
Problems 28

2 Statistical entropy 32
2.1 Boltzmann and atoms 32
2.2 Microstates and macrostates 33
2.3 Fundamental postulate 36
2.4 Statistical entropy and multiplicity 39
2.5 Maxwell's demon 47
2.6 Relative versus absolute entropy 49
Problems 50

3 Entropy of classical systems 53
3.1 Ideal gas: volume dependence 53
3.2 Ideal gas: volume and energy dependence 54
3.3 Imposing extensivity 58
3.4 Occupation numbers 60

3.5	Ideal classical gas	66
3.6	Ideal classical solid	67
3.7	Boltzmann's tomb	71
	Problems	73
4	**Entropy of quantized systems**	75
4.1	Quantum conditions	75
4.2	Quantized harmonic oscillators	76
4.3	Einstein solid	81
4.4	Phonons	82
4.5	Third law	85
4.6	Paramagnetism	88
4.7	Negative absolute temperature	90
	Problems	93
5	**Entropy of a non-isolated system**	96
5.1	Beyond the fundamental postulate	96
5.2	The Gibbs entropy formula	97
5.3	Canonical ensemble	100
5.4	Partition functions	102
5.5	Entropy metaphors	103
	Problems	104
6	**Entropy of fermion systems**	105
6.1	Symmetries and wave functions	105
6.2	Intrinsic semiconductors	106
6.3	Ideal Fermi gas	110
6.4	Average energy approximation	118
	Problems	120
7	**Entropy of systems of bosons**	122
7.1	Photons	122
7.2	Blackbody radiation	123
7.3	Ideal Bose gas	126
7.4	Bose–Einstein condensate	133
7.5	Modeling the ideal gas	136
	Problems	138
8	**Entropy of information**	140
8.1	Messages and message sources	140
8.2	Hartley's information	141
8.3	Information and entropy	143

8.4 Shannon entropy 145
8.5 Fano code 148
8.6 Data compression and error correction 151
8.7 Missing information and statistical physics 153
Problems 156

Epilogue 159
Appendix I *Physical constants and standard definitions* 161
Appendix II *Formulary* 162
Appendix III *Glossary* 163
Appendix IV *Time line* 169
Appendix V *Answers to problems* 172
Appendix VI *Annotated further reading* 175
Index 178