BRIEF CONTENTS

PART 1. Relativity

CHAPTER 1 The Space and Time of Relativity ........................................ 2
CHAPTER 2 Relativistic Mechanics ......................................................... 46

PART 2. Quantum Mechanics

CHAPTER 3 Atoms ................................................................................. 86
CHAPTER 4 Quantization of Light ......................................................... 125
CHAPTER 5 Quantization of Atomic Energy Levels ............................ 144
CHAPTER 6 Matter Waves ................................................................... 168
CHAPTER 7 The Schrödinger Equation in One Dimension ................. 203
CHAPTER 8 The Three-Dimensional Schrödinger Equation .............. 248
CHAPTER 9 Electron Spin ..................................................................... 287
CHAPTER 10 Multielectron Atoms; the Pauli Principle and Periodic Table .... 307
CHAPTER 11 Atomic Transitions and Radiation ............................... 334

PART 3. Systems with Two or More Atoms

CHAPTER 12 Molecules ...................................................................... 368
CHAPTER 13 Solids – Theory ............................................................... 409
CHAPTER 14 Solids – Applications .................................................... 454
CHAPTER 15 Statistical Mechanics ..................................................... 495

PART 4. Subatomic Physics

CHAPTER 16 The Structure of Atomic Nuclei ....................................... 534
CHAPTER 17 Radioactivity and Nuclear Reactions ............................ 568
CHAPTER 18 Elementary Particles ....................................................... 628

APPENDIX A Physical Constants ....................................................... 678
APPENDIX B Useful Mathematical Relations ..................................... 681
APPENDIX C Alphabetical Lists of the Elements ............................. 684
APPENDIX D Atomic and Nuclear Data ............................................... 686

Suggestions for Further Reading ....................................................... 697
Picture Credits and References ....................................................... 699
Answers to Odd-Numbered Problems ........................................... 700
Index ................................................................................................. 710
CONTENTS

Preface xiii
To the Student xvii

PART 1. Relativity

CHAPTER 1. The Space and Time of Relativity 2
  1.1 Relativity 2
  1.2 The Relativity of Orientation and Origin 3
  1.3 Moving Reference Frames 4
  1.4 Classical Relativity and the Speed of Light 7
  1.5 The Michelson–Morley Experiment* 10
  1.6 The Postulates of Relativity 12
  1.7 Measurement of Time 14
  1.8 The Relativity of Time; Time Dilation 15
  1.9 Evidence for Time Dilation 19
  1.10 Length Contraction 21
  1.11 The Lorentz Transformation 25
  1.12 Applications of the Lorentz Transformation 28
  1.13 The Velocity–Addition Formula 32
  1.14 The Doppler Effect* 34
  Checklist for Chapter 1 39
  Problems for Chapter 1 40

CHAPTER 2. Relativistic Mechanics 46
  2.1 Introduction 46
  2.2 Mass in Relativity 46
  2.3 Relativistic Momentum 47
  2.4 Relativistic Energy 51
  2.5 Two Useful Relations 56
  2.6 Conversion of Mass to Energy 59
  2.7 Force in Relativity 64
  2.8 Massless Particles 67
  2.9 When Is Nonrelativistic Mechanics Good Enough? 70
  2.10 General Relativity* 71
  2.11 The Global Positioning System: An Application of Relativity* 78
  Checklist for Chapter 2 79
  Problems for Chapter 2 80

PART 2. Quantum Mechanics

CHAPTER 3. Atoms 86
  3.1 Introduction 86
  3.2 Elements, Atoms, and Molecules 86

*Sections marked with a star can be omitted without serious loss of continuity.
CHAPTER 10. Multielectron Atoms; the Pauli Principle and Periodic Table  307

10.1  Introduction  307
10.2  The Independent-Particle Approximation  308
10.3  The IPA Energy Levels  310
10.4  The Pauli Exclusion Principle  312
10.5  Fermions and Bosons; the Origin of the Pauli Principle*  314
10.6  Ground States of the First Few Elements  316
10.7  The Remaining Elements  320
10.8  The Periodic Table  324
10.9  Excited States of Atoms*  327
Checklist for Chapter 10  330
Problems for Chapter 10  331

CHAPTER 11. Atomic Transitions and Radiation  334

11.1  Introduction  334
11.2  Radiation by Classical Charges  334
11.3  Stationary States and Transitions  337
11.4  More Quantum Formalism*  338
11.5  Transitions; Time-Dependent Perturbation Theory*  343
11.6  A Brief Review  349
11.7  Spontaneous Emission  349
11.8  Atomic Selection Rules  350
11.9  Lasers  352
11.10  Further Properties of Lasers*  357
Checklist for Chapter 11  362
Problems for Chapter 11  363

PART 3. Systems with Two or More Atoms

CHAPTER 12. Molecules  368

12.1  Introduction  368
12.2  Overview of Molecular Properties  370
12.3  The Ionic Bond  375
12.4  The Covalent Bond  379
12.5  Directional Properties of Covalent Bonds*  387
12.6  Excited States of Molecules*  389
12.7  Molecular Spectra*  397
Checklist for Chapter 12  403
Problems for Chapter 12  403


13.1  Introduction  409
13.2  Bonding of Solids  411
13.3  Crystals and Noncrystals  415
13.4  Energy Levels of Electrons in a Solid; Bands  420
13.5  Conductors and Insulators — A Qualitative View  422
13.6  The Drude Model of Conductivity  425
13.7  Electron Collisions in Metals  429
13.8  The Fermi Speed  432
13.9 Degeneracy Pressure  436
13.10 White Dwarfs, Neutron Stars, and Black Holes  438
13.11 Classical and Quantum Gases  440
13.12 Bose–Einstein Condensation  445
Checklist for Chapter 13  448
Problems for Chapter 13  449

CHAPTER 14. Solids – Applications  454
14.1 Introduction  454
14.2 Semiconductors  455
14.3 The $pn$ Junction Diode  460
14.4 The Transistor  463
14.5 Further Semiconductor Applications  466
14.6 Integrated Circuits  470
14.7 The Scanning Tunneling Microscope  473
14.8 Superconductivity  479
14.9 The Digital Information Age  485
Checklist for Chapter 14  489
Problems for Chapter 14  489

CHAPTER 15. Statistical Mechanics  495
15.1 Introduction  495
15.2 Temperature  496
15.3 The Boltzmann Factor  499
15.4 Counting Microstates: The Equal-Probability Hypothesis  503
15.5 The Origin of the Boltzmann Relation  508
15.6 Entropy and the Second Law of Thermodynamics  511
15.7 The Quantum Ideal Gas — A Many-Particle System  513
15.8 Energy and Speed Distributions in an Ideal Gas  516
15.9 Heat Capacities  521
Checklist for Chapter 15  526
Problems for Chapter 15  527

PART 4. Subatomic Physics

CHAPTER 16. The Structure of Atomic Nuclei  534
16.1 Introduction  534
16.2 Nuclear Properties  535
16.3 The Nuclear Force  539
16.4 Electrons versus Neutrons as Nuclear Constituents  541
16.5 The IPA Potential Energy for Nucleons  544
16.6 The Pauli Principle and the Symmetry Effect  546
16.7 The Semiempirical Binding-Energy Formula  548
16.8 The Shell Model  553
16.9 Mass Spectrometers  560
Checklist for Chapter 16  562
Problems for Chapter 16  563