

CONTENTS

Preface	ix	Chapter 3 Wave Properties of Particles	73
List of Abbreviations	xi	3.1 De Broglie Waves	73
		3.2 Wave Function	74
		3.3 De Broglie Wave Velocity	76
		3.4 Phase and Group Velocities	79
		3.5 The Diffraction of Particles	82
		3.6 The Uncertainty Principle	86
		3.7 Applications of the Uncertainty Principle	91
		3.8 The Wave-particle Duality	93
		Problems	96
PART ONE BASIC CONCEPTS			
Chapter 1 Special Relativity	3		
1.1 The Michelson-Morley Experiment	3		
1.2 The Special Theory of Relativity	9		
1.3 Time Dilation	12		
1.4 The Twin Paradox	16		
1.5 Length Contraction	17		
1.6 Meson Decay	20		
°1.7 The Lorentz Transformation	22		
°1.8 The Inverse Lorentz Transformation	27		
°1.9 Velocity Addition	28		
1.10 The Relativity of Mass	30		
1.11 Mass and Energy	35		
1.12 Mass and Energy: Alternative Derivation	37		
Problems	39		
Chapter 2 Particle Properties of Waves	43		
2.1 The Photoelectric Effect	43		
2.2 The Quantum Theory of Light	47		
2.3 X Rays	51		
2.4 X-Ray Diffraction	56		
2.5 The Compton Effect	60		
2.6 Pair Production	63		
°2.7 Gravitational Red Shift	66		
Problems	70		
PART TWO THE ATOM			
Chapter 4 Atomic Structure	101		
4.1 Atomic Models	101		
°4.2 Alpha-particle Scattering	105		
°4.3 The Rutherford Scattering Formula	109		
4.4 Nuclear Dimensions	112		
4.5 Electron Orbits	113		
4.6 Atomic Spectra	117		
4.7 The Bohr Atom	121		
4.8 Energy Levels and Spectra	125		
4.9 Nuclear Motion	129		
4.10 Atomic Excitation	131		
4.11 The Correspondence Principle	133		
Problems	135		
Chapter 5 Quantum Mechanics	139		
5.1 Introduction to Quantum Mechanics	139		
5.2 The Wave Equation	140		

5.3	Schrödinger's Equation: Time-dependent Form	143	PART THREE	
5.4	Expectation Values	145	PROPERTIES OF MATTER	
5.5	Schrödinger's Equation: Steady-state Form	146	Chapter 8 The Physics of Molecules	243
5.6	The Particle in a Box: Energy Quantization	149	8.1 Molecular Formation	243
5.7	The Particle in a Box: Wave Functions	153	8.2 Electron Sharing	245
5.8	The Particle in a Nonrigid Box	156	8.3 The H ₂ ⁺ Molecular Ion	247
5.9	The Harmonic Oscillator	158	8.4 The H ₂ Molecule	252
*5.10	The Harmonic Oscillator: Solution of Schrödinger's Equation Problems	163	8.5 Molecular Orbitals	254
		169	8.6 Hybrid Orbitals	261
			8.7 Carbon-carbon Bonds	265
			8.8 Rotational Energy Levels	269
			8.9 Vibrational Energy Levels	272
			8.10 Electronic Spectra of Molecules	281
Chapter 6 Quantum Theory of the Hydrogen Atom		173	Chapter 9 Statistical Mechanics	287
6.1	Schrödinger's Equation for the Hydrogen Atom	173	9.1 Statistical Distribution Laws	287
*6.2	Separation of Variables	176	9.2 Phase Space	288
*6.3	Quantum Numbers	178	*9.3 Maxwell-Boltzmann Distribution	289
6.4	Principal Quantum Number	180	*9.4 Evaluation of Constants	293
6.5	Orbital Quantum Number	180	9.5 Molecular Energies in an Ideal Gas	295
6.6	Magnetic Quantum Number	184	9.6 Rotational Spectra	298
6.7	The Normal Zeeman Effect	187	*9.7 Bose-Einstein Distribution	300
6.8	Electron Probability Density	189	9.8 Black-body Radiation	304
6.9	Radiative Transitions	196	*9.9 Fermi-Dirac Distribution	309
6.10	Selection Rules	198	9.10 Comparison of Results	310
	Problems	200	9.11 The Laser	311
			Problems	314
Chapter 7 Many-electron Atoms		203	Chapter 10 The Solid State	317
7.1	Electron Spin	203	10.1 Crystalline and Amorphous Solids	317
7.2	Spin-orbit Coupling	207	10.2 Ionic Crystals	318
7.3	The Exclusion Principle	210	10.3 Covalent Crystals	325
7.4	Electron Configurations	213	10.4 Van Der Waals Forces	327
7.5	The Periodic Table	215	10.5 The Metallic Bond	331
7.6	Hund's Rule	222	10.6 The Band Theory of Solids	333
*7.7	Total Angular Momentum	222	*10.7 The Fermi Energy	339
*7.8	LS Coupling	226	*10.8 Electron-energy Distribution	342
*7.9	<i>jj</i> Coupling	228	*10.9 Brillouin Zones	344
*7.10	One-electron Spectra	229	*10.10 Origin of Forbidden Bands	346
*7.11	Two-electron Spectra	232	10.11 Effective Mass	355
7.12	X-ray Spectra	235	Problems	355
	Problems	237		

PART FOUR THE NUCLEUS

Chapter 11 The Atomic Nucleus	361	12.9 Cross Section	413
11.1 Atomic Masses	361	12.10 The Compound Nucleus	417
11.2 The Neutron	364	12.11 Nuclear Fission	420
11.3 Stable Nuclei	366	12.12 Transuranic Elements	423
11.4 Nuclear Sizes and Shapes	370	12.13 Thermonuclear Energy	424
11.5 Binding Energy	372	Problems	427
*11.6 The Deuteron	374		
*11.7 Ground State of the Deuteron	377	Chapter 13 Elementary Particles	431
11.8 Triplet and Singlet States	379	13.1 Antiparticles	431
11.9 The Liquid-drop Model	380	13.2 Meson Theory of Nuclear Forces	433
11.10 The Shell Model	383	13.3 Pions and Muons	436
Problems	387	13.4 Kaons and Hyperons	438
		13.5 Systematics of Elementary Particles	439
Chapter 12 Nuclear Transformations	389	13.6 Strangeness Number	444
12.1 Radioactive Decay	389	13.7 Isotopic Spin	446
12.2 Radioactive Series	393	13.8 Symmetries and Conservation Principles	447
12.3 Alpha Decay	396	13.9 Theories of Elementary Particles	451
*12.4 Barrier Penetration	399	Problems	
*12.5 Theory of Alpha Decay	404		
12.6 Beta Decay	408	Answers to Odd-numbered Problems	457
12.7 Inverse Beta Decay	411		
12.8 Gamma Decay	412	Index	461