

Contents

Introduction	1
1 Perceptions of Ancient Scientists	9
1.1 The Theory of Basic Matter	10
1.2 Transformation Concepts of the Alchemists	10
1.3 The Phlogiston Theory	11
1.4 Historic Acid–Base Theories	12
1.5 “Horror Vacui” and the Particle Concept	14
1.6 Atoms and the Structure of Matter	15
References	20
2 Students’ Misconceptions and How to Overcome Them	21
2.1 Students’ Preconcepts	21
2.2 School-Made Misconceptions	24
2.3 Students’ Concepts and Scientific Language	26
2.4 Effective Strategies for Teaching and Learning	28
References	33
Further Reading	34
3 Substances and Properties	37
3.1 Animistic Modes of Speech	38
3.2 Concepts of Transformation	39
3.3 Concepts of Miscibility for Compounds	41
3.4 Concepts of Destruction	43
3.5 Concepts of Combustion	46
3.6 Concepts of “Gases as not Substances”	50
3.7 Experiments on Substances and Their Properties	52
References	64
Further Reading	65
4 Particle Concept of Matter	67
4.1 Smallest Particles of Matter and Mental Models	69
4.2 Preformed and Non-preformed Particles	73

4.3	Smallest Particles as Portions of Matter	76
4.4	Particles and the “Horror Vacui”	78
4.5	Particles – Generic Term for Atoms, Ions and Molecules	82
4.6	Formation of Particles and Spatial Ability	83
4.7	Diagnosis Test for Understanding the Particle Model of Matter	86
4.8	Experiments on Particle Model of Matter	93
	References	99
	Further Reading	100
5	Structure–Property Relationships	103
5.1	Structure and Properties of Metals and Alloys	103
5.2	Existence of Ions and Structure of Salts	108
5.3	Mental Models on Ionic Bonding	115
5.4	Chemical Structures and Symbolic Language	125
5.5	Experiments on Structure–Property Relationships	130
	References	140
	Further Reading	142
6	Chemical Equilibrium	145
6.1	Overview of the Most Common Misconceptions	145
6.2	Empirical Research	146
6.3	Teaching and Learning Suggestions	156
6.4	Experiments on Chemical Equilibrium	165
	References	169
	Further Reading	170
7	Acid–Base Reactions	173
7.1	Acid–Base Reactions and the Proton Transfer	173
7.2	Misconceptions	175
7.3	Teaching and Learning Suggestions	183
7.4	Experiments on Acids and Bases	193
	References	204
	Further Reading	204
8	Redox Reactions	207
8.1	Misconceptions	209
8.2	Teaching and Learning Suggestions	217
8.3	Experiments on Redox Reactions	226
	References	231
	Further Reading	232
9	Complex Reactions	235
9.1	Misconceptions	237
9.2	Teaching and Learning Suggestions	245

9.3 Experiments on Complex Reactions	252
References	259
10 Energy	261
10.1 Misconceptions	262
10.2 Empirical Research	265
10.3 Energy and Temperature	269
10.4 Fuel and Chemical Energy	272
10.5 Experiments on Energy	279
References	286
Further Reading	287
List of Experiments	289
Epilogue	293