

Contents

1 The quantum mechanical basis of the Periodic Table 1

- 1.1 Introduction 1
- 1.2 Atomic orbitals 1
- 1.3 Polyelectronic atoms 6
- 1.4 The modern Periodic Table 11
- 1.5 Exchange energies 14
- 1.6 Closed shells and half-filled shells 15
- 1.7 Orbital types and the Periodic Table 17
- 1.8 Angular part of the wave function 19
- 1.9 Radial part of the wave function 24
- 1.10 Commonality of electronic configurations 27
- 1.11 Nuclear stabilities 29
- 1.12 Summary 33

2 Vertical trends for the s and p block elements 35

- 2.1 Trends associated with properties of isolated atoms 35
- 2.2 Trends associated with the physical properties of elements 46
- 2.3 Trends associated with the chemical properties of the elements 59
- 2.4 Structural and bonding aspects of compounds 70
- 2.5 Trends associated with physical properties of compounds 93
- 2.6 Trends in chemical properties of compounds 104
- 2.7 Modification of properties using steric and electronic effects 113
- 2.8 Tables of properties and summaries of trends 124

3 Horizontal and diagonal trends for the s and p block elements 162

- 3.1 Introduction 162
- 3.2 Variations in atomic properties 162
- 3.3 Variations in physical properties of the elements 169
- 3.4 Variations in chemical properties 173
- 3.5 Ionic-covalent transition 177

- 3.6 Oxides 181
- 3.7 Hydrides 184
- 3.8 Common oxidizing and reducing agents 187
- 3.9 Catenation 194
- 3.10 Lone pairs and empty orbitals 195
- 3.11 Comparison of N and $N + 10$ groups 196
- 3.12 Diagonal relationships 202
- 3.13 Diagonal relationships in rows 2 and 3 207

4 Isoelectronic and isostoichiometric relationships 211

- 4.1 Introduction 211
- 4.2 Isoelectronic molecules and ions 213
- 4.3 Reactivity consequences of the structure matrix 222
- 4.4 Reactivity patterns for isoelectronic molecules 225
- 4.5 Octet rule, hybridization schemes, and multiple bonding 228
- 4.6 Molecular orbital analysis 248
- 4.7 Isoelectronic relationships in catenated and polyhedral molecules 254
- 4.8 Zintl isoelectronic relationships 262
- 4.9 Isoelectronic relationships in infinite solids 263
- 4.10 Isostoichiometric relationships 267

5 Transition elements (d block), lanthanides, and actinides (f block elements) 273

- 5.1 Introduction 273
- 5.2 Trends associated with isolated atoms 275
- 5.3 Physical properties of the metals 279
- 5.4 Chemical properties of the metals 283
- 5.5 General bonding considerations 286
- 5.6 Chemical properties of compounds 346
- 5.7 Vertical trends associated with the transition metals 361
- 5.8 Lanthanides 373
- 5.9 Actinides 380

Index 389