

# Contents

Preface.....	xv
Acknowledgements.....	xvii

<b>Chapter 1</b>	<b>General Chemistry</b> .....	1
1.1	Matter.....	1
1.1.1	Classes of Matter.....	1
1.1.2	Properties of Matter.....	2
1.1.3	States of Matter.....	2
1.1.4	Law of Conservation of Mass.....	2
1.1.5	Law of Definite Proportions.....	3
1.1.6	Law of Multiple Proportions.....	3
1.2	Atomic Structure.....	3
1.2.1	Constituents of the Atom.....	3
1.2.2	Atomic Masses.....	4
1.2.3	The Mole.....	5
1.2.4	Quantum Numbers.....	6
1.2.5	Atomic Orbitals.....	9
1.3	Electron Configuration and Periodic Trends.....	10
1.3.1	Electronic Configuration of the Elements.....	11
1.3.2	Periodic Table of Elements.....	14
1.3.3	Ionization Energy.....	15
1.3.4	Electronegativity.....	16
1.3.5	Atomic Radius.....	18
1.3.6	Atomic Mass.....	20
1.4	Types of Chemical Bonds.....	21
1.4.1	Covalent Bonds.....	21
1.4.2	Coordinate Covalent Bonds (Dative Bond).....	21
1.4.3	Ionic Bonds.....	22
1.4.4	Metallic Bonds.....	22
1.5	Chemical Bonding.....	22
1.5.1	Lewis Theory.....	22
1.5.2	Valence Bond Theory.....	26
1.5.3	Molecular Orbital Theory.....	32
1.5.4	Valence Shell Electron Pair Repulsion Theory.....	36
1.6	Chemical Formulas and Equations.....	38
1.6.1	Chemical Formula Anatomy.....	38
1.6.2	Chemical Equation Anatomy.....	39
1.7	Classification of Chemical Reactions.....	39
1.7.1	Synthesis Reactions.....	40
1.7.2	Decomposition Reactions.....	41
1.7.3	Single Replacement Reactions.....	41
1.7.4	Double Replacement Reactions.....	42
1.7.5	Combustion.....	42
1.8	Activity Series of Metals.....	42
1.9	Gases.....	43
1.9.1	Boyle's Law.....	43
1.9.2	Charles's Law.....	44

1.9.3	Gay-Lussac's Law	44
1.9.4	Avogadro's Law	44
1.9.5	Combined Gas Law	44
1.9.6	Dalton's Law of Partial Pressures	44
1.9.7	Ideal Gas Law	44
1.9.8	Gas Density and Molar Mass	45
1.9.9	Kinetic Molecular Theory	45
1.9.10	Root-Mean-Square Speed	45
1.9.11	Diffusion and Effusion	45
1.9.12	Equation of State of Real Gases	46
1.10	Intermolecular Forces: Liquids and Solids	46
1.10.1	London Forces (Dispersion)	46
1.10.2	Dipole-Dipole Bonding	47
1.10.3	Hydrogen Bonding	47
1.10.4	Ion-Dipole Bonding (Solvation)	47
1.10.5	Liquids	47
1.10.6	Solids	49
1.10.7	Phase Change Diagram	51
1.10.8	Phase Diagram	51
1.11	Solutions	53
1.11.1	Mass Percent	53
1.11.2	Mole Fraction ( $X$ )	53
1.11.3	Molarity ( $M$ )	53
1.11.4	Molality ( $m$ )	53
1.11.5	Dilutions	53
1.12	Acids and Bases	53
1.12.1	Arrhenius Concept	53
1.12.2	Bronsted-Lowery Concept	54
1.12.3	Lewis Concept	54
1.12.4	Ion Product of Water	54
1.12.5	pH	55
1.12.6	Ionic Equilibrium	55
1.12.7	Relationship between $K_a$ and $K_b$ Conjugate Pair	56
1.12.8	Hydrolysis	56
1.12.9	Salt of a Strong Acid—Strong Base	56
1.12.10	Salt of a Strong Acid—Weak Base	56
1.12.11	Salt of a Weak Acid—Strong Base	57
1.13	Thermodynamics	57
1.13.1	First Law of Thermodynamics	57
1.13.2	Enthalpy	58
1.13.3	Entropy	58
1.13.4	Gibbs Free Energy	58
1.13.5	Standard States	58
1.13.6	Hess's Law of Heat Summation	58
1.14	Equilibria	59
1.14.1	Homogeneous Equilibrium	60
1.14.2	Heterogeneous Equilibrium	60
1.14.3	Le Chatelier's Principle	61
1.14.4	Solubility Product	61
1.14.5	Common Ion Effect	62
1.15	Kinetics	62
1.15.1	Zero-Order Reactions	62
1.15.2	First-Order Reactions	62
1.15.3	Second-Order Reactions	62
1.15.4	Collision Theory	63
1.15.5	Transition State Theory	63
1.15.6	Catalysts	64

1.16	Electrochemistry.....	65
1.16.1	Oxidation-Reduction .....	65
1.16.2	Redox Reagents .....	65
1.16.3	Balancing Redox Reactions.....	65
1.16.4	Galvanic Cells.....	68
1.16.5	Cell Potential.....	69
<b>Chapter 2</b>	<b>Inorganic Chemistry</b> .....	<b>73</b>
2.1	Group IA Elements.....	73
2.2	Group IIA Elements .....	74
2.3	Group IIIA Elements .....	75
2.4	Group IVA Elements.....	76
2.5	Group VA Elements .....	76
2.6	Group VIA Elements.....	76
2.7	Group VIIA Elements .....	77
2.8	Group VIIIA Elements .....	77
2.9	Transition Metal Elements.....	78
2.10	Crystalline Solids.....	79
2.10.1	Crystal Systems .....	79
2.10.2	Crystal Lattice Packing.....	81
2.10.3	Common Crystalline Solids.....	81
2.10.4	Crystals Defects.....	83
2.11	Crystal Lattice Energy .....	83
2.11.1	Born-Haber Cycle .....	83
2.11.2	Madelung Constant.....	84
2.12	Coordination Number.....	85
2.13	Complexes.....	85
2.13.1	Unidentate Ligands.....	85
2.13.2	Bidentate Ligands .....	86
2.13.3	Tridentate Ligands .....	86
2.13.4	Quadridentate Ligands.....	86
2.13.5	Pentadentate Ligands.....	86
2.13.6	Hexadentate Ligands.....	87
<b>Chapter 3</b>	<b>Organic Chemistry</b> .....	<b>89</b>
3.1	Classification of Organic Compounds.....	89
3.1.1	General Classification.....	89
3.1.2	Classification by Functional Group.....	90
3.2	Alkanes.....	90
3.2.1	Preparation of Alkanes .....	90
3.2.2	Reactions of Alkanes .....	91
3.3	Alkenes.....	91
3.3.1	Preparation of Alkenes.....	91
3.3.2	Reactions of Alkenes .....	92
3.4	Dienes .....	94
3.4.1	Preparation of Conjugated Dienes.....	94
3.4.2	Reactions of Dienes .....	94
3.5	Alkynes.....	95
3.5.1	Preparation of Alkynes.....	95
3.5.2	Reactions of Alkynes .....	95
3.6	Benzene .....	96
3.6.1	Preparation of Benzene .....	96
3.6.2	Reactions of Benzenes .....	96
3.7	Alkylbenzenes.....	97
3.7.1	Preparation of Alkylbenzenes.....	97
3.7.2	Reactions of Alkylbenzenes.....	98

3.8	Alkenylbenzenes.....	99
3.8.1	Preparation of Alkenylbenzenes .....	99
3.8.2	Reactions of Alkenylbenzenes.....	99
3.9	Alkyl Halides .....	100
3.9.1	Preparation of Alkyl Halides.....	100
3.9.2	Reactions of Alkyl Halides .....	100
3.10	Aryl Halides .....	102
3.10.1	Preparation of Aryl Halides.....	102
3.10.2	Reactions of Aryl Halides .....	103
3.11	Alcohols.....	103
3.11.1	Preparation of Alcohols .....	103
3.11.2	Reactions of Alcohols .....	104
3.12	Phenols.....	105
3.12.1	Preparation of Phenols.....	105
3.12.2	Reactions of Phenols.....	106
3.13	Ethers.....	109
3.13.1	Preparation of Ethers.....	109
3.13.2	Reactions of Ethers.....	109
3.14	Epoxides.....	110
3.14.1	Preparation of Epoxides .....	110
3.14.2	Reactions of Epoxides .....	110
3.15	Aldehydes and Ketones.....	110
3.15.1	Preparation of Aldehydes.....	110
3.15.2	Reactions Specific to Aldehydes.....	111
3.15.3	Preparation of Ketones .....	111
3.15.4	Reactions Specific to Ketones.....	112
3.15.5	Reactions Common to Aldehydes and Ketones .....	112
3.16	Carboxylic Acids.....	113
3.16.1	Preparation of Carboxylic Acids .....	113
3.16.2	Reactions of Carboxylic Acids.....	114
3.17	Acyl Chlorides.....	115
3.17.1	Preparation of Acyl Chlorides .....	115
3.17.2	Reactions of Acyl Chlorides .....	115
3.18	Acid Anhydrides.....	116
3.18.1	Preparation of Acid Anhydrides.....	116
3.18.2	Reactions of Acid Anhydrides.....	116
3.19	Esters.....	117
3.19.1	Preparation of Esters.....	117
3.19.2	Reactions of Esters.....	118
3.20	Amides.....	119
3.20.1	Preparation of Amides.....	119
3.20.2	Reactions of Amides.....	119
3.21	Amines.....	120
3.21.1	Preparation of Amines.....	120
3.21.2	Reactions of Amines.....	121
3.22	Alicyclic Compounds.....	122
3.22.1	Preparation of Alicyclic Compounds.....	122
3.22.2	Reactions of Alicyclic Compounds.....	122
3.23	Heterocyclic Compounds .....	123
3.23.1	Preparation of Pyrrole, Furan, and Thiophene.....	123
3.23.2	Reactions of Pyrrole, Furan, and Thiophene.....	123
3.23.3	Preparation of Pyridine, Quinoline, and Isoquinoline .....	124
3.23.4	Reactions of Pyridine, Quinoline, and Isoquinoline.....	125
3.24	Isomers .....	125
3.24.1	Isomers and Stereoisomers.....	125
3.24.2	Optical Activity .....	126
3.24.3	Enantiomers.....	126

3.24.4	Chirality.....	126
3.24.5	Diastereomers.....	126
3.24.6	Racemic Mixture.....	127
3.24.7	Meso Compounds.....	127
3.24.8	Positional Isomers.....	128
3.24.9	Geometric Isomers.....	128
3.24.10	Conformational Isomers.....	129
3.24.11	Configurational Isomers.....	130
3.25	Polymers.....	130
3.25.1	Classes of Polymers—Polymerization.....	131
3.25.2	Classes of Polymers—Molecular Forces.....	133
3.25.3	Classes of Polymers—Structure.....	134
3.25.4	Classes of Polymers—Sources.....	136
3.25.5	Common Polymers.....	137
3.25.6	Terminology.....	145
3.26	Biochemistry.....	146
3.26.1	Carbohydrates.....	146
3.26.2	Lipids.....	150
3.26.3	Proteins.....	151
3.26.4	Enzymes.....	155
3.26.5	Nucleic Acids.....	156
<b>Chapter 4</b>	<b>Nomenclature.....</b>	<b>159</b>
4.1	Inorganic Nomenclature.....	159
4.1.1	Ionic Compounds.....	159
4.1.2	Naming Ionic Ions and Compounds.....	159
4.1.3	Naming Molecular Compounds.....	163
4.1.4	Naming Acids.....	164
4.2	Organic Nomenclature.....	165
4.2.1	Alkanes.....	166
4.2.2	Cycloalkanes.....	166
4.2.3	Alkenes.....	167
4.2.4	Alkynes.....	167
4.2.5	Aromatic Hydrocarbons.....	167
4.2.6	Alkyl Halides.....	168
4.2.7	Aromatic Halides.....	169
4.2.8	Alcohols.....	169
4.2.9	Ethers.....	170
4.2.10	Aldehydes.....	170
4.2.11	Ketones.....	170
4.2.12	Carboxylic Acids.....	170
4.2.13	Esters.....	171
4.2.14	Amines.....	171
4.2.15	Amides.....	172
4.2.16	Multifunctional Group Compounds.....	172
4.3	Organic Ring Structures.....	173
4.3.1	Alicyclic Rings.....	173
4.3.2	Aromatic Rings.....	173
4.3.3	Heterocyclic Rings.....	174
4.4	Greek Alphabet.....	176
4.5	Abbreviations.....	176
<b>Chapter 5</b>	<b>Qualitative Chemical Analysis.....</b>	<b>183</b>
5.1	Inorganic Analysis.....	183
5.1.1	Flame Tests.....	183
5.1.2	Bead Tests.....	184

5.1.3	Tests for Gases.....	185
5.1.4	Solubility Rules.....	185
5.1.5	Solubility Table.....	186
5.1.6	Qualitative Analysis—Cationic.....	187
5.1.7	Qualitative Analysis—Anionic.....	195
5.2	Organic Analysis.....	197
5.2.1	Solubilities.....	197
5.2.2	Classification Tests.....	199
5.3	Laboratory Reagents.....	203
5.3.1	Dilute Acids.....	203
5.3.2	Dilute Bases.....	204
5.3.3	Reagents.....	204
5.4	Acid—Base Indicators.....	216
<b>Chapter 6</b>	<b>Spectroscopy Tables.....</b>	<b>217</b>
6.1	The Electromagnetic Spectrum.....	217
6.1.1	The Electromagnetic Spectrum.....	217
6.2	Ultraviolet-Visible Spectroscopy.....	218
6.2.1	Solvents.....	218
6.2.2	Woodward's Rules for Diene Absorption.....	218
6.2.3	Selected UV-Vis Tables.....	219
6.3	Infrared Spectroscopy.....	220
6.3.1	Infrared Media.....	220
6.3.2	Infrared Absorption Frequencies Chart.....	221
6.3.3	Infrared Absorption Frequencies Tables.....	221
6.4	Nuclear Magnetic Resonance Spectroscopy.....	229
6.4.1	Reference Standards for Proton NMR.....	229
6.4.2	Common NMR Solvents.....	229
6.4.3	NMR Proton Chemical Shift Chart.....	230
6.4.4	<sup>1</sup> H Chemical Shifts.....	232
6.5	Mass Spectroscopy.....	236
<b>Chapter 7</b>	<b>Nuclear Chemistry.....</b>	<b>239</b>
7.1	Radioactivity.....	239
7.2	Types of Radiation.....	239
7.3	Nuclear Reactions.....	240
7.3.1	Spontaneous Radioactive Decay.....	240
7.3.2	Transmutation.....	241
7.4	Half-Life.....	242
7.5	Nuclear Stability.....	244
7.6	Radioactive Decay Series.....	245
7.7	Mass Defect and Nuclear Binding Energy.....	246
7.8	Fission.....	246
7.9	Fusion.....	247
<b>Chapter 8</b>	<b>Units and Measurements.....</b>	<b>249</b>
8.1	Fundamental Physical Constants.....	249
8.2	Units.....	250
8.3	Prefixes.....	251
8.4	Conversion Factors.....	251
<b>Chapter 9</b>	<b>Mathematical Concepts.....</b>	<b>253</b>
9.1	Algebraic Formulas.....	253
9.1.1	Laws of Exponents.....	253
9.1.2	Laws of Logarithms.....	253

9.1.3	Quadratic Equation .....	253
9.1.4	Graphs (a, b, c, m, and Real Numbers) .....	254
9.2	Plane Figure Formulas .....	254
9.2.1	Rectangle .....	254
9.2.2	Parallelogram .....	254
9.2.3	Trapezoid .....	254
9.2.4	Equilateral Triangle .....	255
9.2.5	Circle .....	255
9.2.6	Ellipse .....	255
9.3	Solid Figure Formulas .....	255
9.3.1	Rectangular Solid .....	255
9.3.2	Right Cylinder .....	255
9.3.3	Right Circular Cone .....	255
9.3.4	Sphere .....	255
9.4	Significant Figures .....	255
9.4.1	Rules for Significant Figure .....	256
9.4.2	Rounding of Significant Figures .....	256
9.4.3	Multiplication and Division of Significant Figures .....	256
9.4.4	Addition and Subtraction of Significant Figures .....	256
<i>Appendix A</i> .....		257
<i>Appendix B</i> .....		259
<i>Appendix C</i> .....		275
<i>Bibliography</i> .....		281
<i>Index</i> .....		283