# CONTENTS

#### CHAPTER ONE

### THE CHEMICAL EQUATION

| The atomic theory              | 2  |
|--------------------------------|----|
| Laws of combining volumes      | 3  |
| Occam's razor                  | 6  |
| Laws, hypotheses, and theories | 7  |
| The mole concept               | 9  |
| Balancing a chemical equation  | 11 |
| Equivalents and normalities    | 19 |
| The chemical balance sheet     | 22 |
| PROBLEMS                       | 24 |
| SUGGESTED READING              | 26 |

-

### CHAPTER TWO

### CHEMICAL EQUILIBRIUM

27

1

| General laws of chemical equilibrium             | 30 |
|--|----|
| Numerical examples                               | 33 |
| Shifts of equilibrium at constant temperature    | 42 |
| Influence of temperature on equilibrium constant | 45 |
| Heat changes in chemical reactions -             | 49 |

|        | Equilibria in solution                      | 53         |
|--------|---|------------|
|        | Factors influencing equilibrium constants   | 55         |
|        | Calculation of equilibrium constants        | 59         |
|        | PROBLEMS                                    | 59         |
|        | SUGGESTED READING                           | 62         |
|        | CHAPTER THREE                               |            |
| THE ST | RUCTURE OF THE ATOM                         | 63         |
|        | Faraday's laws of electrolysis              | 63         |
|        | Discharge-tube experiments                  | 64         |
|        | Charges and masses of elementary particles  | 65         |
|        | Radioactivity                               | 69         |
|        | The nuclear atom                            | 69         |
|        | The periodic table                          | 74         |
|        | The Bohr-Sommerfeld atom                    | 75         |
|        | Quantum mechanics                           | 83         |
|        | Electronic configurations of atoms          | 92         |
|        | Sizes of atoms and ions                     | 103        |
|        | Ionization potential and electron affinity  | 110        |
|        | PROBLEMS                                    | 113        |
|        | SUGGESTED READING                           | 114        |
|        | CHAPTER FOUR                                |            |
| THE ST | RUCTURE OF MOLECULES                        | 115        |
|        | Types of chemical bonds                     | 120        |
|        | The ionic bond                              | 121        |
|        | The covalent bond                           | 123        |
|        | Other types of bonding                      | 153        |
|        | PROBLEMS                                    | 158        |
|        | SUGGESTED READING                           | 159        |
| 2.2    | CHAPTER FIVE                                |            |
| THE GA | SEOUS STATE                                 | 161        |
|        | The gas laws<br>The kinetic theory of gases | 161<br>169 |
| vlii   | CONTENTS                                    |            |

N

| Molecular energies               | 174 |
|----------------------------------|-----|
| Molecular rotation and vibration | 180 |
| Imperfect gases                  | 191 |
| PROBLEMS                         | 199 |
| SUGGESTED READING                | 200 |

### CHAPTER SIX

THE SOLID STATE

201

.

| Crystals                     | 202 |
|------------------------------|-----|
| Sublimation and condensation | 205 |
| Types of solid,              | 209 |
| Semi-conductors              | 216 |
| Heat capacities of solids    | 217 |
| PROBLEMS                     | 221 |
| SUGGESTED READING            | 222 |

### CHAPTER SEVEN

| THE LIQUID STATE | 223 |
|------------------|-----|
|                  |     |

| Liquid-vapor equilibrium      | 224 |
|-------------------------------|-----|
| The kinetic theory of liquids | 228 |
| Water                         | 231 |
| PROBLEMS                      | 234 |
| SUGGESTED READING             | 234 |

#### CHAPTER EIGHT

## SOLUTIONS OF NONELECTROLYTES

235

.

| Raoult's law                         |   | 236 |
|--------------------------------------|---|-----|
| Boiling-point elevation              | • | 239 |
| Freezing-point depression            |   | 241 |
| Osmotic pressure                     |   | 243 |
| Solutions of two volatile substances |   | 246 |
| Nonideal solutions                   |   | 248 |
| PROBLEMS                             |   | 251 |
| SUGGESTED READING                    | - | 252 |

**ix** CONTENTS

|    | CHAPTER NINE                                 |     |
|----|--|-----|
|    | SOLUTIONS OF ELECTROLYTES                    | 253 |
|    | Equivalent conductance                       | 254 |
|    | Strong electrolytes                          | 258 |
|    | Weak electrolytes                            | 259 |
|    | Ionization of water                          | 266 |
|    | The pH scale/ 10 nigation,                   | 267 |
|    | Conjugate acids and bases                    | 268 |
|    | Solubility product                           | 270 |
|    | Ions in aqueous solution                     | 273 |
|    | Standard oxidation potentials                | 278 |
|    | Standard electrode potentials                | 286 |
|    | The Nernst equation                          | 287 |
|    | Cell potentials and equilibrium constants,   | 289 |
|    | PROBLEMS                                     | 290 |
|    | SUGGESTED READING                            | 292 |
|    | CHAPTER TEN                                  |     |
|    | THE RATES OF CHEMICAL REACTIONS              | 293 |
|    | Rates and rate constants                     | 294 |
|    | Order of reaction                            | 297 |
|    | Molecularity of a reaction                   | 300 |
|    | The Arrhenius law                            | 304 |
|    | The activated complex                        | 309 |
|    | Calculating reaction rates                   | 313 |
|    | Reactions in solution                        | 316 |
|    | Complex reactions                            | 320 |
|    | Catalysis                                    | 327 |
|    | Very fast reactions                          | 331 |
|    | PROBLEMS                                     | 335 |
|    | SUGGESTED READING                            | 337 |
| et | CHAPTER ELEVEN                               |     |
|    | THE EXPERIMENTAL STUDY OF CHEMICAL STRUCTURE | 339 |
|    | Molecular weight                             | 341 |
|    | Sizes and shapes of molecules                | 346 |
|    | 1  |     |

.

X CONTENTS

| Bond lengths and bond angles     | 349 |
|----------------------------------|-----|
| Molecular vibration              | 356 |
| Bond dissociation energy         | 357 |
| Dipole moment                    | 362 |
| Molecular magnetism              | 366 |
| Optical activity                 | 368 |
| Fine structure of chemical bonds | 370 |
| PROBLEMS                         | 374 |
| SUGGESTED READING                | 375 |
| ANSWERS TO ODD-NUMBERED PROBLEMS | 377 |

#### INDEX

381

### **xi** CONTENTS