



TIMBERLAKE  
**CHEMISTRY**

An Introduction to  
General, Organic,  
and Biological  
Chemistry

**Thirteenth  
Edition**

 Pearson

# Periodic Table of Elements

Alkali metals → 1 Group 1A → Alkali earth metals → 2 Group 2A → Representative elements → Halogens → 17 Group 7A → Noble gases → 18 Group 8A

Transition elements → 3B to 10B

| Period number | 1           | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10          | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Group         | 1A          | 2A          | 3B          | 4B          | 5B          | 6B          | 7B          | 8B          |             |             | 1B          | 2B          | 3A          | 4A          | 5A          | 6A          | 7A          | 8A          |
| 1             | H<br>1.008  |             |             |             |             |             |             |             |             |             |             |             | B<br>10.81  | C<br>12.01  | N<br>14.01  | O<br>16.00  | F<br>19.00  | He<br>4.003 |
| 2             | Li<br>6.941 | Be<br>9.012 |             |             |             |             |             |             |             |             |             |             | Al<br>26.98 | Si<br>28.09 | P<br>30.97  | S<br>32.07  | Cl<br>35.45 | Ne<br>20.18 |
| 3             | Na<br>22.99 | Mg<br>24.31 | 3B          | 4B          | 5B          | 6B          | 7B          | 8B          |             |             |             |             | Al<br>26.98 | Si<br>28.09 | P<br>30.97  | S<br>32.07  | Cl<br>35.45 | Ar<br>39.95 |
| 4             | K<br>39.10  | Ca<br>40.08 | Sc<br>44.96 | Ti<br>47.87 | V<br>50.94  | Cr<br>52.00 | Mn<br>54.94 | Fe<br>55.85 | Co<br>58.93 | Ni<br>58.69 | Cu<br>63.55 | Zn<br>65.41 | Ga<br>69.72 | Ge<br>72.64 | As<br>74.92 | Se<br>78.96 | Br<br>79.90 | Kr<br>83.80 |
| 5             | Rb<br>85.47 | Sr<br>87.62 | Y<br>88.91  | Zr<br>91.22 | Nb<br>92.91 | Mo<br>95.94 | Tc<br>(99)  | Ru<br>101.1 | Rh<br>102.9 | Pd<br>106.4 | Ag<br>107.9 | Cd<br>112.4 | In<br>114.8 | Sn<br>118.7 | Sb<br>121.8 | Te<br>127.6 | I<br>126.9  | Xe<br>131.3 |
| 6             | Cs<br>132.9 | Ba<br>137.3 | La<br>138.9 | Hf<br>178.5 | Ta<br>180.9 | W<br>183.8  | Re<br>186.2 | Os<br>190.2 | Ir<br>192.2 | Pt<br>195.1 | Au<br>197.0 | Hg<br>200.6 | Tl<br>204.4 | Pb<br>207.2 | Bi<br>209.0 | Po<br>(209) | At<br>(210) | Rn<br>(222) |
| 7             | Fr<br>(223) | Ra<br>(226) | †Actinides  | Rf<br>(261) | Db<br>(262) | Sg<br>(266) | Bh<br>(264) | Hs<br>(265) | Mt<br>(268) | Ds<br>(271) | Rg<br>(272) | Cn<br>(285) | Nh<br>(286) | Fl<br>(289) | Mc<br>(289) | Lv<br>(293) | Ts<br>(294) | Og<br>(294) |

\*Lanthanides: 58 Ce (140.1), 59 Pr (140.9), 60 Nd (144.2), 61 Pm (145), 62 Sm (150.4), 63 Eu (152.0), 64 Gd (157.3), 65 Tb (158.9), 66 Dy (162.5), 67 Ho (164.9), 68 Er (167.3), 69 Tm (168.9), 70 Yb (173.0), 71 Lu (175.0)

†Actinides: 90 Th (232.0), 91 Pa (231.0), 92 U (238.0), 93 Np (237), 94 Pu (244), 95 Am (243), 96 Cm (247), 97 Bk (247), 98 Cf (251), 99 Es (252), 100 Fm (257), 101 Md (258), 102 No (259), 103 Lr (262)

Metals      Metalloids      Nonmetals

## Atomic Masses of the Elements

| Name         | Symbol | Atomic Number | Atomic Mass <sup>a</sup> | Name          | Symbol | Atomic Number | Atomic Mass <sup>a</sup> |
|--------------|--------|---------------|--------------------------|---------------|--------|---------------|--------------------------|
| Actinium     | Ac     | 89            | (227) <sup>b</sup>       | Mendelevium   | Md     | 101           | (258)                    |
| Aluminum     | Al     | 13            | 26.98                    | Mercury       | Hg     | 80            | 200.6                    |
| Americium    | Am     | 95            | (243)                    | Molybdenum    | Mo     | 42            | 95.94                    |
| Antimony     | Sb     | 51            | 121.8                    | Moscovium     | Mc     | 115           | (289)                    |
| Argon        | Ar     | 18            | 39.95                    | Neodymium     | Nd     | 60            | 144.2                    |
| Arsenic      | As     | 33            | 74.92                    | Neon          | Ne     | 10            | 20.18                    |
| Astatine     | At     | 85            | (210)                    | Neptunium     | Np     | 93            | (237)                    |
| Barium       | Ba     | 56            | 137.3                    | Nickel        | Ni     | 28            | 58.69                    |
| Berkelium    | Bk     | 97            | (247)                    | Nihonium      | Nh     | 113           | (286)                    |
| Beryllium    | Be     | 4             | 9.012                    | Niobium       | Nb     | 41            | 92.91                    |
| Bismuth      | Bi     | 83            | 209.0                    | Nitrogen      | N      | 7             | 14.01                    |
| Bohrium      | Bh     | 107           | (264)                    | Nobelium      | No     | 102           | (259)                    |
| Boron        | B      | 5             | 10.81                    | Oganesson     | Og     | 118           | (294)                    |
| Bromine      | Br     | 35            | 79.90                    | Osmium        | Os     | 76            | 190.2                    |
| Cadmium      | Cd     | 48            | 112.4                    | Oxygen        | O      | 8             | 16.00                    |
| Calcium      | Ca     | 20            | 40.08                    | Palladium     | Pd     | 46            | 106.4                    |
| Californium  | Cf     | 98            | (251)                    | Phosphorus    | P      | 15            | 30.97                    |
| Carbon       | C      | 6             | 12.01                    | Platinum      | Pt     | 78            | 195.1                    |
| Cerium       | Ce     | 58            | 140.1                    | Plutonium     | Pu     | 94            | (244)                    |
| Cesium       | Cs     | 55            | 132.9                    | Polonium      | Po     | 84            | (209)                    |
| Chlorine     | Cl     | 17            | 35.45                    | Potassium     | K      | 19            | 39.10                    |
| Chromium     | Cr     | 24            | 52.00                    | Praseodymium  | Pr     | 59            | 140.9                    |
| Cobalt       | Co     | 27            | 58.93                    | Promethium    | Pm     | 61            | (145)                    |
| Copernicium  | Cn     | 112           | (285)                    | Protactinium  | Pa     | 91            | 231.0                    |
| Copper       | Cu     | 29            | 63.55                    | Radium        | Ra     | 88            | (226)                    |
| Curium       | Cm     | 96            | (247)                    | Radon         | Rn     | 86            | (222)                    |
| Darmstadtium | Ds     | 110           | (271)                    | Rhenium       | Re     | 75            | 186.2                    |
| Dubnium      | Db     | 105           | (262)                    | Rhodium       | Rh     | 45            | 102.9                    |
| Dysprosium   | Dy     | 66            | 162.5                    | Roentgenium   | Rg     | 111           | (272)                    |
| Einsteinium  | Es     | 99            | (252)                    | Rubidium      | Rb     | 37            | 85.47                    |
| Erbium       | Er     | 68            | 167.3                    | Ruthenium     | Ru     | 44            | 101.1                    |
| Europium     | Eu     | 63            | 152.0                    | Rutherfordium | Rf     | 104           | (261)                    |
| Fermium      | Fm     | 100           | (257)                    | Samarium      | Sm     | 62            | 150.4                    |
| Flerovium    | Fl     | 114           | (289)                    | Scandium      | Sc     | 21            | 44.96                    |
| Fluorine     | F      | 9             | 19.00                    | Seaborgium    | Sg     | 106           | (266)                    |
| Francium     | Fr     | 87            | (223)                    | Selenium      | Se     | 34            | 78.96                    |
| Gadolinium   | Gd     | 64            | 157.3                    | Silicon       | Si     | 14            | 28.09                    |
| Gallium      | Ga     | 31            | 69.72                    | Silver        | Ag     | 47            | 107.9                    |
| Germanium    | Ge     | 32            | 72.64                    | Sodium        | Na     | 11            | 22.99                    |
| Gold         | Au     | 79            | 197.0                    | Strontium     | Sr     | 38            | 87.62                    |
| Hafnium      | Hf     | 72            | 178.5                    | Sulfur        | S      | 16            | 32.07                    |
| Hassium      | Hs     | 108           | (265)                    | Tantalum      | Ta     | 73            | 180.9                    |
| Helium       | He     | 2             | 4.003                    | Technetium    | Tc     | 43            | (99)                     |
| Holmium      | Ho     | 67            | 164.9                    | Tellurium     | Te     | 52            | 127.6                    |
| Hydrogen     | H      | 1             | 1.008                    | Tennessine    | Ts     | 117           | (294)                    |
| Indium       | In     | 49            | 114.8                    | Terbium       | Tb     | 65            | 158.9                    |
| Iodine       | I      | 53            | 126.9                    | Thallium      | Tl     | 81            | 204.4                    |
| Iridium      | Ir     | 77            | 192.2                    | Thorium       | Th     | 90            | 232.0                    |
| Iron         | Fe     | 26            | 55.85                    | Thulium       | Tm     | 69            | 168.9                    |
| Krypton      | Kr     | 36            | 83.80                    | Tin           | Sn     | 50            | 118.7                    |
| Lanthanum    | La     | 57            | 138.9                    | Titanium      | Ti     | 22            | 47.87                    |
| Lawrencium   | Lr     | 103           | (262)                    | Tungsten      | W      | 74            | 183.8                    |
| Lead         | Pb     | 82            | 207.2                    | Uranium       | U      | 92            | 238.0                    |
| Lithium      | Li     | 3             | 6.941                    | Vanadium      | V      | 23            | 50.94                    |
| Livermorium  | Lv     | 116           | (293)                    | Xenon         | Xe     | 54            | 131.3                    |
| Lutetium     | Lu     | 71            | 175.0                    | Ytterbium     | Yb     | 70            | 173.0                    |
| Magnesium    | Mg     | 12            | 24.31                    | Yttrium       | Y      | 39            | 88.91                    |
| Manganese    | Mn     | 25            | 54.94                    | Zinc          | Zn     | 30            | 65.41                    |
| Meitnerium   | Mt     | 109           | (268)                    | Zirconium     | Zr     | 40            | 91.22                    |

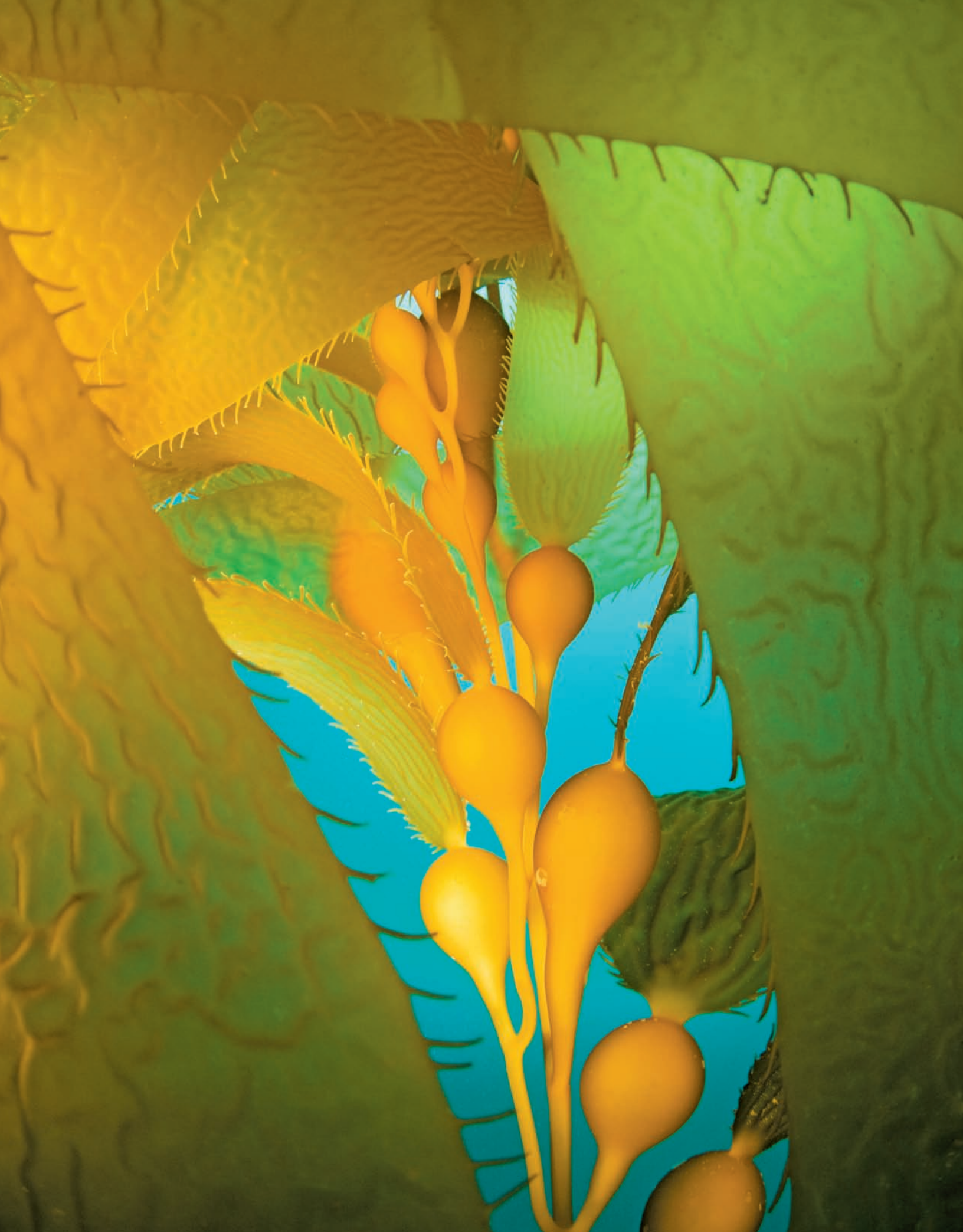
<sup>a</sup>Values for atomic masses are given to four significant figures.

<sup>b</sup>Values in parentheses are the mass number of an important radioactive isotope.

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and Biological Chemistry**





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**Thirteenth Edition**

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# Brief Contents

- 1** Chemistry in Our Lives 1
- 2** Chemistry and Measurements 25
- 3** Matter and Energy 60
- 4** Atoms and Elements 98
- 5** Nuclear Chemistry 136
- 6** Ionic and Molecular Compounds 168
- 7** Chemical Quantities and Reactions 216
- 8** Gases 259
- 9** Solutions 285
- 10** Acids and Bases and Equilibrium 324
- 11** Introduction to Organic Chemistry: Hydrocarbons 363
- 12** Alcohols, Thiols, Ethers, Aldehydes, and Ketones 398
- 13** Carbohydrates 432
- 14** Carboxylic Acids, Esters, Amines, and Amides 470
- 15** Lipids 509
- 16** Amino Acids, Proteins, and Enzymes 548
- 17** Nucleic Acids and Protein Synthesis 584
- 18** Metabolic Pathways and ATP Production 619



# Table of Contents

## 1 Chemistry in Our Lives 1



**CAREER Forensic Scientist** 1

**CLINICAL UPDATE Forensic Evidence Helps Solve the Crime** 1

- 1.1 Chemistry and Chemicals 2
- 1.2 Scientific Method: Thinking Like a Scientist 3

**CHEMISTRY LINK TO HEALTH**

- Early Chemist: Paracelsus 4
- 1.3 Studying and Learning Chemistry 5
- 1.4 Key Math Skills for Chemistry 9
- 1.5 Writing Numbers in Scientific Notation 16

**CLINICAL UPDATE**

- Forensic Evidence Helps Solve the Crime 19
- Concept Map 20
- Chapter Review 20
- Key Terms 21
- Key Math Skills 21
- Understanding the Concepts 22
- Additional Practice Problems 23
- Challenge Problems 23
- Answers 24

## 2 Chemistry and Measurements 25



**CAREER Registered Nurse** 25

**CLINICAL UPDATE Greg's Visit with His Doctor** 25

- 2.1 Units of Measurement 26
- 2.2 Measured Numbers and Significant Figures 29
- 2.3 Significant Figures in Calculations 31
- 2.4 Prefixes and Equalities 35
- 2.5 Writing Conversion Factors 39
- 2.6 Problem Solving Using Unit Conversion 42
- 2.7 Density 46

**CHEMISTRY LINK TO HEALTH**

- Bone Density 49

vi

**CLINICAL UPDATE**

- Greg's Visit with His Doctor 52
- Concept Map 52
- Chapter Review 52
- Key Terms 53
- Key Math Skill 54
- Core Chemistry Skills 54
- Understanding the Concepts 55
- Additional Practice Problems 56
- Challenge Problems 57
- Answers 58

## 3 Matter and Energy 60



**CAREER Dietitian** 60

**CLINICAL UPDATE A Diet and Exercise Program** 60

- 3.1 Classification of Matter 61

**CHEMISTRY LINK TO HEALTH**

- Breathing Mixtures 63
- 3.2 States and Properties of Matter 64
- 3.3 Temperature 67

**CHEMISTRY LINK TO HEALTH**

- Variation in Body Temperature 71
- 3.4 Energy 71

**CHEMISTRY LINK TO THE ENVIRONMENT**

- Carbon Dioxide and Climate Change 73
- 3.5 Energy and Nutrition 74

**CHEMISTRY LINK TO HEALTH**

- Losing and Gaining Weight 76
- 3.6 Specific Heat 77
- 3.7 Changes of State 80

**CHEMISTRY LINK TO HEALTH**

- Steam Burns 86

**CLINICAL UPDATE**

- A Diet and Exercise Program 87
- Concept Map 88
- Chapter Review 88
- Key Terms 89
- Core Chemistry Skills 90
- Understanding the Concepts 91
- Additional Practice Problems 92

Challenge Problems 94

Answers 94

**COMBINING IDEAS** from Chapters 1 to 3 96

# 4

## Atoms and Elements 98

**CAREER Farmer** 98**CLINICAL UPDATE Improving Crop Production** 98

4.1 Elements and Symbols 99

**CHEMISTRY LINK TO HEALTH**

Toxicity of Mercury 100

4.2 The Periodic Table 101

**CHEMISTRY LINK TO HEALTH**

Elements Essential to Health 104

4.3 The Atom 106

4.4 Atomic Number and Mass Number 109

**CHEMISTRY LINK TO THE ENVIRONMENT**

Many Forms of Carbon 111

4.5 Isotopes and Atomic Mass 112

4.6 Electron Energy Levels 115

**CHEMISTRY LINK TO HEALTH**

Biological Reactions to UV Light 119

4.7 Trends in Periodic Properties 120

**CLINICAL UPDATE**

Improving Crop Production 127

Concept Map 128

Chapter Review 128

Key Terms 129

Core Chemistry Skills 130

Understanding the Concepts 131

Additional Practice Problems 132

Challenge Problems 133

Answers 133

# 5

## Nuclear Chemistry 136

**CAREER Radiation Technologist** 136**CLINICAL UPDATE Cardiac Imaging Using a Radioisotope** 136

5.1 Natural Radioactivity 137

5.2 Nuclear Reactions 140

**CHEMISTRY LINK TO HEALTH**

Radon in Our Homes 142

5.3 Radiation Measurement 147

**CHEMISTRY LINK TO HEALTH**

Radiation and Food 148

5.4 Half-Life of a Radioisotope 150

**CHEMISTRY LINK TO THE ENVIRONMENT**

Dating Ancient Objects 152

5.5 Medical Applications Using Radioactivity 154

**CHEMISTRY LINK TO HEALTH**

Brachytherapy 157

5.6 Nuclear Fission and Fusion 158

**CHEMISTRY LINK TO THE ENVIRONMENT**

Nuclear Power Plants 161

**CLINICAL UPDATE**

Cardiac Imaging Using a Radioisotope 161

Concept Map 162

Chapter Review 162

Key Terms 163

Core Chemistry Skills 163

Understanding the Concepts 164

Additional Practice Problems 165

Challenge Problems 165

Answers 166

# 6

## Ionic and Molecular Compounds 168

**CAREER Pharmacy Technician** 168**CLINICAL UPDATE Compounds at the Pharmacy** 168

6.1 Ions: Transfer of Electrons 169

**CHEMISTRY LINK TO HEALTH**

Some Important Ions in the Body 172

6.2 Ionic Compounds 174

6.3 Naming and Writing Ionic Formulas 176

6.4 Polyatomic Ions 181

6.5 Molecular Compounds: Sharing Electrons 185

6.6 Lewis Structures for Molecules 189

6.7 Electronegativity and Bond Polarity 193

6.8 Shapes of Molecules 196

6.9 Polarity of Molecules and Intermolecular Forces 199

**CLINICAL UPDATE**

Compounds at the Pharmacy 203

Concept Map 204

Chapter Review 204

Key Terms 205

Core Chemistry Skills 206

- Understanding the Concepts 208
- Additional Practice Problems 209
- Challenge Problems 210
- Answers 211

**COMBINING IDEAS** from Chapters 4 to 6 214

# 7

## Chemical Quantities and Reactions 216


**CAREER** Exercise Physiologist 216

**CLINICAL UPDATE** Improving Natalie's Overall Fitness 216

- 7.1 The Mole 217
- 7.2 Molar Mass 221
- 7.3 Calculations Using Molar Mass 223
- 7.4 Equations for Chemical Reactions 226
- 7.5 Types of Chemical Reactions 233

**CHEMISTRY LINK TO HEALTH**

Incomplete Combustion: Toxicity of Carbon Monoxide 237

- 7.6 Oxidation–Reduction Reactions 238
- 7.7 Mole Relationships in Chemical Equations 241
- 7.8 Mass Calculations for Chemical Reactions 244
- 7.9 Energy in Chemical Reactions 246

**CHEMISTRY LINK TO HEALTH**

Cold Packs and Hot Packs 247

**CLINICAL UPDATE**

Improving Natalie's Overall Fitness 249

- Concept Map 250
- Chapter Review 250
- Key Terms 251
- Core Chemistry Skills 252
- Understanding the Concepts 253
- Additional Practice Problems 255
- Challenge Problems 256
- Answers 257

# 8

## Gases 259


**CAREER** Respiratory Therapist 259

**CLINICAL UPDATE** Exercise-Induced Asthma 259

- 8.1 Properties of Gases 260

**CHEMISTRY LINK TO HEALTH**

Measuring Blood Pressure 262

- 8.2 Pressure and Volume (Boyle's Law) 265

**CHEMISTRY LINK TO HEALTH**

Pressure–Volume Relationship in Breathing 266

- 8.3 Temperature and Volume (Charles's Law) 268
- 8.4 Temperature and Pressure (Gay-Lussac's Law) 270
- 8.5 The Combined Gas Law 272
- 8.6 Volume and Moles (Avogadro's Law) 273
- 8.7 Partial Pressures (Dalton's Law) 276

**CHEMISTRY LINK TO HEALTH**

Hyperbaric Chambers 278

**CLINICAL UPDATE**

Exercise-Induced Asthma 279

- Concept Map 279
- Chapter Review 280
- Key Terms 280
- Core Chemistry Skills 281
- Understanding the Concepts 281
- Additional Practice Problems 282
- Challenge Problems 283
- Answers 283

# 9

## Solutions 285


**CAREER** Dialysis Nurse 285

**CLINICAL UPDATE** Using Dialysis for Renal Failure 285

- 9.1 Solutions 286
- CHEMISTRY LINK TO HEALTH**
- Water in the Body 288
- 9.2 Electrolytes and Nonelectrolytes 290

**CHEMISTRY LINK TO HEALTH**

Electrolytes in Body Fluids 292

- 9.3 Solubility 294

**CHEMISTRY LINK TO HEALTH**

Gout and Kidney Stones: A Problem of Saturation in Body Fluids 295

- 9.4 Solution Concentrations 298
- 9.5 Dilution of Solutions 306
- 9.6 Properties of Solutions 309

**CHEMISTRY LINK TO HEALTH**

Dialysis by the Kidneys and the Artificial Kidney 312

**CLINICAL UPDATE**

Using Dialysis for Renal Failure 314

|                              |     |
|------------------------------|-----|
| Concept Map                  | 314 |
| Chapter Review               | 314 |
| Key Terms                    | 315 |
| Core Chemistry Skills        | 316 |
| Understanding the Concepts   | 316 |
| Additional Practice Problems | 317 |
| Challenge Problems           | 318 |
| Answers                      | 319 |

**COMBINING IDEAS** from Chapters 7 to 9 321

# 10

## Acids and Bases and Equilibrium 324



**CAREER** Clinical Laboratory Technician 324

**CLINICAL UPDATE** Acid Reflux Disease 324

|                                     |     |
|-------------------------------------|-----|
| 10.1 Acids and Bases                | 325 |
| 10.2 Brønsted–Lowry Acids and Bases | 327 |
| 10.3 Strengths of Acids and Bases   | 330 |
| 10.4 Acid–Base Equilibrium          | 333 |

**CHEMISTRY LINK TO HEALTH**

Oxygen–Hemoglobin Equilibrium and Hypoxia 336

|                            |     |
|----------------------------|-----|
| 10.5 Dissociation of Water | 338 |
| 10.6 The pH Scale          | 340 |

**CHEMISTRY LINK TO HEALTH**

Stomach Acid, HCl 345

|                                   |     |
|-----------------------------------|-----|
| 10.7 Reactions of Acids and Bases | 346 |
|-----------------------------------|-----|

**CHEMISTRY LINK TO HEALTH**

Antacids 349

|              |     |
|--------------|-----|
| 10.8 Buffers | 350 |
|--------------|-----|

**CHEMISTRY LINK TO HEALTH**

Buffers in the Blood Plasma 352

**CLINICAL UPDATE**

Acid Reflux Disease 354

|                              |     |
|------------------------------|-----|
| Concept Map                  | 355 |
| Chapter Review               | 355 |
| Key Terms                    | 357 |
| Key Math Skills              | 357 |
| Core Chemistry Skills        | 357 |
| Understanding the Concepts   | 358 |
| Additional Practice Problems | 359 |
| Challenge Problems           | 360 |
| Answers                      | 361 |

# 11

## Introduction to Organic Chemistry: Hydrocarbons 363



**CAREER** Firefighter/Emergency Medical Technician 363

**CLINICAL UPDATE** Diane's Treatment in the Burn Unit 363

|                                |     |
|--------------------------------|-----|
| 11.1 Organic Compounds         | 364 |
| 11.2 Alkanes                   | 366 |
| 11.3 Alkanes with Substituents | 370 |
| 11.4 Properties of Alkanes     | 375 |
| 11.5 Alkenes and Alkynes       | 376 |
| 11.6 Cis–Trans Isomers         | 379 |

**CHEMISTRY LINK TO THE ENVIRONMENT**

Pheromones in Insect Communication 381

**CHEMISTRY LINK TO HEALTH**

Cis–Trans Isomers for Night Vision 382

|                                     |     |
|-------------------------------------|-----|
| 11.7 Addition Reactions for Alkenes | 382 |
|-------------------------------------|-----|

**CHEMISTRY LINK TO HEALTH**

Hydrogenation of Unsaturated Fats 383

|                         |     |
|-------------------------|-----|
| 11.8 Aromatic Compounds | 385 |
|-------------------------|-----|

**CHEMISTRY LINK TO HEALTH**

Some Common Aromatic Compounds 387

**CHEMISTRY LINK TO HEALTH**

Polycyclic Aromatic Hydrocarbons (PAHs) 388

**CLINICAL UPDATE**

Diane's Treatment in the Burn Unit 389

|                              |     |
|------------------------------|-----|
| Concept Map                  | 389 |
| Chapter Review               | 390 |
| Summary of Naming            | 391 |
| Summary of Reactions         | 391 |
| Key Terms                    | 391 |
| Core Chemistry Skills        | 392 |
| Understanding the Concepts   | 392 |
| Additional Practice Problems | 393 |
| Challenge Problems           | 394 |
| Answers                      | 395 |

# 12

## Alcohols, Thiols, Ethers, Aldehydes, and Ketones 398



**CAREER** Dermatology Nurse 398

**CLINICAL UPDATE** Diana's Skin Protection Plan 398

|  |     |
|--|-----|
| 12.1 Alcohols, Phenols, Thiols, and Ethers | 399 |
|--|-----|

CHEMISTRY LINK TO HEALTH

Some Important Alcohols and Phenols 402

CHEMISTRY LINK TO HEALTH

Ethers as Anesthetics 404

12.2 Properties of Alcohols 405

CHEMISTRY LINK TO HEALTH

Hand Sanitizers 407

12.3 Aldehydes and Ketones 408

CHEMISTRY LINK TO HEALTH

Some Important Aldehydes and Ketones 412

12.4 Reactions of Alcohols, Thiols, Aldehydes, and Ketones 414

CHEMISTRY LINK TO HEALTH

Oxidation of Alcohol in the Body 417

CLINICAL UPDATE

Diana's Skin Protection Plan 421

Concept Map 421

Chapter Review 422

Summary of Naming 423

Summary of Reactions 423

Key Terms 423

Core Chemistry Skills 424

Understanding the Concepts 424

Additional Practice Problems 425

Challenge Problems 427

Answers 427

**COMBINING IDEAS** from Chapters 10 to 12 430

# 13

## Carbohydrates 432



**CAREER** Diabetes Nurse 432

**CLINICAL UPDATE** Kate's Program for Type 2 Diabetes 432

13.1 Carbohydrates 433

13.2 Chiral Molecules 436

CHEMISTRY LINK TO HEALTH

Enantiomers in Biological Systems 441

13.3 Fischer Projections of Monosaccharides 443

CHEMISTRY LINK TO HEALTH

Hyperglycemia and Hypoglycemia 445

13.4 Haworth Structures of Monosaccharides 446

13.5 Chemical Properties of Monosaccharides 450

CHEMISTRY LINK TO HEALTH

Testing for Glucose 452

13.6 Disaccharides 453

CHEMISTRY LINK TO HEALTH

How Sweet Is My Sweetener? 455

CHEMISTRY LINK TO HEALTH

Blood Types and Carbohydrates 456

13.7 Polysaccharides 459

CLINICAL UPDATE

Kate's Program for Type 2 Diabetes 461

Concept Map 462

Chapter Review 462

Summary of Carbohydrates 463

Summary of Reactions 464

Key Terms 464

Core Chemistry Skills 465

Understanding the Concepts 465

Additional Practice Problems 466

Challenge Problems 467

Answers 468

# 14

## Carboxylic Acids, Esters, Amines, and Amides 470



**CAREER** Environmental Health Practitioner 470

**CLINICAL UPDATE** Testing Soil and Water Samples for Chemicals 470

14.1 Carboxylic Acids 471

14.2 Properties of Carboxylic Acids 473

CHEMISTRY LINK TO HEALTH

Carboxylic Acids in Metabolism 476

14.3 Esters 477

CHEMISTRY LINK TO HEALTH

Salicylic Acid from a Willow Tree 479

CHEMISTRY LINK TO THE ENVIRONMENT

Plastics 480

14.4 Hydrolysis of Esters 482

14.5 Amines 484

CHEMISTRY LINK TO HEALTH

Amines in Health and Medicine 486

CHEMISTRY LINK TO THE ENVIRONMENT

Alkaloids: Amines in Plants 490

14.6 Amides 491



**CHEMISTRY LINK TO HEALTH**

Amides in Health and Medicine 494

**CLINICAL UPDATE**

Testing Soil and Water Samples for Chemicals 497

Concept Map 498

Chapter Review 498

Summary of Naming 499

Summary of Reactions 499

Key Terms 501

Core Chemistry Skills 501

Understanding the Concepts 501

Additional Practice Problems 502

Challenge Problems 504

Answers 505

**15****Lipids** 509**CAREER Clinical Lipid Specialist** 509**CLINICAL UPDATE Rebecca's Program to Lower Cholesterol** 509**15.1** Lipids 510**15.2** Fatty Acids 511**CHEMISTRY LINK TO HEALTH**

Omega-3 Fatty Acids in Fish Oils 515

**15.3** Waxes and Triacylglycerols 517**15.4** Chemical Properties of Triacylglycerols 521**CHEMISTRY LINK TO HEALTH**

Converting Unsaturated Fats to Saturated Fats: Hydrogenation 522

**15.5** Phospholipids 525**CHEMISTRY LINK TO HEALTH**

Infant Respiratory Distress Syndrome (IRDS) 529

**15.6** Steroids: Cholesterol, Bile Salts, and Steroid Hormones 530**CHEMISTRY LINK TO HEALTH**

Anabolic Steroids 534

**15.7** Cell Membranes 536**CLINICAL UPDATE**

Rebecca's Program to Lower Cholesterol 538

Concept Map 539

Chapter Review 539

Summary of Reactions 540

Key Terms 540

Core Chemistry Skills 541

Understanding the Concepts 541

Additional Practice Problems 542

Challenge Problems 542

Answers 543

**COMBINING IDEAS** from Chapters 13 to 15 546**16**  
**Amino Acids,  
Proteins,  
and Enzymes** 548**CAREER Physician Assistant** 548**CLINICAL UPDATE Jeremy's Diagnosis and Treatment for Sickle-Cell Anemia** 548**16.1** Proteins and Amino Acids 549**16.2** Proteins: Primary Structure 553**CHEMISTRY LINK TO HEALTH**

Essential Amino Acids and Complete Proteins 555

**CHEMISTRY LINK TO HEALTH**

Polypeptides in the Body 557

**16.3** Proteins: Secondary, Tertiary, and Quaternary Structures 558**CHEMISTRY LINK TO HEALTH**

Protein Secondary Structures and Alzheimer's Disease 560

**CHEMISTRY LINK TO HEALTH**

Sickle-Cell Anemia 565

**16.4** Enzymes 566**CHEMISTRY LINK TO HEALTH**

Isoenzymes as Diagnostic Tools 569

**16.5** Factors Affecting Enzyme Activity 571**CLINICAL UPDATE**

Jeremy's Diagnosis and Treatment for Sickle-Cell Anemia 576

Concept Map 577

Chapter Review 577

Key Terms 578

Core Chemistry Skills 579

Understanding the Concepts 579

Additional Practice Problems 580

Challenge Problems 581

Understanding Protein Structures 581

Answers 581

# 17

## Nucleic Acids and Protein Synthesis

584



**CAREER** Histology Technician 584

**CLINICAL UPDATE** Ellen's Medical Treatment Following Breast Cancer Surgery 584

- 17.1 Components of Nucleic Acids 585
- 17.2 Primary Structure of Nucleic Acids 588
- 17.3 DNA Double Helix and Replication 590
- 17.4 RNA and Transcription 593
- 17.5 The Genetic Code and Protein Synthesis 596

### CHEMISTRY LINK TO HEALTH

Many Antibiotics Inhibit Protein Synthesis 599

- 17.6 Genetic Mutations 600
- 17.7 Recombinant DNA 605
- 17.8 Viruses 607

### CHEMISTRY LINK TO HEALTH

Cancer 610

### CLINICAL UPDATE

Ellen's Medical Treatment Following Breast Cancer Surgery 611

Concept Map 612

Chapter Review 612

Key Terms 613

Core Chemistry Skills 614

Understanding the Concepts 614

Additional Practice Problems 615

Challenge Problems 616

Answers 616

### CHEMISTRY LINK TO HEALTH

Lactose Intolerance 624

- 18.3 Coenzymes in Metabolic Pathways 626
- 18.4 Glycolysis: Oxidation of Glucose 630
- 18.5 The Citric Acid Cycle 635
- 18.6 Electron Transport and Oxidative Phosphorylation 639

### CHEMISTRY LINK TO HEALTH

ATP Synthase and Heating the Body 642

- 18.7 Oxidation of Fatty Acids 645

### CHEMISTRY LINK TO HEALTH

Stored Fat and Obesity 648

### CHEMISTRY LINK TO HEALTH

Ketone Bodies and Diabetes 651

- 18.8 Degradation of Amino Acids 651

### CLINICAL UPDATE

Treatment of Luke's Hepatitis C 654

Concept Map 655

Chapter Review 656

Summary of Reactions 657

Key Terms 659

Core Chemistry Skills 659

Understanding the Concepts 660

Additional Practice Problems 661

Challenge Problems 661

Answers 661

**COMBINING IDEAS** from Chapters 16 to 18 663

**Credits** C-1

**Glossary/Index** I-1

# 18

## Metabolic Pathways and ATP Production

619



**CAREER** Public Health Nurse (PHN) 619

**CLINICAL UPDATE** Treatment of Luke's Hepatitis C 619

- 18.1 Metabolism and ATP Energy 620
- 18.2 Digestion of Foods 623

# Applications and Activities

## KEY MATH SKILLS

- Identifying Place Values 10
- Using Positive and Negative Numbers in Calculations 11
- Calculating Percentages 12
- Solving Equations 13
- Interpreting Graphs 14
- Writing Numbers in Scientific Notation 17
- Rounding Off 32
- Calculating pH from  $[H_3O^+]$  342
- Calculating  $[H_3O^+]$  from pH 344

## CORE CHEMISTRY SKILLS

- Counting Significant Figures 29
- Using Significant Figures in Calculations 32
- Using Prefixes 36
- Writing Conversion Factors from Equalities 39
- Using Conversion Factors 43
- Using Density as a Conversion Factor 49
- Identifying Physical and Chemical Changes 66
- Converting between Temperature Scales 67
- Using Energy Units 72
- Using the Heat Equation 78
- Calculating Heat for Change of State 81
- Counting Protons and Neutrons 109
- Writing Atomic Symbols for Isotopes 112
- Writing Electron Arrangements 117
- Identifying Trends in Periodic Properties 120
- Drawing Lewis Symbols 122
- Writing Nuclear Equations 140
- Using Half-Lives 151
- Writing Positive and Negative Ions 170
- Writing Ionic Formulas 175
- Naming Ionic Compounds 176
- Writing the Names and Formulas for Molecular Compounds 186
- Drawing Lewis Structures 190
- Using Electronegativity 193
- Predicting Shape 196
- Identifying Polarity of Molecules and Intermolecular Forces 199
- Converting Particles to Moles 217
- Calculating Molar Mass 222
- Using Molar Mass as a Conversion Factor 223
- Balancing a Chemical Equation 229
- Classifying Types of Chemical Reactions 233

- Identifying Oxidized and Reduced Substances 239
- Using Mole–Mole Factors 242
- Converting Grams to Grams 244
- Using the Gas Laws 266
- Calculating Partial Pressure 276
- Using Solubility Rules 297
- Calculating Concentration 299
- Using Concentration as a Conversion Factor 300
- Identifying Conjugate Acid–Base Pairs 328
- Using Le Châtelier’s Principle 335
- Calculating  $[H_3O^+]$  and  $[OH^-]$  in Solutions 339
- Writing Equations for Reactions of Acids and Bases 346
- Calculating Molarity or Volume of an Acid or Base in a Titration 348
- Naming and Drawing Alkanes 367
- Writing Equations for Hydrogenation and Hydration 382
- Identifying Functional Groups 399
- Naming Alcohols and Phenols 399
- Naming Aldehydes and Ketones 409
- Writing Equations for the Dehydration of Alcohols 414
- Writing Equations for the Oxidation of Alcohols 415
- Identifying Chiral Molecules 437
- Identifying D and L Fischer Projections for Carbohydrates 443
- Drawing Haworth Structures 446
- Naming Carboxylic Acids 471
- Hydrolyzing Esters 482
- Forming Amides 492
- Identifying Fatty Acids 511
- Drawing Structures for Triacylglycerols 518
- Drawing the Products for the Hydrogenation, Hydrolysis, and Saponification of a Triacylglycerol 522
- Identifying the Steroid Nucleus 530
- Drawing the Structure for an Amino Acid at Physiological pH 552
- Identifying the Primary, Secondary, Tertiary, and Quaternary Structures of Proteins 558
- Describing Enzyme Action 569
- Writing the Complementary DNA Strand 592
- Writing the mRNA Segment for a DNA Template 596
- Writing the Amino Acid for an mRNA Codon 597
- Identifying the Compounds in Glycolysis 630
- Describing the Reactions in the Citric Acid Cycle 637
- Calculating the ATP Produced from Glucose 642
- Calculating the ATP from Fatty Acid Oxidation ( $\beta$  Oxidation) 648

## Interactive Videos

|  |     |
|--|-----|
| Solving Equations  | 14  |
| Conversion Factors                                       | 43  |
| Chemical vs. Physical Changes                            | 66  |
| Rutherford's Gold-Foil Experiment                        | 107 |
| Writing Equations for an Isotope Produced by Bombardment | 145 |
| Half-Lives   | 151 |
| Problem 7.65   | 245 |
| Kinetic Molecular Theory                                 | 260 |
| Solutions  | 305 |
| Titration of an Acid                                     | 349 |
| Naming Alkanes   | 372 |
| Addition to an Asymmetric Bond                           | 384 |
| Oxidation of Alcohols                                    | 416 |
| Chirality  | 436 |
| Membrane Structure                                       | 536 |
| Different Levels of Protein Structure                    | 563 |
| Protein Synthesis  | 598 |

# About the Author



**KAREN TIMBERLAKE** is Professor Emerita of chemistry at Los Angeles Valley College, where she taught chemistry for allied health and preparatory chemistry for 36 years. She received her bachelor's degree in chemistry from the University of Washington and her master's degree in biochemistry from the University of California at Los Angeles.

Professor Timberlake has been writing chemistry textbooks for 40 years. During that time, her name has become associated with the strategic use of pedagogical tools that promote student success in chemistry and the application of chemistry to real-life situations. More than one million students have learned chemistry using texts, laboratory manuals, and study guides written by Karen Timberlake. In addition to *An Introduction to General, Organic and Biological Chemistry*, thirteenth edition, she is also the author of *General, Organic, and Biological Chemistry*, fifth edition, with the accompanying *Study Guide and Selected Solutions Manual*, *Laboratory Manual* and *Essentials Laboratory Manual*, and *Basic Chemistry*, fifth edition, with the accompanying *Study Guide and Selected Solutions Manual*.

Professor Timberlake belongs to numerous scientific and educational organizations including the American Chemical Society (ACS) and the National Science Teachers Association (NSTA). She has been the Western Regional Winner of the Excellence in College Chemistry Teaching Award given by the Chemical Manufacturers Association. She received the McGuffey Award in Physical Sciences from the Textbook Authors Association for her textbook

*Chemistry: An Introduction to General, Organic, and Biological Chemistry*, eighth edition, which has demonstrated her excellence over time. She received the “Texty” Textbook Excellence Award from the Textbook Authors Association for the first edition of *Basic Chemistry*. She has participated in education grants for science teaching including the Los Angeles Collaborative for Teaching Excellence (LACTE) and a Title III grant at her college. She speaks at conferences and educational meetings on the use of student-centered teaching methods in chemistry to promote the learning success of students.

When Professor Timberlake is not writing textbooks, she and her husband relax by playing tennis, ballroom dancing, traveling, trying new restaurants, cooking, and taking care of their grandchildren, Daniel and Emily.

## DEDICATION

### I dedicate this book to

- My husband, Bill, for his patience, loving support, and preparation of late meals
- My son, John, daughter-in-law, Cindy, grandson, Daniel, and granddaughter, Emily, for the precious things in life
- The wonderful students over many years whose hard work and commitment always motivated me and put purpose in my writing

## FAVORITE QUOTES

The whole art of teaching is only the art of awakening the natural curiosity of young minds.

—Anatole France

One must learn by doing the thing; though you think you know it, you have no certainty until you try.

—Sophocles

Discovery consists of seeing what everybody has seen and thinking what nobody has thought.

—Albert Szent-Gyorgyi

I never teach my pupils; I only attempt to provide the conditions in which they can learn.

—Albert Einstein



# Preface

Welcome to the thirteenth edition of *An Introduction to General, Organic, and Biological Chemistry*. This chemistry text was written and designed to help you prepare for a career in a health-related profession, such as nursing, dietetics, respiratory therapy, and environmental and agricultural science. This text assumes no prior knowledge of chemistry. My main objective in writing this text is to make the study of chemistry an engaging and a positive experience for you by relating the structure and behavior of matter to its role in health and the environment. This new edition introduces more problem-solving strategies, more problem-solving guides, new Analyze the Problem with Connect features, new Try It First and Engage features, conceptual and challenge problems, and new sets of combined problems.

It is my goal to help you become a critical thinker by understanding scientific concepts that will form a basis for making important decisions about issues concerning health and the environment. Thus, I have utilized materials that

- help you to learn and enjoy chemistry
- relate chemistry to careers that interest you
- develop problem-solving skills that lead to your success in chemistry
- promote learning and success in chemistry

## New for the Thirteenth Edition

New and updated features have been added throughout this thirteenth edition, including the following:

- **NEW AND UPDATED! Chapter Openers** provide engaging clinical stories in the health profession and introduce the chemical concepts in each chapter.
- **NEW! Clinical Updates** added at the end of each Chapter continue the story of the chapter opener and describe the follow-up treatment.
- **NEW! Engage** feature in the margin asks students to think about the paragraph they are reading and to test their understanding by answering the Engage question, which is related to the topic.
- **NEW! Try It First** precedes the Solution section of each Sample Problem to encourage the student to work on the problem before reading the given Solution.
- **NEW! Connect** feature added to **Analyze the Problem** boxes indicates the relationships between *Given* and *Need*.
- **NEW! Clinical Applications** added to Practice Problems show the relevance between the chemistry content and medicine and health.
- **NEW! Strategies for Learning Chemistry** are added that utilize successful ways to study and learn chemistry.

- **NEW! TEST** feature added in the margin encourages students to solve related Practice Problems to practice retrieval of content for exams.
- **NEW! Interactive Videos** give students the experience of step-by-step problem solving for problems from the text.
- **NEW! Review** topics placed in the margin at the beginning of a Section list the Key Math Skills and Core Chemistry Skills from the previous chapters, which provide the foundation for learning new chemistry principles in the current chapter.
- **UPDATED! Solution Guides** are now included in selected Sample Problems.
- **UPDATED! Key Math Skills** review basic math relevant to the chemistry the students are learning throughout the text. A **Key Math Skill Review** at the end of each chapter summarizes and gives additional examples.
- **UPDATED! Core Chemistry Skills** identify the key chemical principles in each chapter that are required for successfully learning chemistry. A **Core Chemistry Skill Review** at the end of each chapter helps reinforce the material and gives additional examples.
- **UPDATED! Analyze the Problem** features included in the Solutions of the Sample Problems strengthen critical-thinking skills and illustrate the breakdown of a word problem into the components required to solve it.
- **UPDATED! Practice Problems, Sample Problems, and art** demonstrate the connection between the chemistry being discussed and how these skills will be needed in professional experience.
- **UPDATED! Combining Ideas** features offer sets of integrated problems that test students' understanding and develop critical thinking by integrating topics from two or more previous chapters.

## Chapter Organization of the Thirteenth Edition

In each textbook I write, I consider it essential to relate every chemical concept to real-life issues. Because a chemistry course may be taught in different time frames, it may be difficult to cover all the chapters in this text. However, each chapter is a complete package, which allows some chapters to be skipped or the order of presentation to be changed.

**Chapter 1, Chemistry in Our Lives**, discusses the Scientific Method in everyday terms, guides students in developing a study plan for learning chemistry, with a section of Key Math

Skills that reviews the basic math, including scientific notation, needed in chemistry calculations.

- The Chapter Opener tells the story of a murder and features the work and career of forensic scientists.
- A new Clinical Update feature describes the forensic evidence that helps to solve the murder and includes Clinical Applications.
- “Scientific Method: Thinking Like a Scientist” is expanded to include *law* and *theory*.
- Writing Numbers in Scientific Notation is now a new Section.
- An updated Section titled Studying and Learning Chemistry expands the discussion of strategies that improve learning and understanding of content.
- Key Math Skills are: Identifying Place Values, Using Positive and Negative Numbers in Calculations, Calculating Percentages, Solving Equations, Interpreting Graphs, and Writing Numbers in Scientific Notation.

**Chapter 2, Chemistry and Measurements,** looks at measurement and emphasizes the need to understand numerical relationships of the metric system. Significant figures are discussed in the determination of final answers. Prefixes from the metric system are used to write equalities and conversion factors for problem-solving strategies. Density is discussed and used as a conversion factor.

- The Chapter Opener tells the story of a patient with high blood pressure and features the work and career of a registered nurse.
- A new Clinical Update describes the patient’s status and follow-up visit with his doctor.
- New photos, including an endoscope, propranolol tablets, cough syrup, people exercising, a urine dipstick, and a pint of blood, are added to improve visual introduction to clinical applications of chemistry. Previous art is updated to improve clarity.
- Sample Problems relate problem solving to health-related topics such as the measurements of blood volume, omega-3 fatty acids, radiological imaging, body fat, cholesterol, and medication orders.
- New Clinical Applications feature questions about measurements, daily values for minerals and vitamins, equalities and conversion factors for medications.
- New material illustrates how to count significant figures in equalities and in conversion factors used in a problem setup.
- A new Key Math Skill, Rounding Off, has been added.
- Core Chemistry Skills are: Counting Significant Figures, Using Significant Figures in Calculations, Using Prefixes, Writing Conversion Factors from Equalities, Using Conversion Factors, and Using Density as a Conversion Factor.

**Chapter 3, Matter and Energy,** classifies matter and states of matter, describes temperature measurement, and discusses energy, specific heat, energy in nutrition, and changes of state. Physical and chemical properties and physical and chemical changes are discussed.

- The chapter opener describes diet and exercise for an overweight adolescent at risk for type 2 diabetes and features the work and career of a dietitian.
- A new Clinical Update describes the new diet prepared with a dietitian for weight loss.
- Practice Problems and Sample Problems include high temperatures used in cancer treatment, the energy produced by a high-energy shock output of a defibrillator, body temperature lowering using a cooling cap, ice bag therapy for muscle injury, and energy values for food.
- Core Chemistry Skills are: Identifying Physical and Chemical Changes, Converting between Temperature Scales, Using Energy Units, Using the Heat Equation, and Calculating Heat for Change of State.
- The interchapter problem set, Combining Ideas from Chapters 1 to 3, completes the chapter.

**Chapter 4, Atoms and Elements,** introduces elements and atoms and the periodic table. The names and symbols for the newest elements 113, Nihonium, Nh, 115, Moscovium, Mc, 117, Tennessine, Ts, and 118, Oganesson, Og, are added to the periodic table. Electron arrangements are written for atoms and the trends in periodic properties are described. Atomic numbers and mass numbers are determined for isotopes. The most abundant isotope of an element is determined by its atomic mass.

- The Chapter Opener and Follow Up feature the work and career of a farmer.
- A new Clinical Update describes the improvement in crop production by the farmer.
- Atomic number and mass number are used to calculate the number of protons and neutrons in an atom.
- The number of protons and neutrons are used to calculate the mass number and to write the atomic symbol for an isotope.
- The trends in periodic properties are described for valence electrons, atomic size, ionization energy, and metallic character.
- Core Chemistry Skills are: Counting Protons and Neutrons, Writing Atomic Symbols for Isotopes, Writing Electron Arrangements, Identifying Trends in Periodic Properties, and Drawing Lewis Symbols.

**Chapter 5, Nuclear Chemistry,** looks at the types of radiation emitted from the nuclei of radioactive atoms. Nuclear equations are written and balanced for both naturally occurring radioactivity and artificially produced radioactivity. The half-lives of radioisotopes are discussed, and the amount of time for a sample to decay is calculated. Radioisotopes important in the

field of nuclear medicine are described. Fission and fusion and their role in energy production are discussed.

- The new chapter opener describes a patient with possible coronary heart disease who undergoes a nuclear stress test and features the work and career of a radiation technologist.
- A new Clinical Update discusses the results of cardiac imaging using the radioisotope Tl-201.
- Sample Problems and Practice Problems use nursing and medical examples, including phosphorus-32 for the treatment of leukemia, titanium seeds containing a radioactive isotope implanted in the body to treat cancer, yttrium injections for arthritis pain, and millicuries in a dose of phosphorus-32.
- Core Chemistry Skills are: Writing Nuclear Equations and Using Half-Lives.

**Chapter 6, Ionic and Molecular Compounds**, describes the formation of ionic and covalent bonds. Chemical formulas are written, and ionic compounds—including those with polyatomic ions—and molecular compounds are named.

- The chapter opener describes aspirin as a molecular compound and features the work and career of a pharmacy technician.
- A new Clinical Update describes several types of compounds at a pharmacy and includes Clinical Applications.
- Section 6.6 is now titled “Lewis Structures for Molecules,” 6.7 is “Electronegativity and Bond Polarity,” 6.8 is “Shapes of Molecules,” and 6.9 is “Polarity of Molecules and Intermolecular Forces.”
- The term Lewis structure has replaced the term electron-dot formula.
- Updated material on polyatomic ions compares the names of *ate* ions and *ite* ions, the charge of carbonate and hydrogen carbonate, and the formulas and charges of halogen polyatomic ions with oxygen.
- A new art comparing the particles and bonding of ionic compounds and molecular compounds has been added.
- A new flowchart for naming chemical compounds in Section 6.5 shows naming patterns for ionic and molecular compounds.
- Core Chemistry Skills are: Writing Positive and Negative Ions, Writing Ionic Formulas, Naming Ionic Compounds, Writing the Names and Formulas for Molecular Compounds, Drawing Lewis Structures, Using Electronegativity, Predicting Shape, and Identifying Polarity of Molecules and Intermolecular Forces.
- The interchapter problem set, Combining Ideas from Chapters 4 to 6, completes the chapter.

**Chapter 7, Chemical Quantities and Reactions**, discusses Avogadro’s number, the mole, and molar masses of compounds, which are used in calculations to determine the mass or number

of particles in a given quantity of an element or a substance. Students learn to balance chemical equations and to recognize the types of chemical reactions: combination, decomposition, single replacement, double replacement, and combustion. Chapter discussion includes Oxidation–Reduction Reactions using real-life examples, including biological reactions, Mole Relationships in Chemical Equations, Mass Calculations for Chemical Reactions, and Energy in Chemical Reactions, which discusses activation energy and energy changes in exothermic and endothermic reactions.

- The chapter opener describes the symptoms of pulmonary emphysema and discusses the career of an exercise physiologist.
- A new Clinical Update explains the treatment for interstitial lung disease.
- Sample Problems and Challenge Problems use nursing and medical examples.
- New expanded art shows visible evidence of a chemical reaction.
- Core Chemistry Skills are: Converting Particles to Moles, Calculating Molar Mass, Using Molar Mass as a Conversion Factor, Balancing a Chemical Equation, Classifying Types of Chemical Reactions, Identifying Oxidized and Reduced Substances, Using Mole–Mole Factors, and Converting Grams to Grams.

**Chapter 8, Gases**, discusses the properties of gases and calculates changes in gases using the gas laws: Boyle’s, Charles’s, Gay-Lussac’s, Avogadro’s, and Dalton’s. Problem-solving strategies enhance the discussion and calculations with gas laws.

- The chapter opener features the work and career of a respiratory therapist.
- New Clinical Update describes exercise to prevent exercise-induced asthma. Clinical Applications are related to lung volume and gas laws.
- Sample Problems and Challenge Problems use nursing and medical examples, including, calculating the volume of oxygen gas delivered through a face mask during oxygen therapy, preparing a heliox breathing mixture for a scuba diver, and home oxygen tanks.
- Core Chemistry Skills are: Using the Gas Laws and Calculating Partial Pressure.

**Chapter 9, Solutions**, describes solutions, electrolytes, saturation and solubility, insoluble salts, concentrations, and osmosis. The concentrations of solutions are used to determine volume or mass of solute. The volumes and molarities of solutions are used in calculations of dilutions and titrations. Properties of solutions, osmosis in the body, and dialysis are discussed.

- The chapter opener describes a patient with kidney failure and dialysis treatment and features the work and career of a dialysis nurse.

- A new Clinical Update explains dialysis treatment and electrolyte levels in dialysate fluid.
- Art updates include gout and intravenous solutions.
- Table 9.6 on electrolytes in intravenous solutions is expanded.
- Core Chemistry Skills are: Using Solubility Rules, Calculating Concentration, and Using Concentration as a Conversion Factor.
- The interchapter problem set, Combining Ideas from Chapters 7 to 9, completes the chapter.

**Chapter 10, Acids and Bases and Equilibrium**, discusses acids and bases and conjugate acid–base pairs. The dissociation of strong and weak acids and bases is related to their strengths as acids or bases. The dissociation of water leads to the water dissociation expression,  $K_w$ , the pH scale, and the calculation of pH. The reactions of acids and bases with metals, carbonates, and bicarbonates are discussed. Chemical equations for acids in reactions are balanced and titration of an acid is illustrated. Buffers are discussed along with their role in the blood.

- The chapter opener describes an accident victim with respiratory acidosis and the work and career of a clinical laboratory technician.
- A Clinical Update discusses the symptoms and treatment for acid reflux disease.
- The section “Acid–Base Equilibrium” includes Le Châtelier’s principle.
- Clinical Applications include calculating  $[\text{OH}^-]$  or  $[\text{H}_3\text{O}^+]$  of body fluids, foods, blood plasma, and the pH of body fluids.
- Key Math Skills are: Calculating pH from  $[\text{H}_3\text{O}^+]$  and Calculating  $[\text{H}_3\text{O}^+]$  from pH.
- New Core Chemistry Skills are: Identifying Conjugate Acid–Base Pairs, Using Le Chatelier’s Principle, Calculating  $[\text{H}_3\text{O}^+]$  and  $[\text{OH}^-]$  in Solutions, Writing Equations for Reactions of Acids and Bases, and Calculating Molarity or Volume of an Acid or Base in a Titration.

**Chapter 11, Introduction to Organic Chemistry: Hydrocarbons**, compares inorganic and organic compounds, and describes the structures and naming of alkanes, alkenes including cis–trans isomers, alkynes, and aromatic compounds.

- The chapter opener describes a fire victim and the search for traces of accelerants and fuel at the arson scene and features the work and career of a firefighter/emergency medical technician.
- A new Clinical Update describes the treatment of burns in the hospital and the types of fuels identified in the fire.
- Wedge–dash models have been added to the representations of methane and ethane.
- Line-angle formulas are now included in Table 11.2 IUPAC Names and Formulas of the First Ten Alkanes.

- Core Chemistry Skills are: Naming and Drawing Alkanes and Writing Equations for Hydrogenation and Hydration.

**Chapter 12, Alcohols, Thiols, Ethers, Aldehydes, and Ketones**, describes the functional groups and names of alcohols, thiols, ethers, aldehydes, and ketones. The solubility of alcohols, phenols, aldehydes, and ketones in water is discussed.

- A new chapter opener describes the risk factors for melanoma and discusses work and career of a dermatology nurse.
- A new Clinical Update discusses melanoma, skin protection, and functional groups of sunscreens.
- A table Solubility of Selected Aldehydes and Ketones has been updated.
- New material on antiseptics is added.
- The oxidation of methanol in the body is included in the Chemistry Link to Health “Oxidation of Alcohol in the Body.”
- Core Chemistry Skills are: Identifying Functional Groups, Naming Alcohols and Phenols, Naming Aldehydes and Ketones, Writing Equations for the Dehydration of Alcohols, and Writing Equations for the Oxidation of Alcohols.
- The interchapter problem set, Combining Ideas from Chapters 10 to 12, completes the chapter.

**Chapter 13, Carbohydrates**, describes the carbohydrate molecules monosaccharides, disaccharides, and polysaccharides and their formation by photosynthesis. Monosaccharides are classified as aldo or keto pentoses or hexoses. Chiral molecules are discussed along with Fischer projections and D and L notations. Chiral objects are modeled using gumdrops and toothpicks. Carbohydrates used as sweeteners are described and carbohydrates used in blood typing are discussed. The formation of glycosidic bonds in disaccharides and polysaccharides is described.

- A chapter opener describes a diabetes patient and her diet and features the work and career of a diabetes nurse.
- A new Clinical Update describes a diet to lower blood glucose.
- Chiral molecules are discussed and Fischer projections are drawn.
- A new Sample Problem identifies chiral carbons in glycerol and ibuprofen.
- New art shows that insulin needed for the metabolism of glucose is produced in the pancreas.
- Examples of chiral molecules in nature are included to Chemistry Link to Health, “Enantiomers in Biological Systems.”
- New Clinical Applications include psicose in foods, lyxose in bacterial glycolipids, xylose in absorption tests, and tagatose in fruit.



- New art shows the rotation of groups on carbon 5 for the Haworth structures of glucose and galactose.
- Drawing Haworth Structures is updated.
- The Chemistry Link to Health “Blood Types and Carbohydrates” has updated structures of the saccharides that determine each blood type.
- Core Chemistry Skills are: Identifying Chiral Molecules, Identifying D and L Fischer Projections, and Drawing Haworth Structures.

**Chapter 14, Carboxylic Acids, Esters, Amines, and Amides**, discusses the functional groups and naming of carboxylic acids, esters, amines, and amides. Chemical reactions include esterification, amidation, and acid and base hydrolysis of esters and amides.

- A chapter opener describes pesticides and pharmaceuticals used on a ranch and discusses the career of an environmental health practitioner.
- A new Clinical Update describes an insecticide used to spray animals.
- Line-angle structures for carboxylic acids are added to Table 14.1.
- Core Chemistry Skills are: Naming Carboxylic Acids, Hydrolyzing Esters, and Forming Amides.

**Chapter 15, Lipids**, discusses fatty acids and the formation of ester bonds in triacylglycerols and glycerophospholipids. Chemical properties of fatty acids and their melting points along with the hydrogenation of unsaturated triacylglycerols are discussed. Steroids, such as cholesterol and bile salts, are described. Chemistry Links to Health include “Converting Unsaturated Fats to Saturated Fats: Hydrogenation.” The role of phospholipids in the lipid bilayer of cell membranes is discussed as well as the lipids that function as steroid hormones.

- A new chapter opener describes a patient with symptoms of familial hypercholesterolemia and features the work and career of a clinical lipid specialist.
- A new Clinical Update describes a program to lower cholesterol.
- New notation for number of carbon atoms and double bonds in a fatty acid is added.
- New art of unsaturated fatty acids with cis and trans double bonds is added.
- New art of normal and damaged myelin sheath shows deterioration in multiple sclerosis.
- New art of the gallbladder and the bile duct where gallstones pass causing obstruction and pain.
- Core Chemistry Skills are: Identifying Fatty Acids, Drawing Structures for Triacylglycerols, Drawing the Products for the Hydrogenation, Hydrolysis, and Saponification of a Triacylglycerol, and Identifying the Steroid Nucleus.
- The interchapter problem set, Combining Ideas from Chapters 13 to 15, completes the chapter.

**Chapter 16, Amino Acids, Proteins, and Enzymes**, discusses amino acids, formation of peptide bonds and proteins, structural levels of proteins, enzymes, and enzyme action. The structures of amino acids are drawn at physiological pH. Enzymes are discussed as biological catalysts, along with the impact of inhibitors and denaturation on enzyme action.

- A new chapter opener discusses the symptoms of sickle-cell anemia in a child, the mutation in amino acids that causes the crescent shape of abnormal red blood cells, and the career of a physician assistant.
- The use of electrophoresis to diagnose sickle-cell anemia was added to Chemistry Link to Health “Sickle-Cell Anemia.”
- Abbreviations for amino acid names use three letters as well as one letter.
- New ribbon models of beta-amyloid proteins in normal brain and an Alzheimer’s brain are added to Chemistry Link to Health “Protein Secondary Structures and Alzheimer’s Disease”.
- Diagrams illustrate enzyme action and the effect of competitive and noncompetitive inhibitors on enzyme structure.
- Core Chemistry Skills are: Drawing the Structure for an Amino Acid at Physiological pH, Identifying the Primary, Secondary, Tertiary, and Quaternary Structures of Proteins, and Describing Enzyme Action.

**Chapter 17, Nucleic Acids and Protein Synthesis**, describes the nucleic acids and their importance as biomolecules that store and direct information for the synthesis of cellular components. The role of complementary base pairing is discussed in both DNA replication and the formation of mRNA during protein synthesis. The role of RNA is discussed in the relationship of the genetic code to the sequence of amino acids in a protein. Mutations describe ways in which the nucleotide sequences are altered in genetic diseases.

- A new chapter opener describes a patient’s diagnosis and treatment of breast cancer and discusses the work and career of a histology technician.
- A new Clinical Update describes estrogen-positive tumors, the impact of the altered genes BRCA1 and BRCA2 on the estrogen receptor, and medications to suppress tumor growth.
- A new Section discusses recombinant DNA, polymerase chain reaction, and DNA fingerprinting.
- New art illustrates point mutation, deletion mutation, and insertion mutation.
- Core Chemistry Skills are: Writing the Complementary DNA Strand, Writing the mRNA Segment for a DNA Template, and Writing the Amino Acid for an mRNA Codon.

**Chapter 18, Metabolic Pathways and ATP Production**, describes the metabolic pathways of biomolecules from the digestion of foodstuffs to the synthesis of ATP. The stages of



catabolism and the digestion of carbohydrates along with the coenzymes required in metabolic pathways are described. The breakdown of glucose to pyruvate is described using glycolysis, which is followed by the decarboxylation of pyruvate to acetyl CoA and the entry of acetyl CoA into the citric acid cycle. Electron transport, oxidative phosphorylation, and the synthesis of ATP is described. The oxidation of lipids and the degradation of amino acids are also discussed.

- A new chapter opener describes elevated levels of liver enzymes for a patient with chronic hepatitis C infection and discusses the career of a public health nurse.
- A new Clinical Update describes interferon and ribavirin therapy for hepatitis C.

## Acknowledgments

The preparation of a new text is a continuous effort of many people. I am thankful for the support, encouragement, and dedication of many people who put in hours of tireless effort to produce a high-quality book that provides an outstanding learning package. I am thankful for the outstanding contributions of Professor MaryKay Orgill whose updates and clarifications enhanced the content of the biochemistry chapters 16 to 18. The editorial team at Pearson has done an exceptional job. I want to thank Jeanne Zalesky, Director, Courseware Portfolio Management, and Scott Dustan, Courseware Portfolio Manager, who supported our vision of this thirteenth edition.

I appreciate all the wonderful work of Lizette Faraji, Content Producer, who skillfully brought together reviews, art, web site materials, and all the things it takes to prepare a book for production. I appreciate the work of Karen Berry and Christian Arsenault at SPi Global, who brilliantly coordinated all phases of the manuscript to the final pages of a beautiful book. Thanks to Mark Quirie, manuscript and accuracy reviewer, and Laura Patchkofsky and Linda Smith, who precisely analyzed and edited the initial and final manuscripts and pages to make sure the words and problems were correct to help students learn chemistry. Their keen eyes and thoughtful comments were extremely helpful in the development of this text.

I am especially proud of the art program in this text, which lends beauty and understanding to chemistry. I would like to

- Updated art for glycolysis, the citric acid cycle, and electron transport is added.
- The values of ATP produced from the metabolism of glucose, fatty acids, and amino acids is calculated using the updated values of 2.5 ATP for NADH and 1.5 ATP for FADH<sub>2</sub>.
- Core Chemistry Skills are: Identifying the Compounds in Glycolysis, Describing the Reactions in the Citric Acid Cycle, Calculating the ATP Produced from Glucose, and Calculating the ATP from Fatty Acid Oxidation ( $\beta$  Oxidation).
- The interchapter problem set, Combining Ideas from Chapters 16 to 18, completes the chapter.

thank Wynne Au Yeung and Stephanie Marquez, art specialists; Mark Ong and Tamara Newnam, interior and cover designers, whose creative ideas provided the outstanding design for the cover and pages of the book. Eric Shrader, photo researcher, was outstanding in researching and selecting vivid photos for the text so that students can see the beauty of chemistry. Thanks also to *Bio-Rad Laboratories* for their courtesy and use of *KnowItAll ChemWindows*, drawing software that helped us produce chemical structures for the manuscript. The macro-to-micro illustrations designed by Production Solutions and Precision Graphics give students visual impressions of the atomic and molecular organization of everyday things and are a fantastic learning tool. I also appreciate all the hard work in the field put in by the marketing team and Elizabeth Ellsworth, marketing manager.

I am extremely grateful to an incredible group of peers for their careful assessment of all the new ideas for the text; for their suggested additions, corrections, changes, and deletions; and for providing an incredible amount of feedback about improvements for the book. I admire and appreciate every one of you.

If you would like to share your experience with chemistry, or have questions and comments about this text, I would appreciate hearing from you.

*Karen Timberlake*  
Email: khemist@aol.com

# Instructor and Student Supplements

*Chemistry: An Introduction to General, Organic, and Biological Chemistry*, thirteenth edition, provides an integrated teaching and learning package of support material for both students and professors.

| Name of Supplement   | Available in Print | Available Online | Instructor or Student Supplement        | Description  |
|--|--------------------|------------------|---|--|
| Study Guide and Selected Solutions Manual (9780134553986)  | ✓                  |                  | Supplement for Students                 | The <i>Study Guide and Selected Solutions Manual</i> , by Karen Timberlake and Mark Quirie, promotes active learning through a variety of exercises with answers as well as practice tests that are connected directly to the learning goals of the textbook. Complete solutions to odd-numbered problems are included.  |
| MasteringChemistry™ (www.masteringchemistry.com) (9780134551272)   |                    | ✓                | Supplement for Students and Instructors | This product includes all of the resources of MasteringChemistry™ plus the now fully mobile eText 2.0. eText 2.0 mobile app offers offline access and can be downloaded for most iOS and Android phones/tablets from the Apple App Store or Google Play. Added integration brings videos and other rich media to the student's reading experience. MasteringChemistry™ from Pearson is the leading online homework, tutorial, and assessment system, designed to improve results by engaging students with powerful content. Instructors ensure students arrive ready to learn by assigning educationally effective content and encourage critical thinking and retention with in-class resources such as Learning Catalytics™. Students can further master concepts through traditional and adaptive homework assignments that provide hints and answer specific feedback. The Mastering™ gradebook records scores for all automatically-graded assignments in one place, while diagnostic tools give instructors access to rich data to assess student understanding and misconceptions. <a href="http://www.masteringchemistry.com">http://www.masteringchemistry.com</a> . |
| Pearson eText enhanced with media (stand-alone: ISBN 9780134545684; within MasteringChemistry™: 9780134552170)<br> |                    | ✓                | Supplement for Students                 | The thirteenth edition of <i>Chemistry: An Introduction to General, Organic, and Biological Chemistry</i> features a Pearson eText enhanced with media within Mastering. In conjunction with Mastering assessment capabilities, new <b>Interactive Videos and 3D animations</b> will improve student engagement and knowledge retention. Each chapter contains a balance of interactive animations, videos, sample calculations, and self-assessments / quizzes embedded directly in the eText. Additionally, the Pearson eText offers students the power to create notes, highlight text in different colors, create bookmarks, zoom, and view single or multiple pages. Icons in the margins throughout the text signify that there is a new <b>Interactive Video</b> or animation located within MasteringChemistry™ for <i>Chemistry: An Introduction to General, Organic, and Biological Chemistry</i> , thirteenth edition.  |
| Laboratory Manual by Karen Timberlake (9780321811851)  | ✓                  |                  | Supplement for Students                 | This best-selling lab manual coordinates 35 experiments with the topics in <i>Chemistry: An Introduction to General, Organic, and Biological Chemistry</i> , thirteenth edition, uses laboratory investigations to explore chemical concepts, develop skills of manipulating equipment, reporting data, solving problems, making calculations, and drawing conclusions.  |
| Instructor's Solutions Manual (9780134564661)  |                    | ✓                | Supplement for Instructors              | Prepared by Mark Quirie, the Instructor's solutions manual highlights chapter topics, and includes answers and solutions for all Practice Problems in the text.  |
| Instructor Resource Materials—Download Only (9780134552262)  |                    | ✓                | Supplement for Instructors              | Includes all the art, photos, and tables from the book in JPEG format for use in classroom projection or when creating study materials and tests. In addition, the instructors can access modifiable PowerPoint™ lecture outlines. Also available are downloadable files of the Instructor's Solutions Manual and a set of “clicker questions” designed for use with classroom-response systems. Also visit the Pearson Education catalog page for Timberlake's <i>Chemistry: An Introduction to General, Organic, Biological Chemistry</i> , thirteenth edition, at <a href="http://www.pearsonhighered.com">www.pearsonhighered.com</a> to download available instructor supplements.  |
| TestGen Test Bank-Download Only (9780134564678)  |                    | ✓                | Supplement for Instructors              | Prepared by William Timberlake, this resource includes more than 1600 questions in multiple-choice, matching, true / false, and short-answer format.   |
| Online Instructor Manual for Laboratory Manual (9780321812858)   |                    | ✓                | Supplement for Instructors              | This manual contains answers to report sheet pages for the <i>Laboratory Manual</i> and a list of the materials needed for each experiment with amounts given for 20 students working in pairs, available for download at <a href="http://www.pearsonhighered.com">www.pearsonhighered.com</a> .   |

# Career Focus Engages Students

Best-selling author Karen Timberlake connects chemistry to real-world and career applications like no one else. The 13th edition of *Chemistry: An Introduction to General, Organic, and Biological Chemistry* engages students by helping them to see the connections between chemistry, the world around them, and future careers.

## 3 Matter and Energy

### CHARLES IS 13 YEARS OLD AND OVERWEIGHT.

His doctor is worried that Charles is at risk for type 2 diabetes and advises his mother to make an appointment with a dietitian. Daniel, a dietitian, explains to them that choosing the appropriate foods is important to living a healthy lifestyle, losing weight, and preventing or managing diabetes.

Daniel also explains that food contains potential or stored energy and different foods contain different amounts of potential energy. For instance, carbohydrates contain 4 kcal/g (17 kJ/g), whereas fats contain 9 kcal/g (38 kJ/g). He then explains that diets high in fat require more exercise

to burn the fats, as they contain more energy. When Daniel looks at Charles's typical daily diet, he calculates that Charles obtains 2500 kcal in one day. The American Heart Association recommends 1800 kcal for boys 9 to 13 years of age. Daniel encourages Charles and his mother to include whole grains, fruits, and vegetables in their diet instead of foods high in fat. They also discuss food labels and the fact that smaller serving sizes of healthy foods are necessary to lose weight. Daniel also recommends that Charles exercises at least 60 minutes every day. Before leaving, Charles and his mother make an appointment for the following week to look at a weight loss plan.

### CAREER Dietitian

Dietitians specialize in helping individuals learn about good nutrition and the need for a balanced diet. This requires them to understand biochemical processes, the importance of vitamins and food labels, as well as the differences between carbohydrates, fats, and proteins in terms of their energy value and how they are metabolized. Dietitians work in a variety of environments, including hospitals, nursing homes, school cafeterias, and public health clinics. In these roles, they create specialized diets for individuals diagnosed with a specific disease or create meal plans for those in a nursing home.



### CLINICAL UPDATE A Diet and Exercise Program

When Daniel sees Charles and his mother, they discuss a menu for weight loss. Charles is going to record his food intake and return to discuss his diet with Daniel. You can view the results in the [CLINICAL UPDATE A Diet and Exercise Program](#) on page 87, and calculate the kilocalories that Charles consumes in one day, and also the weight that Charles has lost.

**Chapter Openers** emphasize clinical connections by showing students relevant, engaging, topical examples of how health professionals use chemistry everyday. Clinical Updates at the end of each chapter relate the chemistry the student learns in the chapter to expand the clinical content in the Chapter Opener and include clinical applications.

**Chemistry Links to Health**, woven throughout each chapter, apply chemical concepts to topics in health and medicine such as weight loss and weight gain, alcohol abuse, blood buffers, and kidney dialysis, illustrating the importance of understanding chemistry in real-life situations.



### CHEMISTRY LINK TO HEALTH Breathing Mixtures

The air we breathe is composed mostly of the gases oxygen (21%) and nitrogen (79%). The homogeneous breathing mixtures used by scuba divers differ from the air we breathe depending on the depth of the dive. Nitrox is a mixture of oxygen and nitrogen, but with more oxygen gas (up to 32%) and less nitrogen gas (68%) than air. A breathing mixture with less nitrogen gas decreases the risk of *nitrogen narcosis* associated with breathing regular air while diving. Heliox contains oxygen and helium, which is typically used for diving to more than 200 ft. By replacing nitrogen with helium, nitrogen narcosis does not occur. However, at dive depths over 300 ft, helium is associated with severe shaking and a drop in body temperature.

A breathing mixture used for dives over 400 ft is trimix, which contains oxygen, helium, and some nitrogen. The addition of some

nitrogen lessens the problem of shaking that comes with breathing high levels of helium. Heliox and trimix are used only by professional, military, or other highly trained divers.

In hospitals, heliox may be used as a treatment for respiratory disorders and lung constriction in adults and premature infants. Heliox is less dense than air, which reduces the effort of breathing and helps distribute the oxygen gas to the tissues.



A nitrox mixture is used to fill scuba tanks.

# Builds Students' Critical-Thinking and Problem-Solving Skills

One of Karen Timberlake's goals is to help students to become critical thinkers. Color-coded tips found throughout each chapter are designed to provide guidance and to encourage students to really think about what they are reading, helping to develop important critical-thinking skills.

## 3.3 Temperature

**LEARNING GOAL** Given a temperature, calculate the corresponding temperature on another scale.

Temperatures in science are measured and reported in *Celsius* ( $^{\circ}\text{C}$ ) units. On the Celsius scale, the reference points are the freezing point of water, defined as  $0^{\circ}\text{C}$ , and the boiling point,  $100^{\circ}\text{C}$ . In the United States, everyday temperatures are commonly reported in *Fahrenheit* ( $^{\circ}\text{F}$ ) units. On the Fahrenheit scale, water freezes at  $32^{\circ}\text{F}$  and boils at  $212^{\circ}\text{F}$ . A typical room temperature of  $22^{\circ}\text{C}$  would be the same as  $72^{\circ}\text{F}$ . Normal human body temperature is  $37.0^{\circ}\text{C}$ , which is the same temperature as  $98.6^{\circ}\text{F}$ .

On the Celsius and Fahrenheit temperature scales, the temperature difference between freezing and boiling is divided into smaller units called *degrees*. On the Celsius scale, there are 100 degrees Celsius between the freezing and boiling points of water, whereas the Fahrenheit scale has 180 degrees Fahrenheit between the freezing and boiling points of water. That makes a degree Celsius almost twice the size of a degree Fahrenheit:  $1^{\circ}\text{C} = 1.8^{\circ}\text{F}$  (see **FIGURE 3.4**).

$$180 \text{ degrees Fahrenheit} = 100 \text{ degrees Celsius}$$

$$\frac{180 \text{ degrees Fahrenheit}}{100 \text{ degrees Celsius}} = \frac{1.8^{\circ}\text{F}}{1^{\circ}\text{C}}$$

We can write a temperature equation that relates a Fahrenheit temperature and its corresponding Celsius temperature.

$$T_{\text{F}} = 1.8(T_{\text{C}}) + 32 \quad \text{Temperature equation to obtain degrees Fahrenheit}$$

Changes  $^{\circ}\text{C}$  to  $^{\circ}\text{F}$       Adjusts freezing point

In the equation, the Celsius temperature is multiplied by 1.8 to change  $^{\circ}\text{C}$  to  $^{\circ}\text{F}$ ; then 32 is added to adjust the freezing point from  $0^{\circ}\text{C}$  to the Fahrenheit freezing point,  $32^{\circ}\text{F}$ . The values, 1.8 and 32, used in the temperature equation are exact numbers and are not used to determine significant figures in the answer.

To convert from degrees Fahrenheit to degrees Celsius, the temperature equation is rearranged to solve for  $T_{\text{C}}$ . First, we subtract 32 from both sides since we must apply the same operation to both sides of the equation.

$$T_{\text{F}} - 32 = 1.8(T_{\text{C}}) + 32 - 32$$

$$T_{\text{F}} - 32 = 1.8(T_{\text{C}})$$

### REVIEW

Using Positive and Negative Numbers in Calculations (1.4)  
Solving Equations (1.4)  
Counting Significant Figures (2.2)

**NEW! Review Feature** lists the core chemistry skills and key math skills from previous chapters which provide the foundation for learning the new chemistry principles in the current chapter.

### ENGAGE

Why is a degree Celsius a larger unit of temperature than a degree Fahrenheit?

**NEW! Engage Feature** asks students to think about the paragraph they are reading and immediately test their understanding by answering the Engage question, which is related to the topic. Students connect new concepts to prior knowledge to increase retrieval of content.

### CORE CHEMISTRY SKILL

Converting between Temperature Scales

**UPDATED! Core Chemistry Skills** found throughout the chapter identify the fundamental chemistry concepts that students need to understand in the current chapter.



Four NEW problem solving features enhance Karen Timberlake's unmatched problem-solving strategies and help students deepen their understanding of content while improving their problem-solving skills.

**NEW! Try It First** precedes the Solution section of each Sample Problem to encourage the student to work on the problem before reading the given Solution.

**NEW! Connect Feature** added to Analyze the Problem boxes indicates the relationships between Given and Need.

**NEW! Solution Guide** provides STEPS for successful Problem Solving within the Sample Problem

### SAMPLE PROBLEM 3.7 Using Specific Heat

#### TRY IT FIRST

During surgery or when a patient has suffered a cardiac arrest or stroke, lowering the body temperature will reduce the amount of oxygen needed by the body. Some methods used to lower body temperature include cooled saline solution, cool water blankets, or cooling caps worn on the head. How many kilojoules are lost when the body temperature of a surgery patient with a blood volume of 5500 mL is cooled from 38.5 °C to 33.2 °C? (Assume that the specific heat and density of blood are the same as for water.)



A cooling cap lowers the body temperature to reduce the oxygen required by the tissues.

#### SOLUTION GUIDE

**STEP 1** State the given and needed quantities.

|                     | Given  | Need                  | Connect                                     |
|---------------------|--|-----------------------|---|
| ANALYZE THE PROBLEM | 5500 mL of blood<br>= 5500 g of blood,<br>cooled from 38.5 °C to 33.2 °C | kilojoules<br>removed | heat equation,<br>specific heat<br>of water |

**STEP 2** Calculate the temperature change ( $\Delta T$ ).

$$\Delta T = 38.5\text{ °C} - 33.2\text{ °C} = 5.3\text{ °C}$$

**STEP 3** Write the heat equation and needed conversion factors.

$$\text{Heat} = m \times \Delta T \times SH$$

$$SH_{\text{water}} = \frac{4.184\text{ J}}{\text{g } ^\circ\text{C}}$$

$$\frac{4.184\text{ J}}{\text{g } ^\circ\text{C}} \text{ and } \frac{\text{g } ^\circ\text{C}}{4.184\text{ J}}$$

$$1\text{ kJ} = 1000\text{ J}$$

$$\frac{1000\text{ J}}{1\text{ kJ}} \text{ and } \frac{1\text{ kJ}}{1000\text{ J}}$$

**STEP 4** Substitute in the given values and calculate the heat, making sure units cancel.

$$\text{Heat} = \underset{\text{Two SFs}}{5500\text{ g}} \times \underset{\text{Two SFs}}{5.3\text{ }^\circ\text{C}} \times \underset{\text{Exact}}{\frac{4.184\text{ J}}{\text{g } ^\circ\text{C}}} \times \underset{\text{Exact}}{\frac{1\text{ kJ}}{1000\text{ J}}} = 120\text{ kJ}$$

Two SFs      Two SFs      Exact      Exact      Two SFs

#### STUDY CHECK 3.7

Some cooking pans have a layer of copper on the bottom. How many kilojoules are needed to raise the temperature of 125 g of copper from 22 °C to 325 °C (see Table 3.11)?

#### ANSWER

14.6 kJ



The copper on a pan conducts heat rapidly to the food in the pan.

#### TEST

Try Practice Problems 3.39 to 3.42

**NEW! Test Feature** added in the margin encourages students to solve related Practice Problems to practice retrieval of content for exams.

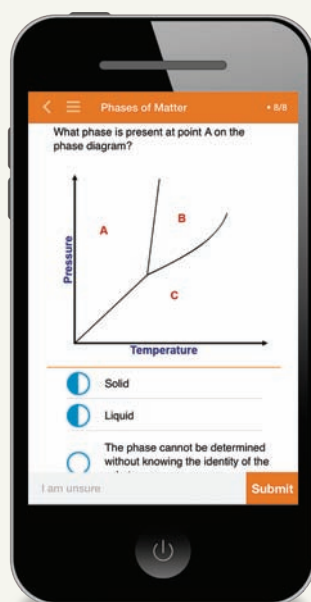


# Continuous Learning Before, During, and After Class

## BEFORE CLASS

### Dynamic Study Modules

**NEW! 66 Dynamic Study Modules**, specific to GOB Chemistry, help students study effectively on their own by continuously assessing their activity and performance in real time.

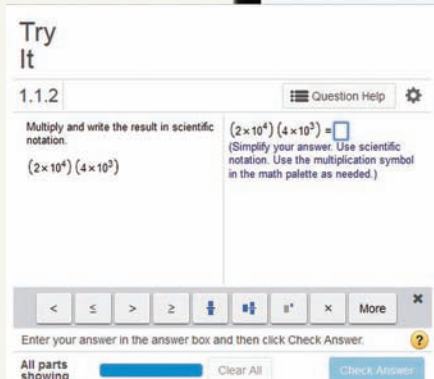
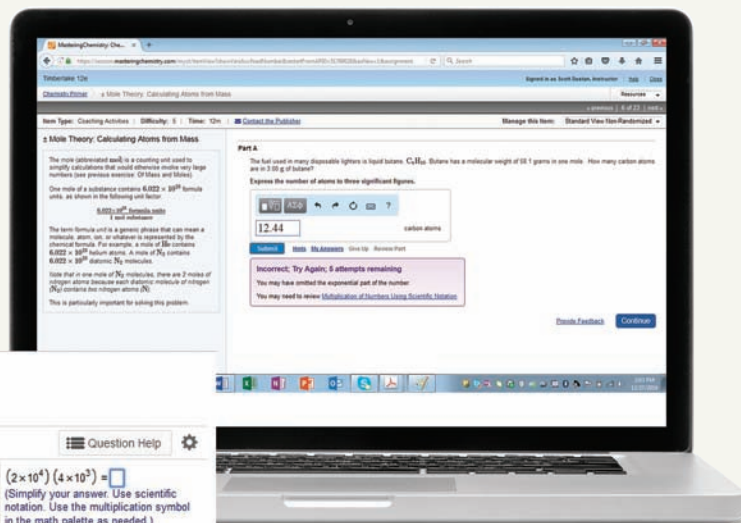


Students complete a set of questions with a unique answer format that also asks them to indicate their confidence level. Questions repeat until the student can answer them all correctly and confidently. Once completed, Dynamic Study Modules explain the concept. These are available as graded assignments prior to class, and accessible on smartphones, tablets, and computers.

### Chemistry Primer

**NEW! Chemistry Primer** is a series of tutorials focused on remediating students taking their first college chemistry course. Topics include math in the context of chemistry, chemical skills and literacy, as well as some basics of balancing chemical equations, mole-mole factor, and mass-mass calculations—all of which were chosen based on extensive surveys of chemistry professors across the country.

The main body of each item in the primer offers diagnostic questions designed to help students recognize that they need help. If they struggle, the primer offers extensive formative help in the hint structure via wrong answer feedback, instructional videos, and step-wise worked examples that provide scaffolding to build up students' understanding as needed. The primer is offered as a pre-built assignment that is automatically generated with all chemistry courses.

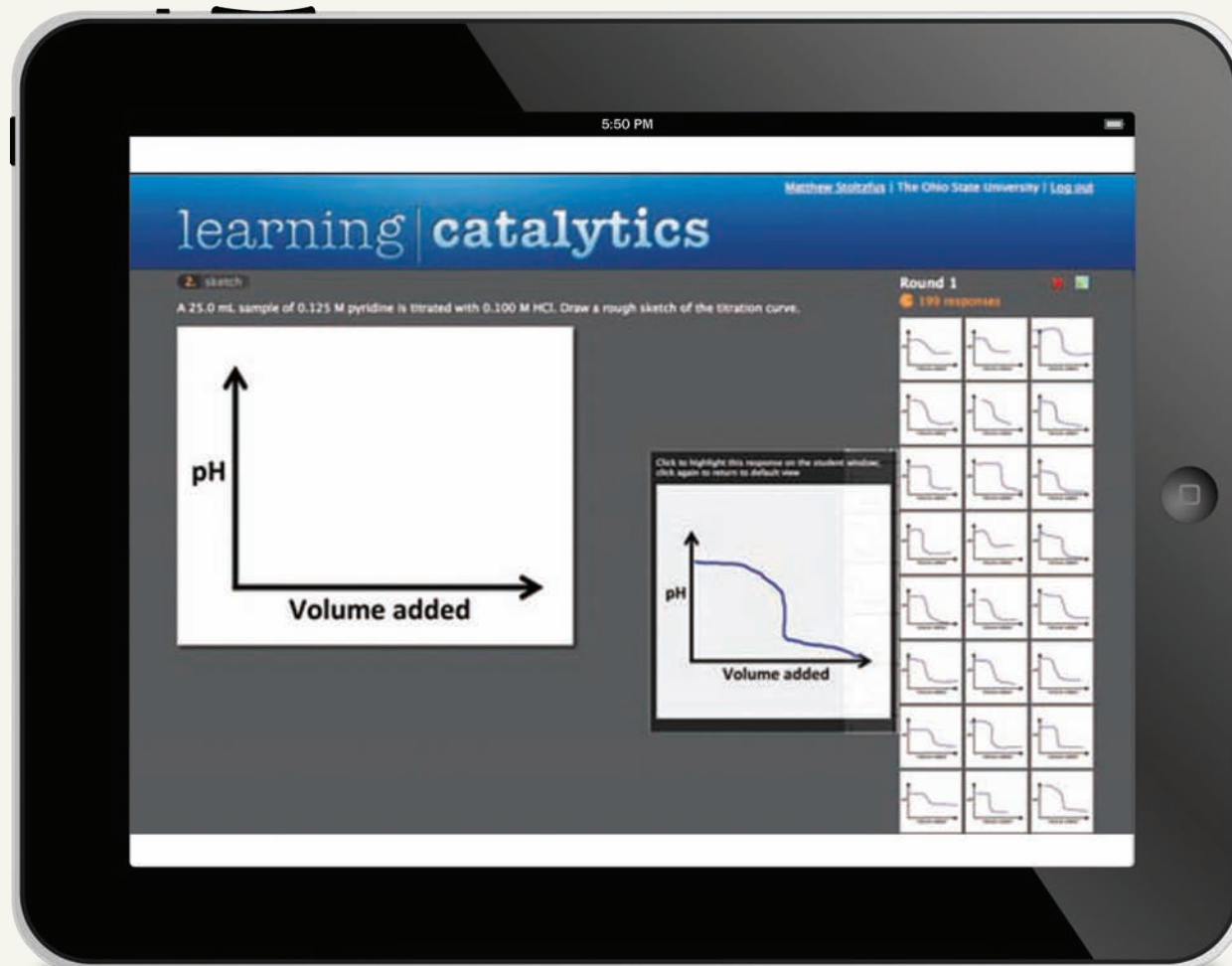


## DURING CLASS

### Learning Catalytics

Learning Catalytics generates class discussion, guides your lecture, and promotes peer-to-peer learning with real-time analytics. MasteringChemistry with eText now provides Learning Catalytics—an interactive student response tool that uses students' smartphones, tablets, or laptops to engage them in more sophisticated tasks and thinking. Instructors can:

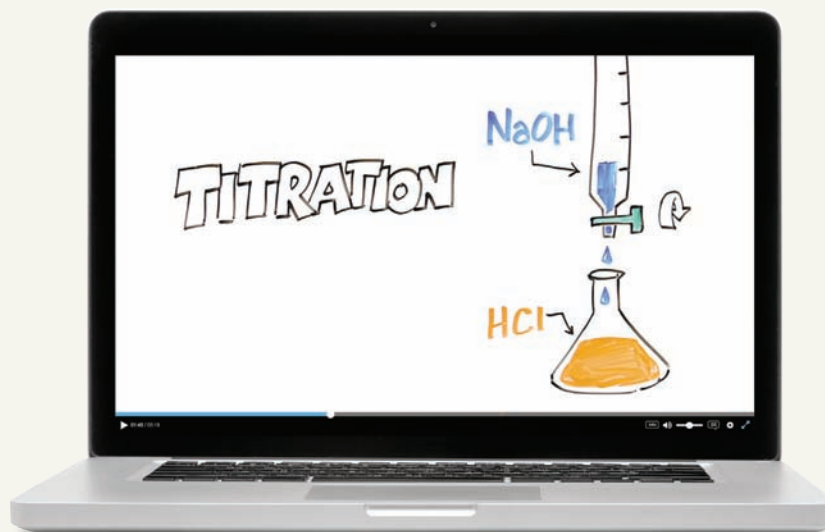
- **NEW!** Upload a full PowerPoint® deck for easy creation of slide questions.
- Help students develop critical thinking skills.
- Monitor responses to find out where students are struggling.
- Rely on real-time data to adjust teaching strategies.
- Automatically group students for discussion, teamwork, and peer-to-peer learning.



## AFTER CLASS

**NEW!** **Interactive Videos** clarify and reinforce important concepts such as solving equations, conversion factors, solutions, and more. Sample Calculations now correspond to a key concept/topic in most chapters, giving students an opportunity to reinforce what they just learned by showing how chemistry works in real life and introducing a bit of humor into chemical problem solving and demonstrations.

MasteringChemistry™ offers a wide variety of problems, ranging from multi-step tutorials with extensive hints and feedback to multiple-choice End-of-Chapter Problems and Test Bank questions.



2. Chemistry and Measurements | Problem 2.40 with feedback | Resources

Item Type: End-of-Chapter | Difficulty: 2 | Time: 8m | Learning Outcomes | Contact the Publisher | Manage this Item: Standard View Randomized

± Problem 2.40 with feedback

Complete each of the following metric relationships.  
You may want reference (11 pages 35-39) Section 2.4 while completing this problem.

Part A  
Express your answer to one significant figure.

1  $\mu\text{g}$  =  g

Submit My Answers Give Up

**Incorrect; Try Again**  
The units are not equivalent. You need to convert the mass from 1  $\mu\text{g}$  to units of grams. You may need to review [Conversion between Units in the Metric System](#).

To provide additional scaffolding for students moving from Tutorial Problems to End-of-Chapter Problems we created **New!** **Enhanced End-of-Chapter** problems that now contain specific wrong-answer feedback.

# eText 2.0



## eText 2.0

- Full eReader functionality includes page navigation, search, glossary, highlighting, note taking, annotations, and more.
- A responsive design allows the eText to reflow/resize to a device or screen. eText 2.0 now works on supported smartphones, tablets, and laptop/desktop computers.
- In-context glossary offers students instant access to definitions by simply hovering over key terms.
- Seamlessly integrated videos and activities allow students to watch and practice key concepts within the eText learning experience.
- Accessible (screen-reader ready).
- Configurable reading settings, including resizable type and night reading mode.
- Study Check Questions allow students to interact in eText 2.0 with the questions which follow each Sample Problem. With one click, these activities are brought to life, allowing students to study on their own and test their understanding in real-time. These interactives help students extinguish misconceptions and enhance their problem-solving skills.

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# 1 Chemistry in Our Lives

## A CALL CAME IN TO 911 FROM A MAN WHO

arrived home from work to find his wife lying on the floor of their home. When the police arrived, they pronounced the woman dead. The victim's body was lying on the floor of the living room. There was no blood at the scene, but the police did find a glass on the side table that contained a small amount of liquid. In an adjacent laundry room, the police found a half-empty bottle of antifreeze, which contains the toxic compound ethylene glycol. The bottle, glass, and liquid were bagged and sent to the forensic laboratory.

In another 911 call, a man was found lying on the grass outside his home. Blood was present on his body, and some bullet casings were found on the grass. Inside

the victim's home, a weapon was recovered. The bullet casings and the weapon were bagged and sent to the forensic laboratory.

Sarah and Mark, forensic scientists, use scientific procedures and chemical tests to examine the evidence from law enforcement agencies. Sarah analyzes blood, stomach contents, and the unknown liquid from the first victim's home. She will look for the presence of drugs, poisons, and alcohol. Her lab partner, Mark, analyzes the fingerprints on the glass. He will also match the characteristics of the bullet casings to the weapon that was found at the second crime scene.

## CAREER Forensic Scientist

Most forensic scientists work in crime laboratories that are part of city or county legal systems where they analyze bodily fluids and tissue samples collected by crime scene investigators. In analyzing these samples, forensic scientists identify the presence or absence of specific chemicals within the body to help solve the criminal case. Some of the chemicals they look for include alcohol, illegal or prescription drugs, poisons, arson debris, metals, and various gases such as carbon monoxide. In order to identify these substances, a variety of chemical instruments and highly specific methodologies are used. Forensic scientists analyze samples from criminal suspects, athletes, and potential employees. They also work on cases involving environmental contamination and animal samples for wildlife crimes. Forensic scientists usually have a bachelor's degree that includes courses in math, chemistry, and biology.



## CLINICAL UPDATE Forensic Evidence Helps Solve the Crime

In the forensic laboratory, Sarah analyzes the victim's stomach contents and blood for toxic compounds. You can view the results of the tests on the forensic evidence in the [CLINICAL UPDATE Forensic Evidence Helps Solve the Crime](#), page 19, and determine if the victim ingested a toxic level of ethylene glycol (antifreeze).

## LOOKING AHEAD

- 1.1 Chemistry and Chemicals
- 1.2 Scientific Method: Thinking Like a Scientist
- 1.3 Studying and Learning Chemistry
- 1.4 Key Math Skills for Chemistry
- 1.5 Writing Numbers in Scientific Notation



In the blood, hemoglobin transports oxygen to the tissues and carbon dioxide to the lungs.



Antacid tablets undergo a chemical reaction when dropped into water.

## ENGAGE

Why is water a chemical?



Toothpaste is a combination of many chemicals.

## TEST

Try Practice Problems 1.1 to 1.6

## 1.1 Chemistry and Chemicals

**LEARNING GOAL** Define the term chemistry and identify substances as chemicals.

Now that you are in a chemistry class, you may be wondering what you will be learning. What questions in science have you been curious about? Perhaps you are interested in what hemoglobin does in the blood or how aspirin relieves a headache. Just like you, chemists are curious about the world we live in.

What does hemoglobin do in the body? Hemoglobin consists of four polypeptide chains, each containing a heme group with an iron atom that binds to oxygen ( $O_2$ ) in the lungs. From the lungs, hemoglobin transports oxygen to the tissues of the body where it is used to provide energy. Once the oxygen is released, hemoglobin binds to carbon dioxide ( $CO_2$ ) for transport to the lungs where it is released.

Why does aspirin relieve a headache? When a part of the body is injured, substances called prostaglandins are produced, which cause inflammation and pain. Aspirin acts to block the production of prostaglandins, reducing inflammation and pain. Chemists in the medical field develop new treatments for diabetes, genetic defects, cancer, AIDS, and other diseases. For the chemist in the forensic laboratory, the nurse in the dialysis unit, the dietitian, the chemical engineer, or the agricultural scientist, chemistry plays a central role in understanding problems and assessing possible solutions.

## Chemistry

**Chemistry** is the study of the composition, structure, properties, and reactions of matter. *Matter* is another word for all the substances that make up our world. Perhaps you imagine that chemistry takes place only in a laboratory where a chemist is working in a white coat and goggles. Actually, chemistry happens all around you every day and has an impact on everything you use and do. You are doing chemistry when you cook food, add bleach to your laundry, or start your car. A chemical reaction has taken place when silver tarnishes or an antacid tablet fizzes when dropped into water. Plants grow because chemical reactions convert carbon dioxide, water, and energy to carbohydrates. Chemical reactions take place when you digest food and break it down into substances that you need for energy and health.

## Chemicals

A **chemical** is a substance that always has the same composition and properties wherever it is found. All the things you see around you are composed of one or more chemicals. Chemical processes take place in chemistry laboratories, manufacturing plants, and pharmaceutical labs as well as every day in nature and in our bodies. Often the terms *chemical* and *substance* are used interchangeably to describe a specific type of matter.

Every day, you use products containing substances that were developed and prepared by chemists. Soaps and shampoos contain chemicals that remove oils on your skin and scalp. In cosmetics and lotions, chemicals are used to moisturize, prevent deterioration of the product, fight bacteria, and thicken the product. Perhaps you wear a ring or watch made of gold, silver, or platinum. Your breakfast cereal is probably fortified with iron, calcium, and phosphorus, whereas the milk you drink is enriched with vitamins A and D. When you brush your teeth, the substances in toothpaste clean your teeth, prevent plaque formation, and stop tooth decay. Some of the chemicals used to make toothpaste are listed in **TABLE 1.1**.

**TABLE 1.1** Chemicals Commonly Used in Toothpaste

| Chemical               | Function   |
|------------------------|--|
| Calcium carbonate      | Used as an abrasive to remove plaque                                       |
| Sorbitol               | Prevents loss of water and hardening of toothpaste                         |
| Sodium lauryl sulfate  | Used to loosen plaque  |
| Titanium dioxide       | Makes toothpaste white and opaque  |
| Sodium fluorophosphate | Prevents formation of cavities by strengthening tooth enamel with fluoride |
| Methyl salicylate      | Gives toothpaste a pleasant wintergreen flavor                             |

## PRACTICE PROBLEMS

### 1.1 Chemistry and Chemicals

**LEARNING GOAL** Define the term chemistry and identify substances as chemicals.

In every chapter, odd-numbered exercises in the *Practice Problems* are paired with even-numbered exercises. The answers for the magenta, odd-numbered *Practice Problems* are given at the end of each chapter. The complete solutions to the odd-numbered *Practice Problems* are in the *Study Guide and Student Solutions Manual*.

- 1.1 Write a one-sentence definition for each of the following:
  - a. chemistry
  - b. chemical
- 1.2 Ask two of your friends (not in this class) to define the terms in problem 1.1. Do their answers agree with the definitions you provided?

### Clinical Applications

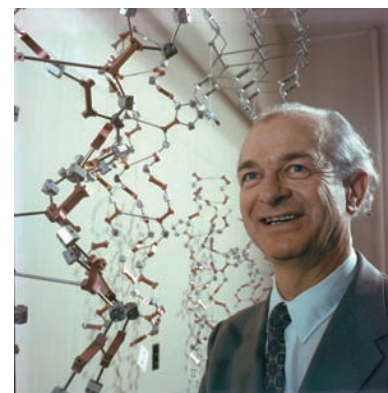
- 1.3 Obtain a bottle of multivitamins and read the list of ingredients. What are four chemicals from the list?
- 1.4 Obtain a box of breakfast cereal and read the list of ingredients. What are four chemicals from the list?
- 1.5 Read the labels on some items found in your medicine cabinet. What are the names of some chemicals contained in those items?
- 1.6 Read the labels on products used to wash your dishes. What are the names of some chemicals contained in those products?

## 1.2 Scientific Method: Thinking Like a Scientist

**LEARNING GOAL** Describe the activities that are part of the scientific method.

When you were very young, you explored the things around you by touching and tasting. As you grew, you asked questions about the world in which you live. What is lightning? Where does a rainbow come from? Why is the sky blue? As an adult, you may have wondered how antibiotics work or why vitamins are important to your health. Every day, you ask questions and seek answers to organize and make sense of the world around you.

When the late Nobel Laureate Linus Pauling described his student life in Oregon, he recalled that he read many books on chemistry, mineralogy, and physics. “I mulled over the properties of materials: why are some substances colored and others not, why are some minerals or inorganic compounds hard and others soft?” He said, “I was building up this tremendous background of empirical knowledge and at the same time asking a great number of questions.” Linus Pauling won two Nobel Prizes: the first, in 1954, was in chemistry for his work on the nature of chemical bonds and the determination of the structures of complex substances; the second, in 1962, was the Peace Prize.

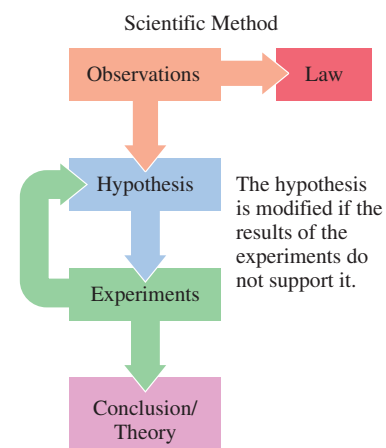


Linus Pauling won the Nobel Prize in Chemistry in 1954.

### The Scientific Method

The process of trying to understand nature is unique to each scientist. However, the **scientific method** is a process that scientists use to make observations in nature, gather data, and explain natural phenomena.

1. **Observations** The first step in the scientific method is to make observations about nature and ask questions about what you observe. When an observation always seems to be true, it may be stated as a *law* that predicts that behavior and is often measurable. However, a law does not explain that observation. For example, we can use the *Law of Gravity* to predict that if we drop our chemistry book it would fall on the table or the floor but this law does not explain why our book falls.
2. **Hypothesis** A scientist forms a hypothesis, which gives a possible explanation of an observation or a law. The hypothesis must be stated in such a way that it can be tested by experiments.
3. **Experiments** To determine if a hypothesis is true or false, experiments are done to find a relationship between the hypothesis and the observations. The results of the experiments may confirm the hypothesis. However, if the experiments do not confirm the hypothesis, it is modified or discarded. Then new experiments will be designed to test the hypothesis.
4. **Conclusion/Theory** When the results of the experiments are analyzed, a conclusion is made as to whether the hypothesis is *true* or *false*. When experiments give consistent results, the hypothesis may be stated to be true. Even then, the hypothesis continues



The scientific method develops a conclusion or theory about nature using observations, hypotheses, and experiments.



to be tested and, based on new experimental results, may need to be modified or replaced. If many additional experiments by a group of scientists continue to support the hypothesis, it may become a *scientific theory*, which gives an explanation for the initial observations.



## CHEMISTRY LINK TO HEALTH

### Early Chemist: Paracelsus

For many centuries, chemistry has been the study of changes in matter. From the time of the ancient Greeks to the sixteenth century, alchemists described matter in terms of four components of nature: earth, air, fire, and water. By the eighth century, alchemists believed that they could change metals such as copper and lead into gold and silver. Although these efforts failed, the alchemists provided information on the chemical reactions involved in the extraction of metals from ores. The alchemists also designed some of the first laboratory equipment and developed early laboratory procedures. These early efforts were some of the first observations and experiments using the scientific method.

Paracelsus (1493–1541) was a physician and an alchemist who thought that alchemy should be about preparing new medicines. Using observation and experimentation, he proposed that a healthy body was regulated by a series of chemical processes that could be unbalanced by certain chemical compounds and rebalanced by using minerals and

medicines. For example, he determined that inhaled dust caused lung disease in miners. He also thought that goiter was a problem caused

by contaminated water, and he treated syphilis with compounds of mercury. His opinion of medicines was that the right dose makes the difference between a poison and a cure. Paracelsus changed alchemy in ways that helped establish modern medicine and chemistry.



Swiss physician and alchemist Paracelsus (1493–1541) believed that chemicals and minerals could be used as medicines.



Through observation you may think that you are allergic to cats.

#### ENGAGE

Why would the following statement “Today I placed two tomato seedlings in the garden, and two more in a closet. I will give all the plants the same amount of water and fertilizer.” be considered an experiment?

### Using the Scientific Method in Everyday Life

You may be surprised to realize that you use the scientific method in your everyday life. Suppose you visit a friend in her home. Soon after you arrive, your eyes start to itch and you begin to sneeze. Then you observe that your friend has a new cat. Perhaps you form the hypothesis that you are allergic to cats. To test your hypothesis, you leave your friend’s home. If the sneezing stops, perhaps your hypothesis is correct. You test your hypothesis further by visiting another friend who also has a cat. If you start to sneeze again, your experimental results support your hypothesis and you come to the conclusion that you are allergic to cats. However, if you continue sneezing after you leave your friend’s home, your hypothesis is not supported. Now you need to form a new hypothesis, which could be that you have a cold.

#### SAMPLE PROBLEM 1.1 Scientific Method

##### TRY IT FIRST

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- During an assessment in the emergency room, a nurse writes that the patient has a resting pulse of 30 beats/min.
- Repeated studies show that lowering sodium in the diet leads to a decrease in blood pressure.
- A nurse thinks that an incision from a recent surgery that is red and swollen is infected.

##### SOLUTION

a. observation

b. conclusion

c. hypothesis



Nurses make observations in the hospital.

**STUDY CHECK 1.1**

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- Drinking coffee at night keeps me awake.
- I will try drinking coffee only in the morning.
- If I stop drinking coffee in the afternoon, I will be able to sleep at night.

**ANSWER**

- a. observation                      b. experiment                      c. hypothesis

**TEST**

Try Practice Problems 1.7 to 1.10

**PRACTICE PROBLEMS****1.2 Scientific Method: Thinking Like a Scientist**

**LEARNING GOAL** Describe the activities that are part of the scientific method.

- 1.7** Identify each activity, **a** to **f**, as an observation, a hypothesis, an experiment, or a conclusion.

At a popular restaurant, where Chang is the head chef, the following occurred:

- Chang determined that sales of the house salad had dropped.
- Chang decided that the house salad needed a new dressing.
- In a taste test, Chang prepared four bowls of lettuce, each with a new dressing: sesame seed, olive oil and balsamic vinegar, creamy Italian, and blue cheese.
- Tasters rated the sesame seed salad dressing as the favorite.
- After two weeks, Chang noted that the orders for the house salad with the new sesame seed dressing had doubled.
- Chang decided that the sesame seed dressing improved the sales of the house salad because the sesame seed dressing enhanced the taste.



Customers rated the sesame seed dressing as the best.

- 1.8** Identify each activity, **a** to **f**, as an observation, a hypothesis, an experiment, or a conclusion.

Lucia wants to develop a process for dyeing shirts so that the color will not fade when the shirt is washed. She proceeds with the following activities:

- Lucia notices that the dye in a design fades when the shirt is washed.
- Lucia decides that the dye needs something to help it combine with the fabric.

- She places a spot of dye on each of four shirts and then places each one separately in water, salt water, vinegar, and baking soda and water.
- After one hour, all the shirts are removed and washed with a detergent.
- Lucia notices that the dye has faded on the shirts in water, salt water, and baking soda, whereas the dye did not fade on the shirt soaked in vinegar.
- Lucia thinks that the vinegar binds with the dye so it does not fade when the shirt is washed.

**Clinical Applications**

- 1.9** Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- One hour after drinking a glass of regular milk, Jim experienced stomach cramps.
- Jim thinks he may be lactose intolerant.
- Jim drinks a glass of lactose-free milk and does not have any stomach cramps.
- Jim drinks a glass of regular milk to which he has added lactase, an enzyme that breaks down lactose, and has no stomach cramps.

- 1.10** Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- Sally thinks she may be allergic to shrimp.
- Yesterday, one hour after Sally ate a shrimp salad, she broke out in hives.
- Today, Sally had some soup that contained shrimp, but she did not break out in hives.
- Sally realizes that she does not have an allergy to shrimp.

**1.3 Studying and Learning Chemistry**

**LEARNING GOAL** Identify strategies that are effective for learning. Develop a study plan for learning chemistry.

Here you are taking chemistry, perhaps for the first time. Whatever your reasons for choosing to study chemistry, you can look forward to learning many new and exciting ideas.

**Strategies to Improve Learning and Understanding**

Success in chemistry utilizes good study habits, connecting new information with your knowledge base, rechecking what you have learned and what you have forgotten, and retrieving what you have learned for an exam. Let's take a look at ways that can help you



study and learn chemistry. Suppose you were asked to indicate if you think each of the following common study habits is helpful or not helpful:

|   | <b>Helpful</b> | <b>Not helpful</b> |
|---|----------------|--------------------|
| Highlighting                              |                |                    |
| Underlining                               |                |                    |
| Reading the chapter many times            |                |                    |
| Memorizing the key words                  |                |                    |
| Testing practice                          |                |                    |
| Cramming                                  |                |                    |
| Studying different ideas at the same time |                |                    |
| Retesting a few days later                |                |                    |

Learning something requires us to place new information in our long-term memory, which allows us to remember those ideas for an exam, a process called retrieval. Thus, our evaluation of study habits depends on their value in helping us to recall knowledge. The study habits that are not very helpful in retrieval include highlighting, underlining, reading the chapter many times, memorizing key words, and cramming. If we want to recall new information, we need to connect it with prior knowledge that we can retrieve. This can be accomplished by developing study habits that involve a lot of practice testing ourselves on how to retrieve new information. We can determine how much we have learned by going back a few days later and retesting. Another useful learning strategy is to study different ideas at the same time, which allows us to connect those ideas and how to differentiate them. Although these study habits may take more time and seem more difficult, they help us find the gaps in our knowledge and connect new information with what we already know. In the long run, you retain and retrieve more information, making your study for exams less stressful.

### Tips for Using New Study Habits for Successful Learning

- 1. Do not keep rereading text or notes.** Reading the same material over and over will make that material seem familiar but does not mean that you have learned it. You need to test yourself to find out what you do and do not know.
- 2. Ask yourself questions as you read.** Asking yourself questions as you read requires you to interact continually with new material. For example, you might ask yourself how the new material is related to previous material, which helps you make connections. By linking new material with long-term knowledge, you make pathways for retrieving new material.
- 3. Self-test by giving yourself quizzes.** Using problems in the text or sample exams, practice taking tests frequently.
- 4. Study at a regular pace rather than cramming.** Once you have tested yourself, go back in a few days and practice testing and retrieving information again. We do not recall all the information when we first read it. By frequent quizzing and retesting, we identify what we still need to learn. Sleep is also important for strengthening the associations between newly learned information. Lack of sleep may interfere with retrieval of information as well. So staying up all night to cram for your chemistry exam is not a good idea. Success in chemistry is a combined effort to learn new information and then to retrieve that information when you need it for an exam.
- 5. Study different topics in a chapter and relate the new concepts to concepts you know.** We learn material more efficiently by relating it to information we already know. By increasing connections between concepts, we can retrieve information when we need it.

#### Helpful

Testing practice  
Studying different ideas  
at the same time  
Retesting a few days later

#### Not helpful

Highlighting  
Underlining  
Reading the chapter many times  
Memorizing the key words  
Cramming

#### ENGAGE

Why is self-testing helpful for learning new concepts?

**SAMPLE PROBLEM 1.2 Strategies for Learning Chemistry****TRY IT FIRST**

Predict which student will obtain the best exam score.

- A student who reads the chapter four times.
- A student who reads the chapter two times and works all the problems at the end of each Section.
- A student who reads the chapter the night before the exam.

**SOLUTION**

- A student who reads the chapter two times and works all the problems at the end of each Section has interacted with the content in the chapter using self-testing to make connections between concepts and practicing retrieving information learned previously.

**STUDY CHECK 1.2**

What is another way that student **b** in Sample Problem 1.2 could improve his or her retrieval of information?

**ANSWER**

Student **b** in Sample Problem 1.2 could also wait two or three days and practice working the problems in each Section again to determine how much he or she has learned. Retesting strengthens connections between new and previously learned information for longer lasting memory and more efficient retrieval.

## Features in This Text That Help You Study and Learn Chemistry

This text has been designed with study features to complement your individual learning style. On the inside of the front cover is a periodic table of the elements. On the inside of the back cover are tables that summarize useful information needed throughout your study of chemistry. Each chapter begins with *Looking Ahead*, which outlines the topics in the chapter. *Key Terms* are bolded when they first appear in the text, and are summarized at the end of each chapter. They are also listed and defined in the comprehensive *Glossary and Index*, which appears at the end of the text. *Key Math Skills* and *Core Chemistry Skills* that are critical to learning chemistry are indicated by icons in the margin, and summarized at the end of each chapter.

Before you begin reading, obtain an overview of a chapter by reviewing the topics in *Looking Ahead*. As you prepare to read a Section of the chapter, look at the Section title and turn it into a question. Asking yourself questions about new topics builds new connections to material you have already learned. For example, for Section 1.1, “Chemistry and Chemicals,” you could ask, “What is chemistry?” or “What are chemicals?” At the beginning of each Section, a *Learning Goal* states what you need to understand and a *Review* box lists the Key Math Skills and Core Chemistry Skills from previous chapters that relate to new material in the chapter. As you read the text, you will see *Engage* features in the margin, which remind you to pause your reading and test yourself with a question related to the material.

Several *Sample Problems* are included in each Chapter. The *Try It First* feature reminds you to work the problem before you look at the Solution. The *Analyze the Problem* feature includes *Given*, the information you have; *Need*, what you have to accomplish; and *Connect*, how you proceed. It is helpful to try to work a problem first because it helps you link what you know to what you need to learn. This process will help you develop successful problem-solving techniques. Many Sample Problems include a *Solution Guide* that shows the steps you can use for problem solving. Work the associated *Study Check* and compare your answer to the one provided.

At the end of each chapter Section, you will find a set of *Practice Problems* that allows you to apply problem solving immediately to the new concepts. Throughout each

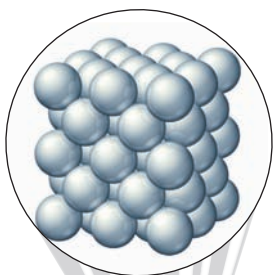
**KEY MATH SKILL****CORE CHEMISTRY SKILL****REVIEW****ENGAGE**

What is the purpose of an Engage question?

**TRY IT FIRST**

| ANALYZE THE PROBLEM | Given  | Need      | Connect           |
|---------------------|--------|-----------|-------------------|
|                     | 165 lb | kilograms | conversion factor |

## TEST



Illustrating the atoms of aluminum in aluminum foil is an example of macro-to-micro art.

## INTERACTIVE VIDEO

Section, *Test* suggestions remind you to solve the indicated Practice Problems as you study. The *Clinical Applications* in the Practice Problems relate the content to health and medicine. The problems are paired, which means that each of the odd-numbered problems is matched to the following even-numbered problem. At the end of each chapter, the answers to all the odd-numbered problems are provided. If the answers match yours, you most likely understand the topic; if not, you need to study the Section again.

Throughout each chapter, boxes titled *Chemistry Link to Health* and *Chemistry Link to the Environment* help you relate the chemical concepts you are learning to real-life situations. Many of the figures and diagrams use macro-to-micro illustrations to depict the atomic level of organization of ordinary objects, such as the atoms in aluminum foil. These visual models illustrate the concepts described in the text and allow you to “see” the world in a microscopic way. *Interactive Video* suggestions illustrate content as well as problem solving.

At the end of each chapter, you will find several study aids that complete the chapter. *Chapter Reviews* provide a summary in easy-to-read bullet points and *Concept Maps* visually show the connections between important topics. *Understanding the Concepts* are problems that use art and models to help you visualize concepts and connect them to your background knowledge. *Additional Practice Problems* and *Challenge Problems* provide additional exercises to test your understanding of the topics in the chapter. *Answers* to all of the odd-numbered problems complete the chapter allowing you to compare your answers to the ones provided.

After some chapters, problem sets called *Combining Ideas* test your ability to solve problems containing material from more than one chapter.

Many students find that studying with a group can be beneficial to learning. In a group, students motivate each other to study, fill in gaps, and correct misunderstandings by teaching and learning together. Studying alone does not allow the process of peer correction. In a group, you can cover the ideas more thoroughly as you discuss the reading and problem solve with other students.

## Making a Study Plan

As you embark on your journey into the world of chemistry, think about your approach to studying and learning chemistry. You might consider some of the ideas in the following list. Check those ideas that will help you successfully learn chemistry. Commit to them now. *Your success depends on you.*

### My study plan for learning chemistry will include the following:

- reading the chapter before class
- going to class
- reviewing the *Learning Goals*
- keeping a problem notebook
- reading the text
- working the *Test* problems as I read each Section
- answering the *Engage* questions
- trying to work the *Sample Problem* before looking at the *Solution*
- working the *Practice Problems* at the end of each Section and checking answers
- studying different topics at the same time
- organizing a study group
- seeing the professor during office hours
- reviewing *Key Math Skills* and *Core Chemistry Skills*
- attending review sessions
- studying as often as I can



Studying in a group can be beneficial to learning.

**SAMPLE PROBLEM 1.3 A Study Plan for Learning Chemistry****TRY IT FIRST**

Which of the following activities should you include in your study plan for learning chemistry successfully?

- reading the chapter over and over until you think you understand it
- going to the professor's office hours
- self-testing during and after reading each Section
- waiting to study until the night before the exam
- trying to work the Sample Problem before looking at the Solution
- retesting on new information a few days later

**SOLUTION**

Your success in chemistry can be improved by:

- going to the professor's office hours
- self-testing during and after reading each Section
- trying to work the Sample Problem before looking at the Solution
- retesting on new information a few days later

**STUDY CHECK 1.3**

Which of the following will help you learn chemistry?

- skipping review sessions
- working problems as you read a Section
- staying up all night before an exam
- reading the assignment before class

**ANSWER**

**b and d**

**TEST**

Try Practice Problems 1.11 to 1.14

**PRACTICE PROBLEMS****1.3 Studying and Learning Chemistry**

**LEARNING GOAL** Identify strategies that are effective for learning. Develop a study plan for learning chemistry.

- 1.11 What are four things you can do to help yourself to succeed in chemistry?
- 1.12 What are four things that would make it difficult for you to learn chemistry?
- 1.13 A student in your class asks you for advice on learning chemistry. Which of the following might you suggest?
  - forming a study group
  - skipping class

- asking yourself questions while reading the text
- waiting until the night before an exam to study
- answering the Engage questions

- 1.14 A student in your class asks you for advice on learning chemistry. Which of the following might you suggest?
  - studying different topics at the same time
  - not reading the text; it's never on the test
  - attending review sessions
  - working the problems again after a few days
  - keeping a problem notebook

**1.4 Key Math Skills for Chemistry**

**LEARNING GOAL** Review math concepts used in chemistry: place values, positive and negative numbers, percentages, solving equations, and interpreting graphs.

During your study of chemistry, you will work many problems that involve numbers. You will need various math skills and operations. We will review some of the key math skills that are particularly important for chemistry. As we move through the chapters, we will also reference the key math skills as they apply.