

GLOBAL  
EDITION



# Chemistry

*An Introduction to General, Organic,  
and Biological Chemistry*

THIRTEENTH EDITION

Timberlake



# CHEMISTRY

**An Introduction to General, Organic,  
and Biological Chemistry**



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**An Introduction to General, Organic,  
and Biological Chemistry**

**Thirteenth Edition  
Global Edition**

**Karen Timberlake**

*Contributions by*  
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# Brief Contents

- 1** Chemistry in Our Lives 31
- 2** Chemistry and Measurements 55
- 3** Matter and Energy 90
- 4** Atoms and Elements 128
- 5** Nuclear Chemistry 166
- 6** Ionic and Molecular Compounds 198
- 7** Chemical Quantities and Reactions 246
- 8** Gases 289
- 9** Solutions 315
- 10** Acids and Bases and Equilibrium 354
- 11** Introduction to Organic Chemistry: Hydrocarbons 393
- 12** Alcohols, Thiols, Ethers, Aldehydes, and Ketones 428
- 13** Carbohydrates 462
- 14** Carboxylic Acids, Esters, Amines, and Amides 500
- 15** Lipids 539
- 16** Amino Acids, Proteins, and Enzymes 578
- 17** Nucleic Acids and Protein Synthesis 614
- 18** Metabolic Pathways and ATP Production 649

# Table of Contents

## 1 Chemistry in Our Lives 31



**CAREER Forensic Scientist** 31

**CLINICAL UPDATE Forensic Evidence Helps Solve the Crime** 31

- 1.1 Chemistry and Chemicals 32
- 1.2 Scientific Method: Thinking Like a Scientist 33

**CHEMISTRY LINK TO HEALTH**

- Early Chemist: Paracelsus 34
- 1.3 Studying and Learning Chemistry 35
- 1.4 Key Math Skills for Chemistry 39
- 1.5 Writing Numbers in Scientific Notation 46

**CLINICAL UPDATE**

- Forensic Evidence Helps Solve the Crime 49
- Concept Map 50
- Chapter Review 50
- Key Terms 51
- Key Math Skills 51
- Understanding the Concepts 52
- Additional Practice Problems 53
- Challenge Problems 53
- Answers 54

## 2 Chemistry and Measurements 55



**CAREER Registered Nurse** 55

**CLINICAL UPDATE Greg's Visit with His Doctor** 55

- 2.1 Units of Measurement 56
- 2.2 Measured Numbers and Significant Figures 59
- 2.3 Significant Figures in Calculations 61
- 2.4 Prefixes and Equalities 65
- 2.5 Writing Conversion Factors 69
- 2.6 Problem Solving Using Unit Conversion 72
- 2.7 Density 76

**CHEMISTRY LINK TO HEALTH**

- Bone Density 79

6

**CLINICAL UPDATE**

- Greg's Visit with His Doctor 82
- Concept Map 82
- Chapter Review 82
- Key Terms 83
- Key Math Skill 84
- Core Chemistry Skills 84
- Understanding the Concepts 85
- Additional Practice Problems 86
- Challenge Problems 87
- Answers 88

## 3 Matter and Energy 90



**CAREER Dietitian** 90

**CLINICAL UPDATE A Diet and Exercise Program** 90

- 3.1 Classification of Matter 91

**CHEMISTRY LINK TO HEALTH**

- Breathing Mixtures 93
- 3.2 States and Properties of Matter 94
- 3.3 Temperature 97

**CHEMISTRY LINK TO HEALTH**

- Variation in Body Temperature 101
- 3.4 Energy 101

**CHEMISTRY LINK TO THE ENVIRONMENT**

- Carbon Dioxide and Climate Change 103
- 3.5 Energy and Nutrition 104

**CHEMISTRY LINK TO HEALTH**

- Losing and Gaining Weight 106
- 3.6 Specific Heat 107
- 3.7 Changes of State 110

**CHEMISTRY LINK TO HEALTH**

- Steam Burns 116

**CLINICAL UPDATE**

- A Diet and Exercise Program 117
- Concept Map 118
- Chapter Review 118
- Key Terms 119
- Core Chemistry Skills 120
- Understanding the Concepts 121
- Additional Practice Problems 122

Challenge Problems 124

Answers 124

**COMBINING IDEAS** from Chapters 1 to 3 126

# 4

## Atoms and Elements 128

**CAREER Farmer** 128**CLINICAL UPDATE Improving Crop Production** 128

4.1 Elements and Symbols 129

**CHEMISTRY LINK TO HEALTH**

Toxicity of Mercury 130

4.2 The Periodic Table 131

**CHEMISTRY LINK TO HEALTH**

Elements Essential to Health 134

4.3 The Atom 136

4.4 Atomic Number and Mass Number 139

**CHEMISTRY LINK TO THE ENVIRONMENT**

Many Forms of Carbon 141

4.5 Isotopes and Atomic Mass 142

4.6 Electron Energy Levels 145

**CHEMISTRY LINK TO HEALTH**

Biological Reactions to UV Light 149

4.7 Trends in Periodic Properties 150

**CLINICAL UPDATE**

Improving Crop Production 157

Concept Map 158

Chapter Review 158

Key Terms 159

Core Chemistry Skills 160

Understanding the Concepts 161

Additional Practice Problems 162

Challenge Problems 163

Answers 163

# 5

## Nuclear Chemistry 166

**CAREER Radiation Technologist** 166**CLINICAL UPDATE Cardiac Imaging Using a Radioisotope** 166

5.1 Natural Radioactivity 167

5.2 Nuclear Reactions 170

**CHEMISTRY LINK TO HEALTH**

Radon in Our Homes 172

5.3 Radiation Measurement 177

**CHEMISTRY LINK TO HEALTH**

Radiation and Food 178

5.4 Half-Life of a Radioisotope 180

**CHEMISTRY LINK TO THE ENVIRONMENT**

Dating Ancient Objects 182

5.5 Medical Applications Using Radioactivity 184

**CHEMISTRY LINK TO HEALTH**

Brachytherapy 187

5.6 Nuclear Fission and Fusion 188

**CHEMISTRY LINK TO THE ENVIRONMENT**

Nuclear Power Plants 191

**CLINICAL UPDATE**

Cardiac Imaging Using a Radioisotope 191

Concept Map 192

Chapter Review 192

Key Terms 193

Core Chemistry Skills 193

Understanding the Concepts 194

Additional Practice Problems 195

Challenge Problems 195

Answers 196

# 6

## Ionic and Molecular Compounds 198

**CAREER Pharmacy Technician** 198**CLINICAL UPDATE Compounds at the Pharmacy** 198

6.1 Ions: Transfer of Electrons 199

**CHEMISTRY LINK TO HEALTH**

Some Important Ions in the Body 202

6.2 Ionic Compounds 204

6.3 Naming and Writing Ionic Formulas 206

6.4 Polyatomic Ions 211

6.5 Molecular Compounds: Sharing Electrons 215

6.6 Lewis Structures for Molecules 219

6.7 Electronegativity and Bond Polarity 223

6.8 Shapes of Molecules 226

6.9 Polarity of Molecules and Intermolecular Forces 229

**CLINICAL UPDATE**

Compounds at the Pharmacy 233

Concept Map 234

Chapter Review 234

Key Terms 235

Core Chemistry Skills 236



Understanding the Concepts	238
Additional Practice Problems	239
Challenge Problems	240
Answers	241

**COMBINING IDEAS** from Chapters 4 to 6 244

# 7

## Chemical Quantities and Reactions

246


**CAREER** Exercise Physiologist 246

**CLINICAL UPDATE** Improving Natalie's Overall Fitness 246

7.1	The Mole	247
7.2	Molar Mass	251
7.3	Calculations Using Molar Mass	253
7.4	Equations for Chemical Reactions	256
7.5	Types of Chemical Reactions	263

**CHEMISTRY LINK TO HEALTH**

Incomplete Combustion: Toxicity of Carbon Monoxide 267

7.6	Oxidation–Reduction Reactions	268
7.7	Mole Relationships in Chemical Equations	271
7.8	Mass Calculations for Chemical Reactions	274
7.9	Energy in Chemical Reactions	276

**CHEMISTRY LINK TO HEALTH**

Cold Packs and Hot Packs 277

**CLINICAL UPDATE**

Improving Natalie's Overall Fitness 279

Concept Map	280
Chapter Review	280
Key Terms	281
Core Chemistry Skills	282
Understanding the Concepts	283
Additional Practice Problems	285
Challenge Problems	286
Answers	287



# 8

## Gases

289

**CAREER** Respiratory Therapist 289

**CLINICAL UPDATE** Exercise-Induced Asthma 289

8.1	Properties of Gases	290
-----	---------------------	-----

**CHEMISTRY LINK TO HEALTH**

Measuring Blood Pressure 292

8.2	Pressure and Volume (Boyle's Law)	295
-----	-----------------------------------	-----

**CHEMISTRY LINK TO HEALTH**

Pressure–Volume Relationship in Breathing 296

8.3	Temperature and Volume (Charles's Law)	298
8.4	Temperature and Pressure (Gay-Lussac's Law)	300
8.5	The Combined Gas Law	302
8.6	Volume and Moles (Avogadro's Law)	303
8.7	Partial Pressures (Dalton's Law)	306

**CHEMISTRY LINK TO HEALTH**

Hyperbaric Chambers 308

**CLINICAL UPDATE**

Exercise-Induced Asthma 309

Concept Map	309
Chapter Review	310
Key Terms	310
Core Chemistry Skills	311
Understanding the Concepts	311
Additional Practice Problems	312
Challenge Problems	313
Answers	313

# 9

## Solutions

315


**CAREER** Dialysis Nurse 315

**CLINICAL UPDATE** Using Dialysis for Renal Failure 315

9.1	Solutions	316
-----	-----------	-----

**CHEMISTRY LINK TO HEALTH**

Water in the Body 318

9.2	Electrolytes and Nonelectrolytes	320
-----	----------------------------------	-----

**CHEMISTRY LINK TO HEALTH**

Electrolytes in Body Fluids 322

9.3	Solubility	324
-----	------------	-----

**CHEMISTRY LINK TO HEALTH**

Gout and Kidney Stones: A Problem of Saturation in Body Fluids 325

9.4	Solution Concentrations	328
9.5	Dilution of Solutions	336
9.6	Properties of Solutions	339

**CHEMISTRY LINK TO HEALTH**

Dialysis by the Kidneys and the Artificial Kidney 342

**CLINICAL UPDATE**

Using Dialysis for Renal Failure 344

Concept Map	344
Chapter Review	344
Key Terms	345
Core Chemistry Skills	346
Understanding the Concepts	346
Additional Practice Problems	347
Challenge Problems	348
Answers	349

**COMBINING IDEAS** from Chapters 7 to 9 351

## 10 Acids and Bases and Equilibrium 354



**CAREER** Clinical Laboratory Technician 354

**CLINICAL UPDATE** Acid Reflux Disease 354

10.1 Acids and Bases 355

10.2 Brønsted–Lowry Acids and Bases 357

10.3 Strengths of Acids and Bases 360

10.4 Acid–Base Equilibrium 363

**CHEMISTRY LINK TO HEALTH**

Oxygen–Hemoglobin Equilibrium and Hypoxia 366

10.5 Dissociation of Water 368

10.6 The pH Scale 370

**CHEMISTRY LINK TO HEALTH**

Stomach Acid, HCl 375

10.7 Reactions of Acids and Bases 376

**CHEMISTRY LINK TO HEALTH**

Antacids 379

10.8 Buffers 380

**CHEMISTRY LINK TO HEALTH**

Buffers in the Blood Plasma 382

**CLINICAL UPDATE**

Acid Reflux Disease 384

Concept Map 385

Chapter Review 385

Key Terms 387

Key Math Skills 387

Core Chemistry Skills 387

Understanding the Concepts 388

Additional Practice Problems 389

Challenge Problems 390

Answers 391

## 11 Introduction to Organic Chemistry: Hydrocarbons 393



**CAREER** Firefighter/Emergency Medical Technician 393

**CLINICAL UPDATE** Diane's Treatment in the Burn Unit 393

11.1 Organic Compounds 394

11.2 Alkanes 396

11.3 Alkanes with Substituents 400

11.4 Properties of Alkanes 405

11.5 Alkenes and Alkynes 406

11.6 Cis–Trans Isomers 409

**CHEMISTRY LINK TO THE ENVIRONMENT**

Pheromones in Insect Communication 411

**CHEMISTRY LINK TO HEALTH**

Cis–Trans Isomers for Night Vision 412

11.7 Addition Reactions for Alkenes 412

**CHEMISTRY LINK TO HEALTH**

Hydrogenation of Unsaturated Fats 413

11.8 Aromatic Compounds 415

**CHEMISTRY LINK TO HEALTH**

Some Common Aromatic Compounds 417

**CHEMISTRY LINK TO HEALTH**

Polycyclic Aromatic Hydrocarbons (PAHs) 418

**CLINICAL UPDATE**

Diane's Treatment in the Burn Unit 419

Concept Map 419

Chapter Review 420

Summary of Naming 421

Summary of Reactions 421

Key Terms 421

Core Chemistry Skills 422

Understanding the Concepts 422

Additional Practice Problems 423

Challenge Problems 424

Answers 425

## 12 Alcohols, Thiols, Ethers, Aldehydes, and Ketones 428



**CAREER** Dermatology Nurse 428

**CLINICAL UPDATE** Diana's Skin Protection Plan 428

12.1 Alcohols, Phenols, Thiols, and Ethers 429

## CHEMISTRY LINK TO HEALTH

Some Important Alcohols and Phenols 432

## CHEMISTRY LINK TO HEALTH

Ethers as Anesthetics 434

## 12.2 Properties of Alcohols 435

## CHEMISTRY LINK TO HEALTH

Hand Sanitizers 437

## 12.3 Aldehydes and Ketones 438

## CHEMISTRY LINK TO HEALTH

Some Important Aldehydes and Ketones 442

## 12.4 Reactions of Alcohols, Thiols, Aldehydes, and Ketones 444

## CHEMISTRY LINK TO HEALTH

Oxidation of Alcohol in the Body 447

## CLINICAL UPDATE

Diana's Skin Protection Plan 451

Concept Map 451

Chapter Review 452

Summary of Naming 453

Summary of Reactions 453

Key Terms 453

Core Chemistry Skills 454

Understanding the Concepts 454

Additional Practice Problems 455

Challenge Problems 457

Answers 457

**COMBINING IDEAS** from Chapters 10 to 12 460

# 13

## Carbohydrates 462

**CAREER** Diabetes Nurse 462**CLINICAL UPDATE** Kate's Program for Type 2 Diabetes 462

## 13.1 Carbohydrates 463

## 13.2 Chiral Molecules 466

## CHEMISTRY LINK TO HEALTH

Enantiomers in Biological Systems 471

## 13.3 Fischer Projections of Monosaccharides 473

## CHEMISTRY LINK TO HEALTH

Hyperglycemia and Hypoglycemia 475

## 13.4 Haworth Structures of Monosaccharides 476

## 13.5 Chemical Properties of Monosaccharides 480

## CHEMISTRY LINK TO HEALTH

Testing for Glucose 482

## 13.6 Disaccharides 483

## CHEMISTRY LINK TO HEALTH

How Sweet Is My Sweetener? 485

## CHEMISTRY LINK TO HEALTH

Blood Types and Carbohydrates 486

## 13.7 Polysaccharides 489

## CLINICAL UPDATE

Kate's Program for Type 2 Diabetes 491

Concept Map 492

Chapter Review 492

Summary of Carbohydrates 493

Summary of Reactions 494

Key Terms 494

Core Chemistry Skills 495

Understanding the Concepts 495

Additional Practice Problems 496

Challenge Problems 497

Answers 498

# 14

## Carboxylic Acids, Esters, Amines, and Amides 500

**CAREER** Environmental Health Practitioner 500**CLINICAL UPDATE** Testing Soil and Water Samples for Chemicals 500

## 14.1 Carboxylic Acids 501

## 14.2 Properties of Carboxylic Acids 503

## CHEMISTRY LINK TO HEALTH

Carboxylic Acids in Metabolism 506

## 14.3 Esters 507

## CHEMISTRY LINK TO HEALTH

Salicylic Acid from a Willow Tree 509

## CHEMISTRY LINK TO THE ENVIRONMENT

Plastics 510

## 14.4 Hydrolysis of Esters 512

## 14.5 Amines 514

## CHEMISTRY LINK TO HEALTH

Amines in Health and Medicine 516

## CHEMISTRY LINK TO THE ENVIRONMENT

Alkaloids: Amines in Plants 520

## 14.6 Amides 521

**CHEMISTRY LINK TO HEALTH**

Amides in Health and Medicine 524

**CLINICAL UPDATE**

Testing Soil and Water Samples for Chemicals 527

Concept Map 528

Chapter Review 528

Summary of Naming 529

Summary of Reactions 529

Key Terms 531

Core Chemistry Skills 531

Understanding the Concepts 531

Additional Practice Problems 532

Challenge Problems 534

Answers 535

**15****Lipids** 539**CAREER Clinical Lipid Specialist** 539**CLINICAL UPDATE Rebecca's Program to Lower Cholesterol** 539**15.1** Lipids 540**15.2** Fatty Acids 541**CHEMISTRY LINK TO HEALTH**

Omega-3 Fatty Acids in Fish Oils 545

**15.3** Waxes and Triacylglycerols 547**15.4** Chemical Properties of Triacylglycerols 551**CHEMISTRY LINK TO HEALTH**

Converting Unsaturated Fats to Saturated Fats: Hydrogenation 552

**15.5** Phospholipids 555**CHEMISTRY LINK TO HEALTH**

Infant Respiratory Distress Syndrome (IRDS) 559

**15.6** Steroids: Cholesterol, Bile Salts, and Steroid Hormones 560**CHEMISTRY LINK TO HEALTH**

Anabolic Steroids 564

**15.7** Cell Membranes 566**CLINICAL UPDATE**

Rebecca's Program to Lower Cholesterol 568

Concept Map 569

Chapter Review 569

Summary of Reactions 570

Key Terms 570

Core Chemistry Skills 571

Understanding the Concepts 571

Additional Practice Problems 572

Challenge Problems 572

Answers 573

**COMBINING IDEAS** from Chapters 13 to 15 576**16**  
**Amino Acids,  
Proteins,  
and Enzymes** 578**CAREER Physician Assistant** 578**CLINICAL UPDATE Jeremy's Diagnosis and Treatment for Sickle-Cell Anemia** 578**16.1** Proteins and Amino Acids 579**16.2** Proteins: Primary Structure 583**CHEMISTRY LINK TO HEALTH**

Essential Amino Acids and Complete Proteins 585

**CHEMISTRY LINK TO HEALTH**

Polypeptides in the Body 587

**16.3** Proteins: Secondary, Tertiary, and Quaternary Structures 588**CHEMISTRY LINK TO HEALTH**

Protein Secondary Structures and Alzheimer's Disease 590

**CHEMISTRY LINK TO HEALTH**

Sickle-Cell Anemia 595

**16.4** Enzymes 596**CHEMISTRY LINK TO HEALTH**

Isoenzymes as Diagnostic Tools 599

**16.5** Factors Affecting Enzyme Activity 601**CLINICAL UPDATE**

Jeremy's Diagnosis and Treatment for Sickle-Cell Anemia 606

Concept Map 607

Chapter Review 607

Key Terms 608

Core Chemistry Skills 609

Understanding the Concepts 609

Additional Practice Problems 610

Challenge Problems 611

Understanding Protein Structures 611

Answers 611

# 17

## Nucleic Acids and Protein Synthesis

614



**CAREER** Histology Technician 614

**CLINICAL UPDATE** Ellen's Medical Treatment Following Breast Cancer Surgery 614

- 17.1 Components of Nucleic Acids 615
- 17.2 Primary Structure of Nucleic Acids 618
- 17.3 DNA Double Helix and Replication 620
- 17.4 RNA and Transcription 623
- 17.5 The Genetic Code and Protein Synthesis 626

### CHEMISTRY LINK TO HEALTH

Many Antibiotics Inhibit Protein Synthesis 629

- 17.6 Genetic Mutations 630
- 17.7 Recombinant DNA 635
- 17.8 Viruses 637

### CHEMISTRY LINK TO HEALTH

Cancer 640

### CLINICAL UPDATE

Ellen's Medical Treatment Following Breast Cancer Surgery 641

Concept Map 642

Chapter Review 642

Key Terms 643

Core Chemistry Skills 644

Understanding the Concepts 644

Additional Practice Problems 645

Challenge Problems 646

Answers 646

### CHEMISTRY LINK TO HEALTH

Lactose Intolerance 654

18.3 Coenzymes in Metabolic Pathways 656

18.4 Glycolysis: Oxidation of Glucose 660

18.5 The Citric Acid Cycle 665

18.6 Electron Transport and Oxidative Phosphorylation 669

### CHEMISTRY LINK TO HEALTH

ATP Synthase and Heating the Body 672

18.7 Oxidation of Fatty Acids 675

### CHEMISTRY LINK TO HEALTH

Stored Fat and Obesity 678

### CHEMISTRY LINK TO HEALTH

Ketone Bodies and Diabetes 681

18.8 Degradation of Amino Acids 681

### CLINICAL UPDATE

Treatment of Luke's Hepatitis C 684

Concept Map 685

Chapter Review 686

Summary of Reactions 687

Key Terms 689

Core Chemistry Skills 689

Understanding the Concepts 690

Additional Practice Problems 691

Challenge Problems 691

Answers 691

**COMBINING IDEAS** from Chapters 16 to 18 693

**Credits** 695

**Glossary/Index** 699

# 18

## Metabolic Pathways and ATP Production

649



**CAREER** Public Health Nurse (PHN) 649

**CLINICAL UPDATE** Treatment of Luke's Hepatitis C 649

18.1 Metabolism and ATP Energy 650

18.2 Digestion of Foods 653

# Applications and Activities

## KEY MATH SKILLS

- Identifying Place Values 40
- Using Positive and Negative Numbers in Calculations 41
- Calculating Percentages 42
- Solving Equations 43
- Interpreting Graphs 44
- Writing Numbers in Scientific Notation 47
- Rounding Off 62
- Calculating pH from  $[H_3O^+]$  372
- Calculating  $[H_3O^+]$  from pH 374

## CORE CHEMISTRY SKILLS

- Counting Significant Figures 59
- Using Significant Figures in Calculations 62
- Using Prefixes 66
- Writing Conversion Factors from Equalities 69
- Using Conversion Factors 73
- Using Density as a Conversion Factor 79
- Identifying Physical and Chemical Changes 96
- Converting between Temperature Scales 97
- Using Energy Units 102
- Using the Heat Equation 108
- Calculating Heat for Change of State 111
- Counting Protons and Neutrons 139
- Writing Atomic Symbols for Isotopes 142
- Writing Electron Arrangements 147
- Identifying Trends in Periodic Properties 150
- Drawing Lewis Symbols 152
- Writing Nuclear Equations 170
- Using Half-Lives 181
- Writing Positive and Negative Ions 200
- Writing Ionic Formulas 205
- Naming Ionic Compounds 206
- Writing the Names and Formulas for Molecular Compounds 216
- Drawing Lewis Structures 220
- Using Electronegativity 223
- Predicting Shape 226
- Identifying Polarity of Molecules and Intermolecular Forces 229
- Converting Particles to Moles 247
- Calculating Molar Mass 252
- Using Molar Mass as a Conversion Factor 253
- Balancing a Chemical Equation 259
- Classifying Types of Chemical Reactions 263

- Identifying Oxidized and Reduced Substances 269
- Using Mole–Mole Factors 272
- Converting Grams to Grams 274
- Using the Gas Laws 296
- Calculating Partial Pressure 306
- Using Solubility Rules 327
- Calculating Concentration 329
- Using Concentration as a Conversion Factor 330
- Identifying Conjugate Acid–Base Pairs 358
- Using Le Châtelier’s Principle 365
- Calculating  $[H_3O^+]$  and  $[OH^-]$  in Solutions 369
- Writing Equations for Reactions of Acids and Bases 376
- Calculating Molarity or Volume of an Acid or Base in a Titration 378
- Naming and Drawing Alkanes 397
- Writing Equations for Hydrogenation and Hydration 412
- Identifying Functional Groups 429
- Naming Alcohols and Phenols 429
- Naming Aldehydes and Ketones 439
- Writing Equations for the Dehydration of Alcohols 444
- Writing Equations for the Oxidation of Alcohols 445
- Identifying Chiral Molecules 467
- Identifying D and L Fischer Projections for Carbohydrates 473
- Drawing Haworth Structures 476
- Naming Carboxylic Acids 501
- Hydrolyzing Esters 512
- Forming Amides 522
- Identifying Fatty Acids 541
- Drawing Structures for Triacylglycerols 548
- Drawing the Products for the Hydrogenation, Hydrolysis, and Saponification of a Triacylglycerol 552
- Identifying the Steroid Nucleus 560
- Drawing the Structure for an Amino Acid at Physiological pH 582
- Identifying the Primary, Secondary, Tertiary, and Quaternary Structures of Proteins 588
- Describing Enzyme Action 599
- Writing the Complementary DNA Strand 622
- Writing the mRNA Segment for a DNA Template 626
- Writing the Amino Acid for an mRNA Codon 627
- Identifying the Compounds in Glycolysis 660
- Describing the Reactions in the Citric Acid Cycle 667
- Calculating the ATP Produced from Glucose 672
- Calculating the ATP from Fatty Acid Oxidation ( $\beta$  Oxidation) 678

## Interactive Videos

Solving Equations	44
Conversion Factors	73
Chemical vs. Physical Changes	96
Rutherford's Gold-Foil Experiment	137
Writing Equations for an Isotope Produced by Bombardment	175
Half-Lives	181
Problem 7.65	275
Kinetic Molecular Theory	290
Solutions	335
Titration of an Acid	379
Naming Alkanes	402
Addition to an Asymmetric Bond	414
Oxidation of Alcohols	446
Chirality	466
Study Check 14.7	514
Membrane Structure	566
Different Levels of Protein Structure	593
Protein Synthesis	628

# 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 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.

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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.

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# 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
Mastering™ Chemistry (www.masteringchemistry.com)		✓	Supplement for Students and Instructors	This product includes all of the resources of Mastering™ Chemistry. Mastering™ Chemistry 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 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		✓	Supplement for Students	The thirteenth edition of <i>Chemistry: An Introduction to General, Organic, and Biological Chemistry</i> features a Pearson eText 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. Icons in the margins throughout the text signify that there is a new <b>Interactive Video</b> or animation located within Mastering™ Chemistry 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		✓	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		✓	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 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.pearsonglobaleditions.com/timberlake">www.pearsonglobaleditions.com/timberlake</a> to download available instructor supplements.
TestGen Test Bank—Download Only		✓	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		✓	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.pearsonglobaleditions.com/timberlake">www.pearsonglobaleditions.com/timberlake</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 117, 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.

3.8 Specific Heat 109

**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
<b>ANALYZE THE PROBLEM</b>	5500 mL of blood = 5500 g of blood, cooled from 38.5 °C to 33.2 °C	kilojoules removed	heat equation, specific heat 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.

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

$$SH_{\text{water}} = \frac{4.184\text{ J}}{\text{g} \cdot \text{°C}}$$

$$\frac{4.184\text{ J}}{\text{g} \cdot \text{°C}} \text{ and } \frac{\text{g} \cdot \text{°C}}{4.184\text{ J}}$$

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

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


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

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

**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.

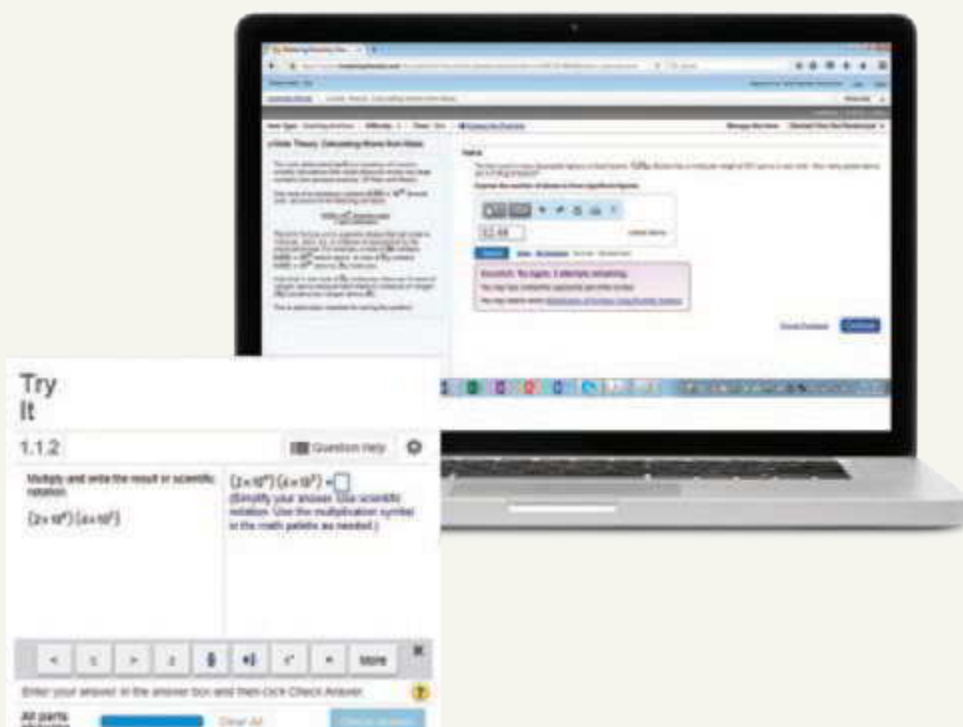
# Continuous Learning Before, During, and After Class

## BEFor E CLASS

### 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 factors, 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.



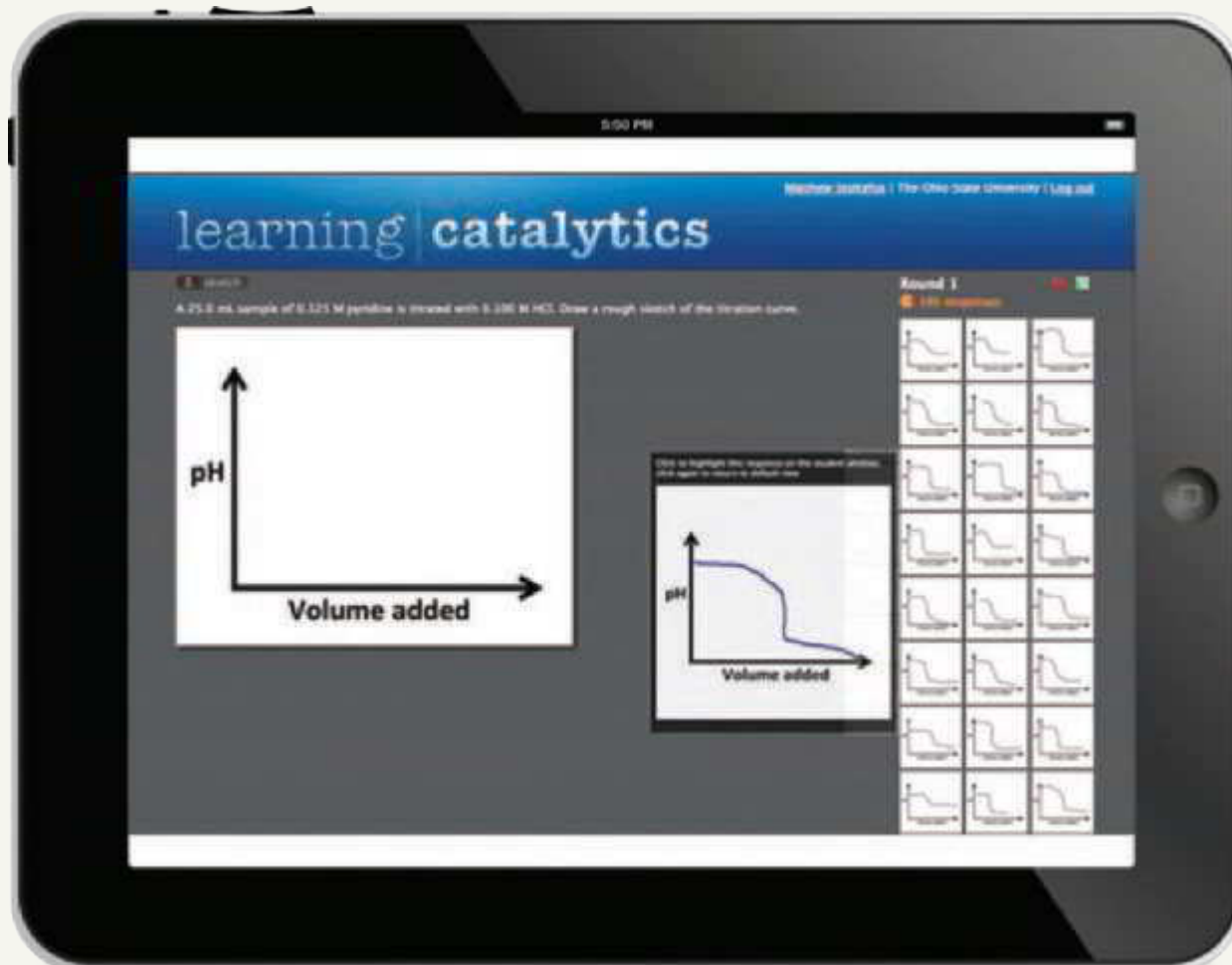
# with Mastering™ Chemistry

## During C LASS

### Learning Catalytics

Learning Catalytics generates class discussion, guides your lecture, and promotes peer-to-peer learning with real-time analytics. Mastering™ Chemistry 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.

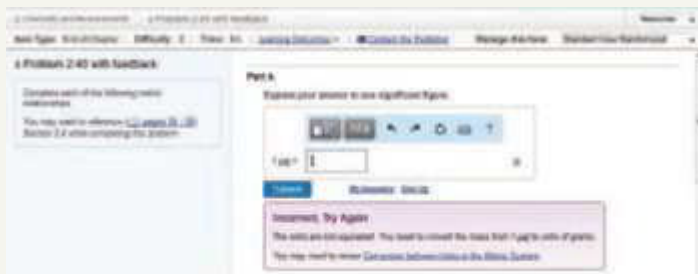
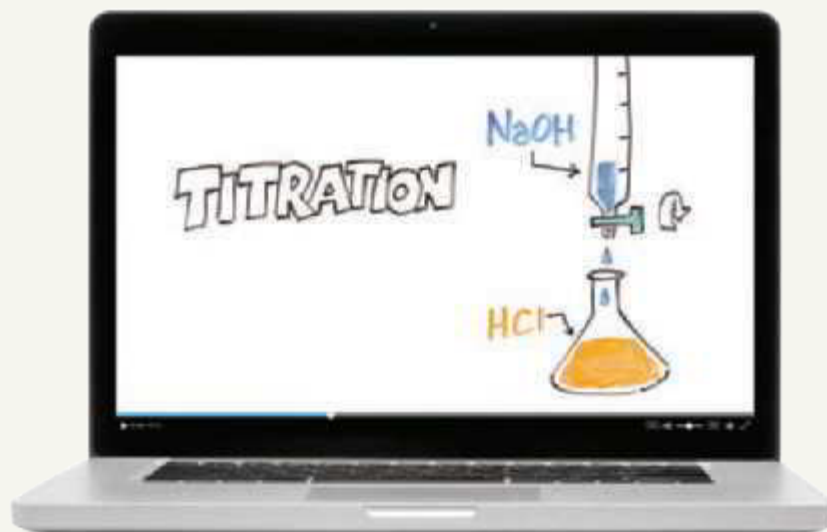


# Mastering™ Chemistry

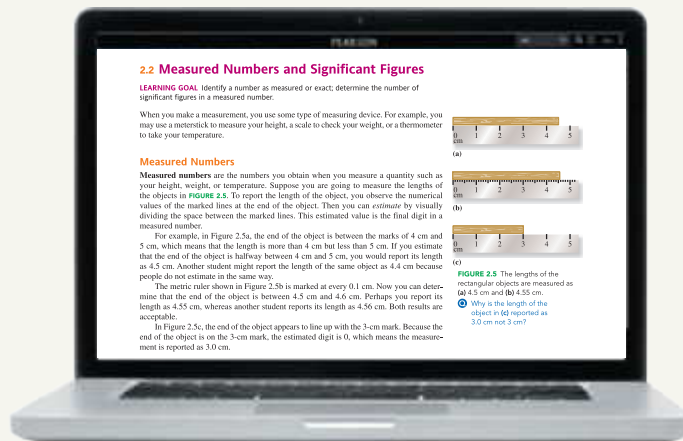
## AFTer CLASS

**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.

**Mastering™ Chemistry** 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.



Wrong-answer feedback supports students moving from Tutorial Problems to End-of-Chapter Problems.



## Pearson eText

- Seamlessly integrated videos and activities allow students to watch and practice key concepts within the eText learning experience.
- Study Check Questions allow students to interact in Pearson eText 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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