

MODERN CHEMISTRY[®]

Raymond E. Davis

Regina Frey

Mickey Sarquis

Jerry L. Sarquis



HOLT, RINEHART AND WINSTON

A Harcourt Education Company

Orlando • Austin • New York • San Diego • London

Authors



RAYMOND E. DAVIS, PH.D.

Professor Emeritus

Department of Chemistry and
Biochemistry
The University of Texas at Austin
Austin, TX



MICKEY SARQUIS

**Professor and Director,
Center for Chemistry
Education**

Department of Chemistry and
Biochemistry
Miami University
Middletown, OH



REGINA FREY, PH.D.

**Senior Lecturer and Director of
the Teaching Center**

Department of Chemistry
Washington University in St. Louis
St. Louis, MO



JERRY L. SARQUIS, PH.D.

Professor

Department of Chemistry and
Biochemistry
Miami University
Oxford, OH

On the cover: A snow crystal image produced by using a low temperature scanning electron microscope.

Copyright © 2009 by Holt, Rinehart and Winston

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Requests for permission to make copies of any part of the work should be mailed to the following address:
Permissions Department, Holt, Rinehart and Winston, 10801 N. MoPac Expressway, Building 3,
Austin, Texas 78759.

CBL is a trademark of Texas Instruments Incorporated.

HOLT, MODERN CHEMISTRY, and the "Owl Design" are trademarks licensed to Holt, Rinehart and Winston, registered in the United States of America and/or other jurisdictions.

SCILINKS is a registered trademark owned and provided by the National Science Teachers Association. All rights reserved.

Printed in the United States of America

If you have received these materials as examination copies free of charge, Holt, Rinehart and Winston retains title to the materials and they may not be resold. Resale of examination copies is strictly prohibited.

Possession of this publication in print format does not entitle users to convert this publication, or any portion of it, into electronic format.

ISBN-13: 978-0-03-036786-1

ISBN-10: 0-03-036786-7

1 2 3 4 5 6 7 048 11 10 09 08 07

Acknowledgments

Contributing Writers

Lisa Saunders Baugh, Ph.D.
Senior Chemist
Chemical Sciences Laboratory
ExxonMobil Research & Engineering
Company
Corporate Strategic Research
Annandale, New Jersey

Robert Davisson
Science Writer
Albuquerque, New Mexico

Seth Madej
Writer/Producer
Pittsburgh, Pennsylvania

Jim Metzner
Executive Producer
Pulse of the Planet Radio Series
Jim Metzner Productions, Inc.
Accord, New York

Jay A. Young, Ph.D.
Chemical Safety Consultant
Silver Spring, Maryland

Inclusion Specialists

Joan Altobelli
Special Education Director
Austin Independent School District
Austin, Texas

John A. Solorio
Multiple Technologies Lab Facilitator
Austin Independent School District
Austin, Texas

Reviewers

Eric V. Anslyn, Ph.D.
Professor
Department of Chemistry and
Biochemistry
University of Texas at Austin
Austin, Texas

George F. Atkinson, Ph.D.
Professor of Chemistry
Department of Chemistry
University of Waterloo
Waterloo, Ontario, Canada

Sonal S.D. Blumenthal, Ph.D.
Life Science Consultant
Austin, Texas

G. Lynn Carlson, Ph.D.
Senior Lecturer Emeritus
Department of Chemistry
University of Wisconsin—Parkside
Kenosha, Wisconsin

Scott A. Darveau, Ph.D.
Associate Professor
Department of Chemistry
University of Nebraska at Kearney
Kearney, Nebraska

Cassandra T. Eagle, Ph.D.
Professor of Chemistry
Department of Chemistry
Appalachian State University
Boone, North Carolina

Linda Gaul, Ph.D., M.P.H.
Epidemiologist
Infectious Disease Epidemiology and
Surveillance
Department of State Health Services
Austin, Texas

Pamela Gollhofer
Science Teacher
Princeton High School
Cincinnati, Ohio

Hima Joshi, Ph.D.
Department of Chemistry
University of San Diego
San Diego, California

Doris Ingram Lewis, Ph.D.
Professor of Chemistry
Suffolk University
Boston, Massachusetts

Gary E. Mueller, Ph.D.
Associate Professor
Department of Nuclear Engineering
University of Missouri—Rolla
Rolla, Missouri

Daniel B. Murphy, Ph.D.
Professor Emeritus of Chemistry
Department of Chemistry
Herbert H. Lehman College
City University of New York
Bronx, New York

R. Thomas Myers, Ph.D.
Professor Emeritus of Chemistry
Kent State University
Kent, Ohio

Keith B. Oldham, Ph.D.
Professor of Chemistry
Trent University
Peterborough, Ontario, Canada

Brian L. Pagenkopf, Ph.D.
Assistant Professor
Department of Chemistry and
Biochemistry
University of Texas at Austin
Austin, Texas

Stanford Peppenhorst, Ed.D.
Chemistry Teacher
Germantown High School
Germantown, Tennessee

Charles Scaife, Ph.D.
Professor of Chemistry, Emeritus
Union College
Schenectady, New York

Peter Sheridan, Ph.D.
Professor
Department of Chemistry and
Biochemistry
Colgate University
Hamilton, New York

Larry Stookey, P.E.
Physics and Chemistry Teacher
Antigo High School
Antigo, Wisconsin

Acknowledgments, continued

David C. Taylor, Ph.D.
Professor of Chemistry
Department of Chemistry
Slippery Rock University
Slippery Rock, Pennsylvania

Richard S. Treptow, Ph.D.
Professor of Chemistry
Department of Chemistry and Physics
Chicago State University
Chicago, Illinois

Barry Tucker
Chemistry Teacher
Colerain High School
Cincinnati, Ohio

Martin Van Dyke, Ph.D.
Chemistry Professor, Emeritus
Front Range Community College
Westminster, Colorado

Joseph E. Vitt, Ph.D.
Associate Professor
Chemistry Department
University of South Dakota
Vermillion, South Dakota

Verne Weidler, Ph.D.
Professor of Chemistry, Retired
Science and Engineering
Black Hawk College
Kewanee, Illinois

Dale Wheeler, Ph.D.
Associate Professor of Chemistry
A. R. Smith Department of Chemistry
Appalachian State University
Boone, North Carolina

David Wilson, Ph.D.
Professor Emeritus
Chemistry Department
Vanderbilt University
Nashville, Tennessee

Candace Woodside
Science Teacher
Winton Woods High School
Forest Park, Ohio

Charles M. Wynn, Sr., Ph.D.
Professor of Chemistry
Department of Physical Sciences
Eastern Connecticut State University
Willimantic, Connecticut

continued on page 948

Contents in Brief

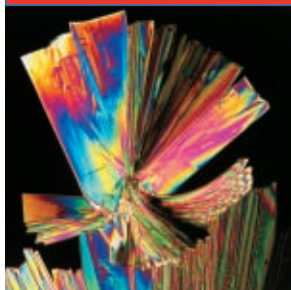
CHAPTER

1	<i>Matter and Change</i>	2
2	<i>Measurements and Calculations</i>	28
3	<i>Atoms: The Building Blocks of Matter</i>	66
4	<i>Arrangement of Electrons in Atoms</i>	96
5	<i>The Periodic Law</i>	132
6	<i>Chemical Bonding</i>	174
7	<i>Chemical Formulas and Chemical Compounds</i>	218
8	<i>Chemical Equations and Reactions</i>	260
9	<i>Stoichiometry</i>	298
10	<i>States of Matter</i>	328
11	<i>Gases</i>	360
12	<i>Solutions</i>	400
13	<i>Ions in Aqueous Solutions and Colligative Properties</i>	434
14	<i>Acids and Bases</i>	466
15	<i>Acid-Base Titration and pH</i>	498
16	<i>Reaction Energy</i>	530
17	<i>Reaction Kinetics</i>	560
18	<i>Chemical Equilibrium</i>	588
19	<i>Oxidation-Reduction Reactions</i>	630
20	<i>Electrochemistry</i>	654
21	<i>Nuclear Chemistry</i>	680
22	<i>Organic Chemistry</i>	710
23	<i>Biological Chemistry</i>	750



Contents

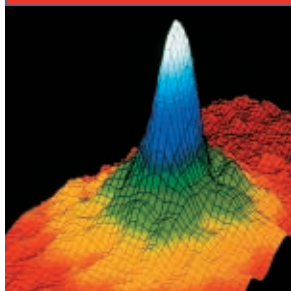
CHAPTER 1



Matter and Change 2

- 1 Chemistry Is a Physical Science 3
- 2 Matter and Its Properties 6
- 3 Elements 16
- Cross-Disciplinary Connection** Secrets of the Cremona Violins 15
- Chemistry in Action** Superconductors 18
- Math Tutor** Significant Figures 24
- Standardized Test Prep** 25
- Chapter Lab** Mixture Separation 26

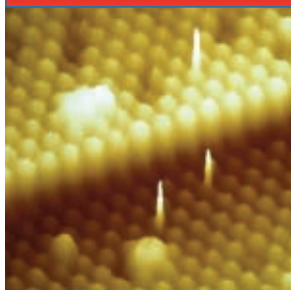
CHAPTER 2



Measurements and Calculations 28

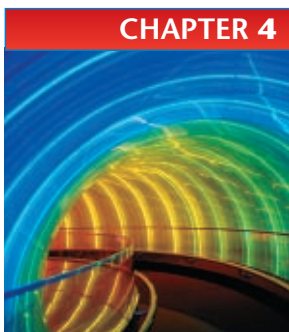
- 1 Scientific Method 29
- 2 Units of Measurement 33
- 3 Using Scientific Measurements 44
- Chemistry in Action** Breaking Up Is Easy to Do 32
- Cross-Disciplinary Connection** Some Handy Comparisons of Units . . . 35
- Quick Lab** Density of Pennies 39
- Historical Chemistry** Classical Ideas About Matter 43
- Math Tutor** Scientific Notation 62
- Standardized Test Prep** 63
- Chapter Lab** Percentage of Water in Popcorn 64

CHAPTER 3



Atoms: The Building Blocks of Matter 66

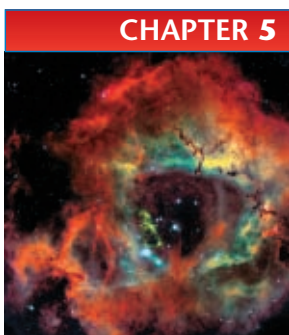
- 1 The Atom: From Philosophical Idea to Scientific Theory 67
- 2 The Structure of the Atom 72
- 3 Counting Atoms 77
- Careers in Chemistry** Physical Chemist 70
- Quick Lab** Constructing a Model 71
- Historical Chemistry** Discovery of Element 43 81
- Math Tutor** Conversion Factors 92
- Standardized Test Prep** 93
- Chapter Lab** Conservation of Mass 94



CHAPTER 4

Arrangement of Electrons in Atoms 96

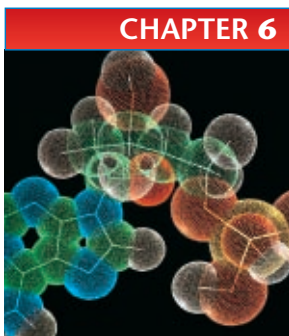
1 The Development of a New Atomic Model	97
2 The Quantum Model of the Atom	104
3 Electron Configurations	111
Chemistry in Action Fireflies	102
Quick Lab The Wave Nature of Light: Interference	106
Historical Chemistry The Noble Decade	114
Math Tutor Weighted Averages and Atomic Mass	128
Standardized Test Prep	129
Chapter Lab Flame Tests	130



CHAPTER 5

The Periodic Law 132

1 History of the Periodic Table	133
2 Electron Configuration and the Periodic Table	138
3 Electron Configuration and Periodic Properties	150
Quick Lab Designing Your Own Periodic Table	137
Careers in Chemistry Materials Scientist	145
Math Tutor Writing Electron Configurations	170
Standardized Test Prep	171
Chapter Lab The Mendeleev Lab of 1869	172



CHAPTER 6

Chemical Bonding 174

1 Introduction to Chemical Bonding	175
2 Covalent Bonding and Molecular Compounds	178
3 Ionic Bonding and Ionic Compounds	190
4 Metallic Bonding	195
5 Molecular Geometry	197
Chemistry in Action Ultrasonic Toxic-Waste Destroyer	180
Careers in Chemistry Computational Chemist	204
Math Tutor Drawing Lewis Structures	214
Standardized Test Prep	215
Chapter Lab Types of Bonding in Solids	216

CHAPTER 7



Chemical Formulas and Chemical Compounds **218**

1 Chemical Names and Formulas	219
2 Oxidation Numbers	232
3 Using Chemical Formulas	237
4 Determining Chemical Formulas	245
Careers in Chemistry Pharmacist	222
Chemistry in Action	
Mass Spectrometry: Identifying Molecules	236
Math Tutor Calculating Percentage Composition	256
Standardized Test Prep	257
Chapter Lab Determining the Empirical Formula of Magnesium Oxide	258

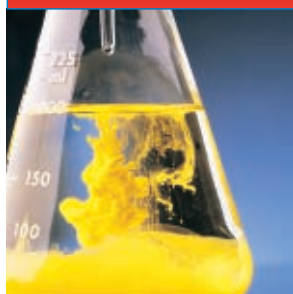
CHAPTER 8



Chemical Equations and Reactions **260**

1 Describing Chemical Reactions	261
2 Types of Chemical Reactions	276
3 Activity Series of the Elements	285
Chemistry in Action Carbon Monoxide Catalyst	275
Chemistry in Action Fluoridation and Tooth Decay	283
Quick Lab Balancing Equations Using Models	284
Chemistry in Action Combustion Synthesis	288
Math Tutor Balancing Chemical Equations	294
Standardized Test Prep	295
Chapter Lab Blueprint Paper	296

CHAPTER 9



Stoichiometry **298**

1 Introduction to Stoichiometry	299
2 Ideal Stoichiometric Calculations	304
3 Limiting Reactants and Percentage Yield	312
Careers in Chemistry Chemical Technician	300
Historical Chemistry The Case of Combustion	302
Quick Lab Limiting Reactants in a Recipe	316
Math Tutor Using Mole Ratios	324
Standardized Test Prep	325
Chapter Lab Stoichiometry and Gravimetric Analysis	326

CHAPTER 10*States of Matter***328**

1 Kinetic Theory of Matter	329
2 Liquids	333
3 Solids	337
4 Changes of State	342
5 Water	349
Chemistry in Action Surface Melting	346
Math Tutor Calculating Using Enthalpies of Fusion	356
Standardized Test Prep	357
Chapter Lab “Wet” Dry Ice	358

CHAPTER 11*Gases***360**

1 Gas and Pressure	361
2 The Gas Laws	369
3 Gas Volumes and the Ideal Gas Law	378
4 Diffusion and Effusion	386
Chemistry in Action The Gas Laws and Scuba Diving	368
Historical Chemistry Chemistry’s First Law	376
Chemistry in Action Automobile Air Bags	380
Quick Lab Diffusion	387
Math Tutor Algebraic Rearrangements of Gas Laws	396
Standardized Test Prep	397
Chapter Lab Mass and Density of Air at Different Pressures	398

CHAPTER 12*Solutions***400**

1 Types of Mixtures	401
2 The Solution Process	407
3 Concentration of Solutions	418
Quick Lab Observing Solutions, Suspensions, and Colloids	405
Careers in Chemistry Environmental Chemist	408
Cross-Disciplinary Connection Artificial Blood	417
Math Tutor Calculating Solution Concentration	430
Standardized Test Prep	431
Chapter Lab Separation of Pen Inks by Paper Chromatography	432

CHAPTER 13



Ions in Aqueous Solutions and Colligative Properties **434**

1 Compounds in Aqueous Solutions	435
2 Colligative Properties of Solutions	446
Historical Chemistry The Riddle of Electrolysis	444
Chemistry in Action Water Purification by Reverse Osmosis	453
Math Tutor Boiling and Freezing Points of Solutions	462
Standardized Test Prep	463
Chapter Lab Testing Water for Ions	464

CHAPTER 14



Acids and Bases **466**

1 Properties of Acids and Bases	467
2 Acid-Base Theories	478
3 Acid-Base Reactions	483
Quick Lab Household Acids and Bases	472
Cross-Disciplinary Connection Acid Water—A Hidden Menace	477
Cross-Disciplinary Connection It's a Bitter Pill	484
Math Tutor Writing Equations for Ionic Reactions	494
Standardized Test Prep	495
Chapter Lab Is It an Acid or a Base?	496

CHAPTER 15



Acid-Base Titration and pH **498**

1 Aqueous Solutions and the Concept of pH	499
2 Determining pH and Titrations	511
Cross-Disciplinary Connection Liming Streams	510
Quick Lab Testing the pH of Rainwater	514
Careers in Chemistry Analytical Chemist	516
Math Tutor Using Logarithms and pH	526
Standardized Test Prep	527
Chapter Lab How Much Calcium Carbonate Is in an Eggshell?	528

CHAPTER 16



Reaction Energy **530**

1 Thermochemistry	531
2 Driving Force of Reactions	546
Chemistry in Action Self-Heating Meals	545
Chemistry in Action Diamonds Are Forever?	549
Math Tutor Hess's Law	556
Standardized Test Prep	557
Chapter Lab Calorimetry and Hess's Law	558

CHAPTER 17*Reaction Kinetics***560**

1 The Reaction Process	561
2 Reaction Rate	568
Chemistry in Action Explosives	572
Quick Lab Factors Influencing Reaction Rate	578
Chemistry in Action Catalytic Converters	579
Math Tutor Writing Rate Laws	584
Standardized Test Prep	585
Chapter Lab Rate of a Chemical Reaction	586

CHAPTER 18*Chemical Equilibrium***588**

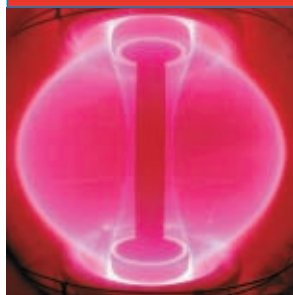
1 The Nature of Chemical Equilibrium	589
2 Shifting Equilibrium	598
3 Equilibria of Acids, Bases, and Salts	605
4 Solubility Equilibrium	613
Historical Chemistry Fixing the Nitrogen Problem	596
Cross-Disciplinary Connection Blood Buffers	609
Math Tutor Determining Equilibrium Constants	626
Standardized Test Prep	627
Chapter Lab Measuring K_a for Acetic Acid	628

CHAPTER 19*Oxidation-Reduction Reactions***630**

1 Oxidation and Reduction	631
2 Balancing Redox Equations	637
3 Oxidizing and Reducing Agents	642
Chemistry in Action Photochromic Lenses	634
Chemistry in Action Skunk-Spray Remedy	636
Quick Lab Redox Reactions	644
Math Tutor Balancing Redox Equations	650
Standardized Test Prep	651
Chapter Lab Reduction of Mn in MnO_4^-	652

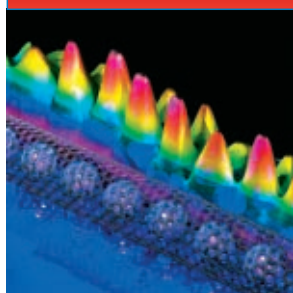
CHAPTER 20*Electrochemistry***654**

1 Introduction to Electrochemistry	655
2 Voltaic Cells	658
3 Electrolytic Cells	667
Chemistry in Action Fuel-Cell Cars	666
Chemistry in Action Sodium Production by Electrolysis	671
Math Tutor Calculating Cell Potentials	676
Standardized Test Prep	677
Chapter Lab Voltaic Cells	678

CHAPTER 21

Nuclear Chemistry 680

1 The Nucleus	681
2 Radioactive Decay	685
3 Nuclear Radiation	693
4 Nuclear Fission and Nuclear Fusion	697
Cross-Disciplinary Connection Quarks	682
Historical Chemistry An Unexpected Finding	700
Math Tutor Calculating with Half-Life	706
Standardized Test Prep	707
Chapter Lab	
Simulation of Nuclear Decay Using Pennies and Paper	708

CHAPTER 22

Organic Chemistry 710

1 Organic Compounds	711
2 Hydrocarbons	716
3 Functional Groups	730
4 Organic Reactions	735
Historical Chemistry The Beginnings of Organic Chemistry	715
Careers in Chemistry Petroleum Engineer	720
Chemistry in Action Carbon Allotropes	725
Math Tutor Calculating Empirical Formulas	746
Standardized Test Prep	747
Chapter Lab Polymers and Toy Balls	748

CHAPTER 23

Biological Chemistry 750

1 Carbohydrates and Lipids	751
2 Amino Acids and Proteins	756
3 Metabolism	766
4 Nucleic Acids	770
Historical Chemistry Charles Drew and Blood Transfusions	762
Careers in Chemistry Forensic Chemist	774
Math Tutor Interpretation of the Genetic Code	780
Standardized Test Prep	781
Chapter Lab Casein Glue	782

GROUP 1 ALKALI METALS 786

- APPLICATION Technology**
Sodium Vapor Lighting 788
- APPLICATION Health**
Electrolyte Balance in the Body 789

GROUP 2 ALKALINE EARTH METALS 792

- APPLICATION Technology**
Fireworks 794
- APPLICATION Health**
Calcium: An Essential Mineral in the Diet . . . 796
Magnesium: An Essential Mineral in the Diet . . 796

GROUPS 3–12 TRANSITION METALS 798

- APPLICATION Geology**
Gemstones and Color 801
- APPLICATION Technology**
Alloys 802
- APPLICATION The Environment**
Mercury Poisoning 805
- APPLICATION Health**
Elements in the Body 806
Role of Iron 807

GROUP 13 BORON FAMILY 808

- APPLICATION Technology**
Aluminum 810
Aluminum Alloys 811



GROUP 14 CARBON FAMILY 812

- APPLICATION Chemical Industry**
Carbon and the Reduction of Iron Ore 814
Carbon Dioxide 815
Carbon Monoxide 815
- APPLICATION Biochemistry**
Carbon Dioxide and Respiration 816
- APPLICATION The Environment**
Carbon Monoxide Poisoning 818
- APPLICATION Biochemistry**
Macromolecules 819
- APPLICATION Chemical Industry**
Silicon and Silicates 825
Silicones 825
- APPLICATION Technology**
Semiconductors 826

GROUP 15 NITROGEN FAMILY 828

- APPLICATION Biology**
Plants and Nitrogen 830
- APPLICATION Chemical Industry**
Fertilizers 831

GROUP 16 OXYGEN FAMILY 832

- APPLICATION Chemical Industry**
Oxides 834
- APPLICATION The Environment**
Ozone 836
- APPLICATION Chemical Industry**
Sulfuric Acid 837

GROUP 17 HALOGEN FAMILY 838

- APPLICATION The Environment**
Chlorine in Water Treatment 840
Fluoride and Tooth Decay 841

Reference

Preparing for Chemistry Lab	842	Appendix D: Problem Bank	881
Appendix A: Reference Tables	854	Appendix E: Selected Answers	916
Appendix B: Study Skills for Chemistry	864	Glossary	924
Appendix C: Graphing Calculator Technology	879	Index	935

Sample Problems and Math Tutors

Chapter 1 *Matter and Change*

Math Tutor Significant Figures	24
---	----

Chapter 2 *Measurements and Calculations*

Sample Problems

A Density	39
B Conversion Factors	41
C Percentage Error	45
D Significant Figures	47
E Significant Figures	49
F Solving Problems Using the Four-Step Approach	54

Math Tutor Scientific Notation	62
---	----

Chapter 3 *Atoms: The Building Blocks of Matter*

Sample Problems

A Subatomic Particles	79
B Gram/Mole Conversions	84
C Gram/Mole Conversions	85
D Conversions with Avogadro's Number	86
E Conversions with Avogadro's Number	86

Math Tutor Conversion Factors	92
--	----

Chapter 4 *Arrangement of Electrons in Atoms*

Sample Problems

A Electron Configurations	113
B Electron Configurations	120
C Electron Configurations	122

Math Tutor

Weighted Averages and Atomic Mass	128
---	-----

Chapter 5 *The Periodic Law*

Sample Problems

A The Periodic Table and Electron Configurations	143
B The Periodic Table and Electron Configurations	146
C The Periodic Table and Electron Configurations	148
D The Periodic Table and Electron Configurations	148
E Atomic Radius	152
F Periodic Trends in Ionization Energy	156
G Periodic Trends in Electronegativity	162

Math Tutor Writing Electron Configurations	170
---	-----

Chapter 6 *Chemical Bonding*

Sample Problems

A Classifying Bonds	177
B Electron-Dot Notation	184
C Lewis Structures	185
D Lewis Structures	188
E VSEPR Theory and Molecular Geometry	198
F VSEPR Theory and Molecular Geometry	201

Math Tutor Drawing Lewis Structures	214
--	-----

Chapter 7 *Chemical Formulas*

and Chemical Compounds

Sample Problems

A Writing Formulas for Ionic Compounds	223
B Naming Ionic Compounds	225
C Writing Formulas for Ionic Compounds	227
D Naming Binary Molecular Compounds	229
E Oxidation Numbers	233
F Formula Mass	238
G Molar Mass	239
H Molar Mass as a Conversion Factor	240
I Molar Mass as a Conversion Factor	241
J Percentage Composition	243
K Percentage Composition	243
L Empirical Formulas	246
M Empirical Formulas	247
N Molecular Formulas	248

Math Tutor

Calculating Percentage Composition	256
--	-----

Chapter 8 *Chemical Equations and Reactions*

Sample Problems

A Writing Word, Formula, and Balanced Chemical Equations	267
B Writing Word, Formula, and Balanced Chemical Equations	268
C Writing Word, Formula, and Balanced Chemical Equations	272
D Balancing Chemical Equations	273
E Balancing Chemical Equations	273
F Activity Series	286

Math Tutor Balancing Chemical Equations	294
--	-----

Chapter 9 *Stoichiometry*

Sample Problems

A Stoichiometric Calculations Using Mole Ratios	305
B Stoichiometric Calculations Using Mole Ratios	306
C Stoichiometric Calculations Using Mole Ratios	307
D Stoichiometric Calculations Using Mole Ratios	309
E Stoichiometric Calculations Using Mole Ratios	310
F Limiting Reactant	313
G Limiting Reactant	314
H Percentage Yield	317

Math Tutor Using Mole Ratios	324
---	-----

Chapter 10 *States of Matter*

Sample Problems

A Using Molar Enthalpy of Vaporization	352
---	-----

Math Tutor

Calculating Using Enthalpies of Fusion	356
--	-----

Chapter 11 Gases

Sample Problems

A	Converting Between Units of Pressure	365
B	Calculating Partial Pressures	367
C	Using Boyle's Law	370
D	Using Charles's Law	372
E	Using Gay-Lussac's Law	373
F	Using the Combined Gas Law	375
G	Calculating with Avogadro's Law	381
H	Gas Stoichiometry	382
I	The Ideal Gas Law	385
J	Graham's Law of Effusion	385

Math Tutor

	Algebraic Rearrangements of Gas Laws	396
--	--------------------------------------	-----

Chapter 12 Solutions

Sample Problems

A	Calculating with Molarity	420
B	Calculating with Molarity	420
C	Calculating with Molarity	421
D	Calculating with Molality	423
E	Calculating with Molality	424

Math Tutor	Calculating Solution Concentration	430
-------------------	------------------------------------	-----

Chapter 13 Ions in Aqueous Solutions and Colligative Properties

Sample Problems

A	Calculating Moles of Dissolved Ions	436
B	Writing Net Ionic Equations	440
C	Calculating Freezing-Point Depression	449
D	Calculating Molal Concentration	449
E	Calculating Boiling-Point Elevation	451
F	Freezing-Point Depression of Electrolytes	454

Math Tutor

	Boiling and Freezing Points of Solutions	462
--	--	-----

Chapter 14 Acids and Bases

Math Tutor

	Writing Equations for Ionic Reactions	494
--	---------------------------------------	-----

Chapter 15 Acid-Base Titration and pH

Sample Problems

A	Calculating Hydronium and Hydroxide Concentrations	502
B	Calculating pH	505
C	Calculating pH	506
D	Calculating Hydronium Concentration Using pH	507
E	Calculating Hydronium and Hydroxide Concentrations	508
F	Calculating the Molarity of an Acid Solution	520

Math Tutor	Using Logarithms and pH	526
-------------------	-------------------------	-----

Chapter 16 Reaction Energy

Sample Problems

A	Specific Heat	533
B	Enthalpy of Reaction	541
C	Enthalpy of Formation	543
D	Calculating Free-Energy Change	550

Math Tutor	Hess's Law	556
-------------------	------------	-----

Chapter 17 Reaction Kinetics

Sample Problems

A	Energy Diagrams	566
B	Determining Rate Law and Rate Constant	574
C	Determining Rate Law and Rate Constant	575
D	Determining Rate-Determining Step and Rate Law	577
E	Determining Effects on Reaction Rate	577

Math Tutor	Writing Rate Laws	584
-------------------	-------------------	-----

Chapter 18 Chemical Equilibrium

Sample Problems

A	Equilibrium Constant	594
B	Solubility Product Constant	616
C	Calculating Solubility	617
D	Precipitation Calculations	619

Math Tutor	Determining Equilibrium Constants	626
-------------------	-----------------------------------	-----

Chapter 19 Oxidation-Reduction Reactions

Sample Problems

A	Balancing Equations for Redox Reactions	639
---	---	-----

Math Tutor	Balancing Redox Equations	650
-------------------	---------------------------	-----

Chapter 20 Electrochemistry

Sample Problems

A	Calculating Cell Potentials	665
---	-----------------------------	-----

Math Tutor	Calculating Cell Potentials	676
-------------------	-----------------------------	-----

Chapter 21 Nuclear Chemistry

Sample Problems

A	Balancing Nuclear Reactions	686
---	-----------------------------	-----

B	Calculating with Half-Life	690
---	----------------------------	-----

Math Tutor	Calculating with Half-Life	706
-------------------	----------------------------	-----

Chapter 22 Organic Chemistry

Sample Problems

A	Naming Alkanes	721
---	----------------	-----

B	Naming Alkenes	726
---	----------------	-----

Math Tutor	Calculating Empirical Formulas	746
-------------------	--------------------------------	-----

Chapter 23 Biological Chemistry

Math Tutor	Interpretation of the Genetic Code	780
-------------------	------------------------------------	-----

Labs

PRE-LABS

Extraction and Filtration	844	Volumetric Analysis	850
Gravimetric Analysis	846	Calorimetry	852
Paper Chromatography	848		

CHAPTER LABS

Chapter

1 Mixture Separation INQUIRY	26
2 Percentage of Water in Popcorn	64
3 Conservation of Mass MICRO / INQUIRY	94
4 Flame Tests MICRO	130
5 The Mendeleev Lab of 1869 INQUIRY	172
6 Types of Bonding in Solids INQUIRY	216
7 Determining the Empirical Formula of Magnesium Oxide	258
8 Blueprint Paper	296
9 Stoichiometry and Gravimetric Analysis	326
10 "Wet" Dry Ice MICRO	358
11 Mass and Density of Air at Different Pressures MICRO	398

Chapter

12 Separation of Pen Inks by Paper Chromatography MICRO	432
13 Testing Water for Ions MICRO	464
14 Is It an Acid or a Base? MICRO / INQUIRY	496
15 How Much Calcium Carbonate Is in an Eggshell? MICRO	528
16 Calorimetry and Hess's Law	558
17 Rate of a Chemical Reaction MICRO	586
18 Measuring K_a for Acetic Acid MICRO	628
19 Reduction of Mn in MnO_4^- MICRO	652
20 Voltaic Cells	678
21 Simulation of Nuclear Decay Using Pennies and Paper	708
22 Polymers and Toy Balls	748
23 Casein Glue	782

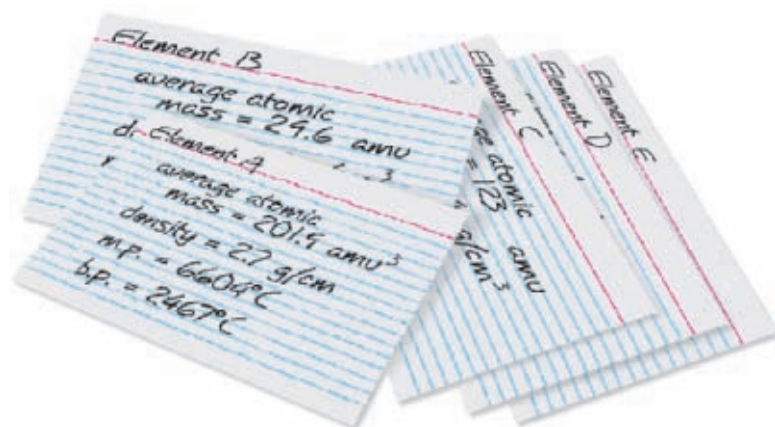
QUICK LABS

Chapter

2 Density of Pennies	39
3 Constructing a Model	71
4 The Wave Nature of Light: Interference	106
5 Designing Your Own Periodic Table	137
8 Balancing Equations Using Models	284
9 Limiting Reactants in a Recipe	316
11 Diffusion	387
12 Observing Solutions, Suspensions, and Colloids	405
14 Household Acids and Bases	472

Chapter

15 Testing the pH of Rainwater	514
17 Factors Influencing Reaction Rate	578
19 Redox Reactions	644



Feature Articles

HISTORICAL CHEMISTRY

Chapter

2	Classical Ideas About Matter	43
3	Discovery of Element 43	81
4	The Noble Decade	114
9	The Case of Combustion	302
11	Chemistry's First Law	376
13	The Riddle of Electrolysis	444
18	Fixing the Nitrogen Problem	596
21	An Unexpected Finding	700
22	The Beginnings of Organic Chemistry	715
23	Charles Drew and Blood Transfusions	762

extension

1	A Broken Rule: Chemical Reactions of the Noble Gases	HC6MTXX
3	Modern Alchemy	HC6ATMX
21	Glenn Seaborg	HC6NUCX
23	Unraveling the Mystery of DNA	HC6BIOX



CROSS-DISCIPLINARY CONNECTION

Chapter

1	Secrets of the Cremona Violins	15
2	Some Handy Comparisons of Units	35
12	Artificial Blood	417
14	Acid Water—A Hidden Menace	477
	It's a Bitter Pill	484
15	Liming Streams	510
18	Blood Buffers	609
21	Quarks	682

extension

4	Spintronics	HC6ARRX
5	Essential Elements	HC6PERX
7	Smell—A Chemical Sense	HC6FRMX
10	Cloud Seeding	HC6STMX
13	Minerals	HC6IONX
16	Free Energy and the Body	HC6NRGX
15	Buffers in the Blood	HC6ABTX
18	Limestone Caves	HC6EQUX
19	Oxidation-Reduction and Photosynthesis	HC6OXRX

extension

Go to go.hrw.com for full-length articles.



CAREERS in Chemistry



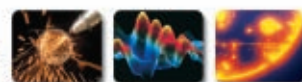
Chapter

3	Physical Chemist	70
5	Materials Scientist	145
6	Computational Chemist	204
7	Pharmacist	222
9	Chemical Technician	300
12	Environmental Chemist	408
15	Analytical Chemist	516
22	Petroleum Engineer	720
23	Forensic Chemist	774

extension

20	Chemical Engineer	HC6ELEX
----	-------------------	---------

Chemistry in Action



Chapter

1	Superconductors	18
2	Breaking Up Is Easy to Do	32
4	Fireflies	102
6	Ultrasonic Toxic-Waste Destroyer	180
7	Mass Spectrometry: Identifying Molecules	236
8	Carbon Monoxide Catalyst	275
	Fluoridation and Tooth Decay	283
	Combustion Synthesis	288
10	Surface Melting	346
11	The Gas Laws and Scuba Diving	368
	Automobile Air Bags	380
13	Water Purification by Reverse Osmosis	453
16	Self-Heating Meals	545
	Diamonds Are Forever?	549
17	Explosives	572
	Catalytic Converters	579
19	Photochromic Lenses	634
	Skunk-Spray Remedy	636
20	Fuel-Cell Cars	666
	Sodium Production by Electrolysis	671
22	Carbon Allotropes	725

extension

2	Roadside Pollution Detector	HC6MEAX
6	Nanoscale Computers	HC6BNDX
8	How Is Our Public Water Treated?	HC6RXNX
9	Air Bags and Stoichiometry	HC6STCX
10	Phase-Change Materials	HC6STMX
12	Surfactants: Molecules with Two Faces	HC6SLNX
14	Unclog That Drain	HC6ACDX
17	Monitoring Reaction Kinetics with Ultraviolet-Visible Spectroscopy	HC6RXXKX
22	Synthetic Diamonds	HC6ORGX
	High-Barrier Plastics	HC6ORGX

Safety in the Chemistry Laboratory

Any chemical can be dangerous if it is misused. Always follow the instructions for the experiment. Pay close attention to the safety notes. Do not do anything differently unless told to do so by your teacher.

Chemicals, even water, can cause harm. The challenge is to know how to use chemicals correctly. To make sure you are using chemicals correctly, follow the rules stated below, pay attention to your teacher's directions, and follow cautions on chemical labels and in the experiments.

Specific experiments will use a system of Safety Symbols to highlight specific types of precautions. No matter what Safety Symbols an experiment may contain, the following safety rules apply any time you are in the lab.

Before You Begin

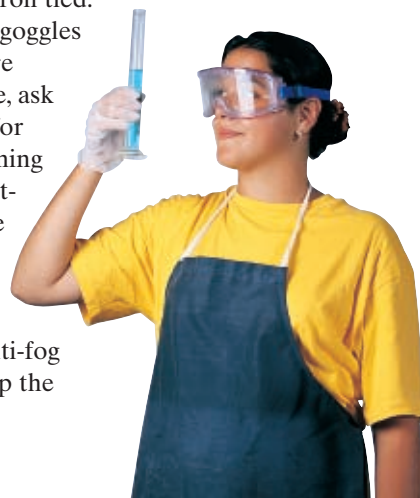
- 1. Read the entire activity before entering the lab.** Be familiar with the instructions before beginning an activity. Do not start an activity until you have asked your teacher to explain any parts of the activity that you do not understand.
- 2. Student-designed procedures or inquiry activities must be approved by your teacher before you attempt the procedures or activities.**
- 3. Wear the right clothing for lab work.** Before beginning work, tie back long hair, roll up loose sleeves, and put on any required personal protective equipment as directed by your teacher. Remove your wristwatch and any necklaces or jewelry that could get caught in moving parts. Avoid or confine loose clothing that could knock things over, catch on fire, get caught in moving parts, contact electrical connections, or absorb chemical solutions. Wear pants rather than shorts or skirts. Nylon and polyester fabrics burn and melt more readily than cotton does. Protect your feet from chemical spills and falling objects. Do not wear open-toed shoes, sandals, or canvas shoes in the lab. In addition, chemical fumes may react with and ruin some jewelry, such as pearl jewelry. Do not apply cosmetics in the lab. Some hair care products and nail polish are highly flammable.
- 4. Do not wear contact lenses in the lab.** Even though you will be wearing safety goggles, chemicals could get between contact lenses and your eyes and could cause irreparable eye damage. If your doctor requires that you wear contact lenses instead of glasses, then you should wear eye-cup safety goggles—similar to goggles worn for

underwater swimming—in the lab. Ask your doctor or your teacher how to use eye-cup safety goggles to protect your eyes.

- 5. Know the location of all safety and emergency equipment used in the lab.** Know proper fire-drill procedures and the location of all fire exits. Ask your teacher where the nearest eyewash stations, safety blankets, safety shower, fire extinguisher, first-aid kit, and chemical spill kit are located. Be sure that you know how to operate the equipment safely.

While You Are Working

- 6. Always wear a lab apron and safety goggles.** Wear these items even if you are not working on an activity. Labs contain chemicals that can damage your clothing, skin, and eyes. Keep the strings of your lab apron tied. If your safety goggles cloud up or are uncomfortable, ask your teacher for help. Lengthening the strap slightly, washing the goggles with soap and warm water, or using an anti-fog spray may help the problem.





- 7. NEVER work alone in the lab.** Work in the lab only when supervised by your teacher. Do not leave equipment unattended while it is in operation.
- 8. Perform only activities specifically assigned by your teacher.** Do not attempt any procedure without your teacher's direction. Use only materials and equipment listed in the activity or authorized by your teacher. Steps in a procedure should be performed only as described in the activity or as approved by your teacher.
- 9. Keep your work area neat and uncluttered.** Have only books and other materials that are needed to conduct the activity in the lab. Keep backpacks, purses, and other items in your desk, locker, or other designated storage areas.
- 10. Always heed safety symbols and cautions listed in activities, listed on handouts, posted in the room, provided on chemical labels, and given verbally by your teacher.** Be aware of the potential hazards of the required materials and procedures, and follow all precautions indicated.
- 11. Be alert, and walk with care in the lab.** Be aware of others near you and your equipment.
- 12. Do not take food, drinks, chewing gum, or tobacco products into the lab.** Do not store or eat food in the lab.
- 13. Use extreme caution when working with hot plates and other heating devices.** Keep your head, hands, hair, and clothing away from the flame or heating area. Remember that metal surfaces connected to the heated area will become hot by conduction. Use tongs when heating containers and never hold or touch them. Gas burners should be lit only with a spark lighter, not with

matches. Make sure that all heating devices and gas valves are turned off before you leave the lab. Never leave a heating device unattended when it is in use. Metal, ceramic, and glass items do not necessarily look hot when they are hot. Allow all items to cool before storing them.

- 14. Remember how easily glass can break and cause a serious cut.** Check the condition of any glassware before and after using it. Inform your teacher of any broken, chipped, or cracked glassware, because it should not be used. Never force glass tubing into rubber tubing, stoppers or wooden corks. To protect your hands, wear heavy cloth gloves or wrap toweling around the glass and the tubing, stopper, or cork, and gently push in the glass. Do not pick up broken glass with your bare hands. Dispose of broken glass in a specially designated disposal container.
- 15. Exercise caution when working with electrical equipment.** Do not use electrical equipment with frayed or twisted wires. Be sure that your hands are dry before using electrical equipment. Do not let electrical cords dangle from work stations. Dangling cords can cause you to trip and can cause an electrical shock. The area under and around electrical equipment should be dry; cords should not lie in puddles of spilled liquid.
- 16. Do not fool around in the lab.** Take your lab work seriously, and behave appropriately in the lab. Lab equipment and apparatus are not toys; never use lab time or equipment for anything other than the intended purpose. Be aware of the safety of your classmates as well as your safety at all times.

Working With Chemicals

- 17. NEVER taste chemicals or allow them to contact your skin.** Keep your hands away from your face and mouth, even if you are wearing gloves.
- 18. Do not inhale fumes directly.** When instructed to smell a substance, use your hand to wave the fumes toward your nose, and inhale gently.
- 19. Read chemical labels.** Follow the instructions and safety precautions stated on the labels.
- 20. If you are working with flammable liquids, use only small amounts.** Be sure no one else is using a lit Bunsen burner or is planning to use one when you are working with flammable liquids, because the fumes can ignite.



21. For all chemicals, take only what you need.

However, if you do happen to take too much and have some left over, **DO NOT** put it back in the bottle. If somebody accidentally puts a chemical into the wrong bottle, the next person to use it will have a contaminated sample. Ask your teacher what to do with any leftover chemicals.

22. NEVER take any chemicals out of the lab.

(This is another one that you should already know. You probably know the remaining rules also, but read them anyway.)

Emergency Procedures

23. Follow standard fire-safety procedures. If your clothing catches on fire, do not run; **WALK** to the safety shower, stand under it, and turn it on. While doing so, call to your teacher. In case of fire, alert your teacher and leave the lab.

24. Report any accident, incident, or hazard—no matter how trivial—to your teacher immediately. Any incident involving bleeding, burns, fainting, nausea, dizziness, chemical exposure, or ingestion should also be reported immediately to the school nurse or to a physician. If you have a close call, tell your teacher so that you and your teacher can find a way to prevent it from happening again.

25. Report all spills to your teacher immediately. Call your teacher rather than trying to clean a spill yourself. Your teacher will tell you whether it is safe for you to clean up the spill; if it is not safe, your teacher will know how to clean up the spill.

26. If you spill a chemical on your skin, wash the chemical off in the sink and call your teacher.

If you spill a solid chemical onto your clothing, brush it off carefully without scattering it onto somebody else and call your teacher. If you get liquid on your clothing, wash it off right away by using the faucet at the sink and call your teacher. If the spill is on your pants or something else that will not fit under the sink faucet, use the safety shower. Remove the pants or other affected clothing while you are under the shower, and call your teacher. (It may be temporarily embarrassing to remove pants or other clothing in front of your classmates, but failure to flush the chemical off your skin could cause permanent damage.)

27. If you get a chemical in your eyes, walk immediately to the eyewash station, turn it on, and lower your head so your eyes are in the running water. Hold your eyelids open with your thumbs and fingers, and roll your eyeballs around. You have to flush your eyes continuously for at least 15 minutes. Call your teacher while you are doing this.

When You Are Finished

28. Clean your work area at the conclusion of each lab period as directed by your teacher. Broken glass, chemicals, and other waste products should be disposed of in separate, special containers. Dispose of waste materials as directed by your teacher. Put away all material and equipment according to your teacher's instructions. Report any damaged or missing equipment or materials to your teacher.

29. Wash your hands with soap and hot water after each lab period. To avoid contamination, wash your hands at the conclusion of each lab period, and before you leave the lab.

A Final Reminder

30. Whether or not the lab instructions remind you, all of these rules apply all of the time.

Safety Symbols

To highlight specific types of precautions, the following symbols are used throughout the lab program. Remember that no matter what safety symbols you see in the textbook, all 30 of the lab safety rules previously described should be followed at all times.



EYE PROTECTION

- Wear safety goggles in the lab at all times.
- Know how to use the eyewash station. If chemicals get into your eyes, flush your eyes (including under the eyelids) with running water at the eyewash station for at least 15 minutes. Use your thumb and fingers to hold your eyelids open and roll your eyeball around. While doing so, ask another student to notify your teacher.



CLOTHING PROTECTION

- Wear an apron or lab coat at all times in the lab.
- Tie back long hair, secure loose clothing, and remove loose jewelry so that they do not knock over equipment or come into contact with hazardous materials.



HAND SAFETY

- Wear protective gloves when working with chemicals.
- Use a hot mitt or tongs to handle equipment that may be hot.



GLASSWARE SAFETY

- Inspect glassware before use; do not use chipped or cracked glassware.
- Never place glassware, containers of chemicals, or anything else near the edges of a lab bench or table.



CHEMICAL SAFETY

- Never return unused chemicals to the original container. Take only what you need.
- Label the beakers and test tubes you use with the chemicals they contain.
- Never transfer substances by sucking on a pipet or straw; use a suction bulb.
- Do not mix any chemicals unless specifically instructed to do so by your teacher.
- If a chemical spills on the floor or lab bench, tell your teacher, and wait for instructions before cleaning it up yourself.



CAUSTIC SUBSTANCE SAFETY

- Do not pour water into a strong acid or base. The mixture can produce heat and can splatter.



HEATING SAFETY

- Avoid using open flames. If possible, work only with hot plates having an on/off switch and an indicator light.
- When heating a chemical in a test tube, point the open end of the test tube away from yourself and others.



HYGIENE CARE

- Keep your hands away from your face and mouth while you work in the lab.
- Do not eat or drink any food from laboratory containers.
- Wash your hands thoroughly before you leave the lab.



WASTE DISPOSAL

- Help protect our environment by following the instructions for proper disposal.

How to Use Your Textbook

Your Roadmap for Success with *Modern Chemistry*

Get Organized

Keep a science notebook so that you are ready to take notes when your teacher reviews material in class. Keep your assignments in this notebook so that you can review them when studying for the chapter test.

STUDY TIP Appendix B, located in the back of the book, describes a number of Study Skills that can help you succeed in chemistry, including several approaches to note taking.

Read for Meaning

Read the **Objectives** at the beginning of each section because they will tell you what you'll need to learn. **Key Terms** are boldfaced in each chapter. Use the glossary to locate definitions quickly. After reading each chapter, turn to the **Chapter Highlights** page. Then, review the list of key terms and read the brief summaries of the chapter's main ideas. You may want to do this even before you read the chapter.

STUDY TIP If you don't understand a definition, reread the page on which the term is introduced. The surrounding text should help make the definition easier to understand.

Organic Compounds

SECTION 1

OBJECTIVES

- Explain how the structure and bonding of carbon lead to the diversity and number of organic compounds.
- Compare the use of molecular and structural formulas to represent organic compounds.
- Compare structural and geometric isomers of organic compounds.

Carbon Bonding and the Diversity of Organic Compounds

The diversity of organic compounds results from the uniqueness of carbon's structure and bonding. Carbon's electronic structure allows it to bind to itself to form chains and rings, to bind covalently to other elements, and to bind to itself and other elements in different arrangements.

FIGURE 1 Aspirin, polyethylene in plastic bags, citric acid in fruit, and amino acids in animals are all examples of organic compounds.



ORGANIC CHEMISTRY 711

Be Resourceful, Use the Web



SciLinks boxes in your textbook take you to resources that you can use for science projects, reports, and research papers. Go to www.scilinks.org, and type in the SciLinks code to get information on a topic.



Visit go.hrw.com
Find resources and reference materials that go with your textbook. Visit go.hrw.com, and type in the keywords found in your textbook to access the available resources.

SAMPLE PROBLEM B

Oxygen gas from the decomposition of potassium chlorate, $KClO_3$, was collected by water displacement. The barometric pressure and the temperature during the experiment were 731.0 torr and 20.0°C, respectively. What was the partial pressure of the oxygen collected?

SOLUTION

- 1 ANALYZE** Given: $PT = P_{atm} = 731.0$ torr
 $P_{H_2O} = 17.5$ torr (vapor pressure of water at 20.0°C, from Table A-8)
 $P_{atm} = P_{O_2} + P_{H_2O}$
 Unknown: P_{O_2} in torr
- 2 PLAN** The partial pressure of the collected oxygen is found by subtracting the partial pressure of water vapor from the atmospheric pressure, according to Dalton's law of partial pressures.
- $$P_{O_2} = P_{atm} - P_{H_2O}$$
- 3 COMPUTE** Substituting values for P_{atm} and P_{H_2O} gives P_{O_2} .
- $$P_{O_2} = 731.0 \text{ torr} - 17.5 \text{ torr} = 713.5 \text{ torr}$$
- 4 EVALUATE** As expected, the oxygen partial pressure is less than atmospheric pressure. It is reasonably close to an estimated value of 713, calculated as $730 - 17$.

PRACTICE Answers in Appendix E

1. Some hydrogen gas is collected over water at 20.0°C. The levels of water inside and outside the gas-collection bottle are the same. The partial pressure of hydrogen is 742.5 torr. What is the barometric pressure at the time the gas is collected?

extension
 Go to go.hrw.com for more practice problems that ask you to calculate partial pressure.

CHAPTER REVIEW

The Development of a New Atomic Model

SECTION 1 REVIEW

- List five examples of electromagnetic radiation.
 - What is the speed of all forms of electromagnetic radiation in a vacuum?
- Prepare a two-column table. List the properties of light that can best be explained by the wave theory in one column. List those best explained by the particle theory in the second column. You may want to consult a physics textbook for reference.
- What are the frequency and wavelength ranges of visible light?
- List the colors of light in the visible spectrum in order of increasing frequency.
- In the early twentieth century, what two experiments involving light and matter could not be explained by the wave theory of light?
 - How are the wavelength and frequency of electromagnetic radiation related?
 - How are the energy and frequency of electromagnetic radiation related?
 - How are the energy and wavelength of electromagnetic radiation related?
- Which theory of light—the wave or particle theory—best explains the following phenomena?
 - the interference of light
 - the photoelectric effect
 - the emission of electromagnetic radiation by an excited atom
- Distinguish between the ground state and an excited state of an atom.
- According to Bohr's model of the hydrogen atom, how is hydrogen's emission spectrum produced?

PRACTICE PROBLEMS

- Determine the frequency of light whose wavelength is 4.257×10^7 cm.
- Determine the energy in joules of a photon whose frequency is 3.55×10^{17} Hz.

- Using the two equations $E = hv$ and $c = \lambda\nu$, derive an equation expressing E in terms of h , c , and λ .
- How long would it take a radio wave whose frequency is 7.25×10^5 Hz to travel from Mars to Earth if the distance between the two planets is approximately 8.00×10^7 km?
- Cobalt-60 is an artificial radioisotope that is produced in a nuclear reactor and is used as a gamma-ray source in the treatment of certain types of cancer. If the wavelength of the gamma radiation from a cobalt-60 source is 1.00×10^{-7} nm, calculate the energy of a photon of this radiation.

The Quantum Model of the Atom

SECTION 2 REVIEW

- Describe two major shortcomings of Bohr's model of the atom.
 - What is the principal quantum number?
 - How is it symbolized?
 - What are shells?
 - How does n relate to the number of electrons allowed per main energy level?
- What information is given by the angular momentum quantum number?
 - What are sublevels, or subshells?
- For each of the following values of n , indicate the numbers and types of sublevels possible for that main energy level. (Hint: See Table 2.)
 - $n = 1$
 - $n = 2$
 - $n = 3$
 - $n = 4$
 - $n = 7$ (number only)
- What information is given by the magnetic quantum number?
 - How many orbital orientations are possible in each of the s , p , d , and f sublevels?
 - Explain and illustrate the notation for distinguishing between the different p orbitals in a sublevel.

Work the Problems

Sample Problems, Math Tutors, and Practice Problems build your reasoning and problem-solving skills by guiding you through example problems.

Prepare for Tests

Section Reviews and Chapter Reviews test your knowledge of the main points of the chapter. Critical Thinking items challenge you to think about the material in different ways and in greater depth. The Standardized Test Prep that is located after each Chapter Review helps you sharpen your test-taking abilities.

STUDY TIP Reread the Objectives and Chapter Highlights when studying for a test to be sure you know the material.

Use the Appendix

Your Appendix contains a variety of resources designed to enhance your learning experience. The Elements Handbook provides additional information about the elements. Appendix A has tables which include essential problem-solving information. Appendix D provides more practice problems.



Visit Holt Online Learning

If your teacher gives you a special password to log onto the **Holt Online Learning** site, you'll find your complete textbook on the Web. In addition, you'll find some great learning tools and online activities. You'll be able to see how well you know the material from your textbook.