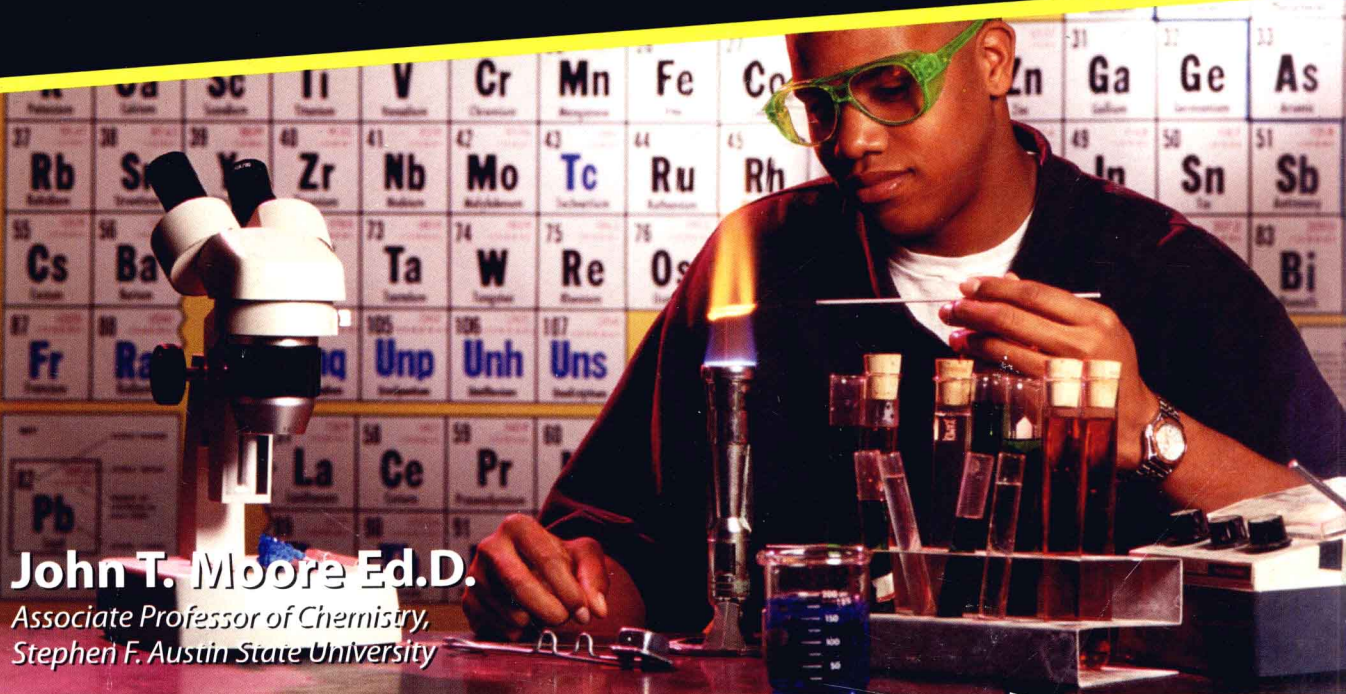


Discover how easy it is to
grasp the basics of chemistry

Chemistry FOR DUMMIES®



John T. Moore Ed.D.

Associate Professor of Chemistry,
Stephen F. Austin State University

A Reference for the Rest of Us!™



**FREE eTips at
dummies.com®**

Chemistry FOR DUMMIES®

by John T. Moore, Ed.D.

江苏工业学院图书馆
藏书章



WILEY

Wiley Publishing, Inc.

Chemistry For Dummies®

Published by
Wiley Publishing, Inc.
909 Third Avenue
New York, NY 10022
www.wiley.com

Copyright © 2003 by Wiley Publishing, Inc., Indianapolis, Indiana

Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Sections 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400, fax 978-750-4744. Requests to the Publisher for permission should be addressed to the Legal Department, Wiley Publishing, Inc., 10475 Crosspoint Blvd., Indianapolis, IN 46256, 317-572-3447, fax 317-572-4447, or e-mail permcoordinator@wiley.com

Trademarks: Wiley, the Wiley Publishing logo, For Dummies, the Dummies Man logo, A Reference for the Rest of Us!, The Dummies Way, Dummies Daily, The Fun and Easy Way, Dummies.com and related trade dress are trademarks or registered trademarks of Wiley Publishing, Inc., in the United States and other countries, and may not be used without written permission. All other trademarks are the property of their respective owners. Wiley Publishing, Inc., is not associated with any product or vendor mentioned in this book.

LIMIT OF LIABILITY/DISCLAIMER OF WARRANTY: WHILE THE PUBLISHER AND AUTHOR HAVE USED THEIR BEST EFFORTS IN PREPARING THIS BOOK, THEY MAKE NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS BOOK AND SPECIFICALLY DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. NO WARRANTY MAY BE CREATED OR EXTENDED BY SALES REPRESENTATIVES OR WRITTEN SALES MATERIALS. THE ADVICE AND STRATEGIES CONTAINED HEREIN MAY NOT BE SUITABLE FOR YOUR SITUATION. YOU SHOULD CONSULT WITH A PROFESSIONAL WHERE APPROPRIATE. NEITHER THE PUBLISHER NOR AUTHOR SHALL BE LIABLE FOR ANY LOSS OF PROFIT OR ANY OTHER COMMERCIAL DAMAGES, INCLUDING BUT NOT LIMITED TO SPECIAL, INCIDENTAL, CONSEQUENTIAL, OR OTHER DAMAGES.

For general information on our other products and services or to obtain technical support, please contact our Customer Care Department within the U.S. at 800-762-2974, outside the U.S. at 317-572-3993, or fax 317-572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Library of Congress Control Number: 2002106030

ISBN: 0-7645-5430-1

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

1B/RV/RR/QS/IN

Chemistry For Dummies®

Cheat Sheet

PERIODIC TABLE OF THE ELEMENTS

PERIODIC TABLE OF THE ELEMENTS

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------------------|---------------------------------|--------------------------------|-------------------------------|-------------------------------|--------------------------------|----------------------------------|----------------------------|-------------------------------|-----------------------------|------------------------------|---------------------------|------------------------------|--------------------------------|--------------------------------|-------------------------------|--------------------------------|------------------------------|-------------------------------|--------------------------------|------------------------------|--------------------------------|-------------------------------|---------------------------------|--------------------------------|---------------------------------|--------------------------------|--------------------------------|-------------------------------|-------------------------------|------------------------------|---------------------------|--------------------------------|---------------------------------|-------------------------------|-----------------------------|-------------------------------|------------------------------|---------------------------------|------------------------------|-------------------------------------|---------------------------------|---------------------------------|--------------------------------|--------------------------------|----------------------------------|--------------------------------|----------------------------------|--------------------------------|------------------------------|--------------------------------|---------------------------------|--------------------------------|-------------------------------|---------------------------------|-------------------------------|------------------------------|-----------------------------|------------------------------|--------------------------------|-----------------------------|-------------------------------|--------------------------------|----------------------------|--------------------------------|-------------------------------|-------------------------------|----------------------------|-------------------------------|-----------------------------|-------------------------------|--------------------------------|-----------------------------------|------------------------------|--------------------------------|--------------------------------|--------------------------------|-----------------------------|--------------------------------|----------------------------------|----------------------------------|-------------------------------|-----------------------------------|--------------------------------|----------------------------------|-------------------------------------|-------------------------------|----------------------------------|-------------------------------|-------------------------------|----------------------------------|-------------------------------|----------------------------------|--------------------------------|------------------------------|------------------------------------|--------------------------------|-----------------------------------|--------------------------------|-----------------------------------|
| 1 H Hydrogen 1.00797 | | | | | | | | | | | | | | | | | 2 He Helium 4.0026 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Li Lithium 6.939 | 4 Be Beryllium 9.0122 | | | | | | | | | | | | | | | 9 F Fluorine 18.9984 | 10 Ne Neon 20.183 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 Na Sodium 22.9898 | 12 Mg Magnesium 24.312 | | | | | | | | | | | | | | | 17 Cl Chlorine 35.453 | 18 Ar Argon 39.948 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 K Potassium 39.102 | 20 Ca Calcium 40.08 | 21 Sc Scandium 44.956 | 22 Ti Titanium 47.90 | 23 V Vanadium 50.942 | 24 Cr Chromium 51.996 | 25 Mn Manganese 54.9380 | 26 Fe Iron 55.847 | 27 Co Cobalt 58.9332 | 28 Ni Nickel 58.71 | 29 Cu Copper 63.546 | 30 Zn Zinc 65.37 | 31 Ga Gallium 69.72 | 32 Ge Germanium 72.59 | 33 As Arsenic 74.9216 | 34 Se Selenium 78.96 | 35 Br Bromine 79.904 | 36 Kr Krypton 83.80 | 37 Rb Rubidium 85.47 | 38 Sr Strontium 87.62 | 39 Y Yttrium 88.905 | 40 Zr Zirconium 91.22 | 41 Nb Niobium 92.906 | 42 Mo Molybdenum 95.94 | 43 Tc Technetium (99) | 44 Ru Ruthenium 101.07 | 45 Rh Rhodium 102.905 | 46 Pd Palladium 106.4 | 47 Ag Silver 107.868 | 48 Cd Cadmium 112.40 | 49 In Indium 114.82 | 50 Sn Tin 118.69 | 51 Sb Antimony 121.75 | 52 Te Tellurium 127.60 | 53 I Iodine 126.9044 | 54 Xe Xenon 131.30 | 55 Cs Cesium 132.905 | 56 Ba Barium 137.34 | 57 La Lanthanum 138.91 | 58 Ce Cerium 140.12 | 59 Pr Praseodymium 140.907 | 60 Nd Neodymium 144.24 | 61 Pm Promethium (145) | 62 Sm Samarium 150.35 | 63 Eu Europium 151.96 | 64 Gd Gadolinium 157.25 | 65 Tb Terbium 158.924 | 66 Dy Dysprosium 162.50 | 67 Ho Holmium 164.930 | 68 Er Erbium 167.26 | 69 Tm Thulium 168.934 | 70 Yb Ytterbium 173.04 | 71 Lu Lutetium 174.97 | 72 Hf Hafnium 178.49 | 73 Ta Tantalum 180.948 | 74 W Tungsten 183.85 | 75 Re Rhenium 186.2 | 76 Os Osmium 190.2 | 77 Ir Iridium 192.2 | 78 Pt Platinum 195.09 | 79 Au Gold 196.967 | 80 Hg Mercury 200.59 | 81 Tl Thallium 204.37 | 82 Pb Lead 207.19 | 83 Bi Bismuth 208.980 | 84 Po Polonium (210) | 85 At Astatine (210) | 86 Rn Radon (222) | 87 Fr Francium (223) | 88 Ra Radium (226) | 89 Ac Actinium (227) | 90 Th Thorium 232.038 | 91 Pa Protactinium (231) | 92 U Uranium 238.03 | 93 Np Neptunium (237) | 94 Pu Plutonium (242) | 95 Am Americium (243) | 96 Cm Curium (247) | 97 Bk Berkelium (247) | 98 Cf Californium (251) | 99 Es Einsteinium (254) | 100 Fm Fermium (257) | 101 Md Mendelevium (258) | 102 No Nobelium (259) | 103 Lr Lawrencium (260) | 104 Rf Rutherfordium (261) | 105 Db Dubnium (262) | 106 Sg Seaborgium (266) | 107 Bh Bohrium (264) | 108 Hs Hassium (269) | 109 Mt Meitnerium (268) | 110 Un Ununium (269) | 111 Uuu Unununium (272) | 112 Uub Unubium (277) | 113 Uut Ununtrium § | 114 Uuq Ununquadium (285) | 115 Uup Ununpentium § | 116 Uuh Ununhexium (289) | 117 Uus Ununseptium § | 118 Uuo Ununoctium (293) |

Lanthanide Series

Actinide Series

§ Note: Elements 113, 115, and 117 are not known at this time, but are included in the table to show their expected positions.

Bonding

- ✓ In bonding, atoms lose, gain, or share electrons in order to have the same number of electrons as the nearest noble gas.
- ✓ Metal + nonmetal = ionic bond
- ✓ Nonmetal + nonmetal = covalent bond
- ✓ Electron filling pattern: 1s, 2s, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f

Solution Concentrations

weight/weight (w/w) % = (grams solute / grams solution) × 100

molarity (M) = moles solute / liters solution

parts-per-million (ppm) = grams solute / 1,000,000 grams solution = mg/l

Isotope Representation



X = element symbol, Z = atomic number (# of protons), A = mass number (# of protons + # of neutrons)

Acids and Bases

An *acid* is an H⁺ donor, and a *base* is an H⁺ acceptor.

pH = -log[H⁺]; [H⁺] = 10^{-pH}

pH = 7 is *neutral*; pH less than 7 is *acidic*; pH greater than 7 is *basic*.

Useful Conversions And Metric Prefixes

Temperature conversions:

- ✓ °F = 9/5(°C) + 32
- ✓ °C = 5/9(°F - 32)
- ✓ K = °C + 273

Metric/English conversions:

- ✓ 2.54 cm = 1 in
- ✓ 454 g = 1 lb
- ✓ 0.946L = 1 qt

Pressure conversion: 1atm = 760 mmHg = 760 torr

Common metric prefixes:

- ✓ *milli-* = 0.001
- ✓ *centi-* = 1/100
- ✓ *kilo-* = 1000

Redox

Oxidation is loss of electrons; *reduction* is gain of electrons.

Gas Laws

Combined Gas Law:

$(P_1V_1)/T_1 = (P_2V_2)/T_2$ (T must be in kelvins)

Ideal Gas Law:

$PV = nRT$ (where R = 0.0821 l·atm/K·mol)

Mole Concept

1 mole = 6.022 × 10²³ particles/mol = formula weight expressed in grams

About the Author

John T. Moore, Ed.D grew up in the foothills of western North Carolina. He attended the University of North Carolina-Asheville where he received his bachelor's degree in chemistry. He earned his Master's degree in chemistry from Furman University in Greenville, South Carolina. After a stint in the United States Army, he decided to try his hand at teaching. In 1971, he joined the chemistry faculty of Stephen F. Austin State University in Nacogdoches, Texas, where he still teaches chemistry. In 1985, he started back to school part-time and in 1991 received his Doctorate in Education from Texas A&M University.

John's area of specialty is chemical education. He has developed several courses for students planning on teaching chemistry at the high school level. In the early 1990s, he shifted his emphasis to training elementary education majors and in-service elementary teachers in hands-on chemical activities. He has received four Eisenhower grants for professional development of elementary teachers and for the last five years has been the co-editor (along with one of his former students) of the "Chemistry for Kids" feature of *The Journal of Chemical Education*.

Although teaching has always been foremost in his heart, John found time to work part-time for almost five years in the medical laboratory of the local hospital and has been a consultant for a textbook publisher. He is active in a number of local, state, and national organizations, such as the Nacogdoches Kiwanis Club and the American Chemical Society.

John lives in the Piney Woods of East Texas with his wife Robin and their three dogs and cat. He enjoys brewing his own beer and mead. And he loves to cook. In fact, he and his wife have recently bought a gourmet food & kitchen shop called *The Cottage*. ("I was spending so much there it was cheaper to just go ahead and buy the store.") His two boys, Jason and Matt, remain in the mountains of North Carolina.

Dedication

This book is dedicated to those children, past, present, and future, who will grow to love chemistry, just as I have done. You may never make a living as a chemist, but I hope that you will remember the thrill of your experiments and will pass that enjoyment on to your children. This book is also dedicated to my wife Robin, who took time out of her busy campaign schedule to encourage me and have faith in me during those times when I didn't have much faith in myself. This time you were the wind beneath my wings. And it's dedicated to my close friends who helped keep me grounded in reality, especially Sue Mary, who always had just the right quote from a Jimmy Buffett song to lift me up, and Jan, whose gift of a tie-dyed lab coat kept me from taking myself too seriously. And finally, this book is dedicated to my sons, Matthew and Jason, and my wonderful daughter-in-law, Sara. I love you guys.

Author's Acknowledgments

I would not have had the opportunity to write this book without the encouragement of my agent, Grace Freedson. She took the time to answer my constant e-mails and teach me a little about the publishing business. I owe many thanks to the staff at Wiley, especially acquisitions editor Greg Tubach, project editor Tim Gallan, copy editor Greg Pearson, and technical reviewer Bill Cummings, for their comments and help with this project. Special thanks also to the MMSEC elementary teachers of Nacogdoches ISD, especially Jan, Derinda, and Sondra. You made me a better teacher, and you showed your support and concern for me as I was writing this book. Special thanks also to Andi and The Cottage Girls, Kim, Jonell, Stephanie, Amanda, and Laura, for taking such good care of the shop while I was involved in this project. Thanks to my colleagues who kept asking me how it was going and especially Rich Langley, who was always there to point out my procrastination. And let me offer many thanks to all my students over the past thirty years, especially the ones who became teachers. I've learned from you and I hope that you've learned from me.

Publisher's Acknowledgments

We're proud of this book; please send us your comments through our Dummies online registration form located at www.dummies.com/register/.

Some of the people who helped bring this book to market include the following:

Acquisitions, Editorial, and Media Development

Senior Project Editor: Tim Gallan

Acquisitions Editors: Greg Tubach, Kathy Cox

Copy Editors: Greg Pearson, Sandy Blackthorn

Technical Editor: Bill Cummings

Editorial Manager: Christine Meloy Beck

Editorial Assistant: Melissa Bennett

Cover Photos: © Chris Salvo/
Getty Images/FPG

Cartoons: Rich Tennant, www.the5thwave.com

Production

Project Coordinator: Erin Smith

Layout and Graphics: Melanie DesJardins,
Carrie Foster, Joyce Haughey,
LeAndra Johnson, Barry Offringa,
Laurie Petrone, Heather Pope,
Jacque Schneider, Betty Schulte,
Erin Zeltner

Illustrators: Kelly Hardesty, Rashell Smith,
Kathie Schutte

Proofreaders: Laura Albert, John Bitter,
John Tyler Connoley, Andy Hollandbeck,
Arielle Carole Mennelle

Indexer: Sherry Massey

Publishing and Editorial for Consumer Dummies

Diane Graves Steele, Vice President and Publisher, Consumer Dummies

Joyce Pepple, Acquisitions Director, Consumer Dummies

Kristin A. Cocks, Product Development Director, Consumer Dummies

Michael Spring, Vice President and Publisher, Travel

Brice Gosnell, Publishing Director, Travel

Suzanne Jannetta, Editorial Director, Travel

Publishing for Technology Dummies

Andy Cummings, Vice President and Publisher, Dummies Technology/General User

Composition Services

Gerry Fahey, Vice President of Production Services

Debbie Stailey, Director of Composition Services

Contents at a Glance

| | |
|---|------------|
| Introduction | 1 |
| Part I: Basic Concepts of Chemistry | 7 |
| Chapter 1: What Is Chemistry, and Why Do I Need to Know Some? | 9 |
| Chapter 2: Matter and Energy | 15 |
| Chapter 3: Something Smaller Than an Atom? Atomic Structure | 31 |
| Chapter 4: The Periodic Table (But No Chairs) | 53 |
| Chapter 5: Nuclear Chemistry: It'll Blow Your Mind | 65 |
| Part II: Blessed Be the Bonds That Tie | 83 |
| Chapter 6: Opposites Do Attract: Ionic Bonds | 85 |
| Chapter 7: Covalent Bonds: Let's Share Nicely | 99 |
| Chapter 8: Chemical Cooking: Chemical Reactions | 121 |
| Chapter 9: Electrochemistry: Batteries to Teapots | 147 |
| Part III: The Mole: The Chemist's Best Friend | 163 |
| Chapter 10: The Mole: Can You Dig It? | 165 |
| Chapter 11: Mixing Matter Up: Solutions | 177 |
| Chapter 12: Sour and Bitter: Acids and Bases | 193 |
| Chapter 13: Balloons, Tires, and Scuba Tanks: The Wonderful World of Gases | 211 |
| Part IV: Chemistry in Everyday Life: Benefits and Problems | 229 |
| Chapter 14: The Chemistry of Carbon: Organic Chemistry | 231 |
| Chapter 15: Petroleum: Chemicals for Burning or Building | 247 |
| Chapter 16: Polymers: Making Big Ones from Little Ones | 257 |
| Chapter 17: Chemistry in the Home | 271 |
| Chapter 18: Cough! Cough! Hack! Hack! Air Pollution | 289 |
| Chapter 19: Brown, Chunky Water? Water Pollution | 301 |
| Part V: The Part of Tens | 315 |
| Chapter 20: Ten Serendipitous Discoveries in Chemistry | 317 |
| Chapter 21: Ten Great Chemistry Nerds | 321 |
| Chapter 22: Ten Useful Chemistry Web Sites | 325 |

| | |
|---|-------------------|
| <i>Appendix A: Scientific Units: The Metric System</i> | <i>329</i> |
| <i>Appendix B: How to Handle Really Big or Really Small Numbers.....</i> | <i>333</i> |
| <i>Appendix C: Unit Conversion Method</i> | <i>337</i> |
| <i>Appendix D: Significant Figures and Rounding Off</i> | <i>341</i> |
| <i>Index</i> | <i>345</i> |

Table of Contents

Introduction 1

| | |
|---|---|
| About This Book | 2 |
| How to Use This Book | 2 |
| Assumptions (And You Know What They Say about Assumptions!) | 2 |
| How This Book Is Organized | 3 |
| Part I: Basic Concepts of Chemistry | 3 |
| Part II: Blessed Be the Bonds That Tie | 3 |
| Part III: The Mole: The Chemist's Best Friend | 4 |
| Part IV: Chemistry in Everyday Life: Benefits and Problems | 4 |
| Part V: The Part of Tens | 5 |
| Icons Used in This Book | 5 |
| Where to Go from Here | 6 |

Part I: Basic Concepts of Chemistry 7

Chapter 1: What Is Chemistry, and Why Do I Need to Know Some? 9

| | |
|---|----|
| What Exactly Is Chemistry? | 9 |
| Branches in the tree of chemistry | 10 |
| Macroscopic versus microscopic viewpoints | 12 |
| Pure versus applied chemistry | 12 |
| So What Does a Chemist Do All Day? | 13 |
| And Where Do Chemists Actually Work? | 13 |

Chapter 2: Matter and Energy 15

| | |
|--|----|
| States of Matter: Macroscopic and Microscopic Views | 15 |
| Solids | 16 |
| Liquids | 16 |
| Gases | 17 |
| Ice in Alaska, Water in Texas: Matter Changes States | 17 |
| I'm melting away! Oh, what a world! | 17 |
| Boiling point | 18 |
| Freezing point: The miracle of ice cubes | 18 |
| Sublimate this! | 19 |
| Pure Substances and Mixtures | 19 |
| Pure substances | 20 |
| Throwing mixtures into the mix | 21 |



| | |
|--|-----------|
| Measuring Matter | 22 |
| The SI system | 22 |
| SI/English conversions | 22 |
| Nice Properties You've Got There | 23 |
| How dense are you? | 24 |
| Measuring density | 25 |
| Energy (Wish I Had More) | 26 |
| Kinetic energy — moving right along | 26 |
| Potential energy — sitting pretty | 27 |
| Measuring Energy | 27 |
| Temperature and temperature scales | 28 |
| Feel the heat | 29 |
| Chapter 3: Something Smaller Than an Atom? Atomic Structure ... | 31 |
| Subatomic Particles: So That's What's in an Atom | 31 |
| The Nucleus: Center Stage | 33 |
| Where Are Those Electrons? | 38 |
| The Bohr model — it's really not boring | 38 |
| Quantum mechanical model | 40 |
| Electron configurations (Bed Check for Electrons) | 44 |
| The dreaded energy level diagram | 45 |
| Electron configurations: Easy and space efficient | 47 |
| Valence electrons: Living on the edge | 48 |
| Isotopes and Ions: These Are a Few of My Favorite Things | 49 |
| Isolating the isotope | 49 |
| Keeping an eye on ions | 50 |
| Chapter 4: The Periodic Table (But No Chairs) | 53 |
| Repeating Patterns of Periodicity | 53 |
| Understanding How Elements Are Arranged in the Periodic Table | 56 |
| Metals, nonmetals, and metalloids | 57 |
| Families and periods | 60 |
| Chapter 5: Nuclear Chemistry: It'll Blow Your Mind | 65 |
| It All Starts with the Atom | 66 |
| Radioactivity and Man-Made Radioactive Decay | 66 |
| Natural Radioactive Decay: How Nature Does It | 68 |
| Alpha emission | 69 |
| Beta emission | 69 |
| Gamma emission | 70 |
| Positron emission | 70 |
| Electron capture | 71 |
| Half-Lives and Radioactive Dating | 71 |
| Safe handling | 73 |
| Radioactive dating | 74 |

| | |
|--|----|
| Gone (Nuclear) Fission | 74 |
| Chain reactions and critical mass | 75 |
| Atomic bombs (big bangs that aren't theories) | 76 |
| Nuclear power plants | 77 |
| Breeder reactors: Making more nuclear stuff | 79 |
| Nuclear Fusion: The Hope for Our Energy Future | 80 |
| Control issues | 80 |
| What the future holds | 81 |
| Am I Glowing? The Effects of Radiation | 82 |

***Part II: Blessed Be the Bonds That Tie*83**

Chapter 6: Opposites Do Attract: Ionic Bonds 85

| | |
|--|----|
| The Magic of an Ionic Bond: Sodium + Chlorine = Table Salt | 85 |
| Understanding the components | 86 |
| Understanding the reaction | 87 |
| Ending up with a bond | 88 |
| Positive and Negative Ions: Cations and Anions | 89 |
| Polyatomic Ions | 92 |
| Putting Ions Together: Ionic Compounds | 94 |
| Putting magnesium and bromine together | 94 |
| Using the crisscross rule | 95 |
| Naming Ionic Compounds | 96 |
| Electrolytes and Nonelectrolytes | 97 |

Chapter 7: Covalent Bonds: Let's Share Nicely 99

| | |
|--|-----|
| Covalent Bond Basics | 99 |
| A hydrogen example | 100 |
| Comparing covalent bonds with other bonds | 101 |
| Understanding multiple bonds | 102 |
| Naming Binary Covalent Compounds | 103 |
| So Many Formulas, So Little Time | 104 |
| Empirical formula: Just the elements | 105 |
| Molecular or true formula: Inside the numbers | 105 |
| Structural formula: Add the bonding pattern | 106 |
| Some Atoms Are More Attractive Than Others | 110 |
| Attracting electrons: Electronegativities | 111 |
| Polar covalent bonding | 113 |
| Water: A really strange molecule | 114 |
| What Does Water Really Look Like? The VSEPR Theory | 117 |

Chapter 8: Chemical Cooking: Chemical Reactions 121

| | |
|---|-----|
| What You Have and What You'll Get: Reactants and Products | 122 |
| How Do Reactions Occur? Collision Theory | 123 |
| An exothermic example | 124 |
| An endothermic example | 125 |

| | |
|--|-----|
| What Kind of Reaction Do You Think I Am? | 126 |
| Combination reactions | 126 |
| Decomposition reactions | 127 |
| Single displacement reactions | 127 |
| Double displacement reactions | 129 |
| Combustion reactions | 130 |
| Redox reactions | 131 |
| Balancing Chemical Reactions | 131 |
| Smell that ammonia | 131 |
| Flick that bic | 133 |
| Chemical Equilibrium | 134 |
| Le Chatelier's Principle | 136 |
| Changing the concentration | 137 |
| Changing the temperature | 138 |
| Changing the pressure | 139 |
| Reacting Fast and Reacting Slow: Chemical Kinetics | 140 |
| Nature of the reactants | 140 |
| Particle size of the reactants | 141 |
| Concentration of the reactants | 141 |
| Pressure of gaseous reactants | 141 |
| Temperature | 142 |
| Catalysts | 143 |

Chapter 9: Electrochemistry: Batteries to Teapots 147

| | |
|---|-----|
| There Go Those Pesky Electrons: Redox Reactions | 148 |
| Now where did I put those electrons? Oxidation | 148 |
| Look what I found! Reduction | 149 |
| One's loss is the other's gain | 150 |
| Playing the numbers: Oxidation numbers, that is | 151 |
| Balancing redox equations | 152 |
| Power On the Go: Electrochemical Cells | 155 |
| Nice cell there, Daniell | 156 |
| Let the light shine: Flashlight cells | 157 |
| Gentlemen, start your engines: Automobile batteries | 158 |
| Five Dollars for a Gold Chain? Electroplating | 159 |
| This Burns Me Up! Combustion of Fuels and Foods | 161 |

Part III: The Mole: The Chemist's Best Friend 163

Chapter 10: The Mole: Can You Dig It? 165

| | |
|--|-----|
| Counting by Weighing | 165 |
| Pairs, Dozens, Reams, and Moles | 166 |
| Avogadro's number: Not in the phone book | 167 |
| Using moles in the real world | 167 |

| | |
|--|------------|
| Chemical Reactions and Moles | 169 |
| How much needed, how much made: | |
| Reaction stoichiometry | 171 |
| Where did it go? Percent yield | 173 |
| Running out of something and leaving something behind: | |
| Limiting reactants | 174 |
| Chapter 11: Mixing Matter Up: Solutions | 177 |
| Solutes, Solvents, and Solutions | 177 |
| A discussion of dissolving | 178 |
| Saturated facts | 178 |
| Solution Concentration Units | 179 |
| Percent composition | 179 |
| It's number one! Molarity | 182 |
| Molality: Another use for the mole | 184 |
| Parts per million: The pollution unit | 184 |
| Colligative Properties of Solutions | 185 |
| Vapor pressure lowering | 186 |
| Why use antifreeze in the summer? Boiling point elevation | 186 |
| Making ice cream: Freezing point depression | 187 |
| Keeping blood cells alive and well: Osmotic pressure | 188 |
| Smoke, Clouds, Whipped Cream, and Marshmallows: Colloids All | 190 |
| Chapter 12: Sour and Bitter: Acids and Bases | 193 |
| Properties of Acids and Bases: Macroscopic View | 193 |
| What Do Acids and Bases Look Like? — Microscopic View | 195 |
| The Arrhenius theory: Must have water | 195 |
| The Bronsted-Lowery acid-base theory: | |
| Giving and accepting | 196 |
| Acids to Corrode, Acids to Drink: Strong and | |
| Weak Acids and Bases | 197 |
| Strong acids | 197 |
| Strong bases | 198 |
| Weak acids | 199 |
| Weak bases | 201 |
| Give me that proton: Bronsted-Lowery acid-base reactions | 201 |
| Make up your mind: Amphoteric water | 201 |
| An Old Laxative and Red Cabbage: Acid-Base Indicators | 202 |
| Good old litmus paper | 203 |
| Phenolphthalein: Helps keep you regular | 203 |
| How Acidic Is That Coffee: The pH Scale | 205 |
| Buffers: Controlling pH | 208 |
| Antacids: Good, Basic Chemistry | 209 |

Chapter 13: Balloons, Tires, and Scuba Tanks: The Wonderful World of Gases 211

| | |
|---|-----|
| Microscopic View of Gases: The Kinetic Molecular Theory | 211 |
| I'm Under Pressure — Atmospheric Pressure, That Is | 214 |
| Measuring atmospheric pressure: The barometer | 214 |
| Measuring confined gas pressure: The manometer | 216 |
| Gases Obey Laws, Too — Gas Laws | 216 |
| Boyle's Law: Nothing to do with boiling | 217 |
| Charles's Law: Don't call me Chuck | 219 |
| Gay-Lussac's Law | 220 |
| The combined gas law | 221 |
| Avogadro's Law | 222 |
| The ideal gas equation | 224 |
| Stoichiometry and the Gas Laws | 225 |
| Dalton's and Graham's Laws | 225 |
| Dalton's Law | 226 |
| Graham's Law | 226 |

Part IV: Chemistry in Everyday Life: Benefits and Problems 229

Chapter 14: The Chemistry of Carbon: Organic Chemistry 231

| | |
|--|-----|
| Hydrocarbons: From Simple to Complex | 232 |
| From gas grills to gasoline: Alkanes | 232 |
| Unsaturated hydrocarbons: Alkenes | 239 |
| It takes alkynes to make the world | 240 |
| Aromatic compounds: Benzene and other smelly compounds | 241 |
| Functional Groups: That Special Spot | 241 |
| Alcohols (rubbing to drinking): R-OH | 242 |
| Carboxylic acids (smelly things): R-COOH | 243 |
| Esters (more smelly things, but mostly good odors): R-COOR' | 244 |
| Aldehydes and ketones: Related to alcohols | 244 |
| Ethers (sleepy time): R-O-R | 245 |
| Amines and amides: Organic bases | 246 |

Chapter 15: Petroleum: Chemicals for Burning or Building 247

| | |
|--|-----|
| Don't Be Crude, Get Refined | 247 |
| Fractional distillation: Separating chemicals | 248 |
| This cracks me up: Catalytic cracking | 249 |
| Moving molecular parts around: Catalytic reforming | 251 |

| | |
|---|------------|
| The Gasoline Story | 252 |
| How good is your gas: Octane ratings | 252 |
| Additives: Put the lead in, get the lead out | 254 |
| Chapter 16: Polymers: Making Big Ones from Little Ones | 257 |
| Natural Monomers and Polymers | 258 |
| Classifying Unnatural (Synthetic) Monomers and Polymers | 259 |
| We all need a little structure | 259 |
| Feel the heat | 259 |
| Used and abused | 260 |
| Chemical process | 260 |
| Reduce, Reuse, Recycle — Plastics | 268 |
| Chapter 17: Chemistry in the Home | 271 |
| Chemistry in the Laundry Room | 271 |
| Keep it clean: Soap | 273 |
| Get rid of that bathtub ring: Detergents | 274 |
| Make it soft: Water softeners | 275 |
| Make it whiter: Bleach | 276 |
| Chemistry in the Kitchen | 277 |
| Clean it all: Multipurpose cleaners | 277 |
| Wash those pots: Dishwashing products | 277 |
| Chemistry in the Bathroom | 277 |
| Detergent for the mouth: Toothpaste | 278 |
| Phew! Deodorants and antiperspirants | 278 |
| Skin care chemistry: Keeping it soft and pretty | 279 |
| Clean it, color it, curl it: Hair care chemistry | 283 |
| Chemistry in the Medicine Cabinet | 287 |
| The aspirin story | 287 |
| Minoxidil and Viagra | 287 |
| Chapter 18: Cough! Cough! Hack! Hack! Air Pollution | 289 |
| Civilization's Effect on the Atmosphere | |
| (Or Where This Mess Began) | 289 |
| To Breathe or Not to Breathe: Our Atmosphere | 290 |
| The troposphere: What humans affect most | 290 |
| The stratosphere: Protecting humans with the ozone layer | 291 |
| Leave My Ozone Alone: Hair Spray, CFCs, and Ozone Depletion | 291 |
| How do CFCs hurt the ozone layer? | 292 |
| Because they're harmful, are CFCs still produced? | 293 |
| Is It Hot in Here to You? (The Greenhouse Effect) | 293 |
| Brown Air? (Photochemical Smog) | 295 |
| London smog | 295 |
| Photochemical smog | 295 |