

# FUNDAMENTALS OF CHEMISTRY

Fourth Edition

David E.  
Goldberg

THE MCGRAW-HILL COMPANIES  
FOR DONATION ONLY  
NOT FOR RESALE  
HIGHER EDUCATION  
23-ASA-006



GIFT OF THE ASIA FOUNDATION  
NOT FOR RE-SALE  
QUÀ TẶNG CỦA QUỸ CHÂU Á  
KHÔNG ĐƯỢC BÁN LẠI

58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.9077	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.9254	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.9303	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.9342	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
90 <b>Th</b> 232.0381	91 <b>Pa</b> 231.0359	92 <b>U</b> 238.029	93 <b>Np</b> 237.0482	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (249)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (255)	101 <b>Md</b> (256)	102 <b>No</b> (254)	103 <b>Lr</b> (257)





# IMPORTANT:

HERE IS YOUR REGISTRATION CODE TO ACCESS  
YOUR PREMIUM MCGRAW-HILL ONLINE RESOURCES.

For key premium online resources you need THIS CODE to gain access. Once the code is entered, you will be able to use the Web resources for the length of your course.

If your course is using **WebCT** or **Blackboard**, you'll be able to use this code to access the McGraw-Hill content within your instructor's online course.

Access is provided if you have purchased a new book. If the registration code is missing from this book, the registration screen on our Website, and within your WebCT or Blackboard course, will tell you how to obtain your new code.

## Registering for McGraw-Hill Online Resources



to gain access to your mcgraw-hill web  
resources simply follow the steps below:

- 1 USE YOUR WEB BROWSER TO GO TO: <http://www.mhhe.com/goldberg>
- 2 CLICK ON **FIRST TIME USER**.
- 3 ENTER THE REGISTRATION CODE\* PRINTED ON THE TEAR-OFF BOOKMARK ON THE RIGHT.
- 4 AFTER YOU HAVE ENTERED YOUR REGISTRATION CODE, CLICK **REGISTER**.
- 5 FOLLOW THE INSTRUCTIONS TO SET-UP YOUR PERSONAL UserID AND PASSWORD.
- 6 WRITE YOUR UserID AND PASSWORD DOWN FOR FUTURE REFERENCE.  
KEEP IT IN A SAFE PLACE.

TO GAIN ACCESS to the McGraw-Hill content in your instructor's **WebCT** or **Blackboard** course simply log in to the course with the UserID and Password provided by your instructor. Enter the registration code exactly as it appears in the box to the right when prompted by the system. You will only need to use the code the first time you click on McGraw-Hill content.

Thank you, and welcome  
to your mcgraw-hill  
online resources!



**Higher  
Education**

\*YOUR REGISTRATION CODE CAN BE USED ONLY ONCE TO ESTABLISH ACCESS. IT IS NOT TRANSFERABLE.  
0-07-293171-X GOLDBERG: FUNDAMENTALS OF CHEMISTRY, 4/E

MCGRAW-HILL

ONLINE RESOURCES



YQGR-VIB1-2JMV-3L00-FBUS

REGISTRATION CODE

**Mc  
Graw  
Hill** Higher  
Education



# How's Your Math?

**Do you have the math skills you need to succeed?**



Why risk not succeeding because you struggle with your math skills?

Get access to a web-based, personal math tutor:

- Available 24/7, unlimited use
- Driven by artificial intelligence
- Self-paced
- An entire month's subscription **for much less** than the cost of one hour with a human tutor

ALEKS is an inexpensive, private, infinitely patient math tutor that's accessible any time, anywhere you log on.

**ALEKS®**



Log On for a  
**FREE** 48-hour Trial

**[www.highedstudent.aleks.com](http://www.highedstudent.aleks.com)**

ALEKS is a registered trademark of ALEKS Corporation.



# FUNDAMENTALS OF **CHEMISTRY**

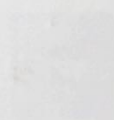
David A. Goldberg

Indiana University

LIBRARY OF THE AMERICAN CHEMICAL SOCIETY  
NOTES

CHINA UNIVERSITY OF CHEMISTRY  
LIBRARY

LIBRARY  
UNIVERSITY OF CALIFORNIA  
LIBRARY



Higher Education

# FUNDAMENTALS OF CHEMISTRY

Fourth Edition

**David E. Goldberg**

*Brooklyn College*

GIFT OF THE ASIA FOUNDATION  
NOT FOR RE-SALE

QUÀ TẶNG CỦA QUỸ CHÂU Á  
KHÔNG ĐƯỢC BÁN LẠI



**Higher Education**

Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis  
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City  
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto



## FUNDAMENTALS OF CHEMISTRY, FOURTH EDITION

Published by McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. Copyright © 2004, 2001, 1998, 1994 by The McGraw-Hill Companies, Inc. All rights reserved. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of The McGraw-Hill Companies, Inc., including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

Printed in China

2 3 4 5 6 7 8 9 0 SDB/SDB 0 9 8 7 6 5

ISBN 0-07-293883-8

Publisher: Kent A. Peterson

Sponsoring editor: Thomas D. Timp

Senior developmental editor: Shirley R. Oberbroeckling

Senior project manager: Gloria G. Schiesl

Senior production supervisor: Laura Fuller

Media project manager: Judi K. Banowetz

Senior media technology producer: Jeffery Schmitt

Designer: K. Wayne Harms

Cover/interior designer: Scan Communications Group Inc.

Cover images: Flask: Getty Images/L. Lefkowitz; Background Image: PhotoDisc-Technology Perspectives

Lead photo research coordinator: Carrie K. Burger

Compositor: The GTS Companies

Typeface: 10/12 Times Roman

Printer: R.R. Donnelley and Sons Inc.

The credits section for this book begins on page 657 and is considered an extension of the copyright page.

## Library of Congress Cataloging-in-Publication Data

Goldberg, David E. (David Elliott), 1932-

Fundamentals of chemistry / David E. Goldberg. — 4th ed.

p. cm.

Includes index.

ISBN 0-07-247224-3 (acid-free paper)

1. Chemistry. I. Title.

QD33.2.G65 2004

540—dc21

2002044878

CIP



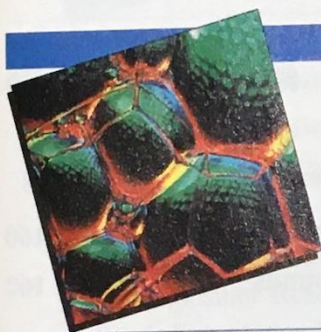
# Brief Contents

CHAPTER 1	Basic Concepts	1	CHAPTER 15	Solutions	399
CHAPTER 2	Measurement	25	CHAPTER 16	Oxidation Numbers	424
CHAPTER 3	Atoms and Atomic Masses	75	CHAPTER 17	Chemical Equilibrium	454
CHAPTER 4	Electronic Configuration of the Atom	97	CHAPTER 18	Acid-Base Theory	476
CHAPTER 5	Chemical Bonding	126	CHAPTER 19	Organic Chemistry	499
CHAPTER 6	Nomenclature	159	CHAPTER 20	Nuclear Reactions	532
CHAPTER 7	Formula Calculations	183	APPENDIX 1	Scientific Calculations	561
CHAPTER 8	Chemical Reactions	206	APPENDIX 2	Tables of Symbols, Abbreviations, and Prefixes and Suffixes	579
CHAPTER 9	Net Ionic Equations	240	APPENDIX 3	Table of Basic Mathematical Equations	582
CHAPTER 10	Stoichiometry	254	APPENDIX 4	Answers to Practice Problems	583
CHAPTER 11	Molarity	287	APPENDIX 5	Answers to Selected End-of-Chapter Problems	596
CHAPTER 12	Gases	311	GLOSSARY		645
CHAPTER 13	Atomic and Molecular Properties	347	PHOTO CREDITS		657
CHAPTER 14	Solids and Liquids, Energies of Physical and Chemical Changes	370	INDEX		659



# Contents

*Preface* xv  
*To the Student* xxiii  
*Learning System* xxv



## CHAPTER 1

### Basic Concepts 1

1.1	Classification of Matter	2
1.2	Properties	6
1.3	Matter and Energy	10
1.4	Chemical Symbols	11
1.5	The Periodic Table	12
1.6	Laws, Hypotheses, and Theories	17

Summary 19  
Problems 20

## CHAPTER 2



### Measurement 25

2.1	Factor Label Method	27
2.2	The Metric System	32
	Length or Distance	37

Mass 38  
Volume 39

### 2.3 Exponential Numbers 42

Changing the Form of Exponential  
Numbers 44

Multiplication and Division  
of Exponential Numbers 45

Addition and Subtraction  
of Exponential Numbers 48

Raising an Exponential Number  
to a Power 49

### 2.4 Significant Digits 50

Significant Digits in Calculated  
Results 55

Rounding Off 57

### 2.5 Density 60

### 2.6 Temperature Scales 63

Summary 65  
Problems 67

## CHAPTER 3



### Atoms and Atomic Masses 75

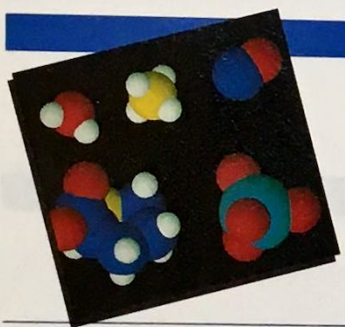
3.1	Laws of Chemical Combination	76
3.2	Dalton's Atomic Theory	79
3.3	Subatomic Particles	81
3.4	Atomic Mass	84



3.5	Development of the Periodic Table	88
	Summary	90
	Problems	91

**CHAPTER 4****Electronic Configuration of the Atom 97**

4.1	A Brief Exploration of Light	98
4.2	Bohr Theory	100
4.3	Quantum Numbers	103
4.4	Relative Energies of Electrons	105
4.5	Shells, Subshells, and Orbitals	109
4.6	Shapes of Orbitals	112
4.7	Energy Level Diagrams	113
4.8	Periodic Variation of Electronic Configuration	115
	Summary	119
	Problems	121

**CHAPTER 5****Chemical Bonding 126**

5.1	Chemical Formulas	127
	Molecules of Elements	127
	Formula Units	130
5.2	Ionic Bonding	132
	Detailed Electronic Configurations of Anions	135
	Detailed Electronic Configurations of Cations	135

5.3	Lewis Electron Dot Diagrams	137
5.4	Formulas for Ionic Compounds	137
5.5	Covalent Bonding	141
	Systematic Method for Drawing Electron Dot Diagrams	144
	Polyatomic Ions	147
	Nonoctet Structures	150
	Summary	152
	Problems	153

**CHAPTER 6****Nomenclature 159**

6.1	Binary Nonmetal-Nonmetal Compounds	160
6.2	Naming Ionic Compounds	162
	Naming Cations	162
	Naming Anions	166
	Naming and Writing Formulas for Ionic Compounds	168
6.3	Naming Acids and Acid Salts	170
	Naming Acids	171
	Naming Acid Salts	172
6.4	Hydrates	175
	Summary	175
	Problems	177

**CHAPTER 7****Formula Calculations 183**

7.1	Formula Masses	184
7.2	Percent Composition	186