



Bettelheim
& March

Introduction to
**General, Organic
& Biochemistry**

SECOND EDITION

062
B565
E.2

8864582

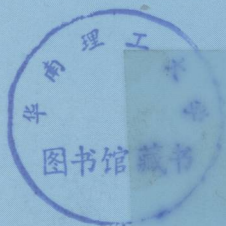
INTRODUCTION TO
**General, Organic
& Biochemistry**

SECOND EDITION

Frederick A. Bettelheim

Jerry March

Adelphi University



E8864582

Saunders Golden Sunburst Series



Saunders College Publishing

New York Chicago San Francisco

Philadelphia Montreal Toronto

London Sydney Tokyo

Copyright © 1988, 1984 by W. B. Saunders Company.

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:
Permissions, Holt, Rinehart and Winston, 111 Fifth Avenue, New York, New York 10003

Text Typeface: Times Roman
Compositor: Progressive Typographers, Inc.
Acquisitions Editor: John J. Vondeling
Project Editor: Sally Kusch
Copy Editor: Jay Freedman
Art Director: Carol Bleistine
Art Assistant: Doris Roessner
Text Designer: Arlene Putterman
Cover Designer: Lawrence R. Didona
Text Artwork: J&R Technical Services, Inc.
Production Manager: Tim Frelick, Harry Dean
Assistant Production Manager: JoAnn Melody

Cover Credit: © FourbyFive.
Frontispiece: The Tyndall effect. Photograph by F. Seib/H. Armstrong Roberts.

Printed in the United States of America

Introduction to General, Organic & Biochemistry, 2/e

0-03-013452-8

Library of Congress Catalog Card Number: 87-26631

789 032 987654321



Preface

**This book is dedicated to
our mothers and wives;
Elizabeth Bettelheim, Fannie March,
Annabelle Bettelheim, and Beverly March.**

Audience

As was the first edition, this book is intended for non-chemistry majors, mainly those entering health science and related fields (such as nursing, medical technology, and nutrition). In its entirety it can be used for a one-year (two-semester or three-quarter) course in chemistry, or parts of the book can be used in a one-term chemistry course.

We assume that the students using the book have little or no chemistry background. Therefore, we introduce the basic concepts slowly at the beginning, although the tempo and the level of sophistication increase as we go on. We progress from the basic tenets of general chemistry to organic chemistry, and finally to biochemistry. We consider this progression an ascent in terms of both practical importance and sophistication. While this progression ascends we always keep a unified view of chemistry. We do not consider the general chemistry sections to be the exclusive domain of inorganic compounds, but frequently use organic and biological substances to illustrate general principles (for example, acid-base reactions).

While it is our aim, through this ascent, to teach the chemistry of the human body as the ultimate goal, we try to show that each subsection of chemistry is important in its own right, besides being required for future understanding.

Boxes (Medical Applications of Chemical Principles)

An important feature of this book is the large number of boxes, most of which contain medical and biological applications of the principles discussed in the text. In this ~~second~~ edition we have added 17 new boxes and discarded some of the less relevant ones from the first edition. There is now a total of 153 boxes. The new boxes have been written along the same lines

Preface

In preparing this second edition, our first thought is an expression of gratitude to our colleagues who, by adopting our textbook for their courses, made this second edition possible. It is our aim not only to update the first edition, but also to enlarge the scope of the book by some reorganization and by the inclusion of new material. One major improvement is the addition of full color, which enhances the readability and comprehensibility of the material.

Audience

As was the first edition, this book is intended for nonchemistry majors, mainly those entering health science and related fields (such as nursing, medical technology, and nutrition). In its entirety it can be used for a one-year (two-semester or three-quarter) course in chemistry, or parts of the book can be used in a one-term chemistry course.

We assume that the students using the book have little or no chemistry background. Therefore, we introduce the basic concepts slowly at the beginning, although the tempo and the level of sophistication increase as we go on. We progress from the basic tenets of general chemistry to organic chemistry, and finally to biochemistry. We consider this progression an ascent in terms of both practical importance and sophistication. While this progression goes on we always keep a unified view of chemistry. We do not consider the general chemistry sections to be the exclusive domain of inorganic compounds, but frequently use organic and biological substances to illustrate general principles (for example, acid-base reactions).

While it is our aim, through this ascent, to teach the chemistry of the human body as the ultimate goal, we try to show that each subsection of chemistry is important in its own right, besides being required for future understanding.

Boxes (Medical Applications of Chemical Principles)

An important feature of this book is the large number of boxes, most of which contain medical and biological applications of the principles discussed in the text. In the second edition we have added 17 new boxes and discarded some of the less relevant ones from the first edition. There is now a total of 158 boxes. The new boxes have been written along the same lines



T cell lymphocytes attacking a cancer cell.



Chernobyl after the nuclear accident. (V. Zufarov, Fotokhronica Tass)

as those in the first edition. They are relevant illustrations of the topics discussed, and they provide interesting and up-to-date information. For example, some of the new boxes describe the Chernobyl nuclear disaster, the role of anabolic steroids in sports physiology, and the use of self-absorbing staples in closing surgical wounds.

The presence of these boxes allows a considerable degree of flexibility. The instructor can assign only the main text, in which case the boxes will not interrupt the continuity and all the essential (core) material will be covered. However, most instructors will probably wish to assign at least some of the boxes, since they enhance the core material. Few courses will have time for all the boxes, but such a large number allows each instructor to choose those that best fit the particular needs of the course and of the students. As an additional aid to instructors and students, problems have been provided for nearly all of the boxes.

Relevance of the Material

Students, especially those already embarked on a career, often ask, “Why do I have to learn this?” Our aim is to answer this question, and we do so in three ways: (1) The previously mentioned boxes. For each topic in the main text, the associated boxes demonstrate the relevance of that topic to the student. (2) Each topic is presented in the context of a larger experience to show how it fits in with the entire discipline of chemistry. (3) We make constant references to past and future sections of the book, where related topics have been (or will be) discussed, in order to emphasize the importance of general and organic chemistry in understanding the working of the body (biochemistry).

Organization

Nine chapters deal with general chemistry, six with organic chemistry, and eleven with biochemistry. Although the organization of the material is largely traditional, there are some noteworthy features. In the organic chemistry chapters, we concentrate on the structure, nomenclature, physical properties, and only the most important reactions of each class of compounds. Except for one box (Box 11D), we have nothing at all on organic reaction mechanisms. We feel that in the relatively brief portion of the course devoted to organic chemistry, students do not have the time to learn a large number of reactions or anything at all about mechanisms. The reactions we do discuss are mostly those that have biological applications. In order to help students learn the reactions, we include summaries of reactions at the ends of the chapters. We also discuss many individual compounds that have physiological activity of one sort or another. In the second edition we have added a new section on inorganic nomenclature.

Metabolism; Color Code

The biological functions of chemical compounds are explained in each of the biochemistry chapters. The emphasis is on chemistry rather than physiology. We have received much positive feedback regarding the way in

which we organized the topic of metabolism (Chapters 20, 21, and 22). We have maintained the structure of these three chapters, but now that we have full color, we have introduced a color code into the equations and illustrations. We hope that the color code will make these complex processes more comprehensible to the student. We continue to introduce first the common catabolic pathway through which all food will be utilized (citric acid cycle; oxidative phosphorylation), and only after that do we discuss the specific pathways leading to the common pathway. This is better pedagogically, and it also enables us to sum up the caloric values of each type of food because their utilization through the common pathway has already been learned. Finally, we separate the catabolic pathways from the anabolic pathways by treating them in different chapters, emphasizing the different ways the body breaks down and builds up molecules.

New Chapter

In the second edition we have added one new chapter, Chapter 26, on nutrition and digestion. Although many instructors may not have the time to teach this topic, it can always be used as reference material. We have also enlarged the coverage of the two most rapidly developing biochemical fields: nucleic acids and protein synthesis (Chapter 23) and chemical communications: neurotransmitters, hormones, and immunoglobulins (Chapter 24). We present the modern view in discussing neurotransmitters, hormones, and immunoglobulins in one chapter. This emphasizes their function as message-carriers and their chemical mode of action: interacting with receptors.

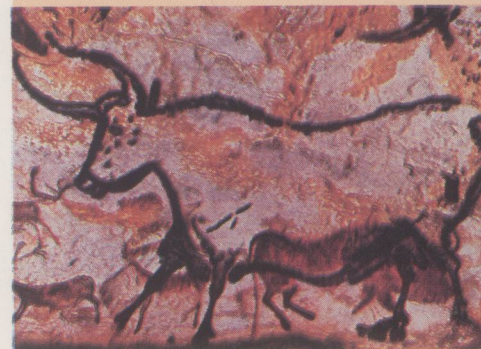
Features

As mentioned earlier, one of the main features of the book is the number of applications of chemistry presented in the boxes. Another important (and unusual) feature is a glossary-index. The definition of each term is given along with the index entry and the page numbers. In this second edition we have added a list of key terms at the end of each chapter, with a notation of the section number in which the term is introduced. Many students will find these lists to be helpful study guides.

Problems

The second edition also has a larger number of difficult (starred) problems at the ends of the chapters. The total number of problems in each chapter has also been increased.

The end-of-chapter problems are strictly arranged in order of topic coverage, except that at the end of each problem set there are additional problems, not arranged in order of topic coverage. These are included to be more challenging, since it is not immediately apparent where the topic is discussed. Answers to all of the in-text problems and to the odd-numbered end-of-chapter problems are given at the end of the book. Answers to the even-numbered problems are included in the Instructor's Manual and the Study Guide. Other features are the summaries at the end of each chapter



Prehistoric cave painting from Lascaux, Dordogne, France.

(including summaries of organic reactions in Chapters 11 to 15) and the substantial number of marginal notes.

Style

In the first edition and even more so in the second, we have taken special care to ease the absorption and understanding of the difficult concepts. Our writing style addresses the students directly in simple and clear phrasing, illuminating some concepts from more than one angle in order to make the picture complete. Our most important aim was clear and concise writing. We have tried to avoid oversimplifications; wherever space limitations permit, we show the ramifications of each topic, in most instances with pertinent examples from health care and related fields.

Ancillaries

This textbook is accompanied by a number of ancillary publications:

1. Laboratory Manual to Accompany *Introduction to General, Organic & Biochemistry*, by J. Lee and F. A. Bettelheim.
2. Study Guide by W. Scovell.
3. Instructor's Manual to Accompany *Introduction to General, Organic & Biochemistry* by Frederick A. Bettelheim and Jerry March.
4. Instructor's Manual to Accompany *Laboratory Manual for Introduction to General, Organic & Biochemistry* by J. Lee and F. A. Bettelheim.
5. Approximately 100 overhead transparencies in both two and four colors.

Acknowledgments

The publication of a book such as this requires the efforts of many more people than merely the authors. A number of reviewers have read all or significant portions of the manuscript at various stages. We thank the following for their constructive criticisms and helpful suggestions:

David Adams, North Shore Community College
Charles Cowell, Rancho Santiago College
Ana A. Ciereszko, Miami-Dade Community College South Campus
Andrew Dachauer, University of San Francisco
Stanley Grenda, University of Nevada
John Griswold, Cedar Crest College
Robert Harris, University of Nebraska
Joseph Landesberg, Adelphi University
Jessie Lee, Philadelphia Community College
William Masterton, University of Connecticut
Melvin Merken, Worcester State College
Norman Meyers, Bowling Green State University
Alan Price, University of Michigan
Jacqueline Scholar, Eastern Michigan University
Ronald M. Scott, Eastern Michigan University

William Scovell, Bowling Green State University
 David Tuleen, Vanderbilt University
 William H. Voige, James Madison University
 William Zuber, Memphis State University

Many of our reviewers pointed out inadvertent errors or certain weaknesses in the first edition. We have attempted to correct these, and thus we hope that the second edition will prove even more useful than the first.

We also wish to thank several of our colleagues at Adelphi University for their useful advice. These include Donald Davis, Stephen Goldberg, Joseph Landesberg, Sung Moon, Donald Opalecky, Reuben Rudman, Anthony Sisti, Madelyn Todd, and Stanley Windwer. We are also grateful for the guidance of John Vondeling, Associate Publisher. We thank Carol Bleistine, Tim Frelick, and Sally Kusch for supervising the art, production and editing of the book you see before you. J & R Technical Services, Inc., transformed our crude drawings into pieces of art. We especially want to thank Beverly March and Charles D. Winters for their many excellent photographs.

F. A. Bettelheim and Jerry March
Adelphi University

1	Chemical Reactions	
2	Gases, Liquids, and Solids	163
3	Solutions and Colloids	185
4	Reaction Rates and Equilibrium	163
5	Acids and Bases	185
6	Nuclear Chemistry	216
7	Organic Chemistry: Alkanes	258
8	Alkenes, Alkynes, and Aromatic Compounds	270
9	Alcohols, Phenols, Ethers, and Halides	300
10	Aldehydes and Ketones	325
11	Carboxylic Acids and Esters	348
12	Amines and Amides	375
13	Carbohydrates	405
14	Lipids	441
15	Proteins	465
16	Enzymes	489
17	Bioenergetics: How the Body Converts Food to Energy	504
18	Specific Catabolic Pathways: Carbohydrate, Lipid, and Protein Metabolism	524
19	Biosynthetic Pathways	546
20	Nucleic Acids and Protein Synthesis	557
21	Chemical Communication: Neurotransmitters, Hormones, and Immunoglobulins	586
22	Body Fluids	604
23	Nutrition and Digestion	620
Appendix	Significant Figures	A-1
	Answers	A-2
	Glossary/Index	G-1

INTRODUCTION TO

General, Organic & Biochemistry

The planet Earth, as seen from Apollo 11 (NASA)

1.1 ■ Introduction

There was a time—only a few hundred years ago—when physicians were powerless to treat many diseases. Cancer, tuberculosis, smallpox, typhus, plague, and many other diseases struck people seemingly at random, and doctors, who had no idea how any of these diseases were caused, could do little or nothing about them. Between 1348 and 1350 the disease known as the Black Death (bubonic plague) wiped out about one third of the population of Europe. Doctors treated it with magic as well as by such measures as bleeding (Fig. 1-1), laxatives, hot plasters, and ointments made from powdered stag horn, saffron, or gold. None of these were of any use, and the doctors, because they came into direct contact with a highly contagious disease, died at a much higher rate than the general public.

Doctors of these times did have remedies for a few conditions, such as the quinine bark that was used to treat malaria, but all such remedies were discovered by trial and error. For most illnesses human beings, including the doctors themselves, were entranced by the mystery of body processes and microorganisms; they knew nothing about them.

Medicine has made great progress since those times. Although people still get sick, they do on the average live much longer, and many once feared diseases have been either essentially eliminated or made easily curable. Smallpox, polio, tuberculosis, syphilis, plague, diphtheria, and other diseases that once killed millions no longer pose a serious problem, at least not in the developed countries.

Contents Overview

Chapter 1	Matter, Energy, and Measurement	1
2	Atoms	28
3	Chemical Bonds	53
4	Chemical Reactions	82
5	Gases, Liquids, and Solids	107
6	Solutions and Colloids	136
7	Reaction Rates and Equilibrium	165
8	Acids and Bases	185
9	Nuclear Chemistry	214
10	Organic Chemistry. Alkanes	238
11	Alkenes, Alkynes, and Aromatic Compounds	270
12	Alcohols, Phenols, Ethers, and Halides	300
13	Aldehydes and Ketones	325
14	Carboxylic Acids and Esters	348
15	Amines and Amides	376
16	Carbohydrates	405
17	Lipids	441
18	Proteins	465
19	Enzymes	489
20	Bioenergetics. How the Body Converts Food to Energy	504
21	Specific Catabolic Pathways: Carbohydrate, Lipid, and Protein Metabolism	524
22	Biosynthetic Pathways	546
23	Nucleic Acids and Protein Synthesis	557
24	Chemical Communication: Neurotransmitters, Hormones, and Immunoglobulins	586
25	Body Fluids	604
26	Nutrition and Digestion	620
Appendix	Significant Figures	A.1
	Answers	A.5
	Glossary-Index	I.1



Rock formation in the Strait of Magellan.

Contents

Chapter 1

Matter, Energy and Measurement

1.1	Introduction	1
1.2	The Scientific Method	3
1.3	Exponential Notation	4
1.4	Measurements	9
1.5	Unit Conversions. The Factor-Label Method	14
1.6	The States of Matter	16
1.7	Density and Specific Gravity	17
1.8	Energy	20
1.9	Heat	21
	Summary	24
	Key Terms	24
	Problems	25

Box 1A	The Scientific Method in Medicine	5
Box 1B	Drug Dosage and Body Mass	12
Box 1C	The Urinometer	19
Box 1D	Hypothermia and Hyperthermia	22
Box 1E	Cold Compresses	23

Chapter 2

Atoms

2.1	Introduction	28
2.2	Classifications of Matter	29
2.3	Dalton's Atomic Theory	31
2.4	Inside the Atom	33
2.5	The Periodic Table	36
2.6	The Electronic Structure of Atoms	39
2.7	Electronic Configuration and the Periodic Table	45
2.8	How Small Are Atoms?	48

28



A. L. Lavoisier and wife by David. (Metropolitan Museum of Art)

Summary	49
Key Terms	50
Problems	50

Box 2A	Elements Necessary for Human Life	30
Box 2B	Strontium-90	37
Box 2C	Vanadium	45
Box 2D	Abundance of the Elements on Earth and in People	47

Chapter 3

Chemical Bonds

53

3.1	Introduction	53
3.2	Ions	53
3.3	Ionic Bonds	57
3.4	Covalent Bonds	59
3.5	Coordinate Covalent Bonds	64
3.6	The Shapes of Molecules	65
3.7	Electronegativity and Dipoles	69
3.8	How to Predict the Kinds of Bonds that Form	73
3.9	What Bonds to What?	73
3.10	Polyatomic Ions	74
3.11	Naming of Simple Inorganic Compounds	74
	Summary	77
	Key Terms	77
	Problems	78

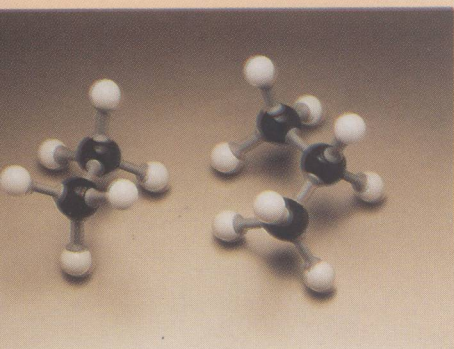
Box 3A	Biologically Important Ions	55
Box 3B	Ionic Compounds in Medicine	58
Box 3C	Hemoglobin	66

Chapter 4

Chemical Reactions

82

4.1	Introduction	82
4.2	Formula Weight	82
4.3	The Mole	83
4.4	Chemical Equations	86
4.5	Weight Relationships in Chemical Reactions	89
4.6	Percentage Yield	92
4.7	Reactions Between Ions in Aqueous Solution	93
4.8	Oxidation-Reduction	95
4.9	Heat of Reaction	98
	Summary	101
	Key Terms	102
	Problems	102



Molecular models of ethane and propane. (Charles D. Winters)

- Box 4A Voltaic Cells 96
 Box 4B Oxidizing Antiseptics 98
 Box 4C Metabolism 100
 Box 4D The Caloric Value of Foods 101

Chapter 5 Gases, Liquids, and Solids

107

- 5.1 The Organization of Matter 107
 5.2 Gases 108
 5.3 Pressure 110
 5.4 Gas Laws 110
 5.5 Avogadro's Law and the Ideal Gas Law 117
 5.6 Dalton's Law and Graham's Law 119
 5.7 Intermolecular Forces 121
 5.8 Liquids 123
 5.9 Evaporation and Condensation. Boiling Point 125
 5.10 Surface Tension 127
 5.11 Solids 127
 5.12 Melting and Freezing. Phase Changes 130
 Summary 132
 Key Terms 133
 Problems 133

- Box 5A The Uses of Atmospheric Gases 109
 Box 5B Mercury as a Poison 111
 Box 5C Blood Pressure Measurement 112
 Box 5D Breathing and Boyle's Law 113
 Box 5E Hyperbaric Medicine 114
 Box 5F Breathing and Dalton's Law 120
 Box 5G Premature Babies 122
 Box 5H The Densities of Ice and Water 124
 Box 5I Ethyl Chloride 126
 Box 5J Diamonds 130
 Box 5K Freezing Biological Tissues 131

Chapter 6 Solutions and Colloids

136

- 6.1 Introduction 136
 6.2 Types of Solutions 137
 6.3 Characteristics of Solutions 137
 6.4 Solubility 138
 6.5 Concentration Units 140
 6.6 Water as a Solvent 147
 6.7 Colloids 151



Hot-air balloon flown by Montgolfier brothers in 1783 at Versailles. (Musée Carnavalet, Paris)

6.8	Colligative Properties. Freezing Point Depression	154
6.9	Osmotic Pressure	155
6.10	Dialysis	158
	Summary	159
	Key Terms	160
	Problems	160

Box 6A	Acid Rain	140
Box 6B	The Bends	141
Box 6C	Hypoglycemia and Potassium Balance	149
Box 6D	Emulsions and Emulsifying Agents	152
Box 6E	Osmotic Pressure in Cataract Formation	156
Box 6F	Magnesium Salts in Hypertonic Solution	158
Box 6G	Hemodialysis	159

Chapter 7 Reaction Rates and Equilibrium 165

7.1	Introduction	165
7.2	Molecular Collisions	166
7.3	Activation Energy and Energy Diagrams	168
7.4	Factors Affecting Rates of Reaction	170
7.5	Reversible Reactions and Equilibrium	173
7.6	Equilibrium Constants	175
7.7	Equilibrium and Reaction Rates	177
7.8	Le Chatelier's Principle	178
	Summary	180
	Key Terms	181
	Problems	181

Box 7A	Fire Hazards in Hospitals	169
Box 7B	Why High Fever is Dangerous	171
Box 7C	The Effects of Lowering Body Temperature	171
Box 7D	The Haber Process	180

Chapter 8 Acids and Bases 185

8.1	Introduction	185
8.2	Acid and Base Strength	186
8.3	Brønsted-Lowry Acids and Bases	188
8.4	Acid Dissociation Constants	190
8.5	Some Properties of Acids and Bases	191
8.6	Reactions of Acids	192
8.7	Self-ionization of water	195
8.8	pH	196
8.9	The pH of Aqueous Salt Solutions	200



Citrus fruit contains acids. (Beverly March)

- 8.10 Buffers 201
- 8.11 Titration, Equivalents, and Normality 206
- Summary 210
- Key Terms 210
- Problems 211

- Box 8A Some Important Acids and Bases 187
- Box 8B Acid and Alkali Burns of the Cornea 192
- Box 8C Drugstore Antacids 193
- Box 8D Rising Cakes and Fire Extinguishers 194
- Box 8E Acidosis and Alkalosis 202
- Box 8F The Henderson–Hasselbach Equation 204

Chapter 9

Nuclear Chemistry

214

- 9.1 Introduction 214
- 9.2 What Happens When a Nucleus Emits Radioactivity? Natural Transmutation 216
- 9.3 Half-life 220
- 9.4 Characteristics of Radiation 222
- 9.5 Radiation Dosimetry and the Effects of Radiation on Human Health 223
- 9.6 Medical Uses of Radioactive Materials 227
- 9.7 Nuclear Fusion. Artificial Transmutation 230
- 9.8 Nuclear Fission. Atomic Energy 231
- Summary 234
- Key Terms 234
- Problems 235

- Box 9A Rutherford's Experiment 215
- Box 9B Transmutation 219
- Box 9C Radioactive Dating 221
- Box 9D Radium in Wristwatch Dials 225
- Box 9E CAT and Nmr Scans 228
- Box 9F Energy from Mass 230
- Box 9G Isotope Generators for Medical Use 231
- Box 9H Radioactive Fallout from Nuclear Accidents 232

Chapter 10

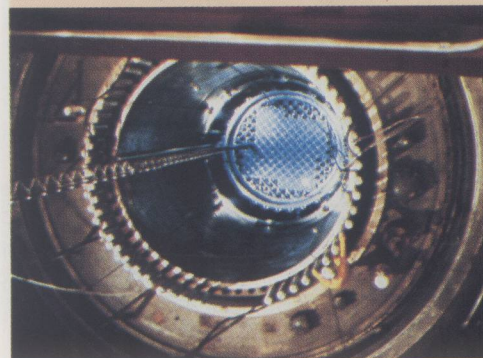
Organic Chemistry. Alkanes

238

- 10.1 Introduction 238
- 10.2 Sources of Organic Compounds 239
- 10.3 Structures of Organic Compounds 241
- 10.4 Hydrocarbons 243
- 10.5 Alkanes 244



Haddam Neck nuclear reactor. (Atomic Industrial Forum)



Core of a nuclear reactor. (Atomic Industrial Forum)

10.6	IUPAC Nomenclature of Alkanes and Alkyl Halides	248
10.7	Cycloalkanes	254
10.8	Stereoisomerism in Cyclic Compounds	256
10.9	Physical Properties	257
10.10	Chemical Properties	258
10.11	Functional Groups	260
	Summary	262
	Key Terms	263
	Problems	263

Box 10A	Cyclopropane as an Anesthetic	254
Box 10B	The Actual Shape of the Cyclohexane Ring	255
Box 10C	The Biological Effects of Alkanes	258
Box 10D	Petroleum	259
Box 10E	Carbon Dioxide and Carbon Monoxide	260

Chapter 11

Alkenes, Alkynes, and Aromatic Compounds 270

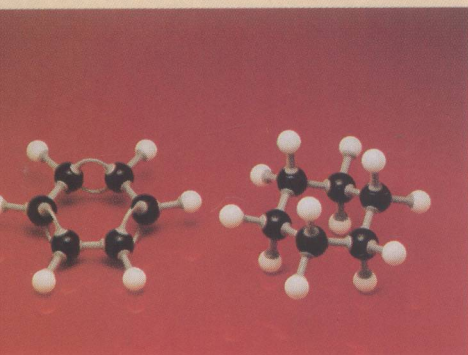
11.1	Introduction	270
11.2	Nomenclature of Alkenes	270
11.3	Geometry and Stereoisomerism of Alkenes	274
11.4	Physical Properties of Alkenes	277
11.5	Chemical Properties of Alkenes: Addition Reactions	278
11.6	Addition Polymers	282
11.7	Alkynes	283
11.8	Aromatic Hydrocarbons	285
11.9	Nomenclature of Benzene Derivatives	287
11.10	Reactions of Aromatic Compounds	290
11.11	Fused Aromatic Rings	291
11.12	Heterocyclic Compounds	291
	Summary	293
	Key Terms	293
	Problems	294

Box 11A	Terpenes	272
Box 11B	Pheromones	275
Box 11C	Cis-Trans Isomerism in Vision	276
Box 11D	The Mechanism of HX Addition	280
Box 11E	Carcinogenic Fused Aromatics and Smoking	291

Chapter 12

Alcohols, Phenols, Ethers, and Halides 300

12.1	Introduction	300
12.2	Nomenclature of Alcohols	300
12.3	Chemical Properties of Alcohols	303



Molecular models of benzene and cyclohexane.
(Charles D. Winters)