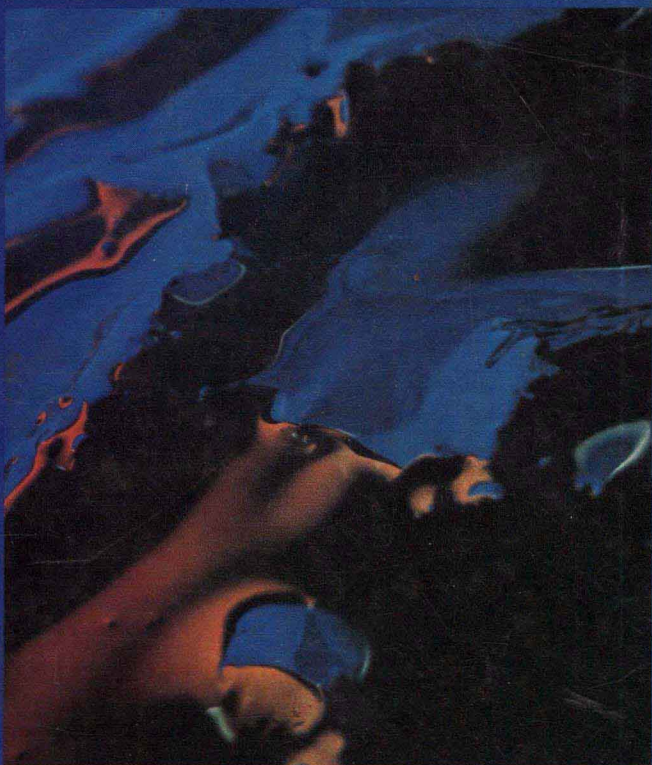
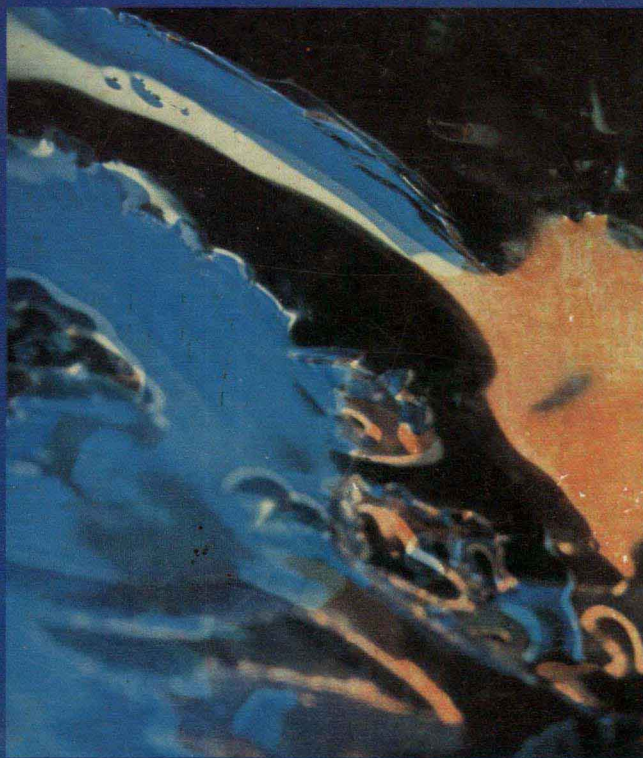
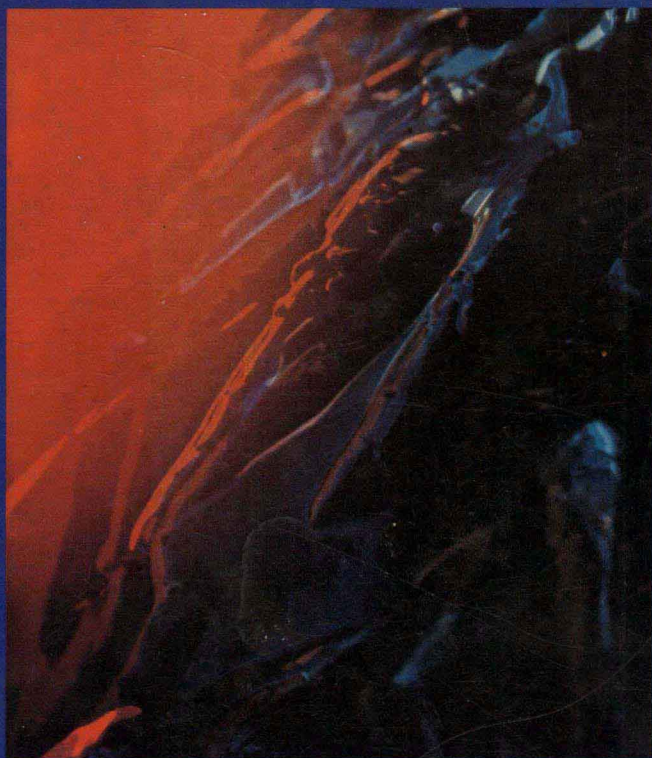


Second Edition

# FUNDAMENTALS OF CHEMISTRY

Brady/Holum



SECOND EDITION

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# FUNDAMENTALS OF CHEMISTRY

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## TABLE OF ATOMIC WEIGHTS AND NUMBERS

Based on the 1977 Report of the Commission on Atomic Weights of the International Union of Pure and Applied Chemistry. Scaled to the relative atomic mass of carbon-12.

Element	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227.0278 (e)
Aluminum	Al	13	26.98154
Americium	Am	95	(243) (f)
Antimony	Sb	51	121.75 (a)
Argon	Ar	18	39.948 (a, b, c)
Arsenic	As	33	74.9216
Astatine	At	85	(210) (f)
Barium	Ba	56	137.33 (c)
Berkelium	Bk	97	(247) (f)
Beryllium	Be	4	9.01218
Bismuth	Bi	83	208.9804
Boron	B	5	10.81 (b, d)
Bromine	Br	35	79.904
Cadmium	Cd	48	112.41 (c)
Calcium	Ca	20	40.08 (c)
Californium	Cf	98	(251) (f)
Carbon	C	6	12.011 (b)
Cerium	Ce	58	140.12 (c)
Cesium	Cs	55	132.9054
Chlorine	Cl	17	35.453
Chromium	Cr	24	51.996
Cobalt	Co	27	58.9332
Copper	Cu	29	63.546 (a, b)
Curium	Cm	96	(247) (f)
Dysprosium	Dy	66	162.50 (a)
Einsteinium	Es	99	(252) (f)
Erbium	Er	68	167.26 (a)
Europium	Eu	63	151.96 (c)
Fermium	Fm	100	(257) (f)
Fluorine	F	9	18.998403
Francium	Fr	87	(223) (f)
Gadolinium	Gd	64	157.25 (a, c)
Gallium	Ga	31	69.72
Germanium	Ge	32	72.59 (a)
Gold	Au	79	196.9665
Hafnium	Hf	72	178.49 (a)
Helium	He	2	4.00260 (c)
Holmium	Ho	67	164.9304
Hydrogen	H	1	1.0079 (b)
Indium	In	49	114.82 (c)
Iodine	I	53	126.9045
Iridium	Ir	77	192.22 (a)
Iron	Fe	26	55.847 (a)
Krypton	Kr	36	83.80 (c, d)
Lanthanum	La	57	138.9055 (a, c)
Lawrencium	Lr	103	(260) (f)
Lead	Pb	82	207.2 (b, c)
Lithium	Li	3	6.941 (a, b, c, d)
Lutetium	Lu	71	174.967 (a)
Magnesium	Mg	12	24.305 (c)
Manganese	Mn	25	54.9380
Mendelevium	Md	101	(258) (f)
Mercury	Hg	80	200.59 (a)

plied Chemistry. Scaled to the relative atomic mass of carbon-12.

Element	Symbol	Atomic Number	Atomic Weight
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24 (a, c)
Neon	Ne	10	20.179 (a, d)
Neptunium	Np	93	237.0482 (e)
Nickel	Ni	28	58.70
Niobium	Nb	41	92.9064
Nitrogen	N	7	14.0067
Nobelium	No	102	(259) (f)
Osmium	Os	76	190.2 (c)
Oxygen	O	8	15.9994 (a, b)
Palladium	Pd	46	106.4 (c)
Phosphorus	P	15	30.97376
Platinum	Pt	78	195.09 (a)
Plutonium	Pu	94	(244) (f)
Polonium	Po	84	(209) (f)
Potassium	K	19	39.0983 (a)
Praseodymium	Pr	59	140.9077
Promethium	Pm	61	(145) (f)
Protactinium	Pa	91	231.0359 (e)
Radium	Ra	88	226.0254 (c, e)
Radon	Rn	86	(222) (f)
Rhenium	Re	75	186.207
Rhodium	Rh	45	102.9055
Rubidium	Rb	37	85.4678 (a, c)
Ruthenium	Ru	44	101.07 (a, c)
Samarium	Sm	62	150.4 (c)
Scandium	Sc	21	44.9559
Selenium	Se	34	78.96 (a)
Silicon	Si	14	28.0855 (a)
Silver	Ag	47	107.868 (c)
Sodium	Na	11	22.98977
Strontium	Sr	38	87.62 (c)
Sulfur	S	16	32.06 (b)
Tantalum	Ta	73	180.9479 (a)
Technetium	Tc	43	(98) (f)
Tellurium	Te	52	127.60 (a, c)
Terbium	Tb	65	158.9254
Thallium	Tl	81	204.37 (a)
Thorium	Th	90	232.0381 (c, e)
Thulium	Tm	69	168.9342
Tin	Sn	50	118.69 (a)
Titanium	Ti	22	47.90 (a)
Tungsten	W	74	183.85 (a)
(Unnilhexium)	(Unh)	106	(263) (f, g)
(Unnilpentium)	(Unp)	105	(262) (f, g)
(Unnilquadium)	(Unq)	104	(261) (f, g)
Uranium	U	92	238.029 (c, d)
Vanadium	V	23	50.9415 (a)
Xenon	Xe	54	131.30 (c, d)
Ytterbium	Yb	70	173.04 (a)
Yttrium	Y	39	88.9059
Zinc	Zn	30	65.38
Zirconium	Zr	40	91.22 (c)

Except as noted in the footnotes that follow, the atomic weight values are good to  $\pm 1$  unit in the last place.

(a) Precise to  $\pm 3$  units in the last place.

(b) Atomic weight cannot be expressed more precisely because among normal terrestrial materials there are known variations in isotopic compositions.

(c) Geological samples of this element have been found with anomalous isotopic composition and atomic weights different from this value.

(d) Considerable variations from this atomic weight value can occur in commercial samples because of changes in isotopic composition.

(e) The atomic weight of the radioisotope of longest half-life.

(f) The mass number of the radioisotope of longest half-life.

(g) The official name and symbol has not been agreed to. Element 105 is unofficially called hahnium. Element 104 is called rutherfordium by American scientists and kurchatovium by Russian scientists.

*TO THE STUDENT:* A Study Guide for the textbook is available through your college bookstore under the title *Study Guide to Accompany FUNDAMENTALS OF CHEMISTRY*, Second Edition by James E. Brady and John R. Holum. The Study Guide can help you with course material by acting as a tutorial, review, and study aid. A manual containing detailed solutions to all the numerical problems in the textbook is also available under the title *Solutions Manual to Accompany FUNDAMENTALS OF CHEMISTRY*, Second Edition by Ernest R. Birnbaum. If these books are not in stock, ask the bookstore manager to order them for you.

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# PREFACE

When we planned the revision of this text, we had two principal goals in mind. First, we wished to include certain topics, omitted from the first edition, that would satisfy the educational needs of a larger number of students. Second, we wished to maintain the flavor of the first edition, with its emphasis on a relaxed, nonthreatening writing style, its pedagogical aids designed to assist students over the hurdles of problem solving, and its many examples that show how chemistry relates to the world in which we live. In working toward these ends, the book has undergone much more than merely a face-lifting. Indeed, in many ways, it is a new book.

## Features in Organization and Content

In seeking to satisfy our first goal, we have made some major changes in the overall flow of concepts. These evolved in part from input from users of the first edition as well as from suggestions by reviewers. For example, those familiar with the first edition will notice that the discussions of the three states of matter are now located together in Chapters 9 and 10, and the chapters on thermodynamics, kinetics, and equilibrium have been resequenced to give a smoother flow of concepts. We have also moved the discussion of the chemistry of carbon to the end of the book where it serves as an introduction to the second-year course in organic chemistry. In addition, a number of chapters have been rewritten, new chapters have been added, and additional topics have been included, such as the calculation of activation energies in the kinetics chapter and the discussion of polyprotic acids in the acid/base equilibrium chapter.

The text's chapter sequence provides a logical development of chemical principles. In a broad sense, the text is divided into a number of major units that can be described as follows.

**Quantitative Aspects of Chemistry** (Chapters 1 to 4). Here we develop the basic groundwork for quantitative measurements of mass and energy and their applications to stoichiometric relationships. This includes the stoichiometry of compounds and chemical reactions as well as thermochemistry. The early introduction of these concepts is an aid in the laboratory.

**Periodic Properties and Atomic Structure** (Chapters 5 to 8). This unit begins with the development of the periodic table and a description of some of the properties of the elements and their compounds that demonstrate a more or less systematic variation within the periodic table. Chapter 5 includes a discussion of inorganic nomenclature. All of this serves as a prelude to the discussions of atomic and molecular structure.

**Properties of Pure Substances** (Chapters 9 and 10). Here the emphasis is on the physical properties of the states of matter, and how these properties are affected by intermolecular attractions. In this edition we have combined all of the discussions relating to gases into one chapter.

**Properties of Mixtures** (Chapters 11 to 13). We begin with mixtures as a medium for chemical reactions. Chapter 11 focuses on acid/base and metathesis reactions, and Chapter 12 examines redox reactions in some detail. Both of these chapters include discussions of solution stoichiometry and titrations. Chapter 13 then turns its attention to the physical properties of solutions.

**Factors Affecting the Outcome of Reactions** (Chapters 14 to 18). The topics of thermodynamics, kinetics, and equilibrium are discussed in this sequence because they address, in order, the questions “Is a reaction possible?”, “How fast can it occur?”, and “What is the system like when it gets to equilibrium?” Electrochemistry, of course, combines aspects of both thermodynamics and equilibrium.

**Properties of Important Elements and Their Compounds** (Chapters 19 to 22). These descriptive chapters are not meant to be encyclopedic, but instead concentrate on major chemicals and chemical reactions. The material is presented so that if time is limited, instructors can easily choose those topics that they believe to be most important or relevant.

**Nuclear Chemistry and the Chemistry of Carbon** (Chapters 23 to 24). The applications of nuclear phenomena to chemistry have been moved toward the end of the text so that topics such as tracer analysis and the kinetics of nuclear decay can be discussed. The text concludes with an integrated treatment of the chemistry of the compounds of carbon, including an overview of polymers and biochemicals. Thus we have provided a bridge to the sophomore course in organic chemistry, which will be taken by most students using the book.

The order of topics described above provides an early introduction of many of the aspects of stoichiometry that are needed in the laboratory. It also reflects a basic philosophy of the text—that chemistry is an experimental science and that theory is based on observation and the collection of facts. Therefore, throughout the book, we have been careful to proceed from the concrete to the abstract in the development of concepts. For example, in Chapter 5 we use the development of the periodic table as a tool for introducing some of the physical and chemical properties of the elements, which serves as a background to descriptions of atomic and molecular structure in the chapters that follow. In this way, these theoretical discussions do not occur in a factual vacuum. Similarly, in Chapter 10, the physical properties of liquids and solids are discussed before explanations for their behavior are given in terms of intermolecular attractions.

As in the previous edition, the level of mathematical sophistication in the text is limited to basic algebraic operations; lengthy derivations are avoided. We continue to use a mix of SI and traditional units, although we place greater emphasis on calculations involving joules rather than calories. We use torr and atmospheres in our calculations involving gases; volumes are generally given in milliliters and liters.

### Features in Problem Solving

One of our aims in this revision has been to improve the framework within which students develop problem-solving skills, and to encourage students to extend what they have learned in one chapter to principles developed in others. From this has evolved a unified approach of repeated review and reinforcement. Within chapters there are numerous worked-out examples, each identified by type so that students will recognize the lesson to be learned or the principle that is demonstrated. These examples show in

considerable detail how problems are solved and emphasize the factor label method. They are then followed by **Practice Exercises** that build confidence, reinforce principles, and allow students to test their understanding. At the ends of chapters there are sets of **Review Exercises**, enlarged and sorted by category in this edition, that provide the student with further practice and reinforcement. Finally, there are additional sets of exercises under the heading **Integration of Concepts** that occur after groups of related chapters. These further review and tie together concepts developed in units that consist of two or more chapters. All of the Practice Exercises and approximately one-half of the numerical problems in the Review Exercises have their answers in Appendix C at the back of the book.

### Features that Enhance Student Interest

To fulfill our second goal, we have been careful to keep the writing style light and conversational, and we have used common chemicals whenever possible as examples both in theoretical discussions and in problems and exercises. To help students appreciate how chemistry is important in other disciplines and to make them aware of the ways that chemistry affects their lives, this edition continues to employ numerous **Special Topics** placed strategically within chapters throughout the text. New to this edition is the set of nineteen **Chemicals in Use** topics located between chapters. These have two functions—to provide additional enrichment material about chemicals and chemical processes that are important to society, and to give the instructor a way to selectively interweave descriptive chemistry with the discussions of principles. The sequencing of topics within the series was carefully chosen so that students would have sufficient background to appreciate the chemical discussions and to make effective use of concepts learned by students in preceding chapters.

### Features in Learning Aids

Instructors will notice the variety of learning aids that are provided to improve student understanding and performance. Each section title appears in a short form to identify the section content, followed by a brief introductory statement that summarizes the section. This gives students a brief preview of the section content and aids them later during review. Within the text itself, numerous **margin comments** and figures supplement discussions. New terms are set in blue boldface type when they are first introduced and defined. As a review aid, a list of these **key terms** appears at the end of a chapter. The key terms are also defined in a **Glossary** at the end of the book, where each term is accompanied by a reference to a principal section in the text where the term is discussed or defined. (A glossary by chapter is also provided in the **Study Guide**.) Another review aid is the **chapter summaries** that provide an overview of important concepts.

James E. Brady

John R. Holum

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# SUPPLEMENTARY MATERIAL FOR STUDENTS AND TEACHERS

A complete package of supplements has been assembled to aid the teacher in presenting the course and to help students accomplish problem solving and other study assignments.

***Study Guide for Fundamentals of Chemistry*** Second edition by James E. Brady and John R. Holum. This softcover book has been carefully structured to assist students in mastering the important subjects in the text. For each section there is a statement of objectives, followed by a brief review that highlights major topics, sometimes with additional worked-out examples. Most sections have a brief "Self-Test," with answers provided, that supplements the text exercises. Each chapter concludes with a glossary of the Key Terms that are listed at the end of the chapter in the text. For those who wish to employ the *Chemicals in Use* series as a means of teaching descriptive chemistry, the Study Guide also provides a set of Review Exercises to accompany each of these units.

***Laboratory Manual for Fundamentals of Chemistry*** Second edition by Jo A. Beran. This manual features a thorough "techniques" section, with photographs of important manipulations, and 43 experiments sequenced to follow the topical development in the text. For the teacher, an instructor's manual accompanies the laboratory manual.

***Solutions Manual for Fundamentals of Chemistry*** by Ernest R. Birnbaum. This softcover supplement provides detailed solutions to all of the numerical problems in the text, including the Practice Exercises, Review Exercises, and Integration of Concepts.

***Teachers Manual for Fundamentals of Chemistry*** This manual, available to teachers only, provides detailed chapter objectives, the answers to *all* the questions and problems in the text, and more than 500 carefully chosen multiple-choice questions.

***Computer-Aided Instruction for General Chemistry*** by William Butler and Raymond Hough is a package of 20 self-contained microcomputer programs designed especially as a course supplement. It is published for the Apple II, IIe, Commodore 64 and Pet.

***The Chemistry Tutor Series*** This is a series of programs by Frank Rinehart and Sandra Olmsted offering students tutorial instruction in the essential skills required in college chemistry courses beginning with *Stoichiometry & Balancing Equations*, and *Oxidation Reduction Reactions*. These programs are available in both instructor and student versions.

**Transparency Masters** Instructors who adopt the book may obtain from Wiley, without charge, a set of  $8\frac{1}{2} \times 11$  in. black and white line drawings that duplicate key figures and tables in the text. They can be used to prepare transparencies.

J.E. B.  
J.R.H.

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