

ELEVENTH EDITION

INTRODUCTION TO  
**CHEMICAL**  
**PRINCIPLES**

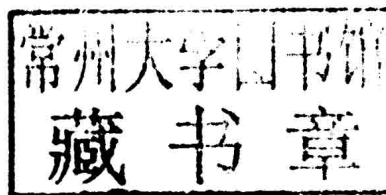
H. STEPHEN STOKER

*Eleventh Edition*

# INTRODUCTION TO CHEMICAL PRINCIPLES

H. Stephen Stoker

*Weber State University*



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# LIST OF ELEMENTS WITH THEIR SYMBOLS AND ATOMIC MASSES

Element	Symbol	Atomic Number	Atomic Mass	Element	Symbol	Atomic Number	Atomic Mass
Actinium	Ac	89	(227)	Mendelevium	Md	101	(258)
Aluminum	Al	13	26.98	Mercury	Hg	80	200.59
Americium	Am	95	(243)	Molybdenum	Mo	42	95.94
Antimony	Sb	51	121.76	Neodymium	Nd	60	144.24
Argon	Ar	18	39.95	Neon	Ne	10	20.18
Arsenic	As	33	74.92	Neptunium	Np	93	(237)
Astatine	At	85	(210)	Nickel	Ni	28	58.69
Barium	Ba	56	137.33	Niobium	Nb	41	92.91
Berkelium	Bk	97	(247)	Nitrogen	N	7	14.01
Beryllium	Be	4	9.012	Nobelium	No	102	(259)
Bismuth	Bi	83	208.98	Osmium	Os	76	190.23
Bohrium	Bh	107	(272)	Oxygen	O	8	16.00
Boron	B	5	10.81	Palladium	Pd	46	106.42
Bromine	Br	35	79.90	Phosphorus	P	15	30.97
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.08
Calcium	Ca	20	40.08	Plutonium	Pu	94	(244)
Californium	Cf	98	(251)	Polonium	Po	84	(209)
Carbon	C	6	12.01	Potassium	K	19	39.10
Cerium	Ce	58	140.12	Praseodymium	Pr	59	140.91
Cesium	Cs	55	132.91	Promethium	Pm	61	(145)
Chlorine	Cl	17	35.45	Protactinium	Pa	91	231.04
Chromium	Cr	24	52.00	Radium	Ra	88	(226)
Cobalt	Co	27	58.93	Radon	Rn	86	(222)
Copernicium	Cn	112	(285)	Rhenium	Re	75	186.21
Copper	Cu	29	63.55	Rhodium	Rh	45	102.91
Curium	Cm	96	(247)	Roentgenium	Rg	111	(280)
Darmstadtium	Ds	110	(281)	Rubidium	Rb	37	85.47
Dubnium	Db	105	(268)	Ruthenium	Ru	44	101.07
Dysprosium	Dy	66	162.50	Rutherfordium	Rf	104	(267)
Einsteinium	Es	99	(252)	Samarium	Sm	62	150.36
Erbium	Er	68	167.26	Scandium	Sc	21	44.96
Europium	Eu	63	151.96	Seaborgium	Sg	106	(271)
Fermium	Fm	100	(257)	Selenium	Se	34	78.96
Flerovium	Fl	114	(289)	Silicon	Si	14	28.09
Fluorine	F	9	19.00	Silver	Ag	47	107.87
Francium	Fr	87	(223)	Sodium	Na	11	22.99
Gadolinium	Gd	64	157.25	Strontium	Sr	38	87.62
Gallium	Ga	31	69.72	Sulfur	S	16	32.06
Germanium	Ge	32	72.63	Tantalum	Ta	73	180.95
Gold	Au	79	196.97	Technetium	Tc	43	(98)
Hafnium	Hf	72	178.49	Tellurium	Te	52	127.60
Hassium	Hs	108	(270)	Terbium	Tb	65	158.93
Helium	He	2	4.003	Thallium	Tl	81	204.38
Holmium	Ho	67	164.93	Thorium	Th	90	232.04
Hydrogen	H	1	1.008	Thulium	Tm	69	168.93
Indium	In	49	114.82	Tin	Sn	50	118.71
Iodine	I	53	126.90	Titanium	Ti	22	47.87
Iridium	Ir	77	192.22	Tungsten	W	74	183.84
Iron	Fe	26	55.85	Uranium	U	92	238.03
Krypton	Kr	36	83.80	Vanadium	V	23	50.94
Lanthanum	La	57	138.91	Xenon	Xe	54	131.293
Lawrencium	Lr	103	(262)	Ytterbium	Yb	70	173.04
Lead	Pb	82	207.2	Yttrium	Y	39	88.91
Lithium	Li	3	6.941	Zinc	Zn	30	65.41
Lutetium	Lu	71	174.97	Zirconium	Zr	40	91.22
Livermorium	Lv	116	(293)	Element 113	—	113	(284)
Magnesium	Mg	12	24.31	Element 115	—	115	(288)
Manganese	Mn	25	54.94	Element 117	—	117	(293)
Meitnerium	Mt	109	(276)	Element 118	—	118	(294)

A mass value which is enclosed in parentheses is the mass number for the most stable isotope of an element that is laboratory produced rather than naturally occurring.



*Eleventh Edition*

# INTRODUCTION TO CHEMICAL PRINCIPLES



# PREFACE

*Introduction to Chemical Principles* is a text for students who have had little or no previous instruction in chemistry or whose instruction was so long ago that a thorough review is needed. The text's purpose is to give students the background (and confidence) needed for a subsequent successful encounter with a main sequence, college-level, general chemistry course.

Many texts written for preparatory chemistry courses are simply watered-down versions of general chemistry texts: They treat almost all topics found in the general chemistry course, but at a superficial level. *Introduction to Chemical Principles* does not fit this mold. My philosophy is that it is better to treat fewer topics extensively and have the student understand those topics in greater depth. I resisted the very real temptation to include lots of additional concepts in this new edition. Instead, my focus for this edition was on rewriting selected portions to improve the clarity of presentation.

## NEW FEATURES OF THE ELEVENTH EDITION

- **“Chemical Insights” are used to bridge the gap between mathematics and chemistry.** This new “insight” feature, which is appended to many of the worked-out example problems in the text that involve calculations, focuses on the element or compound that is the *subject* of the calculation. These insights give information on the subject element's/compound's occurrence, its properties and uses, its relationship to the environment, its relationship to living systems (biochemistry), and so on. It is easy for students to become so involved in the mathematics of problem solving that they completely forget about the “realness” of the type of matter that is the subject of the calculation. There are 85 total insights which address this “realness” issue.
- **A “Student Learning Focus” feature is used as a mini study guide for students.** These learning objectives, found at the start of all sections of all chapters, “pinpoint” for the student what it is hoped they will gain by study of the given section.
- **New Worked-Out Example Problems.** Nineteen of the 236 worked-out example problems in the text are new. *Worked-out-in-detail* example problems with their extensive commentary constitute one of the greatest strengths of the text.
- **Extensive revision of “End-of-Chapter Problem Sets.”** Although the total number of end-of-chapter problems, which already exceeds that of most other similar texts, has not increased significantly, almost 500 of the previous edition's 2200 problems have been replaced with new problems. A special effort was made to create new problems that address specifically the “core concepts” associated with a given chapter section's subject matter. In most chapters several of the newly added problems involve presentation of data in a “visual form” rather than in a “sentence form.” Many of the “visual problems” involve situations where reasoning, with little or no calculation, is needed to test a student's grasp of a key concept.

**Content changes to individual chapters.** After ten successful editions of *Introduction to Chemical Principles*, the need for drastic alterations in chapter ordering and chapter content does not exist. Changes that have been made relate to “fine tuning” of the presentation of the subject matter. Among the most important changes to this edition are the following:

- **Chapters 4 and 5:** The last four sections of chapter 4 of the previous edition (atoms, molecules, and chemical formulas) has been moved to the start of Chapter 5. Material concerning unstable nuclei previously found in chapter 5 has been deleted.
- **Chapter 13:** Material dealing with the use of the molarity concentration unit in chemical calculations now immediately follows the introduction of the concept of molarity. Previously this material was found at the end of the chapter.



## IMPORTANT CONTINUING FEATURES IN THE ELEVENTH EDITION

- 1. Development of each topic starts out at ground level.** Because of the varied degrees of understanding of chemical principles possessed by students taking a preparatory chemistry course, each topic is developed step by step from ground level until the level of sophistication required for a further chemistry course is attained.
- 2. Problem-solving pedagogy is based on dimensional analysis.** Over forty years of teaching experience suggest to me that student “troubles” in general chemistry courses are almost always centered on the inability to set up and solve problems. Whenever possible, I use dimensional analysis in problem solving. This method, which requires no mathematics beyond arithmetic and elementary algebra, is a powerful and widely applicable problem-solving tool. Most important, it is a method that an average student can master with an average amount of diligence. Mastering dimensional analysis also helps build the confidence that is so valuable for future chemistry courses.
- 3. Detailed commentary accompanies all worked-out example problems.** In all chapters, one or more worked-out example problems follow the presentation of key concepts. These examples walk students through the thought processes involved in solving the particular type of problem. Detailed commentary accompanies all of the steps involved in solving a problem.
- 4. “Answer Double Check” feature.** Over half (60%) of the text’s worked-out examples are enhanced by the feature called “answer double check.” The purpose of this feature, which is appended to the end of the worked-out example discussion, is to encourage students to consider whether the answer they obtain in working a problem is a reasonable answer in terms of items such as numerical magnitude, number of significant figures present, sign convention (plus or minus), and direction of change (increase or decrease). An unreasonable answer is often a sign that a calculator error has been made.
- 5. Significant-figure concepts are emphasized in all problem-solving situations.** Routinely, electronic calculators display answers that contain more digits than are needed or acceptable. In all worked-out examples, students are reminded about these unneeded digits by the appearance of two answers to the example: the calculator answer (which does not take into account significant figures) and, in color, the correct answer (which is the calculator answer adjusted to the correct number of significant figures).
- 6. Operation rules for standardizing uncertainty in numbers are used.** Students often experience a relatively high degree of frustration when they correctly solve a problem and yet obtain an answer that differs *slightly* from the one given in the answer section at the back of the book. They want to get the exact number shown in the answer section. Most often the discrepancy is due to differing degrees of uncertainty in the input numbers used for the calculation, for example, in molecular mass values. To minimize such frustration, operational rules have been introduced for standardizing uncertainty in input numbers. The standard mode of operation is always (1) to round all atomic masses to hundredths before using them in molecular mass calculations, and (2) to specify frequently used numbers, such as Avogadro’s number, molar volume, and the ideal gas constant to four significant figures. Using these operational rules for input numbers, student answers will match the back-of-the-book answers *to the last significant digit*.
- 7. Defined terms always appear in self-standing complete sentences.** All definitions are highlighted in the text when they are first presented, using boldface and italic type. Each defined term appears as a complete sentence; students are never required to deduce a definition from context. In addition, the definitions of all terms appear in a separate glossary found at the end of the text. All defined terms have been reexamined to see if they could be stated with greater clarity. The result is a rewording of many defined terms. In addition, the number of defined terms has been increased. There are 29 new or modified definitions in this new edition of the text.
- 8. All end-of-chapter exercises occur in matched pairs.** In essence, each chapter has two independent, but similar, problem sets. Counting subparts to problems, there are over 5000 questions and problems available for students to use in their journey to proficient problem solving. Answers to all of the odd-numbered problems are found at the end of the text. Thus, two problem sets exist, one with answers and one without.

- 9. “Multiple-Choice Practice Test” feature.** The emphasis in this text has always been and still is on working problems from scratch. Some, but certainly not all instructors, use this same approach when giving class examinations. A multiple-choice question examination is another common type of examination given. To aid students whose examinations involve multiple-choice examinations, a 20-question “multiple-choice practice test” is included as the last feature in each chapter. It is intended that students use this feature as an aid in reviewing subject matter for an upcoming multiple-choice examination.
- 10. Historical vignettes are used to address some of the “people aspects” of chemistry.** These vignettes, entitled “The Human Side of Chemistry,” are brief biographies of scientists who helped develop the foundations of modern chemistry. In courses such as the one for which this text is written, it is very easy for students to completely lose any feeling for the people involved in the development of the subject matter they are considering. If it were not for the contributions of these people, many of whom worked under adverse conditions, chemistry would not be the central science that it is today.
- 11. Marginal notes are used extensively.** The two main functions of the marginal notes are (1) to summarize key concepts and often give help for remembering concepts or distinguishing between similar concepts, and (2) to provide additional details, links between concepts, or historical information about the concepts under discussion.

## SUPPLEMENTS

### For the Instructor

***Instructor Solutions Manual (download only): (ISBN: 0321815130)*** by Nancy J. Gardner, California State University–Long Beach. Contains full solutions to all of the end-of-chapter problems in the text.

***TestGen Computerized Test Bank: (ISBN: 0321815319)*** by Pamela Kerrigan, Mount Saint Vincent. Contains approximately 1000 multiple-choice and short-answer questions, all referenced to the text.

***CourseSmart: (ISBN: 0321815149)*** Access your college textbook in online format at [www.coursesmart.com](http://www.coursesmart.com).

### For the Student

***Student Solutions Manual: (ISBN: 0321815122)*** by Nancy J. Gardner, California State University–Long Beach. Includes full solutions to all odd-numbered end-of-chapter problems and answers to all multiple choice practice test questions in the text.

# ACKNOWLEDGMENTS

I'd like to gratefully acknowledge the valuable contributions of my accuracy reviewer Andreas Lippert of Weber State University.

Every effort has been made to rid this text of any typographical errors. I encourage my readers who notice anything suspicious, or who have other questions or comments, to e-mail me at the address below.

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