SECOND EDITION

Principles of Environmental Chemistry

James E. Girard

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American University

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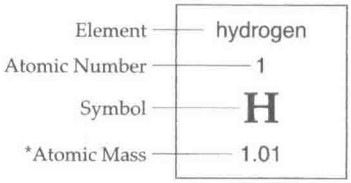

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII
2	lithium 3 **Li** 6.94	beryllium 4 **Be** 9.01							
3	sodium 11 **Na** 22.99	magnesium 12 **Mg** 24.31							
4	potassium 19 **K** 39.10	calcium 20 **Ca** 40.08	scandium 21 **Sc** 44.96	titanium 22 **Ti** 47.88	vanadium 23 **V** 50.94	chromium 24 **Cr** 52.00	manganese 25 **Mn** 54.94	iron 26 **Fe** 55.85	cobalt 27 **Co** 58.93
5	rubidium 37 **Rb** 85.47	strontium 38 **Sr** 87.62	yttrium 39 **Y** 88.91	zirconium 40 **Zr** 91.22	niobium 41 **Nb** 92.91	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** (99)	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91
6	cesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	lanthanum 57 **La** 138.91	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.85	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.2	iridium 77 **Ir** 192.22
7	francium 87 **Fr** (223)	radium 88 **Ra** (226)	actinium 89 **Ac** (227)	rutherfordium 104 **Rf** (261)	dubnium 105 **Db** (262)	seaborgium 106 **Sg** (263)	bohrium 107 **Bh** (262)	hassium 108 **Hs** (265)	meitnerium 109 **Mt** (266)

Lanthanide Series	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** (147)	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.97
Actinide Series	thorium 90 **Th** 232.04	protactinium 91 **Pa** (231)	uranium 92 **U** 238.03	neptunium 93 **Np** (237)	plutonium 94 **Pu** (244)	americium 95 **Am** (243)

*Note: For radioactive elements, the mass number of an important isotope is shown in parenthesis; for thorium and uranium, the atomic mass of the naturally occurring radioisotopes is given.

10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
								helium 2 **He** 4.00
			boron 5 **B** 10.81	carbon 6 **C** 12.01	nitrogen 7 **N** 14.01	oxygen 8 **O** 16.00	fluorine 9 **F** 19.00	neon 10 **Ne** 20.18
			aluminum 13 **Al** 26.98	silicon 14 **Si** 28.09	phosphorus 15 **P** 30.97	sulfur 16 **S** 32.07	chlorine 17 **Cl** 35.45	argon 18 **Ar** 39.95
nickel 28 **Ni** 58.69	copper 29 **Cu** 63.55	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.72	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.92	selenium 34 **Se** 78.96	bromine 35 **Br** 79.90	krypton 36 **Kr** 83.80
palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.75	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** (209)	astatine 85 **At** (210)	radon 86 **Rn** (222)
ununnilium 110 **Uun** (269)	unununium 111 **Uuu** (272)	ununbium 112 **Uub** (277)						

gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04	lutetium 71 **Lu** 174.97
curium 96 **Cm** (247)	berkelium 97 **Bk** (247)	californium 98 **Cf** (251)	einsteinium 99 **Es** (252)	fermium 100 **Fm** (257)	mendelevium 101 **Md** (258)	nobelium 102 **No** (259)	lawrencium 103 **Lr** (260)

PRINCIPLES OF ENVIRONMENTAL CHEMISTRY

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McKinney

Principles of Atmospheric Science
Frederick

Writing Science Through Critical Thinking
Moriarty

Dedicated to my wife, Connie Diamant,
the real environmentalist in our home.

BRIEF CONTENTS

PREFACE

At present there is worldwide concern that many of our human activities are endangering—perhaps permanently—the quality of the environment, and that time is running out to address these problems. The public is becoming increasingly aware of the environmental damage caused by pesticides, toxic wastes, chlorofluorocarbons, nuclear radiation, oil spills, and the greenhouse effect, to name just a few issues. Environmental organizations like the Sierra Club, the National Wildlife Federation, and Friends of the Earth are gaining support—especially on college campuses—and are becoming a major influence in the political arena. Articles on environmental issues appear daily in the newspapers, and members of Congress are introducing legislation to combat threats to the environment.

I developed an environmental chemistry course, and subsequently wrote this book, to expose students to environmental issues from a perspective that appreciates the chemical reactions that drive natural environmental processes. Furthermore, I wanted to help students see the connection between natural environmental processes, human behavior, and the potential for the latter to cause environmental processes to go awry.

■ Objectives

The primary objective of this text is to enable students to understand environmental issues and the underlying chemistry. The text emphasizes that all parts of our environment are made up of chemicals, and that the natural processes continuously occurring in the environment all involve chemical reactions. Appropriate chemical analysis of the lithosphere, hydrosphere, and atmosphere helps illustrate to students what composes an unpolluted environment and sets a benchmark from which our stewardship of the Earth can be monitored. With a grasp of this information, students begin to comprehend the chemical basis of the changing world around them and the consequences of their actions.

■ Organization

This textbook describes the Earth's lithosphere, hydrosphere, atmosphere, and sources of energy. Like other environmental texts, this book focuses on important physical and chemical principles that define each of these parts of our Earth. However, the organization and approach of this text differ in several significant ways from other environmental chemistry books. First, this book emphasizes the role of the U.S. Environmental Protection Agency, EPA regulations for pollutants, and the limits the EPA sets for those pollutants. Next, it features the analytical methods and techniques that are used to measure pollutants. Throughout the text, the appropriate instrumental method that measures the concentration of specific pollutants is presented and described. In some cases the analyses presented may be as mundane as the yearly automobile tailpipe emissions tests that each automobile owner endures, or the concentration of pollutants in wastewater that are measured by environmental contractors, or as sophisticated as remote measurements of our atmosphere from satellites in space. In this way, students not only learn environmental chemistry, but also gain practical knowledge of instrumental and quantitative analysis, two subjects that are the foci of entire courses.

The second edition has been updated and revised. The first chapter provides a description of the Earth's lithosphere and its ecosystems. This early coverage of the dynamic nature of the Earth and its natural cycles not only establishes the importance of maintaining a sustainable natural world but also gives students a refresher in inorganic elements and their distribution.

The next five chapters (Chapters 2–6) concentrate on the chemistry of the atmosphere of the Earth. Chapter 2 discusses the major atmospheric layers and how energy from the sun is captured by Earth. A new Chapter 3 focuses on what may be the most important issue of our time—global warming. Chapter 4 presents the chemistry of the troposphere: CO, NO_x, SO_2, volatile organic chemicals, and photochemical smog. Chapter 5 describes the production and destruction of ozone in the stratosphere. Chapter 6 presents *in situ* and remote analytical methods for measuring the composition of the atmosphere.

Chapters 7–9 cover water—its properties, its importance to life on Earth, and the dangers of polluting and misusing it. Chapter 7 begins with a discussion of the distribution of water on Earth and the unique properties of water. It is followed by Chapter 8, which describes water pollution and water treatment. This section is completed by Chapter 9, which describes the analytical methods that are used to measure water pollution.

The next three chapters (10–12) focus on energy. Chapter 10 describes fossil fuels and their use as our major energy source, and the consequences of the depletion of these nonrenewable resources. Chapter 11 describes the chemistry of nuclear power and the nuclear fuel cycle. Chapter 12 explores other energy sources such as wind power and geothermal and solar energy. The use of hydrogen as a major fuel and fuel cell chemistry are also presented in Chapter 12.

The next four chapters (13–16) present specific environmental topics in more depth. Chapter 13 describes inorganic pollutants such as lead, mercury, and cadmium and the analytical methods that are used to measure these elements in the environment. Persistent organic pollutants (POPs) are introduced in Chapter 14 and students are taught how to use the EPA's PBT Profiler to determine if a chemical might be a persistent, bioaccumulative, or toxic organic pollutant. Different classes of insecticides, herbicides, and the analytical methods that are used to measure them in the environment are presented in Chapter 15. Alternative methods of insect control are also presented, including the use of juvenile hormones and sex pheromones.

The following chapter (16) introduces the student to toxicology and risk assessment. This chapter includes insightful discussions of how to measure the risks posed by chemicals. Chapter 17 describes asbestos: the different fiber types, asbestos disease, and analytical methods that are used to measure the amount of asbestos in the air. The last chapter (18) examines the laws governing the proper disposal of hazardous and radioactive chemicals, such as the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). It also presents the EPA Superfund methods used for analysis of hazardous waste.

■ Chapter Elements

Examples and Exercises Illustrative worked examples, each one accompanied by a challenging practice exercise, are included throughout the text, particularly in the chapters covering basic chemical principles.

Keywords and Concepts Lists of keywords and concepts introduced in the chapter are included at chapter's end to help reinforce the most important information.

Questions and Problems Each chapter includes a wide selection of problems and questions (40–50), with answers to all even-numbered ones given in an appendix. Quantitative, review, and discussion-type questions are included.

Additional Sources of Information A bibliography provides sources for the material covered in the chapter and serves as a suggested list for further reading.

■ Course Use

Principles of Environmental Chemistry offers the flexibility to tailor a course to suit both instructors' preferences and the needs of particular audiences. The full text may be used for a comprehensive two-semester course in which the instructor has the time to explore the underlying chemical principles in detail. Appendix B contains a chapter on basic organic chemistry, which may be useful to cover early in the course to refresh the memory of your students.

The book may be used in several ways for a one-semester course. An option for a one-semester course is to use the first eight chapters, followed by selections from the remaining chapters on more advanced chemistry and environmental applications according to the teacher's preferences. Those who wish to teach a more traditional one-semester course, not emphasizing environmental analysis, should begin with Chapter 1 and proceed through the first 12 chapters in order, skipping Chapters 6 and 9, and then cover more in-depth environmental topics in the later chapters according to preference.

■ Instructors' Supplements

These supplements can be accessed online, via http://www.jbpub.com/science/chemistry.

Online Solutions Manual Contains solutions to chapter-end exercises.

Online Image Bank Provides a PowerPoint® library of all the art and tables in the text to which Jones and Bartlett owns the copyright or has digital print rights.

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Jim Girard

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