Chemistry in Context

Applying Chemistry to Society

Third Edition

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Third Edition

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CHEMISTRY IN CONTEXT: APPLYING CHEMISTRY TO SOCIETY, THIRD EDITION

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Foreword

he Chinese characters representing "chemistry" literally signify "the study of change." Change is what chemistry is all about: the transformation of one substance into another through the rearrangement of atoms. Chemical education is also undergoing change, and *Chemistry in Context* has proved to be a potent catalyst for altering the way in which chemistry is taught. The first edition of the book (1994) was the first college text to use contemporary issues in a consistent and concerted fashion to introduce chemical concepts, and to develop those concepts, *as needed*, to inform an understanding of the issues. The second edition (1997) built on the success of the first and further refined its pedagogical techniques. The book you hold in your hands continues the tradition and further improves upon it.

A text built on current events requires frequent updating, and that has most certainly been done for this edition. Moreover, the many Web and internet-based activities will ensure that instructors and students have access to the latest information. Many new Your Turn and Consider This activities have been added, and, at the request of many users, the end-of-chapter questions have been significantly expanded.

The writing team has also undergone some changes, with Conrad Stanitski, a veteran of the first two editions now serving as senior author and editor-in-chief. New contributors have brought new skills and former members have moved on to the Advisory Board. But the vision of *Chemistry in Context* remains clear and unaltered. It is a vision that has not only served the intended audience well, but has also influenced other courses, other syllabi, and other textbooks for non-science majors and for science majors as well. If imitation is the sincerest form of flattery, then *Chemistry in Context* has been frequently flattered. Through this book and many other innovative curriculum projects, the American Chemical Society continues to be a major agent for change in the teaching of chemistry.

A. Truman Schwartz
Advisory Board Chair

Preface

The Conclusion section of the last chapter of this textbook begins with a question related to genetic engineering: How can we balance the great potential benefits of modern chemical sciences and technology and the risks that seem inevitably to be part of the Faustian bargain that brought us knowledge? (Faust is a literary figure, an old philosopher who sells his soul to the devil in exchange for knowledge and power.)

It might seem unusual, perhaps even odd, to begin the Preface of a book with a question from the last chapter of the work. Yet, the compelling question given above shapes and motivates much of what the third edition of *Chemistry in Context* and its two previous editions are about—establishing chemical principles within a contextual framework of significant societal-technological issues. Thus, the basic philosophy of the third edition is unchanged from that of its antecedents. The wide acceptance of *Chemistry in Context* affirms the validity of its approach to develop the chemical content on a need-to-know basis so that students can more fully appreciate its contextual relationships to the intricate web of topics addressed in the book. Indeed, for three editions, a web is featured on the cover of the book because the word "context" is derived from the Latin word meaning "to weave"; this book weaves chemistry into the web of issues developed herein. By using this approach, we believe that students develop critical thinking ability, the competence to better assess risks and benefits, and the skills that lead them to be able to make informed and thus, reasoned decisions about technology-based matters.

With this third edition, the concept of the web takes on an expanded, contemporary meaning—the use of the internet worldwide web to seek answers to in-chapter and end-of-chapter questions. On the web, students can: (1) apply the Toxics Release Inventory information and other local environmental data to link environmental quality issues to their own city or state; (2) use real-time data, such as that provided by satellites about stratospheric ozone levels; (3) get up-to-date information concerning rapidly changing topics such as electric cars, nuclear waste, new pharmaceuticals, and genetic engineering; and (4) evaluate controversies using the web sites provided by experts, would-be experts, and skeptics on controversial topics such as global warming, food irradiation, and nuclear energy. Thus, the web presents students with the opportunity *and the responsibility* to critically evaluate web information among web sites of widely differing quality and validity. *Chemistry in Context* has its own web site at www.mhhe.com/cic with password-protected items exclusively for faculty members as well as those available to students.

Changes in this edition reflect comments from users and reviewers of the second edition, consultants, as well as the opportunities presented by technological developments, such as the worldwide web, not widely available for the first two editions. There is material in a book such as this one that is time sensitive, and efforts have been made to have the tables, figures, and new information as up-to-date as possible using a printed format. Even so, the pace of chemical discoveries and their applications outstrips that of the printed word. Using the worldwide web helps to offset this imbalance. We also urge professors to supplement the text material with topical and current items from national, regional, and local media (print and non-print forms). Supplemental readings are listed on the *Chemistry in Context* web site rather than in the text so that updates can be provided in a more timely way.

In this edition, the number of chapters has been reduced from thirteen to twelve by incorporating a number of items from Onondaga Lake: A Case Study, Chapter 7 of the earlier editions, into other chapters. With this exception, the sequence of chapters from the second edition remains unchanged. The focus of the water chapter (5) has shifted from water quantity to water quality. The shift also brings into play three brief case studies of selected water quality issues, each coupled to the analytical chemical technique used to identify the particular substance of concern. As in prior editions, the first six chapters have an environmental focus. The next two bring a non–fossil fuel energy orientation and the remaining ones feature aspects of organic and biochemistry. Thus, one-third of the book has an organic/biochemistry flavor. We continue to suggest that the first four to six chapters serve as a core, with additional chapters selected as time and interests dictate. Most users teach from seven to nine chapters in a typical one-semester course.

In addition to the web-based activities, several other items are new to the third edition. The green leaf inset on the cover is emblematic of green chemistry, which makes its debut in this edition. Green chemistry, an important and rapidly emerging field, is introduced in Chapter 1 and then developed further with mini–case studies of its applications throughout the rest of the book. Risk-benefit analysis treatment has been expanded so that it appears as an aspect of additional issues. Other new items or expanded coverage include sun tanning (Chapter 2), low-level nuclear waste (Chapter 7), photovoltaics, fuel cells, and electric vehicles

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(Chapter 8), generic and pioneer drugs (Chapter 10), Olestra as well as the use of irradiation to preserve food (Chapter 11), and mammalian cloning (Chapter 12). The coverage of covalent bonding, molecular shapes, and bond energies has been expanded a bit to provide a more leisurely discussion of those topics. The art program has increased the number of illustrations and photographs.

The **Your Turn**, **Consider This**, and **Sceptical Chymist** in-chapter activities remain integral and unique features of this book. They and the end-of-chapter questions have been thoroughly revised and expanded. Each chapter has 50 end-of-chapter questions. Interpretive questions related to molecular-scale interpretations of macroscale phenomena, graphical presentation and interpretation of data, and web-based assignments have been incorporated. As with the first two editions, a new edition of the detailed *Instructor's Resource Guide* is available, compiled by Joseph Bieron. For those who have a laboratory program with this course, a new edition of the *Laboratory Manual* is available, which includes experiments using microscale equipment (wellplates and Beral-type pipets) and common materials. Instructors are urged to have their students read the introductory section "Tracing the Web: A Reader's Guide to *Chemistry in Context*," which describes the purposes of the various pedagogical devices that are an integral part of the text.

A work of this type is not done in isolation; it depends on the assistance of others. Truman Schwartz, the Editor-in-Chief of the first two editions of *Chemistry in Context*, chaired the Advisory Board for this edition with his typical erudition and keen insights. Robert Silberman, Diane Bunce, and Arden Zipp were members of the author team for the first edition, the Editorial Team for the second edition, and served on the Advisory Board for the third edition. Advisory Board members contributed technical expertise as well as close reading of the manuscript as it developed. Our gratitude goes to the ACS Division of Education and International Activities staff, lead by Sylvia Ware, whose vision and professionalism continue to advance the agenda for quality chemistry education from kindergarten through graduate school by this project and other curricular initiatives. No other scientific society matches such efforts, which are reflections of the commitment of the leadership and membership of the American Chemical Society to curricular enhancement. The unstinting support of Kent Peterson (Chemistry Editor), Margaret Horn (Developmental Editor), and Vicki Krug (Project Manager), along with members of the production staff at McGraw-Hill is gratefully acknowledged. Sincere thanks also go to the reviewers, users, and consultants who provided comments that kept the manuscript on course. Errors in the Acknowledgments list are those of omission, not commission.

Another important third edition change to be noted is the revised editorial team. Two new members, Catherine Middlecamp and Lucy Pryde Eubanks, join Wilmer Stratton and me, veterans of the first two editions of this textbook. The third edition of *Chemistry in Context* maintains the outlook, philosophy, and strengths of its previous editions while bringing new and exciting dimensions to the textbook that has become the leader in its field. We are excited about this new edition and look forward to your comments.

Conrad L. Stanitski
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Tracing the Web:
A Reader's Guide to *Chemistry in Context*

The symbol selected for *Chemistry in Context* is a spider web, a remarkably strong and flexible structure created by elegant chemistry within a spider's body. The web also represents the complex connections that exist between chemistry and society. Appropriately, the word "context" derives from a Latin word meaning "to weave." Thus, the title says it all: a major purpose of this book is to weave chemistry into its social, political, economic, and ethical context. This introduction is intended to help you find your way through the web without getting trapped.

If you have already had a chemistry course, the first thing you likely will notice is that the **Table of Contents** of this text is quite different from that of a more traditional chemistry book. In *Chemistry in Context*, the chapter titles reflect today's headlines and the issues surrounding them. Ozone depletion, global warming, new energy sources, nutrition, genetic engineering, and the other topics treated in this text are all closely connected to chemistry. For you to understand and respond thoughtfully in an informed manner to these vitally important issues, you must know something about the chemical principles that underlie the sociotechnological issues. This book presents those principles, when and where they are needed, in a manner intended to better prepare you to be a well-informed citizen.

We have introduced a number of features that we hope will be helpful to you, and we encourage you to make use of them. The most traditional features are the **Your Turn** activities. They provide opportunities for you to practice a skill or calculation that has, in most cases, already been illustrated in the text, usually just before the Your Turn activity. These activities test your understanding and are good practice for chapter-end questions or examinations. Even if your instructor does not assign all of the Your Turn activities, we urge you to attempt them. Hints or complete solutions are often provided, and answers appear either immediately following the question or in Appendix 4.

Many modern problems involving chemistry are a good deal more complicated than those in the Your Turn category, and for that reason we have constructed **Consider This** questions. Here you may be asked to engage in risk-benefit analysis, consider opposing viewpoints, speculate on the consequences of a particular action, or formulate and defend a personal position. Some of these questions invoke the use of the worldwide web to gather data and update information in the textbook. These decision-making activities can be used in a wide variety of ways, and your instructor will provide detailed assignments related to them that might involve library research, writing, group work, discussion, debate, or role playing. A typical Consider This activity, like many aspects of life, may not have a single "right" answer. However, the issues raised demand correct information, critical thinking, sound reasoning, and clear communication to form and present an informed opinion. Although no course will be able to address all of the Consider This questions, we encourage you to read them all, because they provide much food for thought.

The third special feature, **The Sceptical Chymist**, takes its title (and peculiar spelling) from an influential book published in 1661 written by Robert Boyle, an early investigator of the properties of air. In his book, Boyle observed that scientific truth would be more solidly established "if men would more carefully distinguish those things that they know from those that they ignore or do but think." The popular press is full of statements and stories that seem to confuse what is known and what is thought. Modern "chymists" and students of "chymistry" are advised to develop the critical habit of mind that leads them to doubt and question what they read or hear. The Sceptical Chymist gives you an opportunity to sharpen those analytical skills by responding to a variety of statements and assertions. Often we provide some guidance; sometimes we leave you to your own devices.

Each chapter begins with a **Chapter Overview** that indicates what is to follow and ends with a **Conclusion** that draws together the major themes. The **Chapter Summary**, with its "Having studied this chapter, you should be able to:" heading calls attention to the most important skills and applications introduced and developed in the chapter. **Marginal Notes** are used throughout the book to succinctly summarize and emphasize key points, or to point out linkages with sections in other chapters.

The end-of-chapter study materials also include **Questions**, some of which will likely be assigned by your instructor. The Questions are divided into three categories. *Emphasizing Essentials* are questions on which you practice and sharpen the chemistry skills developed in the chapter. *Concentrating on Concepts* questions have you focus on chemical concepts and their relationships to the socio-technological topics under discussion. Questions in the *Exploring Extensions* category present a challenge to go beyond the textbook material by providing an opportunity to extend and integrate skills, concepts, and communication. The latter two categories of questions also incorporate the use of the worldwide web as a source of data and opinions. The questions with colored numbers are answered in Appendix 5.

Among the in-chapter questions and the end-of-chapter questions are questions that have you use the worldwide web to find data and commentary on a variety of topics to answer the questions. An important resource in this regard is the *Chemistry in Context* web site at www.mhhe.com/cic.

The end of the book includes **Appendices** on conversion factors and constants (Appendix 1), exponents (Appendix 2), and logarithms, including an expanded treatment of pH (Appendix 3); answers to Your Turn questions (Appendix 4), and selected end-of-chapter questions (Appendix 5); a **Glossary** that defines the major terms used in the text and provides references to the pages where the terms are explained in context; and an **Index**.

We recognize that the great majority of the readers of *Chemistry in Context* will not become chemists. But, we are convinced that the areas where chemistry has an impact on society are far too important to be left to chemists alone, or to politicians, for that matter. We obviously cannot include all the current or potential socio-technological problems that involve chemistry. Nevertheless, we hope that the issues selected, the facts and principles presented, and the habits of mind you and your fellow readers develop as you study in this course will assist you to live responsibly in a future in which chemistry will continue to be the science that is central to better understand our world.

Conrad L. Stanitski
Lucy Pryde Eubanks
Catherine H. Middlecamp
Wilmer J. Stratton

Guided Tour

REAL LIFE APPLICATIONS

The material is presented to the student in a manner that demonstrates how chemistry actually impacts their lives.

Here are a few sample pages showing chemistry in relation to environmental topics such as fresh water, air pollution, and solar radiation.

5.5 How Pure is Drinking Water?

Regardless of its source, drinking water is rarely, if ever, just pure H_2O. You can be assured that almost certainly it contains other substances. For example, a label on Evian bottled water includes the following information:

Mineral Composition, mg/liter			
Calcium	78	Bicarbonates	357
Magnesium	24	Sulfates	10
Silica	14	Chlorides	4
		Nitrates (N)	1

Of these seven items for Evian water, all but one of them will be discussed in this chapter. We will also find out that the items listed on the label are themselves not chemical compounds, but are just parts of compounds. The number given with each item indicates how much of that substance (in milligrams) is present in one liter of Evian water. This raises a reasonable question: Should we be concerned about any of these substances and its amount? Calcium, for example, has a definite health benefit in producing stronger bones. Milk, not Evian water, is the preferred source for calcium; you would have to drink 4 liters of Evian water to get the same amount of calcium as that in one 8-oz glass of milk. In contrast, nitrate can be a health problem, especially for infants, depending on its concentration. The other listed substances in Evian bottled water are not likely to be a health problem. Elsewhere on the label it is noted that sodium, a health issue for some people, is present at less than 5 mg per bottle.

1 liter = 1.06 quart

Such composition information can also be obtained for tap water supplied by municipal water companies. A typ… the authors of this text reveale…

Min…
Calci…
Magn…
Sodiu…

5.7 Your Turn

One 500-mL bottle of … requirement of calcium…

a. Use the label inform… that is recommende…

b. How many 500-mL b…

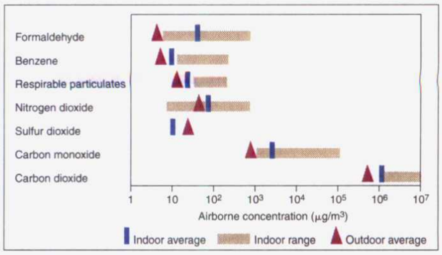
1.14 Breathing Lessons—Indoor Air

The Consider This 1.1 exercise had you "take a breath." That one breath adds up to between 1×10^4 to 2×10^4 L (10–20 m^3) of air each of us breathes daily. As we have learned from previous sections, higher air quality standards have decreased the allowable concentrations of various air pollutants by controlling emissions from automobiles and industries. But air quality depends on where we are. Ironically, such standards have been established for outdoor air, but not for indoor air. Yet, most of us sleep, work, study, and play indoors, spending up to 95% of our time in our dorm rooms, classrooms, offices, and residences. Consequently, we should be concerned not just with outdoor air quality, but that of indoor air as well. Figure 1.11 indicates the concentrations of common pollutants in indoor and outdoor air. Notice from Figure 1.11 that, with the exception of sulfur dioxide, the average indoor concentrations of the pollutants exceed their average outdoor concentrations.

Indoor air is a complex mixture; typically nearly 1000 substances are detectable in it at the ppb level or higher. However, indoor air sources are limited to either the outside air that enters buildings, or air that comes from within buildings. Tobacco smoke, cooking by-products, substances emitted from rugs, furniture, construction materials, and office products are some of the many materials that can degrade indoor air quality. Table 1.10 lists some of the sources of indoor air pollutants.

How quickly indoor air pollutants build up depends on the rates at which outdoor air moves inside and indoor air moves out, as well as on how rapidly pollutants are generated indoors. An insufficient exchange of outside air can cause the concentration of indoor air pollutants to build up to troublesome levels. Consider the risk-benefit trade-off in which buildings constructed within the past two decades have been more airtight to minimize drafts and increase energy efficiency. Although enhanced energy efficiency has been achieved, it has been at the cost of decreasing the flow of outside air into the building to replace the indoor air. When this reduction in air exchange occurs, it allows the concentration of indoor air pollutants to increase. Therefore, initially what was a benefit (better energy efficiency) can turn into an increased risk (increased pollutants concentration). Construction of some large office buildings has been so highly energy efficient that little exchange of outside air occurs within them. In some of these cases, the reduced air exchange has allowed indoor air pollutants to reach levels hazardous to the health of some individuals, creating a condition known as "sick building syndrome."

Figure 1.11
Indoor and outdoor concentrations of common pollutants



2.4 Waves of Light

To better understand how stratospheric ozone screens out much of the Sun's harmful radiation requires knowing the molecular structure of ozone as well as some fundamental properties of light. The interaction of sunlight with matter is important, such as in photosynthesis or the damage high-energy solar radiation can cause in living organisms. Therefore, we turn now to develop an understanding of light.

Every second, five million tons of the Sun's matter are converted into energy, which is radiated into space. The fact that we detect color indicates that the radiation that reaches us is not all identical. Prisms and raindrops break sunlight into a spectrum of colors. Each of these colors can be identified by the numerical value of its wavelength. The word correctly suggests that light behaves rather like a wave in the ocean. The **wavelength** is the distance between successive peaks (Figure 2.1). It is expressed in units of length and symbolized by the Greek letter lambda (λ).

It is both interesting and humbling to realize that out of the vast array of radiant energies, our eyes are sensitive to light only in a very tiny portion of the electromagnetic spectrum—wavelengths between about 700×10^{-9} m (corresponding to red) and 400×10^{-9} m (corresponding to violet). These lengths are very short, so we typically express them in nanometers. One nanometer (nm) is defined as one one-billionth of a meter (m). In symbols,

$$1 \text{ nm} = \frac{1}{1{,}000{,}000{,}000} \text{ m} = \frac{1}{10^9} \text{ m} = 1 \times 10^{-9} \text{ m}$$

We can use this equivalence to convert meters to nanometers; for example, to convert 700×10^{-9} meters to nanometers.

$$\text{wavelength} = \lambda = 700 \times 10^{-9} \cancel{\text{m}} \times \frac{1 \text{ nm}}{1 \times 10^{-9} \cancel{\text{m}}} = 700 \text{ nm}$$

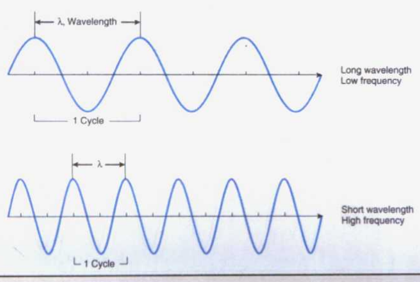
The meter units cancel and we are left with nanometers.

2.9 Your Turn

Violet light in the visible part of the spectrum has a wavelength of 408 nm. Express this wavelength in meters.

Ans. 4.08×10^{-7} m

Figure 2.1
Wave motion.



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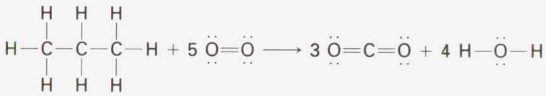
4.10 Your Turn

Use the bond energies in Table 4.1 to calculate the heat of combustion of propane, C_3H_8 (LP or "bottled gas"). Report your answer both in kJ/mole of C_3H_8 and kJ/g C_3H_8. This is the equation for the reaction, written with structural formulas.



Hint: Note that there are 8 moles of C—H bonds, 2 moles of C—C bonds, 5 moles of O═O bonds, 6 moles of C═O bonds and 8 moles of O—H bonds involved in the reaction.

Ans. Energy change = −2016 kJ/mole C_3H_8 or −45.8 kJ/g C_3H_8
Heat of combustion = 2016 kJ/mole C_3H_8 or 45.8 kJ/g C_3H_8.

YOUR TURN

These activities allow students to practice a skill or calculation that has, in most cases, previously been illustrated in the text, typically just before the Your Turn activity. Excellent as reinforcement for chapter-end questions and examinations. Hints and complete solutions are often provided immediately following the questions.

CONSIDER THIS

Develop your students' critical thinking skills with these more complicated problems. These decision-making activities can be used as assignments involving library research, writing, group work, discussion, debate, or role playing.

1.1 Consider This: Take a Breath

One breath does not use much air, but what total volume of air do you exhale in a typical day? One approach to this question is simply to guess, but an educated guess is more reliable than a wild one. By designing and executing a simple experiment, you can come up with a reasonably accurate answer. You will need to determine how much air you exhale in a single breath and how many breaths you take per minute. Once you establish this information, determine how much air you exhale in a day (24 hours). Describe the experiment you performed, the data you obtained, and any factors that you can identify that affect the accuracy of your answer.

3.23 The Sceptical Chymist: Cooler Heads

Has the greenhouse effect been amplified by human activities? **a.** Find some web links to several organizations that don't believe so. Try the Global Warming Skeptics web page, or that from the Greening Earth Society. Newspapers, television, and radio-related web pages may contain editorials that criticize global warming as a scientific concept. **b.** Is there scientific merit to the arguments of those opposing global warming? Cite specific cases.

SCEPTICAL CHYMIST

Students are challenged to use their critical habits of mind to doubt and question chemistry-related statements and stories made by the popular press. Each Sceptical Chymist exercise contains a variety of questionable statements and assertions, providing students an opportunity to sharpen their analytical skills.

GREEN CHEMISTRY

Green Chemistry principles are introduced and used repeatedly to demonstrate creative contemporary chemical approaches that minimize and prevent technological difficulties.

An obvious way to reduce pollution is not to have the pollutants form in the first place. Over the past decade, an important initiative known as "green chemistry," the use of chemistry to prevent pollution, has taken place. **Green chemistry**—designing chemical products and processes that reduce or eliminate the use and/or generation of hazardous substances. Begun under the EPA's Design for the Environment Program, green chemistry reduces pollution through fundamental chemical breakthroughs in designing and re-designing chemical processes, with an eye toward making them environmentally friendly, that is "benign by design." In this regard, Dr. Barry Trost, a Stanford University chemist, advocates an "atom economy" approach to the synthesis of commercial chemical products such as pharmaceuticals, plastics, or pesticides. Such syntheses would be designed so that all reactant atoms end up as desired products, not

Halons are greenhouse gas compounds composed of carbon, fluorine, and bromine atoms used in fire fighting and other applications. As a greenhouse gas, halons are also scheduled to be phased out under the modified Montreal Protocol. Using a green chemistry approach, Pyrocool Technologies has synthesized a halon substitute. The product, called Pyrocool FEF, is an environmentally benign foam that is more effective than halons in fighting fires, even large-scale fires such as those on oil tankers and jet airplanes (Figure 2.20). Pyrocool Technologies won a 1998 Presidential Green Chemistry Challenge award for this development.

The phaseout of CFCs is not without major economic considerations. At its peak, the annual worldwide market for CFCs reached $2 billion, but that was only the tip of a very large financial iceberg. In the United States alone, chlorofluorocarbons were used in or used to produce goods valued at about $28 billion per year. Even today, over $100 billion worth of equipment, probably including your refrigerator and automobile air conditioner, rely on CFCs. Although the conversion to CFC replacements has had some additional costs associated with it, the overall effect on the U.S. economy has been minimal. Companies that produce refrigerators, air conditioners, insulating plastics, and other goods have adapted to using the new compounds. Some substitutes for CFC refrigerants are less energy efficient, hence increasing energy consumption by several percent. But the conversions will provide a market opportunity for innovative syntheses using green chemistry to produce environmentally benign substances.

One of the most interesting efforts to eliminate CFCs has been the Super Efficient Refrigerator Program (SERP). Historically, refrigerators have been major users of electrical

GREEN CHEMISTRY ICONS

Icons identify areas within the text where Green Chemistry principles are discussed.

WEB-BASED ACTIVITIES

Web-based activities are built into the in-chapter and chapter-end questions. Students can explore a variety of issues, including evaluating the accuracy of various web sites.

2.1 Consider This: Ozone Levels Above Your House

What are the current ozone levels in the stratosphere? The National Aeronautics and Space Administration (NASA) can provide you with values. In fact, if a satellite is sending back data as you read this, you may be able to get today's ozone level in the stratosphere right above where you live.

a. Where do you live? Determine your latitude and longitude from a map, from a nearby airport, or by using the link provided at the *Chemistry in Context* web site.

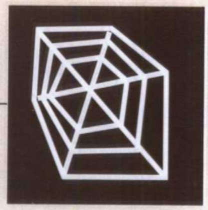
b. Use the NASA link at the *Chemistry in Context* web site to access satellite data. Enter your latitude and longitude from part **a** to find the total column ozone amount at your location for today. Request an earlier date if today's is not available. As you will see later in the chapter, 320 Dobson units is the average ozone level over the northern U.S. How does your value compare with the average?

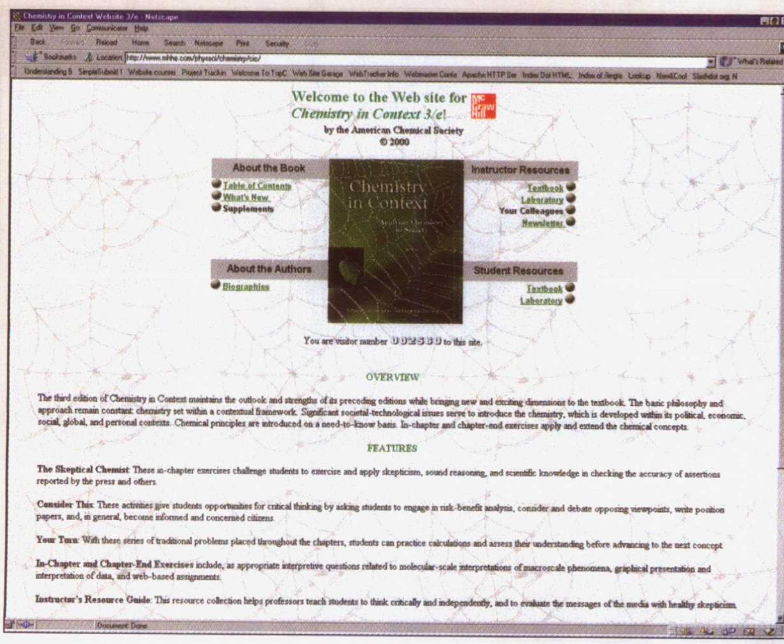
c. Again using the NASA link, obtain ozone values for some other parts of the world.

47. How do researchers determine whether the negative effects of acid deposition on aquatic life are a direct consequence of low pH or the result of Al^{3+} released from rocks and soil? Find at least one web article that gives the details of such a study. In your own words write a summary of the experimental plan and its results.

WEB ICON

A web icon alerts students to web-based activities within the text.





ON-LINE LEARNING CENTER

Log on at—

www.mhhe.com/cic

Also new to the third edition is a *Chemistry in Context* (CIC) web site for both students and instructors. This site includes web activities from the text, information to help students evaluate the quality of web sites, and searching tools. Instructors can find links to documents that are useful source material for lectures and classroom discussions. Also available on-line will be parts of the Instructor's Resource Guide (IRG), such as the answers to end-of-chapter questions.

Chapter Summary

Note: The numbers that follow indicate the sections in which the topics are introduced and explained.

Having studied this chapter, you should be able to:

- Recognize the composition of air and reasons for local and regional variations of it (1.1 – 1.3);
- Understand factors behind air quality and the chief components of air pollution (1.3, 1.11, 1.12);
- Evaluate conditions significant in risk-benefit analysis (1.4);
- Identify the general regions of the atmosphere with respect to altitude and the relationship of air pressure to altitude (1.5);
- Interpret air quality data in terms of concentration units (ppm, ppb) and pollution levels, including unreasonableness of "pollution free" levels (1.2 – 1.3, 1.12, 1.14, 1.15);
- Differentiate among mixtures, elements, and compounds (1.6);
- Understand the differences between atoms and molecules, between symbols for elements and formulas for chemical compounds (1.7);
- Name selected chemical elements and compounds (1.7);
- Write and interpret chemical formulas (1.8);
- Balance chemical equations, including using sphere equation representations (1.9 – 1.10);
- Discuss the green chemistry initiative (1.11);
- Describe the nature of air quality policies in this country and abroad in terms of their effectiveness in controlling air pollution (1.12 – 1.13);
- Identify the sources and nature of indoor air pollution (1.14);
- Interpret the nature of air at the molecular level (1.15);
- Use scientific notation and significant figures in performing basic calculations (1.4 and 1.15, respectively).

Questions

The questions in thi chapters, are divide

- **Emphasizing Ess** nity to practice th chapter. This set *Turns* in the chap questions whose r
- **Concentrating o** on the chemical c lationships to the grate and to apply

28. In Consider This 1.3, you considered how life on Earth would change if the concentration of oxygen were doubled. Now consider the opposite case; discuss how life on Earth would change if the concentration of O_2 were only 10%. Give some specific examples of how burning, rusting, and most metabolic processes in humans and plants would be affected.

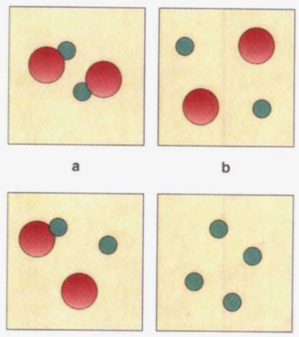
29. Explain why the concentrations of some components in the atmosphere are expressed in percent (parts per hundred) and others are given in ppm (parts per million).

30. Consider the following table of data from the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. The data indicate the number of days metropolitan statistical areas failed to meet acceptable air-quality standards (Pollutant Standards Index rating over 100).

Air Quality of Selected U.S. Metropolitan Areas, 1986–94

Metropolitan statistical area	*1986*	*1988*	*1990*	*1992*	*1994*
Atlanta, GA	18	21	17	5	4
Bakersfield, CA	54	85	48	16	45

36. In these diagrams, the larger circles represent one kind of atom and the smaller circles represent a different kind. Characterize each of the samples as an element, compound, or mixture and give reasons for your answers.



A VARIETY OF PEDOGOGICAL TOOLS

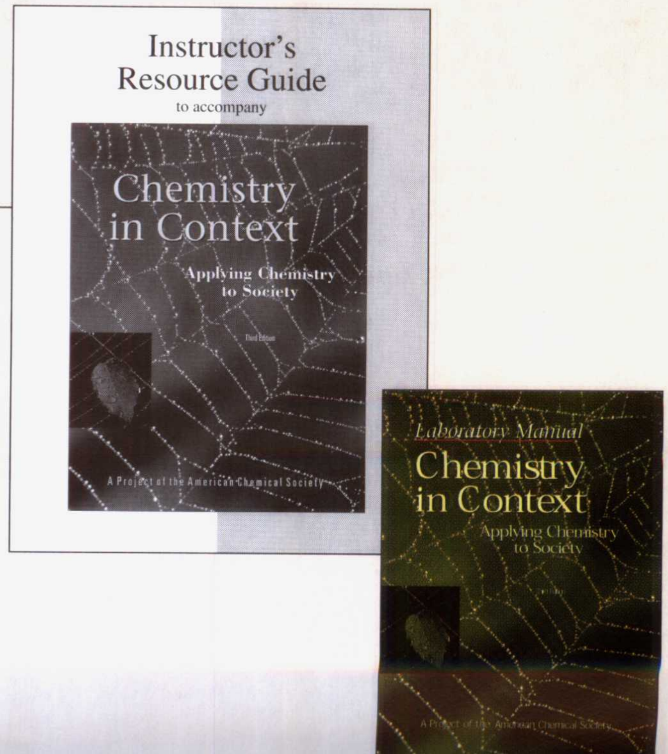
Interpretive questions related to molecular-scale interpretations of macroscale phenomena, graphical presentation and interpretation of data, and web-based assignments are incorporated throughout the text.

QUESTIONS

There are 50 questions at the end of each chapter, an increase of more than 25%.

INSTRUCTOR'S RESOURCE GUIDE AND LABORATORY MANUAL

As with the first two editions of **Chemistry in Context,** a new edition of the detailed *Instructor's Resource Guide* and the *Laboratory Manual* are available.



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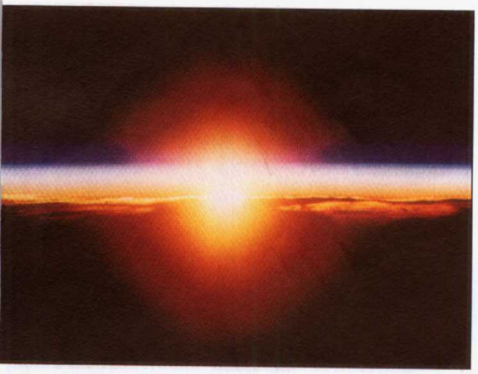

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