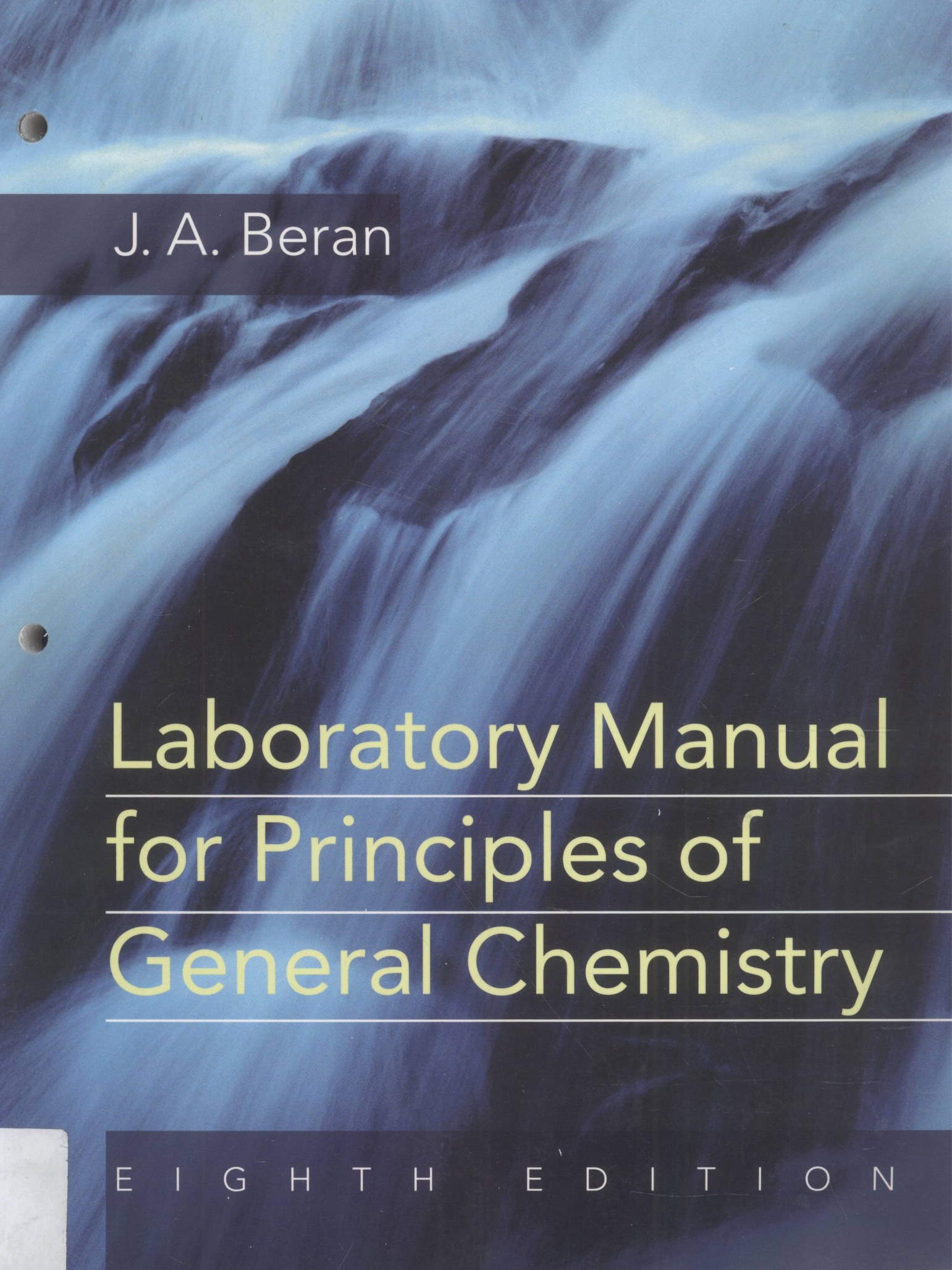
J. A. Beran
Laboratory Manual
for Principles of
General Chemistry
EIGHTH EDITION

Laboratory Manual for Principles of General Chemistry

Eighth Edition

J. A. Beran
Regents Professor, Texas A&M University System
Texas A & M University—Kingsville

John Wiley & Sons, Inc.

The author of this manual has outlined extensive safety precautions in each experiment. Ultimately, it is your responsibility to practice safe laboratory guidelines. The author and publisher disclaim any liability for any loss or damage claimed to have resulted from, or been related to, the experiments.

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Name of Chemist _____ Tel. No. (optional) _____

Local Address (optional) _____

Local Laboratory Information

	First Term	Second Term	Third Term
1. Laboratory Instructor's Name			
2. Laboratory Section Number			
3. Laboratory Room Number			
4. Desk Number			
5. Month / Day / Year			

Location of Safety Equipment Nearest to Your Laboratory Bench

1. Safety Shower			
2. Eye Wash Fountain			
3. Fire Extinguisher			
4. Fume Hood			

QUICK REFERENCE FOR ICONS USED IN THIS TEXT

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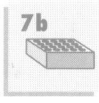

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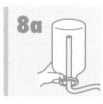

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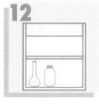

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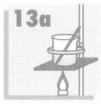

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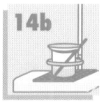

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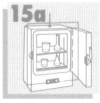

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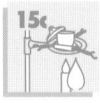

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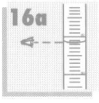

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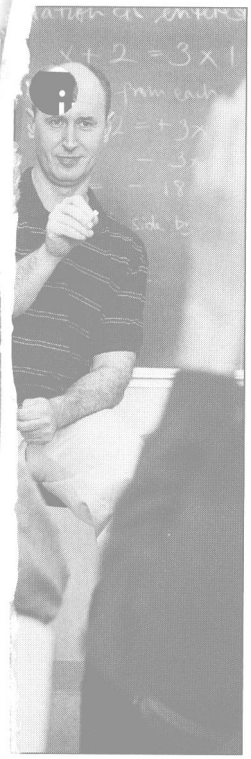

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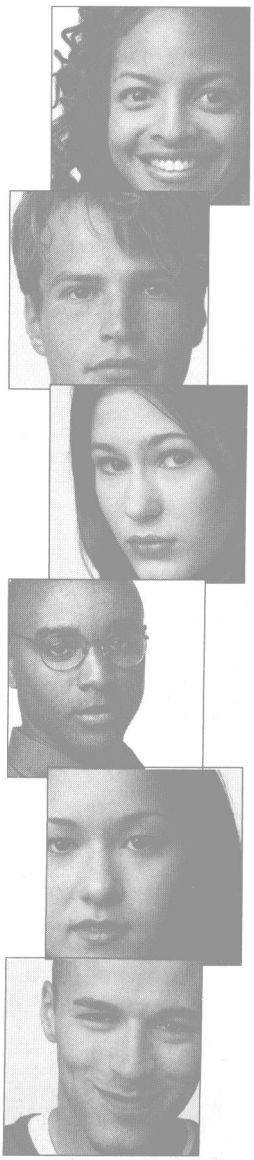

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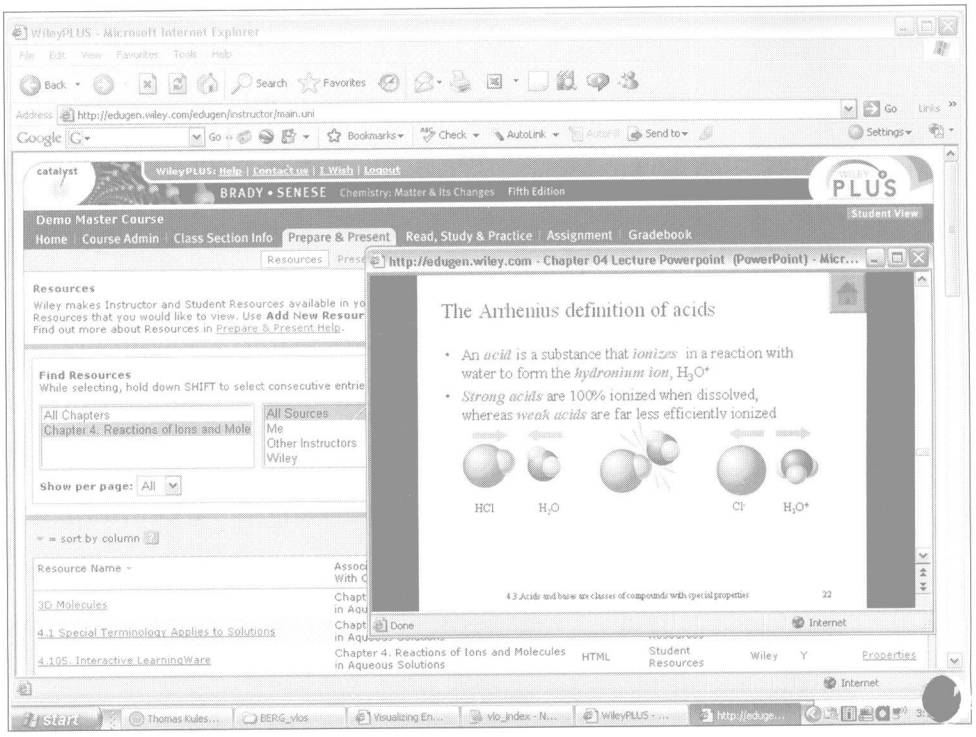

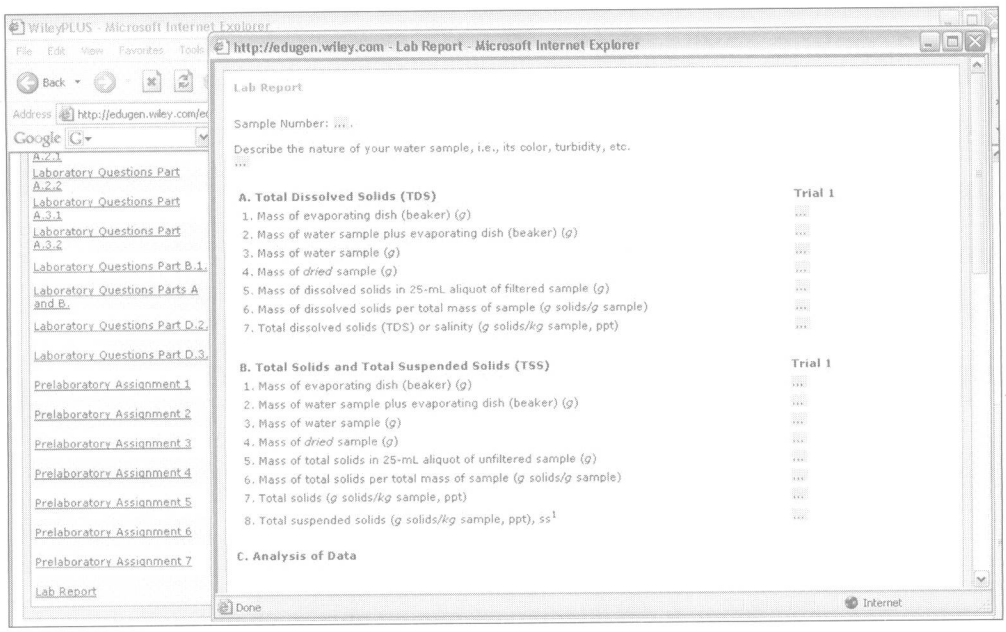

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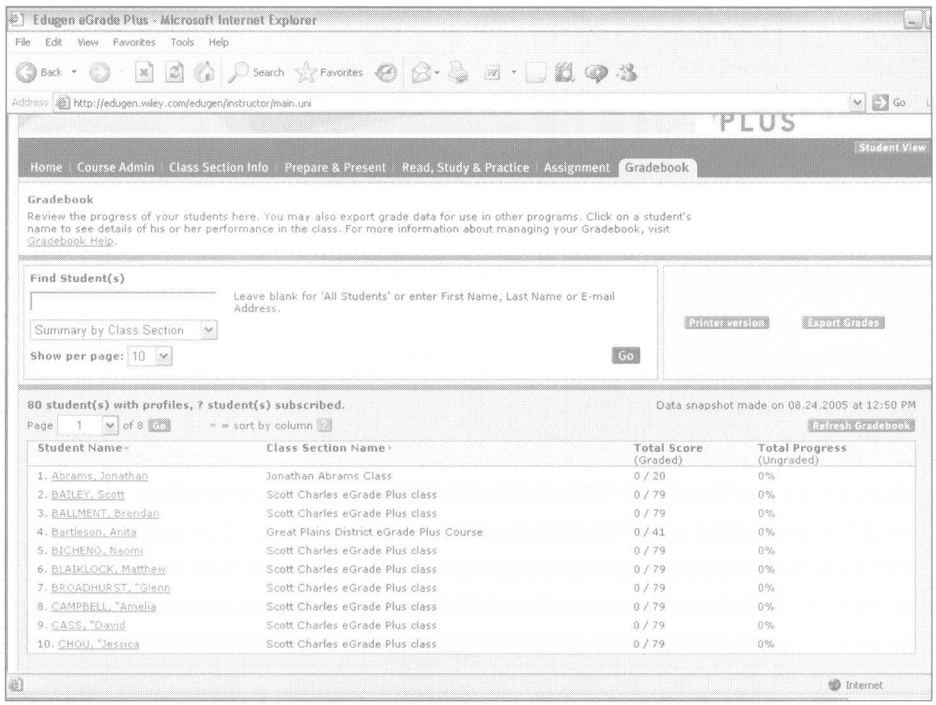

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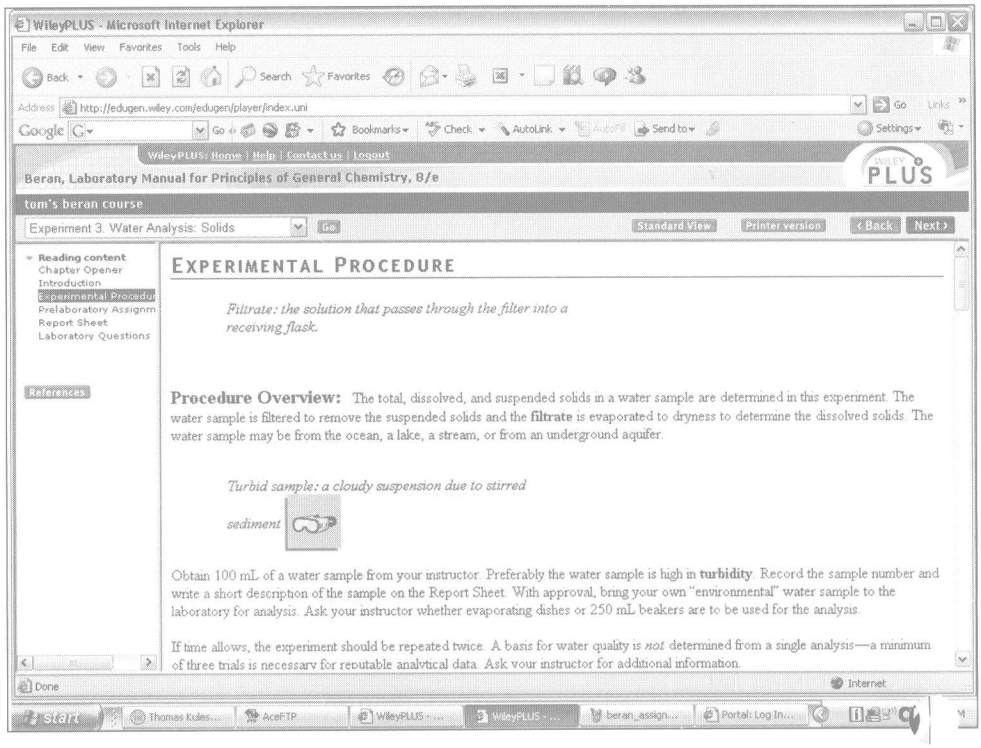

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Laboratory Manual for Principles of General Chemistry

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Each generation has its unique needs and aspirations. When Charles Wiley first opened his small printing shop in lower Manhattan in 1807, it was a generation of boundless potential searching for an identity. And we were there, helping to define a new American literary tradition. Over half a century later, in the midst of the Second Industrial Revolution, it was a generation focused on building the future. Once again, we were there, supplying the critical scientific, technical, and engineering knowledge that helped frame the world. Throughout the 20th Century, and into the new millennium, nations began to reach out beyond their own borders and a new international community was born. Wiley was there, expanding its operations around the world to enable a global exchange of ideas, opinions, and know-how.

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Chemistry laboratories have changed with advances in technology and safety issues.

Preface

Welcome to the 8th edition! The immediate questions that come to mind are, "Why the 8th?" and "What's wrong with the 7th?" To respond to the latter question first: the 7th edition was the most well-received laboratory manual that Wiley has ever produced for general chemistry. The experiments were interesting, challenging, and had good pedagogy regarding laboratory techniques, safety, and experimental procedures. The reporting and analyzing of data and the questions (pre- and post-lab) sought to provide the intuitiveness of the experiment. The answer to "What's wrong with the 7th"—nothing really, except that chemistry like all sciences is constantly incorporating new instrumentation, new technology, and adapting to new developments and scientific trends.

In response to, "Why the 8th?": all of the "good" from the 7th has been retained, but because of these progressive trends in general chemistry, new experiments have added depth, relevance, and appreciation of the laboratory experience. Trends toward safer, more modern laboratory equipment, computer usage, and online information have been included. The open-endedness of each experiment is encouraged in "**The Next Step**" where, upon completion of the experiment, the student has the tools and experience to employ for studying additional chemical systems or topics of his/her interest. It is hoped that laboratory instructors and students will add their own "Next Step" for pursuing personal areas of interest/investigation. Reviewers have applauded the changes and challenges of the 8th edition.

While all comments of users and reviewers from the previous seven editions have been heavily weighed with each new edition, the task of presenting the "perfect" manual, like chemistry and science in general, is impossible. However, at this point in time, we feel it is the "best."

Breadth (and Level) of the 8th Edition

This manual covers two semesters (or three quarters) of a general chemistry laboratory program. A student may expect to spend three hours per experiment in the laboratory; limited, advanced preparation and/or extensive analysis of the data may lengthen this time. The experiments were chosen and written so that they may accompany any general chemistry text.

Features of the 8th Edition

Safety and Disposal. "Safety first" is again emphasized throughout the manual with recent advisories and guidelines being added. The introductory section outlines personal and laboratory safety rules and issues. Icons in the **Experimental Procedures** cite "**Cautions**" for handling various chemicals, the proper "**Disposal**" of chemicals, and the proper "**Cleanup**" of laboratory equipment. Pre-laboratory questions often ask students to review the safety issues for the experiment.

In addition, attention was focused on eliminating chemicals that have prompted disposal concerns. Experiments have been modified or combined to eliminate such chemicals as barium, bismuth, and thioacetamide, and to reduce the amount of silver ion from 7th edition experiments.

Laboratory Techniques. Numbered icons cited at the beginning of each experiment and within the Experimental Procedure are referenced to basic laboratory techniques that enable the student to complete the experiment more safely and efficiently. The **Laboratory Techniques** section provides a full explanation of seventeen basic general chemistry laboratory techniques (along with the corresponding icons) that are used repeatedly in the manual.

Organization. Experiments have been regrouped according to subject matter where, e.g., all redox experiments are grouped (Section 5) such that the sequential numbering for the experiments in the group indicates a greater degree of complexity. For example, Experiment 27, Oxidation-Reduction Reactions is the simplest of the reactions involving oxidation-reduction, not the 27th most difficult experiment in the manual, and Experiment 33, Electrolytic Cells: Avogadro's Number, is perhaps the most difficult of the oxidation-reduction experiments.

Dry Lab 2, Nomenclature, as well as a combined experiment (7th edition, Experiments 12 and 13) on Acids, Bases, and Salts (Experiment 6) have been moved forward in the 8th edition. Such organization appears to be the trend in general chemistry programs.

Report Sheets. They have been simplified! Data entries are now distinguished from calculation entries—the calculated entries are now shaded. Additionally, at the discretion of the instructor, the website, http://www.wiley.com/college/beran, provides downloadable Excel Report Sheet Templates for each experiment in which a numerical analysis is required.

Online References. A significant number of websites have been cited in various experiments and dry labs. An extensive list of online references is also provided in the **Laboratory Data** section of the manual.

NEW TO THE 8TH EDITION

New and Revised Experiments. Experiments of student interest and safety continue to be of importance in the 8th edition. Other than minor changes that appear in most experiments, the major changes and additions are:

- Experiment 3. Water Analysis: Solids. An expansion of the same experiment from the 7th edition, this experiment now introduces more details of the "chemistry" of the system investigated. While the experiment itself is no more difficult than before, an understanding of the salts and ions present is a beginning for understanding chemical systems.
- Experiment 6. Acids, Bases, and Salts. The combination of 7th edition, Experiments 12 and 13, has reduced some of the "drudgery (according to students)" of repetition in those two experiments. Being placed earlier in the manual encourages an earlier introduction to the properties of aqueous solutions.
- Experiment 8. Limiting Reactant. The handling and disposal of barium ion (7th, Experiment 8) had become an increasing problem. The barium phosphate limiting reactant system has been replaced by the calcium oxalate system.
- Experiment 20. New! Alkalinity. Both "T" and "P" alkalinity values are determined along with the interpretation and understanding of the significance of this water quality parameter.
- Experiment 30, Vitamin C Analysis. Simplified! A direct analysis of the vitamin C with potassium iodate is the revised procedure.
- Experiment 31. New! Dissolved Oxygen in Natural Waters. Water samples are obtained and the oxygen is "fixed" on site. The principles for the technique are explained with the subsequent analysis performed in the laboratory. Its significance is of interest to anyone in the biological or biochemical fields.
- Experiment 35. New! Spectrophotometric Metal Ion Analysis. Spectrophotometric analysis is so common in laboratories inside and outside of the general chemistry laboratory that additional exposure to its technique is important and useful to students in science. While a metal ion analysis is the focus of the experiment, the technique can be used and adapted for any student's interest.
- Experiment 38, Qual I: Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}, Cu^{2+}, and Experiment 39, Qual II: Ni^{2+}, Fe^{3+}, Al^{3+}, Zn^{2+}. The three cation qualitative analysis experiments from the 7th edition have been combined into two experiments, eliminating the use of thioacetamide, silver ion, bismuth ion, and manganese ion from the traditional qualitative analysis scheme.

The Next Step. "The Next Step" appears at the conclusion of the Experimental Procedure in each experiment. Based upon the tools and techniques gained upon completion of the experiment, The Next Step takes students from its completion to ideas for an independent, self-designed (and often open-ended) experience or experiment. Occasionally, tools and techniques learned from other experiments may be necessary for use and adaptation in the "project" that the student proposes. The initial title of this feature, "Where do we go from here?" was developed to answer the student's question of, "what

more can I *now* do with what I just learned in the laboratory?" The thinking about chemistry just begins with "The Next Step" when the student leaves the laboratory, rather than ending with, "well, that experiment is over!"

Laboratory Equipment. Simple laboratory glassware and equipment, shown in the first sections of the manual, are necessary for completing most experiments. Where appropriate, the apparatus or technique is shown in the experiment with a line drawing or photograph. Analytical balances, spectrophotometers (Experiments 34 and 35), pH meters (Experiment 18), and multimeters (Experiments 32 and 33) are suggested; however, if this instrumentation is unavailable, these experiments can be modified without penalizing students. In general, hot plates have largely replaced Bunsen burners in the manual; however if not available, the Bunsen flame can still be safely used for heating.

Contents of the Manual

The manual has five major sections:

- *Laboratory Safety and Guidelines.* Information on self-protection, what to do in case of an accident, general laboratory rules, and work ethics in the laboratory are presented.
- *Laboratory Data.* Guidelines for recording and reporting data are described. Sources of supplementary data (handbooks and World Wide Web sites) are listed. Suggestions for setting up a laboratory notebook are presented.
- *Laboratory Techniques.* Seventeen basic laboratory techniques present the proper procedures for handling chemicals and apparatus. Techniques unique to qualitative analysis (Experiments 37–39) are presented in Dry Lab 4.
- *Experiments and Dry Labs.* Thirty-nine experiments and four "dry labs" are subdivided into 12 basic chemical principles.
- *Appendices.* Seven appendices include conversion factors, the treatment of data, the graphing of data, names of common chemicals, vapor pressure of water, concentrations of acids and bases, and water solubility of inorganic salts.

Contents of Each Experiment

Each experiment has six sections:

- *Objectives.* One or more statements establish the purposes and goals of the experiment. The "flavor" of the experiment is introduced with an opening photograph.
- *Techniques.* Icons identify various laboratory techniques that are used in the Experimental Procedure. The icons refer students to the Laboratory Techniques section where the techniques are described and illustrated.
- *Introduction.* The chemical principles, including the appropriate equations and calculations that are applicable to the experiment, and general interest information are presented in the opening paragraphs. New and revised illustrations have been added to this section to further enhance the understanding of the chemical principles that are used in the experiment.
- *Experimental Procedure.* The Procedure Overview, a short introductory paragraph, provides a perspective of the Experimental Procedure. Detailed, stepwise directions are presented in the Experimental Procedure. Occasionally, calculations for amounts of chemicals to be used in the experiment must precede any experimentation.
- *Prelaboratory Assignment.* Questions and problems about the experiment prepare students for the laboratory experience. The questions and problems can be answered easily after studying the Introduction and Experimental Procedure. Approximately 75% of the Prelaboratory questions and problems are new to the 8th edition.
- *Report Sheet.* The Report Sheet organizes the observations and the collection and analysis of data. Data entries on the Report Sheet are distinguished from calculated (shaded) entries. Laboratory Questions, for which students must have a thorough understanding of the experiment, appear at the end of the Report Sheet. Approximately 75% of the Laboratory Questions are new to the 8th edition.

Instructor's Resource Manual

The *Instructor's Resource Manual* (available to instructors from Wiley) continues to be most explicit in presenting the details of each experiment. Sections for each experiment include

- an Overview of the experiment
- an instructor's Lecture Outline
- Teaching Hints

- representative or expected data and results
- Chemicals Required
- Special Equipment
- Suggested Unknowns
- answers to the Prelaboratory Assignment and Laboratory Questions
- a Laboratory Quiz.

Offered as a supplement to the *Instructor's Resource Manual* is a **Report Sheet Template** for those experiments requiring the numerical analysis of data. The format of the templates is based on Microsoft Excel software and is available from Wiley upon adoption.

The Appendices of the *Instructor's Resource Manual* detail the preparation of all of the solutions, including indicators, a list of the pure substances, and a list of the special equipment used in the manual *and* the corresponding experiment number for each listing. Users of the laboratory manual have made mention of the value of the *Instructor's Resource Manual* to the laboratory package.

Reviewers

The valuable suggestions provided by the following reviewers for this 8th edition are greatly appreciated:

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What a staff at Wiley! Thanks to Jennifer Yee, Acquisitions Editor, for her keen insight, helpful suggestions, and unending commitment to see the manual through its birth; Janet Foxman and Jeanine Furino, Production Editors, for coordinating the production of the manual; Tara Sanford, Photo Editor at Wiley, for assistance in obtaining the new photographs for this edition; Jeanine Furino at GGS Book Services, for advancing the quality and detail of the line drawings.

Thanks also to the Chemistry 1111 and 1112 students, and laboratory assistants and staff at Texas A&M—Kingsville for their keen insight and valuable suggestions; also to my colleagues and assistants for their valuable comments.

A special note of appreciation is for Judi, who has unselfishly permitted me to follow my professional dreams and ambitions since long before the 1st edition of this manual in 1978. She has been the "rock" in my life. And also to Kyle and

Greg, who by now have each launched their own families and careers—a Dad could not be more proud of them and their personal and professional accomplishments. My father and mother gave their children the drive, initiative, work ethic, and their blessings to challenge the world beyond that of our small Kansas farm. I shall be forever grateful to them for giving us those tools for success.

James E. Brady, St. Johns University, Jamaica, NY, who was a co-author of the manual in the early editions, remains the motivator to review and update the manual and to stay at the forefront of general chemistry education. Gary Carlson, my *first* chemistry editor at Wiley, gave me the opportunity to kick off my career in a way I never thought possible or even anticipated. Thanks Jim and Gary.

The author invites corrections and suggestions from colleagues and students.

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