Problems in Chemistry

second edition,
revised and expanded

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and
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Second Edition, Revised and Expanded

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Problems in Chemistry

UNDERGRADUATE CHEMISTRY

A Series of Textbooks

edited by

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Department of Chemistry
The University of Texas at Austin

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TO THE INSTRUCTOR

There have been many changes in the teaching of freshman chemistry since the publication of the last edition of this book—in particular, the full use of the SI system of units, the introduction of the unit factor method of solving problems, the use of the terms *atomic* and *molecular mass* in place of *weight*, and the elimination of the term *gram-atom*. All of these changes are reflected in this new edition.

In addition, approximately 200 new sample problems and supplementary problems have been added to the chapters. The section on the use of the slide rule has been replaced with one on the use of calculators and computers. Included in this section is a discussion of the problems associated with significant figures while using computers and calculators and those problems that can arise in switching between $\ln_e$ and the exponent e. A series of useful programs written in general BASIC is included; they can be used on any microcomputer. These programs illustrate the use of computers in solving quadratic equations, approximation methods in solving equations, and nonweighted linear least-squares analysis of data.

As with the first edition, we have chosen our problems with two fundamental concepts in mind: 1) to show students that much of what they learn in freshman chemistry is being used by chemists in their careers, and 2) to encourage students to read the chemical literature. It is important for a student to understand that what is done in the laboratory and what is covered in lectures are related. Whether the course is intended for chemistry, biology, or nonscience majors, students should learn that the knowledge they are acquiring in the lecture part of the course is developed or verified by laboratory experiments.

The interpretation of the results of laboratory experiments involves a chemist in one of the most basic everyday activities associated with chemistry, that is, problem solving. Chemistry is by its very nature a problem-solving-oriented course. All too often, this aspect of chemistry is overlooked by students. Most students require practice in solving problems. Today, students are particularly weak in solving word problems. The more problems a student solves, the more proficient he or she becomes in this aspect of chemistry.

It is the purpose of this book not only to provide the beginning chemistry student with a relatively large number of problems that illustrate chemical principles, but also to facilitate his acquisition of problem-solving skills by helping him see that the skills he acquires even at the introductory level are relevant to the activities of practicing chemists. The hope is that the student will come to see that he is doing what is being done, not that he is merely repeating what has been done. To this end, the problems in the present text are based, wherever possible, on experimental results obtained by chemists, and the corresponding references are cited. The problems and techniques for solving them are intended to reflect the real features of one important aspect of chemistry.

Besides showing that problem solving even at the introductory level is directly relevant to the practice of chemistry, there are other aims implicit in the general approach taken in this book. One of the most important is to illustrate the use of significant figures in a practical way. It is one thing to learn that significant figures are important because one must learn them in order to pass a test. It is another to learn from example that they are constantly used by chemists and therefore are important for learning chemistry. Consistent citation of references should also provide an indirect introduction to the chemical literature (the instructor, of course, also has the option of using these references to introduce students directly to the literature). Finally, it will be no small gain if the student comes to appreciate that chemical knowledge represents the accumulation of results from the activities of a great many people, each one making a contribution, however small, to the enterprise called chemistry.

A brief word concerning the use of this book. Although it is intended primarily as a self-study supplement and answers to problems are given in an appendix, it can also be used by the instructor as a source of test problems and as a supplementary text. The first 18 chapters contain about 860 problems plus an additional 240 or so example problems with solutions worked out.

The problems at the end of these chapters are divided into two sections to facilitate the choosing of representative problems on the material covered in these chapters. Each section contains a complete selection of problems arranged in the same order as that of the corresponding material in the chapter. An additional 200 problems in Chapter 19 are grouped to correspond to standard organization of the descriptive portion of the introductory course. Since most of the earlier literature did not use the modern metric system of units, the original data are retained in the problems, whereas the answers are given in SI units.

In preparing this new edition, one thing became obvious in the literature, that is, many of the experiments that gave useful data for problems are rarely carried out today. Instrumentation is the keyword for most laboratory experiments of the present. The mass spectrometer is used to determine molecular mass rather than freezing point depression. In addition, even though data such as percent composition may be listed for a new compound, the data used to calculate the percent composition and the method used are rarely given. Despite this, we have found sufficient material to introduce new problems in just about every chapter except Chapter 19. We chose not to add any new additional problems to this chapter. Some new and interesting compounds such as AgF_3 have been prepared and data were available for use in the chapter on empirical formulas.

Although there are many people who have been helpful in developing this second edition, we would like to thank in particular Dr. Vahe Marganian of Bridgewater State College for the many discussions we have had with him. We would also like to thank Rosemary Daley, the wife of one of the authors, for the proofreading she has done, and the very cooperative and fine editors from Marcel Dekker, including Sandra Beberman, Henry Boehm, and especially Patricia Brecht, without whose help this revision could not have been accomplished.

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TO THE STUDENT

Solving problems by mathematical manipulation is an essential, daily experience of chemists. Students who seek even an elementary knowledge of chemistry must learn to solve a variety of problems. If for no other reason, then, a knowledge of the chemical principles and the mathematical manipulations necessary to solve typical chemical problems is important.

Students almost universally believe that they must *understand* the principles of chemistry before they can apply them to the solution of problems. Many students fail to realize that it is also necessary to *remember* statements of principles, definitions of terms, and many facts of a descriptive nature. The importance of a thorough understanding of the laws and theories of chemistry is not to be underestimated, but the need to *commit* to *memory* a certain body of information is equally important. A student may understand the concepts of an atom, molecule, mole, equivalent mass, and so on as he reads about them in the text, but this understanding is not enough if the student cannot recall the precise definition of the terms when he attempts to apply them to the solution of a problem.

Before trying to solve problems, *study* the relevant sections of the text and class notes. *Memorize* the precise meaning of important terms and statements of principles. The first step toward the successful solution of a problem is to read very carefully the statement of the problem. Next, reflect on the meaning of the terms and *determine exactly what is asked for by the problem.* (This point cannot be overemphasized. Probably the greatest source of confusion in any kind of problem solving stems from the failure to determine what is asked for. Obviously, we need to "understand" the problem. But we often forget that understanding a problem is above all a matter of knowing what kind of

answer we are looking for.) Once you have determined both what the problem asks for and what principles are required to provide the appropriate kind of answer, you can proceed in an orderly fashion to perform the necessary mathematical manipulations.

At this point, the most important advice is the following: *Be neat*. Fewer errors and time saved are the rewards of a neat, orderly approach to the solution of a problem. Write as legibly as you can and leave space between the steps.

Example

A compound containing 5.28% silicon and 94.66% iodine was prepared at M.I.T. Calculate the empirical formula of the compound. [W. C. Schumb and D. W. Breck, *J. Am. Chem. Soc.*, *74*, 1758 (1952)]

$$\frac{5.28}{28.1} = 0.188 \text{ mol Si}/100\text{ g}$$

$$\frac{\text{g}}{\text{g/mol}} = \text{g} \times \frac{\text{mol}}{\text{g}} = \text{mol}$$

$$\frac{94.7}{127} = 0.745 \text{ mol I}/100\text{ g}$$

$$\frac{0.745}{0.188} = 3.97$$

$$\frac{\text{mol I}}{\text{mol Si}}$$

$\therefore$ SiI_4 is the empirical formula.

If the proper procedure for solving the problem does not occur to you, read the pertinent sections in your text and notes again. Reconsider very carefully the definition of terms and the statements of principles. Very often, the difficulty is due to an inexact definition or failure to consider all that is implied in a definition or principle.

Although students study to acquire knowledge of a subject for many different reasons, they must all face the practical requirements of passing examinations. To prepare for examinations

they must *learn* or memorize definitions and principles, and they must *practice* the application of what they have learned by answering questions and solving problems similar to those that appear on examinations. This book is intended to assist the student in his *active preparation* for examinations in chemistry.

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