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STUDY GUIDE TO ACCOMPANY GENERAL CHEMISTRY PRINCIPLES AND STRUCTURE

PREPARED BY JAMES E. BRADY

THIRD EDITION

STUDY GUIDE

GENERAL CHEMISTRY

Principles and Structure
Third Edition

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PREFACE

In this third edition I have retained the same overall format of the Study Guide because so many students have found it useful. Because students usually study a chapter one section at a time, the Study Guide is divided into sections that exactly parallel those in the textbook. Each begins with a statement of objectives that prepares the student for what is to be presented and outlines what he or she is to accomplish. Also included in each section is a brief review. Here the key concepts that are developed in the section are summarized to bring them into focus. In some instances, especially in the critical early chapters, additional explanations of major topics are presented. In this edition I have added additional worked-out examples where appropriate to further complement those that appear in the textbook.

Most sections contain a brief self-test intended to allow students to test their mastery of the subject matter before moving on. Many of these self-tests have been expanded. They generally provide questions of graded difficulty to permit students to progress from simple problems in the direction of more complex ones. None of the problems are very difficult, however, since there is an ample number of difficult problems (those marked with an asterisk) available in the text itself.

Each section concludes with a list of new terms that have appeared in the corresponding section of the text. Students are urged to learn the meanings of these new terms before moving on.

In this edition the detailed solutions to selected numerical problems have been omitted because they and others are now available in a separate supplement. In their place is a Glossary that provides definitions of all the "new terms" that are listed in the Study Guide. Placement of the Glossary in the Study Guide was chosen so that students could easily refer to it, without losing their place, while studying chapters in the textbook.

James E. Brady

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BEFORE YOU BEGIN...

Before you begin your general chemistry course, read the next several pages. They're designed to tell you how to use this study guide and to give you a few tips on improving your study habits.

How to Use the Study Guide

This book has been written to parallel the topics covered in your text, General Chemistry: Principles and Structure. For each section in the text you'll find a corresponding section in the study guide. In the study guide the sections are divided into Objectives, Review, Self-Test and New Terms. Before you read a section in the text, read the Objectives in the study guide. This will give you a feeling for what to keep an eye on as you read the text. It should help you understand what you must pay attention to.

After you've read a section, return to the study guide and read the Review. This will point out specific ideas that you should be sure you have learned. Sometimes you will be referred back to the text to review specific items there. Sometimes there will be additional explanations of difficult or important concepts, and in some instances there will be additional worked-out sample problems. Work with the review and the text together to be sure you have mastered the material before going on.

In most sections you will also find a short Self-Test to enable you to test your knowledge and problem-solving ability. The answers to all of the self-test questions are located at the end of the chapters in the study guide. Try to answer the questions without having to look at the answers. A space is left after each question so that you can write in your answers and then check them all after you've finished.

An important aspect of learning chemistry is becoming familiar with the language. There are many cases where a lack of understanding can be traced to a lack of familiarity with some of the terms used in a discussion or a problem. A great deal of effort was made in your textbook to avoid using a term without first adequately defining it. Once it has been defined, however, it's used with the assumption that you've learned its meaning. It's important, therefore, to learn new terms as they appear, and for that reason, most of them are set in boldface type in the text. At the end of each section of the study guide there is a list of New Terms. Look them over and check to be sure you know their meaning before proceeding on to the next section. You might find it worthwhile to write out their meanings in your chemistry notebook. Then check yourself by referring to the Glossary at the back of the study guide. This will help you review important terms later when you prepare for quizzes or examinations.

Study Habits

You say you want to get an A in chemistry? That's not as impossible as you may have been led to believe, but it is going to take some work. The key is efficient study, so your precious study time isn't wasted. Efficient study requires a regular routine, not hard study one night and nothing the next. At first it is difficult to train yourself, but after a short time your study routine will indeed become a study habit and your chances of success in chemistry, or any other subject, will be greatly improved.

To help you get more out of class, try to devote a few minutes the evening before to reading, in the text, the topics that you will cover the next day. Read the material quickly just to get a feel for what the topics are about. Don't worry if you don't understand everything; the idea at this stage is to be aware of what your teacher will be talking about.

Your lecture instructor and your textbook serve to complement one another; they provide you with two views of the same subject. Try to attend lecture regularly and take notes during class. These should include not only those things your teacher writes on the blackboard, but also the important points he or she makes verbally. If you pay attention carefully to what your teacher is saying in class, your notes will probably be somewhat sketchy. They should, however, give an indication cf the major

ideas. After class, when you have a few minutes, look over your notes and try to fill in the bare spots while the lecture is still fresh in your mind. This will save you much time later when you finally get around to studying your notes in detail.

In the evening (or whatever part of the day you close yourself off from the rest of the world to really study intensely) review your class notes once again. Use the text and study guide as directed above and really try to learn the material presented to you that day. If you have prepared before class and briefly reviewed the notes afterward, you'll be surprised at how quickly and how well your concentrated study time will progress. You may even find yourself enjoying chemistry!

As you study, continue to fill in the bare spots in your class notes. Write out the definitions of new terms in your notebook. In this way, when it comes time for an exam you should be able to review for it simply from your notes.

At this point you're probably thinking that there isn't enough time to do all the things described above. Actually, the preparation before class and brief review of the notes shortly after class take very little time and will probably save more time than they consume.

Well, you're on your way to an A. There are a few other things that can help you get there. If you possibly can, spend about 30 minutes to an hour at the end of a week to review the week's work. Psychologists have found that a few brief exposures to a subject are more effective at fixing them in the mind than a "cram" session before an exam. The brief time spent at the end of a week can save you hours just before an exam (efficiency!). Try it (you'll like it); it works.

There are some people (you may be one of them) who still have difficulty with chemistry even though they do follow good study habits. Often this is because of weaknesses in their earlier education. If, after following intensive study, you are still fuzzy about something, speak to your teacher about it. Try to clear up these problems before they get worse. Sometimes, by having study sessions with fellow classmates you can help each other over stumbling blocks.

Problem Solving

A stumbling block for many chemistry students is numerical problems. Both the textbook and this study guide have worked-out examples in which the solutions to problems are given in rather great detail. Your instructor will also be showing you how to solve problems. But this is not enough! Learning to solve chemistry problems is like learning to play a musical instrument or drive a car. You only learn by doing. Even if you "understand" how a problem is worked out, you still have to try others yourself to see if you really understand the material sufficiently to solve them. Keep working out problems until you can do them; then you can stop. All the problems in the study guide have answers given. The even-numbered numerical problems in the text also have answers given in Appendix C. Work on these so that you can see whether you are getting them correct.

One of the goals of both the text and this study guide is to teach you how to solve numerical problems. Perhaps this one aspect of chemistry, more than all others, makes you fearful about your fate in the course - you're afraid of the "math." Actually, though, there is very little mathematics involved in solving most of the chemistry problems you will meet. Most of the difficulty comes in trying to interpret a question so that you know what kind of problem you're supposed to solve. In this section we'll go over some basic approaches to solving problems. If you have difficulty with a problem later on, review the ideas presented here and try to apply them. You'll find that they're useful not only in chemistry, but in other areas as well, including problems you encounter in day-to-day living.

"Word problems" always seem to present students with the most difficulty. "What am I supposed to find?" "Where do I begin?" These are the kinds of questions you've probably asked yourself when faced with a word problem. Many people have found the following to be the most effective way of approaching problems of this type.

Step 1. First, preview the problem to get an overview of the question - the "big picture." At this point, don't get bogged down by details. Don't worry about numbers or specific formulas that may be encountered in the question. Read the entire question without trying to analyze it in detail. Remember, at this point you're only interested in getting a view of the whole problem.

Step 2. After you've looked over the entire problem, the next step is to identify what it is you are asked to compute. Look for key phrases such as "Find...." or "How many...." or "What is...." These allow you to know where you're headed in the solution. You might also try to make an educated guess at the magnitude of the answer, although this isn't essential at this point.

Step 3. Now that you know where you're headed, look over the information provided in the question. Don't worry about the numbers yet; simply examine the nature of the preliminary data. Sometimes it's helpful to extract the data from a word problem and tabulate it so that it isn't cluttered with words.

Step 4. Consider next the kinds of calculations that you must perform on the data. Don't worry about the numbers yet. Simply analyze how you must combine the data in the problem to get the answer you want. Be sure you have everything you need. If you use the factor-label method described in Appendix A of the text, you should be able to write simple equality statements such as:

$$1 \text{ ft} = 12 \text{ in.}$$
$$1 \text{ yd} = 3 \text{ ft}$$

Notice that these two statements have the units "ft" in common and provide sufficient information to convert yards to inches, or vice versa. Be sure your equality statements connect all the units so that you have a path from the starting data to the final answer. If a connection between units is missing, you haven't assembled all the relationships that you need to work out the arithmetic. Look for the missing link, either in the data given in the problem or in the knowledge that you're supposed to bring to bear on that kind of problem.

In this step you also must be sure you have any necessary chemical equations or mathematical formulas. Be sure to write them down on paper - don't try to work with them in your head.

Step 5. Well, now you can finally worry about the numbers! At this point all of the necessary information has been compiled and you've decided how you must solve the problem. Now you should go about inserting numbers into formulas or constructing and applying the conversion factors as described in Appendix A of the text. If you've done your preparation in Steps 1 to 4, ob-

taining an answer in this step should not be difficult.

Step 6. Take a deep breath, you've done it! The problem is solved. As a final point, look at the answer you obtained. Does it seem reasonable? Are the units correct? If so, you're finished.

Time to Begin

Well, it's hoped that the few suggestions presented in this introduction will help you over the hurdles in chemistry. Move on to the course now, and good luck on getting that A!

1 INTRODUCTION

As its name implies, this chapter is meant to introduce you to the study of chemistry. It begins to lay the foundation for the remainder of the course. If you have had chemistry in high school, perhaps much of the material covered in this chapter will be familiar to you. You can test your knowledge by reviewing the list of new terms at the end of each section in Chapter 1 of the Study Guide and by taking the self-tests below. If you've never taken chemistry before, you should be sure to begin the course properly by gaining a thorough understanding of the topics treated here.

1.1 THE SCIENTIFIC METHOD

Objectives

To understand how science develops through the process of observation, formation of theories, and the design of new experiments that test these theories. You should know the distinction between a law and a theory; between qualitative and quantitative observations.

Review

The scientific method is the procedure that scientists use, either consciously or unconsciously, in their investigation of nature. Data are collected and condensed into laws. Theories are invented in an attempt to explain the laws. The theories suggest

new experiments that produce new data, new laws and ultimately new theories. This cycle repeates itself over and over as our understanding of nature grows.

Self-Test (True or False)

1. A law is based on repeated observation. _____
2. A law is an explanation of a theory. _____
3. Theories can always be proven to be correct. _____
4. Laws are often expressed in the form of a mathematical equation. _____
5. A hypothesis is a tentative law. _____
6. Numbers are usually associated with qualitative observations. _____

New Terms

scientific method
qualitative observation
quantitative observation
data
law
hypothesis
theory

1.2 MEASUREMENT

Objectives

To understand that the extent of our knowledge of the world about us is limited by the precision of the measurements that we make. You should be able to recognize the number of significant digits in a number and be able to express the result of a computation to the proper number of significant figures.

Review

Remember that in counting up significant figures in a number, only zeros that are not required for the sole purpose of locating the decimal point should be included. Some examples are:

number	number of significant figures
302	3
0.012	2
2.012	4
0.0120	3

In performing computations with numbers that come from measurements, remember these rules:

1. Multiplication or division. The answer has the same number of significant figures as the least precise factor in the calculation; for example,

$$3.05 \times 1.3 = 3.965 = 4.0$$

(3 sig. figures) (2 sig. figures) (answer rounded to 2 sig. figures)

2. Addition or subtraction. The number of significant figures in the answer is controlled by the quantity having the largest uncertainty; for example,

this quantity has largest uncertainty →	214.3	(implies uncertainty of ± 0.1)
	+ 21	(implies uncertainty of ± 1)
	235	(answer has implied uncertainty of ± 1)

Example 1.1

Perform the following arithmetic and express the answer to the proper number of significant figures. All the numbers come from measurement.

$$\frac{(2.500 + 0.10) \times 12.35}{1.468}$$

Solution

We perform the arithmetic within parentheses first.

$$2.500 + 0.10 = 2.60$$

Now our problem is

$$\frac{2.60 \times 12.35}{1.468} = 21.873297$$

Because 2.60 has only three significant figures, the answer is rounded to 21.9.

Exact numbers come from definitions. For instance, 1 mile is exactly 5280 feet, with no uncertainty. Similarly, 1 foot is exactly equal to 12 inches, no more or less. In calculations, these numbers may be assumed to possess any desired number of significant figures.

Example 1.2

A desk was measured to be 34.3 in. along its smallest length. Will it fit through a door that is known to be 2.75 feet wide?

Solution

Let's convert 34.3 in. to feet. We can use the relationship between feet and inches to construct a conversion factor (see Appendix A in the text) that enables us to change the units inches into the units feet.

$$34.3 \cancel{\text{in}} \left(\frac{1 \text{ ft}}{12 \cancel{\text{in}}} \right) = 2.86 \text{ ft}$$

Notice that we may assume that both the 1 and the 12 have as many significant figures as we wish. Since there are three significant figures in 34.3, the answer can be expressed to three significant figures. Also note that the desk won't fit through the door!

In Example 1.2 we have cancelled units just as on Page 7 of the text. You should spend some time now to study and review the factor-label method. It is described in detail in Appendix A (p 798) of the text. Although this method may seem foreign to you now, if you learn to apply it, you will find that setting up the arithmetic of chemistry problems is really not very difficult at all.

Self-Test

7. Give the number of significant figures in each of the following.
   (a) 205.3 _____
   (b) 113 _____

(c) 200.0 _____

(d) 0.005 _____

(e) 0.0000700 _____

8. Evaluate the following expressions to the proper number of significant figures (assume all numbers represent measured quantities).

(a) 2.43 x 1.875 = _____

(b) 0.017 x 5.968 = _____

(c) 1.43 x 2.584 x 0.008 = _____

(d) 12.5 ÷ 2.8 = _____

(e) 14.34 ÷ 4.780 = _____

(f) 5.146 + 0.002 = _____

(g) 5.146 + 0.02 = _____

(h) 8.08 + 80.8 = _____

(i) 14.45 + 7.521 + 100.3 = _____

(j) 2.92 - 8.4 = _____

9. Evaluate the following to the proper number of significant figures (assume all numbers represent measured quantities).

(a) $\dfrac{1.43 \times 2.658}{(2.65 + 0.01)}$ _____

(b) (6.33 x 8.415) + 8.02 _____

New Terms

significant figures
precision
accuracy
factor-label method
exact numbers

1.3 UNITS OF MEASUREMENT

Objectives

To learn the basic SI and metric systems of units and to become familiar with conversions from one unit to another

within the metric system. You should also learn to express numbers in scientific notation.

Review

You should familiarize yourself with the SI base units and their symbols. Those that you will encounter in this course are:

Physical quantity	Unit	Symbol
mass	kilogram	kg
length	meter	m
time	second	s
electric current	ampere	A
temperature	kelvin	K
quantity of substance	mole	mol

It is important to learn the eight SI prefixes printed in color in Table 1.2. Remember that when one of these prefixes is used, it modifies the basic unit by the corresponding factor in the first column of the table. For example, nano is a prefix meaning "x 10^{-9}." Therefore, 1 nanogram = 1 x 10^{-9} gram (or, 1 ng = 1 x 10^{-9} g, using the symbols for the prefixes and units). Study Table 1.3 to be sure you understand how to apply the SI prefixes.

Be sure you are well familiar with the units most used for measurements in the laboratory.

Measurement	Unit
length	meter, centimeter, millimeter
mass	gram
volume	liter, milliliter, cubic centimeter

Learn to convert from one unit to another (e.g., liters to milliliters, centimeters to millimeters, etc.). Remember:

1 cm = 10 mm
1 liter = 1000 ml = 1000 cm (or cc)

Most conversions that you will encounter between the English system and the metric system can be handled by remembering the following:

length: 1.00 inch = 2.54 cm
weight: 2.20 lb = 1.00 kg
volume: 1.00 quart = 946 ml