Study Guide for Chemistry

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INTRODUCTION

The study of chemistry offers many challenges to the beginning student.

- Chemistry cannot be presented in a "linear" fashion. In some respects, we must leap into the center of the subject, keep building on what we've studied, but keep returning to expand topics we have already covered.

- Much of chemistry is not "concrete," but requires abstract models. When you study introductory physics you can experiment with blocks sliding on planes, or balls travelling through trajectories. But you cannot hold an atom or molecule in your hand, or watch an electron in motion. When you are using a model, remember that the model is not the reality, but a simplified way of picturing a reality.

- You may not feel comfortable with chemistry during your introductory course: there are many topics to cover, and the pace is often swift. Some students read the text over and over, and the study guide as well, waiting for the subject to become comfortable <u>before</u> they attack the problems. Remember, chemistry is not a subject that can be mastered by reading. In spite of your discomfort, plunge into the problems: much of learning chemistry comes by doing.

<u>Hints for Studying Chemistry</u>

- Don't get behind! At most colleges and universities, at least three hours of work are expected outside of class each week for every hour in class. Don't expect to master the material in one long study session each week. Study chemistry often in shorter sessions.

- Read the assigned material in the text <u>before</u> it is covered in lecture: scan the chapter, pick out the key words, look at the sample problems. Then read the material in earnest; work out the sample problems. Don't expect the material to be crystal clear on the first pass. Do pick out the concepts that seem unclear. Try some of the basic problems at the end of the chapter.

- Take notes in lecture, but not at the expense of listening to, and trying to <u>understand</u> the lecture. Mark the material you don't understand in your notes.

- Ask questions! The only "dumb" question is the one you didn't ask. Some instructors encourage questions in class. If it is not appropriate to ask questions during a lecture, be sure to see your instructors after class, in the lab, or during office hours. Don't wait! New material lurks in the next lecture.

- Read the material in the text again. Do the problems.

- Don't spend too much time on any one problem. If you haven't made a good start within about 20 minutes, move on to another problem, or get help from an instructor or classmate.

- Do as many problems as you can.

- Make a plan for your solution before you begin; the study guide will give you examples.

- Write out the solutions to your problems: make the method of solution clear; this will help you when you review, and is good practice for your exams and quizzes.

- Carry out your solutions with appropriate units and significant figures.

- Does the numerical answer make sense? Do the units on the answer make sense? If not, go back and look for errors.

- Don't abuse the solutions, if they are available. It is too easy to look at someone else's solution to say, "Oh yes, I understand how to do that." The challenge is to be able to solve the problems yourself. On the other hand, if you are making absolutely no headway on a problem after a solid effort, reach for the solutions. Once that problem is clear, solve another one like it, to check your understanding.

- Don't memorize methods of solving problems. Be able to think out the solution. This study guide will give you some hints.

- If you are using a calculator on your exams, use your calculator to solve all your problems. Be comfortable with your calculator before your exams.

- Find a "buddy" or two to study with. Sometimes your understanding of a topic is improved by explaining it to someone else. Sometimes your fellow students understand your difficulties better than your instructor. Remember, though, in the end, it is <u>your</u> understanding that matters. Don't let your buddies do all the work.

How to Use This Study Guide

Your text has lots of sample problems, with solutions, a list of key terms and a chapter summary. Each section has a purpose listed, giving you your objectives for the section. The study guide will focus on areas where some students need extra help. The guide provides more examples, different ways of solving problems, different approaches to key concepts. Each chapter of the guide provides a quick short answer self-test. This self-test will help you pick out areas that you need to concentrate on.

Studying for an Exam

- Go over your notes and the problems that you've done.

- Do more problems for practice; do the problems with your book closed.

- Design your own practice test. What kinds of problems did your instructor focus on in class? Instructors all have their own styles--each will give a different sort of exam. What do you know about your instructor's style? What kinds of problems were assigned? What sorts of questions can you design to highlight the concepts you have covered? Remember, there will be little rote memorization; the focus will be on understanding concepts and solving problems.

- Be sure to get enough sleep the night before the exam. Make sure that your calculator batteries are charged, and that you have sharpened pencils ready.

Taking the Exam

- Take a deep breath. Relax. A little adrenalin improves your performance. Too much adrenalin can paralyze you. Remember, you've done lots of problems. And, your chemistry exam is designed to test your mastery of chemistry, not your unique value as a human being.

- Scan the entire exam before you begin.

- Pace yourself: if your exam is worth 100 points, and you have 50 minutes, expect to complete at least 10 points of questions in 5 minutes. Don't spend too long on any one problem.

- Do the problems or questions you find easiest first: remember, most exam questions are not arranged in order of difficulty. You may find an easy question at the end of the exam.

- Do set the problem up, before you carry out any calculations. Make your method of solution clear.

- Carry out your calculations with significant figures and appropriate units.

- Check that your answer makes sense. (These steps are ones you've practiced during your problem solving. By now they should feel comfortable.)

After the Exam

- While the exam is fresh in your mind, look at your text and your notes to clear up some of the puzzles. Then put thoughts of the exam aside.

- Your instructor may go over the exam in class, or post solutions to the exam. Figure out what mistakes you made, and, if you can, why you made them. What can you do differently next time? What did you learn about the kinds of exams your instructor gives? Remember, your study of chemistry keeps building on the material you've already covered. If there are holes in your understanding, they will plague you again, either in your study of new material, or on your final exam.

Using Your Calculator

Take time to explore the instruction book for your calculator. Then practice. Use your calculator to solve the problems in the text. Use your calculator to perform calculations in the laboratory. You need to be comfortable with your calculator before you face your first exam.

Entering Data

There are two different methods of entering data into calculators: RPN (Reverse Polish Notation) and algebraic notation (direct formula entry).

RPN resembles computer programming. Calculators using RPN have an ENTER key. To add 5 and 7 on an RPN calculator the key sequence is: 5 ENTER 7 + ; to multiply 5 and 7 the key sequence is: 5 ENTER 7 × .

You can enter a formula directly as written into a calculator using algebraic notation. To add 5 and 7 on a calculator using algebraic notation the key sequence is: 5 + 7 = ; to multiply 5 and 7 the key sequence is: 5 × 7 = . Calculators using algebraic notation have an equals (=) key.

Operations

You can carry out a series of operations on your calculator. But, be aware that each calculator has its own priorities for carrying out operations in a string.

If you have a calculator using algebraic notation try this key sequence.

2 + 3 × 3 =

What is your answer? 11. 2 + 3 × 3 is translated by your calculator into 2 + (3 × 3). Your calculator completes multiplication before it completes addition. If you wanted to calculate (2 + 3) × 3 you would use parentheses [(2 + 3) × 3 =] or use the "equals" key after 2 + 3: [2 + 3 = × 3 =].

Exercise care when "stringing together" division and multiplication. For example, to calculate

$$\frac{1.45 \times 2.62}{17.1 \times .543} =$$

Multiply 1.45 by 2.62, divide by 17.1 and divide by .543.

Estimate answers to catch errors. For example, in the preceding calculation we could estimate that the answer would be approximately

$$\frac{1.5}{15} \times \frac{2.5}{.5} \approx \frac{1}{10} \times 5 \approx \frac{1}{2} = .500$$

Check the answer on your calculator. [.409141331...]. If you found .1206... you made an error in your calculations. Can you find the error?

Significant Figures

A calculator may show too many significant figures after a calculation. We must round off the answer above to three significant figures, .409. Sometimes a calculator shows too few significant figures, Calculate

$$\frac{2556}{1278}$$

Some calculators do not show "trailing" zeros unless they are needed to locate a decimal point; these calculators show

$$\frac{2556}{1278} = 2,$$

not 2.000. Remember, you need to keep track of significant figures: your calculator won't.

Scientific Notation

Learn to enter numbers in scientific notation.

To enter 1.5×10^6, use the key sequence

1 • 5 EXP (or EE↓) 6 .

Do not use the × key!

Your calculator reads 1.5 06.

To enter 7.2×10^{-5}, use the key sequence

7 • 2 EXP +/− (or CHS) 5

Your calculator reads 7.2 − 05. If you use the "change sign" key (+/− or CHS) before you use the exponent key, you change the sign of the number; if you use the "change sign" key after you use the exponent key you only change the sign of the exponent.

Other Function Keys

Learn to:

Take logarithms to the base 10: LOG

Take logarithms to the base e: LN

Raise 10 to a power: 10^x or INV LOG

Raise a number y to a power x:

For example 3^4: 3 y^x 4 =

To take squares and square roots: x^2 , $\sqrt{x}$

To invert a number: $1/x$

Making Corrections

Learn to use your "clear" key [C ; C•CE], to make corrections. Usually an incorrect entry can be replaced so long as it has not been followed by an operation. For example, if you enter 7 × 5 , on a calculator using algebraic notation but the 5 should be a 6, use your "clear" key once: C 6 = 42. If the "clear" key is pressed twice, the calculator will be completely cleared. If the "clear" key is pressed once after an operations key [×, = , etc.] the calculator will be completely cleared.

Units

Remember to include units in your answers - your calculator won't keep track of them for you.

Care and Feeding

Treat your calculator gently. Don't tuck it in your back pocket, as you might damage it when you sit down. Don't let your calculator be crushed by books in your back pack. Keep your calculator dry - avoid contact with coffee, soft drinks and wet bathing suits! Keep your calculator away from heat - avoid hot radiators in the winter and hot vehicles in the summer sun.

Use your calculator often. Return to your instruction book now and then to explore and learn more about your calculator.

If your calculator uses batteries you might want to replace them before they fail completely. Avoid having your calculator "die" during an exam.

Enjoy your calculator. It may be frustrating at times - but calculators are easier to use (and friendlier) than slide rules, log tables and/or hand calculation.

CHAPTER ONE: CHEMICAL FOUNDATIONS

Chemistry is an experimental science, a systematic study of matter, the "stuff" of the universe, and the changes that matter undergoes. Much of chemistry involves quantitative observations, measurements, and the search for patterns among the observations.

Each measurement must be recorded with units and some indication of the uncertainty of the measurement.

Most scientists, and most of the nonscientific world, use the metric system (SI) of units. Most Americans resist the metric system, wary of converting inches to centimeters (1 in = 2.54 cm), quarts to liters (1 qt = .9464 L), miles to kilometers (1 mi = 1.61 km). However, converting among units in the metric system is much easier than in the English system. And once we abandon the English system, these curious conversion factors will be of only historical interest.

You can begin to develop a "metric feel" for the world by remembering:

A dime is about 1 millimeter thick.

Your little finger is about 1 centimeter wide.

Your pace is about 1 meter long (a bit longer than 1 yard).

A cup of water is nearly 1/4 of a liter (.237 L) and weighs nearly 1/4 of a kilogram.

You will probably be asked to convert measurements between the English system and the metric system for practice, but most of a chemist's calculations stay within the metric system.

Many measurements in science deal with very small numbers (e.g., the mass of an atom), and very large numbers (e.g., the number of water molecules in a "teaspoonful"). To simplify writing these numbers, we'll use "scientific" (or "exponential" notation).

Exponents

First, a quick review of exponents: (See Appendix 1.1.)

Exponent

$$10^4 = 10 \times 10 \times 10 \times 10$$

Base

i) When multiplying two numbers expressed to the same base, add exponents:

$$10^4 \times 10^3 = (10 \times 10 \times 10 \times 10) \times (10 \times 10 \times 10) = 10^{4+3} = 10^7$$

ii) When dividing two numbers expressed to the same base, subtract exponents:

$$\frac{10^5}{10^2} = \frac{10 \times 10 \times 10 \times 10 \times 10}{10 \times 10} = 10^{5-2} = 10^3$$

Then,

$$\frac{10^2}{10^5} = \frac{10 \times 10}{10 \times 10 \times 10 \times 10 \times 10} = \frac{1}{10 \times 10 \times 10} = 10^{2-5} = 10^{-3}$$

Therefore, negative exponents represent numbers smaller than 1.

And: $\frac{10^3}{10^3} = 10^{3-3} = 10^0$, which is 1.

Problem 1-1:

Multiply: $(3.2 \times 10^4) \times (1.6 \times 10^2)$:

Solution:

Rearrange and multiply: $(3.2 \times 1.6) \times (10^4 \times 10^2) = 5.12 \times 10^{(4+2)}$

$= 5.12 \times 10^6$

Problem 1-2:

Divide: $\frac{3.51 \times 10^2}{1.56 \times 10^3}$

Solution:

Rearrange: $\frac{3.51}{1.56} \times \frac{10^2}{10^3}$

$2.25 \times 10^{(2-3)} = 2.25 \times 10^{-1}$

Exponential Notation

Any number can be written as a number between 1 and 10, times a power of ten. For example: 357 can be written as 3.57×10^2; .0273 can be written as 2.73×10^{-2}.

Problem 1-3:

a. Write 5081 in exponential notation:

Solution:

Write 5081×10^0 (Remember $10^0 = 1$)

Move the decimal point to the left three places, to give a number between 1 and 10.

Increase the power of ten by 1 for each place you move the decimal point to the left.

$$5081. \times 10^0 = 5.081 \times 10^3$$

b. Write .0000769 in exponential form

Solution:

Write $.0000769 \times 10^0$

Move the decimal point to the right five places.

Decrease the power of ten by 1 for each place you move the decimal point to the right.

$$.0000769 \times 10^0 = 7.69 \times 10^{-5}$$

Learn to enter exponential numbers on your calculator:

Check your instruction book:

For example, to enter 5.081×10^3 key in:

5 . 0 8 1 EXP 3 (or 10^x : Find your exponent key)

Your display will show 5.081 03

the coefficient the power of 10

To enter: 7.69×10^{-5} key in:

7 . 6 9 EXP +/- 5

(Hint: Use the "Change Sign" key after the exponent key.)

Your display should read 7.69 -05

the coefficient the power of 10

Use your calculator to multiply:

$$(5.081 \times 10^{+3}) \times (7.69 \times 10^{-5}) = 3.907.... \times 10^{-1}$$

or .3907....

Learn to estimate your answer:

$$5.081 \times 10^{3} \text{ is about } 5 \times 10^{3}$$

$$7.69 \times 10^{-5} \text{ is about } 8 \times 10^{-5}$$

Our answer should be about $5 \times 8 \times 10^{3} \times 10^{-5}$

$$\approx 40 \times 10^{-2}$$

$$\text{or } 4 \times 10^{-1} \text{ or } .4$$

You can use your estimated answer to check your calculator's answer (or your entry on the calculator).

The Metric System

The metric system uses prefixes to designate larger and smaller units of measure. For example, the prefix *centi* indicates 1/100th; a centimeter is 1/100th of a meter. The prefix *kilo* indicates 1000; a kilometer is 1000 meters. We can "convert" from one unit of measure to another by moving the decimal point the appropriate number of places.

Problem 1-4:

a. A rod is 2.56 m (meters) long. How long is this rod in cm (centimeters)?

Solution:

1 meter = 100 centimeters

This rod is $2.56 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 256 \text{ cm}$

b. A package weighs 468 grams. How many kilograms does it weigh?

Solution:

1 kilogram = 1000 grams

or 1 gram = $\frac{1}{1000}$ kilogram or $\frac{1 \text{ kilogram}}{1000 \text{ grams}}$

This package weighs: $468 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = .468 \text{ kg}$

Memorize the meaning of the most common prefixes in Table 1.2.

Uncertainty

Every measurement involves some uncertainty. If you measure the length of a book with a centimeter ruler, your result will depend on how you position the "zero" point of your ruler, the angle that you read the scale on the ruler, how you estimate the position of the edge of the book, how finely divided the scale is, and how accurate the divisions are.

You should estimate and record the uncertainty of every measurement you make. Record all the certain digits and the first uncertain (estimated) digit in your measurement. These digits are called "significant figures."

If you measure a book with your centimeter ruler, and you record 23.6 cm, you are indicating that the book is 23.6 ± .1 cm (or between 23.5 and 23.7 cm) long. If you record 23, you are indicating the book is between 22 and 24 cm long. 23.6 has three significant figures, 23 has two significant figures.

Often you will calculate a result by combining uncertain measurements. Each result will also be uncertain.

Problem 1-5:

For example, you can determine the density of an object in the lab by weighing it, and measuring the volume of water it displaces in a graduated cylinder.

If you record the following data:

Mass of the object: 16.721 g

Volume reading of water in the cylinder: 22.7 cm^3

Volume reading of water + object in the cylinder: 34.5 cm^3

a. What is the volume of the object?

Solution:

$$\begin{array}{rl} 34.5\ cm^3 & \pm .1\ cm^3 \\ -22.7\ cm^3 & \pm .1\ cm^3 \\ \hline 11.8\ cm^3 & \end{array}$$

The uncertainty in the volume is at least ± .1 cm^3

b. What is the density?

Solution:

$$d = \frac{m}{v} = \frac{16.721\ g \pm .001\ g}{11.8\ cm^3 \pm .1\ cm^3}$$

The calculator reads = 1.417033898 g/cm^3

How well do we <u>really</u> know the density?

If our estimates of uncertainty are right:

The density could be as large as $\frac{16.721 + .001}{11.8 - .1} = 1.42923.... \frac{g}{cm^3}$

(using the largest mass and the smallest volume).

Or as small as $\frac{16.721 - .001}{11.8 + .1} = 1.405.... \frac{g}{cm^3}$

(using the smallest mass and the largest volume).

Therefore we should express the density as $\frac{1.42\ g}{cm^3}$.

$\left(\text{The uncertainty is about } \frac{.01\ g}{cm^3}\right)$.

Significant Figures

We'll use rules for "significant" figures to estimate the uncertainty in our calculated results.

1. In multiplication or division, the number of significant figures in a result is the same as the number of significant figures in the input factor with the fewest number of significant figures.

   In our density problem, 16.721 has 5 significant figures;

   11.8 has 3 significant figures.

   Therefore, the density should have 3 significant figures

   1.417.... g/cm^3

   is closer to 1.42 than to 1.41.

   Thus our answer was 1.42 g/cm^3.

   (Look at the "rounding rules" to come.)

2. In addition or subtraction, align the decimal points for the numbers and carry out the calculation. Then, find the first column from the left with an uncertain digit: that column determines the uncertain digit in your answer.

For example: Add 18.172, 5.18 and .0015

18.172
5.18
.0015
23.2535

certain first uncertain

The answer will be 23.25, with four significant figures.

Don't be misled by the enticing results on your calculator. Express each result with appropriate significant figures and units.

Hints: All non-zero digits are significant.

Leading zeros just determine the position of the decimal point and are not significant.

Trailing zeros after a decimal point or followed by a decimal point are significant.

Trailing zeros without a decimal point are ambiguous: these zeros may or may not be significant; you may have to decide from the context of the problem.

Numbers written in exponential form are not ambiguous.

Consider these numbers:

The leading zeros are not significant	$.00245 = 2.45 \times 10^{-3}$	3 significant figures
	$715.0 = 7.150 \times 10^{2}$	4 significant figures
	$5500 = 5.5 \times 10^{3}$	2 significant figures
	or $= 5.50 \times 10^{3}$	3 significant figures
	or $= 5.500 \times 10^{3}$	4 significant figures

Some measured numbers are exact. Counted numbers are exact (e.g., 35 students, 144 pens).

Other numbers are exact by definition: e.g., 1 kilogram equals exactly 1000 grams. Exact numbers never limit significant figures in calculations.