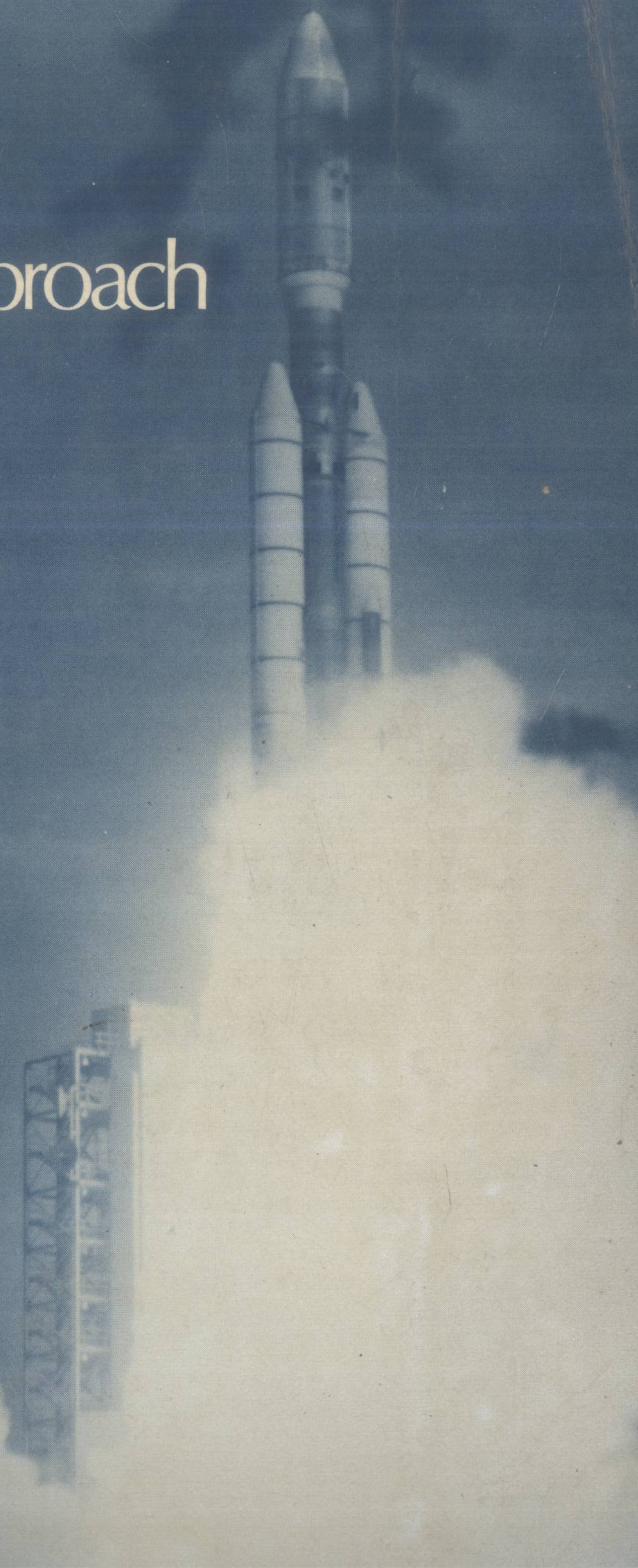
Mortimer

Chemistry
A Conceptual Approach

Fourth Edition

STUDENT SELF-STUDY GUIDE



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CHEMISTRY
A Conceptual Approach

FOURTH EDITION

STUDENT SELF-STUDY GUIDE

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D. VAN NOSTRAND COMPANY
New York Cincinnati Toronto
London Melbourne

D. Van Nostrand Regional Offices:
New York Cincinnati

D. Van Nostrand Company International Offices:
London Toronto Melbourne

ISBN: 0-442-25548-9

Published by D. Van Nostrand Company
135 West 50th Street, New York, N.Y. 10020

10 9 8 7 6 5 4 3 2 1

STUDENT

SELF-STUDY

GUIDE

Preface

The *Self-Study Guide* is designed to accompany the Fourth Edition of *Chemistry: A Conceptual Approach*, by Charles E. Mortimer. The organization of the guide follows that of the text, each chapter corresponding to one in the text. The guide may be used with little or no assistance from the instructor. It should be used, however, after the student has attended lectures and read the text.

Each chapter is divided into four parts: Objectives, Exercises, Answers to Exercises, and Self-Test. The first part provides a list of explicit objectives; the second contains verbal and mathematic exercises designed to help the student meet these objectives.

Exercises should be done sequentially and answers checked immediately upon completion. The answers to all exercises and detailed solutions to most problems are given in the third part. The answer to an exercise is generally given in the left column and the detailed solution to the right. The solutions include many hints, tables, and figures. Text references [in brackets] are given with many answers. The last part is a self-test and should be completed after studying lecture, text, and study guide material. The test is to be completed within a prescribed time, and answers are given without comment in the back of the guide. The self-test is representative of test questions given at Muhlenberg College and is not intended to be comprehensive or indicative of the type of questions that should be on an exam.

We hope that this guide is helpful and makes the study of chemistry more enjoyable.

—Donald and Louise Shive

Contents

Introduction

OBJECTIVES

I. You should be able to demonstrate your knowledge of the following terms by defining them, describing them, or giving specific examples of them:

Celsius temperature scale [1.2]
centi- [1.2]
chemical change [1.1]
compound [1.1]
element [1.1]
energy [1.1]
Fahrenheit temperature scale [1.3]
International System of Units and SI units [1.2]
kilo- [1.2]
matter [1.1]
micro- [1.2]
milli- [1.2]
phase [1.1]
physical change [1.1]
pure substance [1.1]

II. You should be able to write numbers in scientific notation.

III. You should be able to determine and work with the proper number of significant figures.

IV. You should study the instruction manual that came with your calculator.

EXERCISES

I. Write the following numbers in scientific notation:

_______ 1. 751
_______ 2. 781,000
_______ 3. 781,000.0
_______ 4. 0.050
_______ 5. 0.000745
_______ 6. one million
_______ 7. one-millionth
_______ 8. three-tenths

II. How many significant figures are contained in each of the following numbers?

_______ 1. 2.57
_______ 2. 0.0057
_______ 3. 0.570
_______ 4. 5.7×10^{-3}
_______ 5. 2.9979×10^{10}
_______ 6. 0.0821
_______ 7. 6.022×10^{23}
_______ 8. 900,000
_______ 9. 1.00
_______ 10. 0.75
_______ 11. 1.75
_______ 12. 1.750

III. Perform the following calculations and report the answer and the appropriate number of significant figures:

1. $6.0 + 297 + 8.75 =$

2. $7.41 + 0.02 =$

3. $6.9 + 0.001 =$

4. $182 - 99.2 =$

5. $(7.10 \times 10^{21}) + (7.10 \times 10^{20}) =$

6. $(6.4 \times 10^{-1}) - (4.21 \times 10^{-2}) =$

7. $7.1/9.64 =$

8. $(6.022 \times 10^{23})(1.70) =$

9. $(1.074 \times 10^{-4})(9.9) =$

10. $(7.45 \times 6.1)/2.45 =$

ANSWERS TO EXERCISES

I. Scientific notation

It is often inconvenient to work with the standard form of very large or very small numbers. For example, the multiplication involving the numbers 701,000 and 0.00000077 can easily be done incorrectly if we lose track of the zeros. An exponential notation, commonly referred to as scientific notation, is used to simplify calculations involving such numbers. The conversion from standard notation to scientific notation is quite simple, and a method for performing this conversion is summarized as follows:

(a) Move the decimal point so that there is a single digit (not zero) to its left, for example,

0.0000007⊙7

(b) Count the number of digits between the original and new decimal point positions to determine the magnitude of the exponent of 10, for example,

0.0000007⊙7
1234567

10^7

(c) Determine the sign of the exponent of 10 by the direction from the original to the new decimal point position (right is negative, left is positive), for example,

0.0000007⊙7 →

The direction indicates a negative sign. Thus,

0.00000077 equals 7.7×10^{-7}.

Properly used, scientific notation clearly indicates the number of significant figures. When we expressed 0.00000077 in scientific notation, we retained only the two sevens. The zeros preceding the sevens were expressed by the magnitude of the exponent. Thus, the zeros are not significant. Only the two sevens are significant. We can summarize the general rules concerning zeros in a number as follows:

(a) Zeros to the left of any digit other than zero are not significant.

(b) Zeros to the right of any digit other than zero are significant when a decimal point is included in the number. If a decimal point is not included in the number, the zeros to the right of any digit other than zero may or may not be significant.

(c) Zeros between digits other than zero are significant.

In the examples of this and the following section, we will see specific cases in which these general rules apply.

1. 7.51×10^2 3 significant figures

2. The number of significant figures to which the measurement was made is not clear in this example. The number can be written therefore in several forms, depending upon the precision of the measurement.

   7.81×10^5 3 significant figures

   7.810×10^5 4 significant figures

   7.8100×10^5 5 significant figures

   7.81000×10^5 6 significant figures

3. 7.810000×10^5 7 significant figures

4. 5.0×10^{-2} 2 significant figures

5. 7.45×10^{-4} 3 significant figures

6. 1×10^6 When a number if written in word form, we determine the number of significant figures by writing the number in numerical form and applying the general rules. If the number of significant figures is still unclear, we choose the lowest number. Thus, one million is 1,000,000 and has one significant figure. Occasionally, integers are given in word form and are meant to have an infinite number of significant figures. (See Table 1.1.)

7. 1×10^{-6} 1 significant figure

8. 3×10^{-1} 1 significant figure

TABLE 1.1. Significant Figures of Numbers Written in Word Form

Number in Word Form	Numerical Form	Number of Significant Figures
one thousand	1,000	1
one and five one-hundredth	1.05	3
fifty-five	55	2
one hundred and ten	110	2
two thousand and twenty	2,020	3 or 4
five million and twenty-four	5,000,024	7
six million and two thousand	6,002,000	4 to 7

1. 3
2. 2 — The zeros before and after the decimal point only show the position of the decimal point. It is better to write this number in scientific notation as 5.7×10^{-3}. *Zeros to the left of any digit other than zero are not significant.*
3. 3 — *Zeros to the right of any digit other than zero are significant if a decimal point is included in the number.*
4. 2 — When a number if written in scientific notation, the number of significant figures is determined by the whole number. The exponent shows the position of the decimal.
5. 5
6. 3
7. 4 — *Zeros between digits other than zero are significant.*
8. 1, 2, 3, 4, 5, 6 — The number of significant figures depends upon the precision of the measurement.
9. 3 — Rule (b)
10. 2 — Rule (a)
11. 3
12. 4 — Rule (b)

III. Calculations

1. 3.12×10^2 — After the addition is performed, the answer, 311.75, is rounded off to the correct number of significant digits as determined by the smallest number of digits to the right of the decimal point in any of the numbers that are being added. The number 279 has no digits to the right of the decimal. The sum, therefore, is reported as 312, or preferably as 3.12×10^2. This procedure should be followed whenever addition or subtraction is performed.
2. 7.43
3. 6.9
4. 83 — Notice that the number 82.8 is rounded off to 83. The answer has fewer significant figures than either number used in the calculation.
5. 7.81×10^{21}
6. 6.0×10^{-1}

7. 0.74 In both multiplication and division the answer is usually rounded off to the smallest number of significant figures contained in any of the numbers involved in the calculation. This rule normally works well, and we will use it exclusively.

8. 1.02×10^{24}

9. 1.1×10^{-3}

10. 1.9×10^{1}

SELF-TEST

Complete the test in 15 minutes.

I. Answer each of the following:

_______ 1. The process of water changing into steam is called
(a) freezing (c) a physical change
(b) a chemical change (d) fusion

_______ 2. The number 0.070020 has how many significant figures?
(a) 1 (b) 2 (c) 4 (d) 5

_______ 3. The number 0.070020 should be written in scientific notation as
(a) 7.002×10^{2} (c) 7.0020×10^{-2}
(b) 7.002×10^{-2} (d) 7.0020×10^{2}

_______ 4. The number 700 should be written in scientific notation as
(a) 7×10^{2} (c) 7.00×10^{2}
(b) 7.0×10^{2} (d) cannot be determined

_______ 5. One microgram is equal to
(a) 10^{3} g (c) 10^{6} g
(b) 10^{-3} g (d) 10^{-6} g

_______ 6. One kilometer equals
(a) 10^{3} m (c) 10^{6} m
(b) 10^{-3} m (d) 10^{-6} m

_______ 7. The number 700.0 should be written in scientific notation as
(a) 7×10^{2} (c) 7.000×10^{2}
(b) 7.00×10^{2} (d) 7.000×10^{3}

_______ 8. The process of gasoline burning in an automobile cylinder is called
(a) a physical change (c) vaporization
(b) a chemical change (d) boiling

_______ 9. The sum of the number of 71.742, 6.0, and 21.3413 is
(a) 99.0833 (c) 99.1
(b) 99.0 (d) 1.0×10^{2}

10. The number 199.969, rounded off to three significant figures, should be written as
    (a) 200 (c) 2×10^2
    (b) 199 (d) 2.00×10^2

11. The number 0.74 has how many significant figures?
    (a) 1 (c) 3
    (b) 2 (d) 4

12. The physical state of matter that assumes the shape of its container only within the limit of the volume that the sample occupies is
    (a) vapor (c) liquid
    (b) gas (d) solid

13. SI units are
    (a) units of the International System
    (b) Standard International units
    (c) Substituted International units
    (d) Scientific International units

14. Multiplication of the number 23.6 by the number 7.50×10^3 yields
    (a) 1.77×10^3 (c) 1.7×10^5
    (b) 1.77×10^5 (d) 177×10^3

15. A cow produces milk from ingested foodstuffs. This process can be called
    (a) a liquefaction (c) a physical change
    (b) a chemical change (d) a biological marvel

2

Atomic Structure

OBJECTIVES

I. You should be able to demonstrate your knowledge of the following terms by defining them, describing them, or giving specific examples of them:

alpha ray [2.5]
atom [2.1, 2.5]
atomic mass unit, μ [2.8]
atomic number, A [2.8]
atomic weight [2.8]
Balmer lines [2.10]
Bohr theory [2.10]
cathode rays [2.2, 2.3]
coulomb [2.2]
diamagnetism [2.14]
electromagnetic radiation [2.9]
electron [2.2]
electronic configuration [2.14]
frequency [2.9]

gamma ray [2.5]
Hund's rule [2.14]
isotope [2.7]
mass number, Z [2.6]
neutron [2.4]
nucleus [2.5]
orbital [2.12]
paramagnetism [2.14]
Pauli exclusion principle [2.13]
periodic table [2.11]
photon [2.9]
proton [2.3]
quantum numbers [2.13]
quantum theory [2.9]
radioactivity [2.5]
spectrum [2.10]
transition element [2.15]
valence shell [2.14]
wavelength [2.9]
X ray [2.9, 2.11]

II. You should be able to determine the number of protons, neutrons, and electrons in any isotope of any element.

III. You should be able to calculate atomic weights from masses and relative abundances of isotopes.

IV. You should understand the relationship between energy and frequency, $E = h\nu$ or $E = hc/\lambda$, and be able to work problems relating to these equations.

V. You should understand the Bohr theory.

VI. You should be able to write a complete set of quantum numbers for each electron of any element.

VII. You should be able to write the electronic configuration of each element in the periodic table and of any monatomic ion. You should also be able to predict the number of unpaired electrons and the magnetic properties of each of these species.

UNITS, SYMBOLS, MATHEMATICS

I. You should start building your understanding of SI notation and learn some of the prefixes that are used in conjunction with these standard units. For example, the measurement of length is the meter, m. Some of the standard prefixes used with the meter are listed in Table 2.1, along with the meaning of each symbol.