second edition ftp_nm

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Design A Chemistry/Physics

The Molecular Nature of Matter and Change ftp_st

ftp_au **Brian Laird**

ftp_af *University of Kansas*

ftp_tx With significant contributions by

ftp_au_a **Raymond Chang**

ftp_af_a *Williams College*

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FOR CHEMISTRY/PHYSICS TEMPLATE A

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C-17 M-0 Y-8 K-8	C-6 M-0 Y-4 K-4	C-100 M-90 Y-0 K-20	C-4 M-0 Y-0 K-6
C-80 M-0 Y-0 K-40	C-100 M-55 Y-0 K-15	C-100 M-25 Y-25 K-0	C-0 M-0 Y-35 K-15
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Higher Education

fcp_tx UNIVERSITY CHEMISTRY

To Deb, Morgan,
Ava, and Brynna
with all my love

- David -

faa_tt

About the **Author**

faa_au

faa_tx

FPO

Brian Laird was born in Hong Kong and grew up in Shanghai and Hong Kong, China. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers.

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Brief **Contents**

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Expanded **Contents**

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Preface

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New and Improved Changes

We define the main goal of this edition is to further improve areas that will facilitate the instructor and aid students in important areas such as organization, art program, readability, and media.

- » The chapter on coordination chemistry has been moved to near the end of the book.
- » The main goal of this edition is to further improve areas that will faciliate the student to learn better.
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Readability

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Animations

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William E. Acree *University of North Texas*

June Bronfenbrenner *Anne Arundel Community College–Arnold*

Adedoyin Adeyiga *Bennett College*

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—Brian Laird

Features

Each chapter opening section contains a vibrant photograph to introduce the chapter as well as a clear, concise chapter outline. Then, to spark the student's interest, the chapter text begins on the actual opening page.

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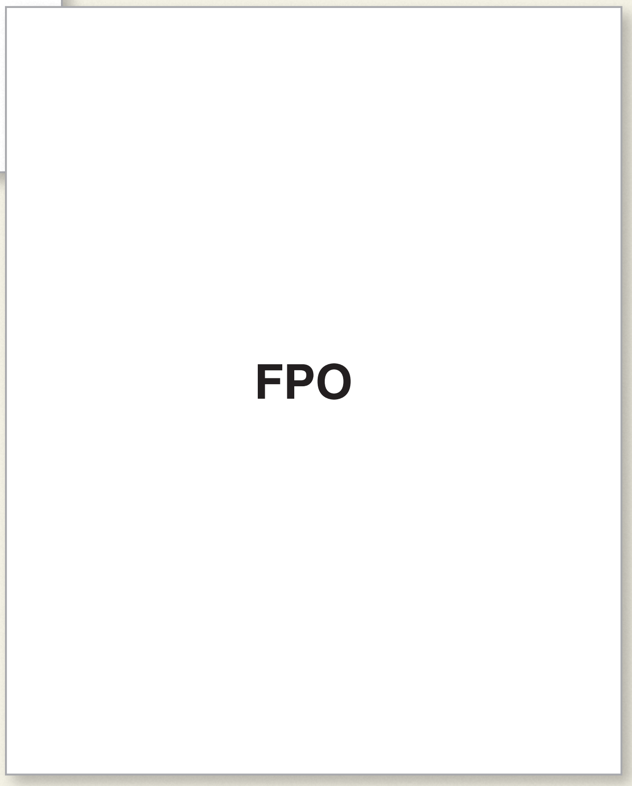

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To the Student

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fts_ha

How to Succeed in Chemistry Class

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fts_lb

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fts_hb

Commitment of Time and Perseverance

fts_ln

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fts_hc

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Getting Organized

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List of Selected Applications

ffm_ha

Biology/Life Science

ffm_lu

Chemistry

Geology/Earth Science

bch_nm

Chapter 0

bch_tt

The Basic Language of Chemistry

FPO

bchop_fgct

Chapter opening photo caption looks like this. It can vary in length, so the box will need to be adjusted as needed.

bopto_tx

Chapter Outline

bopto_tx

bchop_tx

Chapter Overview

Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of society. Its roots are ancient, but as we will soon see, chemistry is every bit a modern science. We will begin our study of chemistry at the macroscopic level, where we can see and measure the materials of which our world is made. In this chapter we will discuss the scientific method, which provides the framework for research not only in chemistry but in all other sciences as well. Next we will discover how scientists define and characterize matter. Then we will familiarize ourselves withe the systems of measurement used in the laboratory. Finally, we will spend some time learning how to handle numerical results of chemical measurremeents and solve numerical problems.

The Chinese characters for chemistry mean "The study of change." bch_fgct_a

11.2 The Relationsip Between Conjugatae Acid-Base Ionization Constants bch_ha

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air). Thus, everything in the universe has a "chemical" connection we can see and touch. bch_tx

Summary of Rules for Writing Equilibrium Constant Expressions bch_hb

A substance is a form of matter that has a definite (constant) composition and distinct properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

a. How many electrons are present in a particular atom? How many electrons are present in a particular atom? bch_la
b. What energies do individual electrons possess? How many electrons are present in a particular atom?

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$ bch_eq

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

Method 1	**Method 2**
3.66 + 8.45 = 30.9	3.66 + 8.45 = 30.93
30.9 + 2.11 = 65.2	30.93 + 2.11 = 65.3

bch_lutt bch_lu

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

B_2H_6	diborane
CH_4	methane
SiH_4	silane
NH_3	ammonia

bch_lu_a

Under certian conditions of pressure and temperature, most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor.

bch_eq_a $$CaCO_3(s) + CaO(s) = CO_2(g) \quad [4.1]$$ bch_eq_nm

The physical properites of a substance often depend on its state. most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor. The physical properites of a

bch_tbnm

Table 4.1 Heats of Solution of Some Ionic Compounds bch_tbtt

Compound	ΔH_{soln} (kJ/mol)	
LiCl	–37.1	exothermic
$CaCl_2$	–82.8 s	
NaCl	4.0	
KCl	17.2 r	endothermic
NH_4Cl	15.2	

bch_tbcn bch_tbtx

bchnt_tt

Physics Today

A gas is a substance that is normally in the gaseous state at ordinary temperatures and pressures; a vapor is the gaseous form of any substance that is a liquid or a solid at normal temperatures and pressures.

bchnt_tx

THIS IS JUST SOME PLA HOLDER TEXT TO SH STYLES.

bch_fgnm

Figure 1.3 (a) The output from an automated DNA sequencing machine. Each lane displays the sequence (indicated in different colors) obtained with a separate DNA sample. (b) Photovoltaic cells. (c) A silicon wafer being processed. (d) The leaf on the left was taken from a tobacco plant that was not genetically engineered but was exposed to tobacco hron worms. The leaf on the right was genetically engineered and is barely attached by the worms. The same technique can be applied to protect the leaves of other types of plants.

bch_fgct

substance often depend on its state. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

bch_lb

- » If a number is greater than 1, then all the zeros written to the right of the decimal point count as significant figures.
- » **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
- » Any digit that is not zero is significant. Thus 845 cm has three significant figures, 1.234 kg has four significant figures, and so on.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

bch_ln

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass, and chemical properties.
12. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

bch_hc

This Is a Third Level Head

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements.

bch_hd

D-Head Runs In The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

Figure 1.3 Thomson's model of the atom, sometimes descibed as the "plum-pudding" modle, after a traditional English dessert containing raisins. The electrons are embedded in a uniform, positively charged sphere. © Harry Bliss. Originally published in the New Yorker Magazine.

bch_fgso

bch_fn

†John Dalton (1766–1844). English chemist, mathmetician, and philosopher. In addition to the atomic theory, he also formulated several gas laws and gave the first detailed description of color blindness.

††John Dalton (1766–1844). English chemist, mathmetician, and philosopher.

bchba_tt

Metal from the Sea

bchba_tx

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

bchba_eq

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

bchba_ha

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties.

bchba_lb

- If a number is greater than 1, then all the zeros written to the right of the decimal point.
- **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
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bchba_ln

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Chemists distinguish among several subcategories of matter based on composition and properties. Chemists distinguish among several subcategories of matter based on composition and properties.

FPO

bchba_fgnm bchba_fgct

Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

bchba_tbtt

Unnumbered Table Per Survey

bchba_tbcn bchba_tbtx

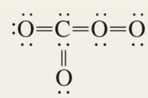
Component	Melting Point (°C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

bchba_tbfn bchba_tbso

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter include substances, mixtures.

bchba_cd



Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures,

bch_tbnm bch_tbtt

Table 10.1 Some Substances Found as Gasses at 1 atm and 25°C

bch_tbsh bch_tbcn bch_tbtx

Straddle Head Example		
Elements	**Compounds**	**Column**
H_2 (molecular hydrogen)	HF (hydrogen fluoride)	0.5
N_2 (molecular nitrogen)	HCl (hydrogen chloride)	0.6
O_2 (molecular oxygen) turnover lines	HBr (hydrogen bromide)	1.2

bch_tbfn bch_tbso

* The boiling point of HCN is 268, but is close enough to qualify as a gas at ordinary atmospheric conditions.

Source: The boiling point of HCN is 268.

elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties.

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass.
2. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

3s $2p_x$ $2p_y$

(a) (b)

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

bchea_tt

bchea_nm

Example 19.1 Calculating Molecular Mass

bchea_tx

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

bchea_ha

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

bchea_la

(a) This is an alpha sublist entry example within an exersice.
(b) This is an alpha sublist entry example within an exersice this is an alpha sublist entry example within an exercise with a runover.

bchea_eq

$$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg } H_2O} \; 5 \; 4.19 \text{ mole EG/Kg } H_2O \; 5 \; 4.19 \text{ m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

Comment 6.07 g is smaller than the molar mass, the answer is reasonable. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

$(NH_2)_2CO$

bch_fgct_b

Solution The number of moles of EG in 651 g EG is. To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

bchea_ld

Step 1: We can deduce the skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 3: Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

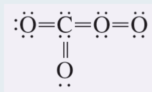
Check Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

bchea_lutt	Reactants	Products
bchea_lu	Al(4)	Al(4)
	O(6)	O(6)

(a) This is an alpha sublist entry example within an exersice.

(b) This is an alpha sublist entry example within an exersice this is an alpha sublist entry example within an exersice with a runover.

bchea_cd



Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances

Example 19.2

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

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$$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg } H_2O} \; 5 \; 4.19 \text{ mole EG/Kg } H_2O \; 5 \; 4.19 \text{ m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

differ from one another in composition and can be identified by their appearance, smell, taste, and other properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

11.3 | The Structure of the Atom

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air).

bch_ld

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bcesu_tt

Chapter Summary

bcesu_ha

Section 1.1

bcesu_lb

» The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. The energyof the rays emitted by the radioactive isotoped is characterstic of arsenic and the intensity of the rays establishes how much arsenic is present in a sample.

» The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Section 1.2

» The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

bcekt_tt

Key Words

bcekt_tm

Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
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Chemical energy, p. 206

Questions and Problems

The Nature of Energy and Types of Energy

Review Questions

5.1 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

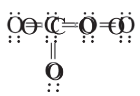
5.2 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

5.3 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.4 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.5 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.



5.6 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Problems

5.7 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered Table Per Survey

Component	Melting Point (˚C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

5.121 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered List entry   List entry
List entry   Unnumbered List entry

5.122 The arsenic in Napoleon's hair was detected.

(a) As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons.

(b) As-76 isotope.

5.123 The arsenic in Napoleon's hair was detected.

Special Problems

5.123 The arsenic in Napoleon's hair was detected using a technique called neutron activ

(a) Does a single molecule have a temperature?

(c) Comment on the validity of the previous statements.

15.124 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

Answers to Practice Exercises

3.1 10.81 amu. **3.2** 3.59 moles. **3.3** 2.57 X 10^3g. **3.4** 8.49 X 10^{21} K atoms. **3.5** 32.04 amu. **3.6** 1.66 moles. **3.7** 5.81 X 10^{24} H atoms. **3.8** H: 2.055%; S: 32.69%; O: 65.25%. **3.9** $KMnO_4$ (potassium permanganate). **3.10** 196 g. **3.11** B_2H_6. **3.12** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.13** 235 g. **3.14** 0.769 g. **3.15** (a) 234 g, (b) 234 g. **3.16** (a) 863 g, (b) 93.0%. **3.17** H: 2.055%; S: 32.69%; O: 65.25%. **3.18** $KMnO_4$ (potassium permanganate). **3.19** 196 g. **3.20** B_2H_6. **3.21** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.22** 235 g. **3.23** 0.769 g. **3.24** (a) 234 g, (b) 234 g. **3.24** (a) 863 g, (b) 93.0%.

eap_nm

Appendix 1

eap_tt

Derivation of the Names of Elements*

eap_tbcn

eap_tbtx

Elements	Symbol	Atomic No.	Atomic Mass	Date of Discovery	Discoverer and Nationality	Derivation
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. aktis, beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.) compound in which it was discovered; derived from L. *alumen,* astringent taste	Alum, the aluminum
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a substance which combines readily; symbol L. *stibium,* mark
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. *aktis,* beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered; derived from L. *alumen,* astringent taste
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. *stibium,* mark
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. *aktis,* beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered

eap_tbso *Source:* Reprinted with permission from "The Elements and Derivation of Their Names and Symbols," G.P. Dinga, Chemistry 41 (2), 20-22 (1968).

eap_tbfn * The boiling point of HCN is 26°, but is close enough to qualify as a gas at ordinary atmospheric conditions.

Appendix 2

Units for the Gas Constant

In this appendix we will see how the gas constant R can be expressed in units J/K mol. Our first step is to derive a realtionship between atm and pascal. We start with:

$$\log 6.7 \text{ X } 10^{24} = 23.17$$
$$\log 6.7 \text{ X } 10^{24} = 23.17$$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithms

The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithms

Common Logorithms

The concept of the logarithms is an extension of the concept of exponents, which is discussed in Chapter 1. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithm	**Exponent**
$\log 1 = 0$	$10^0 = 1$
$\log 10 = 1$	$10^1 = 10$
$\log 100 = 2$	$10^2 = 100$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number.

Inorganic Substances

Substance	(kJ/mol)	(kJ/mol)	(J/K . mol)	Cp
Ag(s)	0	0	42.7	42.7
Ag^{1}(aq)	105.9	77.1	73.9	73.9
AgCl(s)	2127.0	2109.7	96.1	96.1
Ag(s)	0	0	42.7	42.7
Ag^{1}(aq)	105.9	77.1	73.9	73.9

Glossary

egl_tt

egl_tx

The number in parentheses is the number of the section in which the term first appears.

egl_ha

A

egl_tm

egl_df

absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

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absolute temperature scale. A temperature scale that uses the absolute zero. (5.3)

accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

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absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

B

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute.

Answers

esa_tt

esa_st

to Even-Numbered Problems

esa_ha

Chapter 1

esa_ln

1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 **1.12** (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
1.4 (a) Zn(s) 1 Cu21(aq) Zn21(aq) 1 Cu(s) **1.12** (a) Physical. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms (e) Physical change. **1.14** (a) K. (b) Cu21(aq) Zn21(aq) 1 Cu(s).
1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 1.12 (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change. (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
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1.4 (a) Hypothesis. (b) Law. (c) Theory **1.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.

Chapter 2

2.4 (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*) **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) K. (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*). (d) Chemical change (e) Physical change. **2.14** (a) K. (b) [Xe]6$s^2$4f^{14}5d^5
2.4 (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) [Xe]6$s^2$4f^{14}5d^5 (d) Chemical change (e) Physical change. **2.14** (a) K. (b) Sn. (c) Cr. (d) B.
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2.4 (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. **2.14** (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*).

Chapter 3

3.4 (a) Hypothesis. (b) [Xe]6$s^2$4f^{14}5d^5 **3.12** (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **3.14** (a) K. (b) Sn. (c) Cr. (d) B.
3.4 (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*) **3.12** (a) Physical. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **3.14** (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*). **3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. **3.14** (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) [Xe]6$s^2$4f^{14}5d^5 **3.12** (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **3.12 3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **3.14** (a) K. (b) Sn. (c) Cr. (d) B.
3.4 (a) Hypothesis. (b) Sn. (c) Cr. (d) B (b) Sn. (c) Cr. (d) B (b) Law. (c) Theory **3.12** (a) Physical change. (b) Chemical change. (c) [Xe]6$s^2$4f^{14}5d^5 (e) Physical change. **3.14** (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) Law. (c) Theory
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3.14 (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*). (c) Physical change. (d) Chemical change (e) Physical change.
3.15 (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change.
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3.14 (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Zn(*s*) Ú Cu^{2Ú}(*aq*) Zn^{2Ú}(*aq*) Ú Cu(*s*). (c) Physical change. (d) Chemical change (e) Physical change.
3.15 (a) K. (b) Sn. (c) Cr. (d) B. **3.4** (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) Physical change. (b) Chemical change.

Credits

ecr_tt

ecr_ha

ecr_tx

Chapter 1

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Chapter 3

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Chapter 5

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Chapter 6

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Index

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Chapter 4

Chemical Bonding in Polyatomic Molecule

Molecular Geometry and Interaction

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Chapter Outline

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Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of society. Its roots are ancient, but as we will soon see, chemistry is every bit a modern science. We will begin our study of chemistry at the macroscopic level, where we can see and measure the materials of which our world is made. In this chapter we will discuss the scientific method, which provides the framework for research not only in chemistry but in all other sciences as well. Next we will discover how scientists define and characterize matter. Then we will familiarize ourselves withe the systems of measurement used in the laboratory. Finally, we will spend some time learning how to handle numerical results of chemical measurremeents and solve numerical problems.

Metal from the Sea

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties.

- » If a number is greater than 1, then all the zeros written to the right of the decimal point.
- » **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
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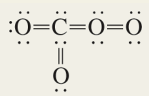
Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

Unnumbered Table Per Survey

Component	Melting Point (˚C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter include substances, mixtures.



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Study Hint

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If you have a clear idea of what you want to accomplish before you begin to read a chapter. your reading will be more effective. The questions in this chapter outline—as well as those in the subheadings of each section—can serve as a checklist for mea[…] progress as your read. A clear picture of what questions are going to be addressed and where the answers will be found forms a mental road map to guide you through the chapter. Take a few minutes to study the outline and fix this road map in your mind. It will be time well spent.

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Summary of Rules for Writing Equilibrium Constant Expressions

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bch_df

Mass is a measure of an object's inertia, the property that causes it to resist a change in its motion.

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bch_et

Aristole's ideas on motion, although not capable of making quantitative predictions, provided explanations that were widely accepted for many centuries and that fit well with some of our own common sense thinking.

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B_2H_6 diborane
CH_4 methane
SiH_4 silane
NH_3 ammonia

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Further Readings

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Espenson, J.H.: *Chemical Kinetics and Reaction Mechanisms,* 2d ed., McGraw-Hill, 1995

Eyring, H., D. Henderson, and W. Jost (eds.): *Physical Chemistry: And Advanced Treatise, Academic,* 1967-1975

Frost, W.: *Theory of Unimolecular Reactions, Academic,* 1973.

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Friebolin, H.: *Basic One- and Two-Dimensional NMR Spectroscopy,* 3d ed., Wiley, 1998

Espenson, J.H.: *Chemical Kinetics and Reaction Mechanisms,* 2d ed., McGraw-Hill, 1995

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Second Edition

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The Molecular Nature of Matter and Change

Brian Laird
University of Kansas

With significant contributions by
Raymond Chang
Williams College

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CTP CHEMISTRY TEMPLATE

C-0 M-0 Y-25 K-10	C-20 M-0 Y-60 K-0	C-17 M-0 Y-8 K-8	C-0 M-0 Y-0 K-10
C-90 M-39 Y-0 K-0	C-25 M-0 Y-100 K-40	C-100 M-25 Y-25 K-0	C-0 M-0 Y-0 K-15
C-98 M-47 Y-0 K-5	C-35 M-0 Y-100 K-45	C-100 M-40 Y-40 K-0	C-0 M-0 Y-0 K-50
C-100 M-55 Y-0 K-15	C-35 M-0 Y-100 K-55	C-100 M-44 Y-44 K-10	C-0 M-0 Y-0 K-75

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University Chemistry

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To Deb, Morgan,
Ava, and Brynna
with all my love

- David -

The McGraw·Hill Companies

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About the Author

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FPO

Brian Laird was born in Hong Kong and grew up in Shanghai and Hong Kong, China. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers.

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Brief Contents

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Expanded Contents

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Preface

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New and Improved Changes

We define the main goal of this edition is to further improve areas that will facilitate the instructor and aid students in important areas such as organization, art program, readability, and media.

- » The chapter on coordination chemistry has been moved to near the end of the book.
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William E. Acree *University of North Texas*
June Bronfenbrenner *Anne Arundel Community College–Arnold*
Adedoyin Adeyiga *Bennett College*
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Gul Afshan *Milwaukee School of Engineering*
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—Brian Laird

Features

Each chapter opening section contains a vibrant photograph to introduce the chapter as well as a clear, concise chapter outline. Then, to spark the student's interest, the chapter text begins on the actual opening page.

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Pedagogy

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To the Student

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How to Succeed in Chemistry Class

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List of Selected Applications

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Biology/Life Science

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Chemistry

Geology/Earth Science

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Chapter

23

The Basic Language of Chemistry

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Chapter Outline

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Chapter Overview

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The Chinese characters for chemistry mean "The study of change."

Summary of Rules for Writing Equilibrium Constant Expressions

A substance is a form of matter that has a definite (constant) composition and distinct properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

a. How many electrons are present in a particular atom? How many electrons are present in a particular atom?
b. What energies do individual electrons possess? How many electrons are present in a particular atom?

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Table 4.1 Heats of Solution of Some Ionic Compounds

Compound	ΔH_{soln} (kJ/mol)
LiCl	–37.1
$CaCl_2$	–82.8
NaCl	4.0
KCl	17.2
NH_4Cl	15.2

bchnt_tt

Physics Today

A gas is a substance that is normally in the gaseous state at ordinary temperatures and pressures; a vapor is the gaseous form of any substance that is a liquid or a solid at normal temperatures and pressures.

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bch_fgnm

Figure 1.3 (a) The output from an automated DNA sequencing machine. Each lane displays the sequence (indicated in different colors) obtained with a separate DNA sample. (b) Photovoltaic cells. (c) A silicon wafer being processed. (d) The leaf on the left was taken from a tobacco plant that was not genetically engineered but was exposed to tobacco hron worms. The leaf on the right was genetically engineered and is barely attached by the worms. The same technique can be applied to protect the leaves of other types of plants.

bch_fgct

example, can be solid ice, liquid water, or steam or eater vapor. The physical properites of a substance often depend on its state. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

bch_lb

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bch_ln

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass, and chemical properties.

12. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

bch_hc

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

This Is a Third Level Head

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Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements.

Figure 1.3 Thomson's model of the atom, sometimes descibed as the "plum-pudding" modle, after a traditional English dessert containing raisins. The electrons are embedded in a uniform, positively charged sphere. © Harry Bliss. Originally published in the New Yorker Magazine.

bch_fgso

bch_fn

†John Dalton (1766–1844). English chemist, mathmetician, and philosopher. In addition to the atomic theory, he also formulated several gas laws and gave the first detailed description of color blindness.

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Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

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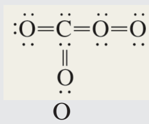

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D-Head Runs In The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Sub-

Table 10.1 Some Substances Found as Gasses at 1 atm and 25°C

Straddle Head Example		
Elements	**Compounds Column**	
H_2 (molecular hydrogen)	HF (hydrogen fluoride)	0.5
N_2 (molecular nitrogen)	HCl (hydrogen chloride)	0.6
O_2 (molecular oxygen) turnover lines	HBr (hydrogen bromide)	1.2

* The boiling point of HCN is 268, but is close enough to qualify as a gas at ordinary atmospheric conditions.

stances differ from one another in composition and can be identified by their appearance. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties.

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass.
2. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

The classifications of matter include substances, mixtures, elements, and com-

3s *$2p_x$ $2p_y$*

(a) (b)

pounds, as well as atoms and molecules, which we will consider in Chapter 2. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures,

bchea_tt

bchea_nm

Example 19.1 Calculating Molecular Mass

bchea_tx

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

bchea_ha

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

bchea_la

(a) This is an alpha sublist entry example within an exersice.
(b) This is an alpha sublist entry example within an exersice this is an alpha sublist entry example within an exercise with a runover.

bchea_eq

$$\frac{10.50\text{ mol}}{\text{EG}}\ 5\ 4.19\text{ mole EG/Kg }H_2O\ 5\ 4.19\text{ m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

Comment 6.07 g is smaller than the molar mass, the answer is reasonable. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

—Continued

$(NH_2)_2CO$

bch_fgct_b

Continued—

Solution The number of moles of EG in 651 g EG is. To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

bchea_ld

Step 1: We can deduce the skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 3: Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

Check Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

bchea_lutt

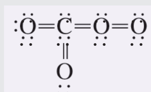
bchea_lu

Reactants	Products
Al(4)	Al(4)
O(6)	O(6)

(a) This is an alpha sublist entry example within an exersice.

(b) This is an alpha sublist entry example within an exercise this is an alpha sublist entry example within an exercise with a runover.

bchea_cd



elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance. Chemists distinguish among several subcategories of matter

Example 19.2

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

(a) This is an alpha sublist entry example within an exercise.

(b) This is an alpha sublist entry example within an exercise this is an alpha sublist.

$$\frac{10.50\ \text{mol}}{\text{EG}}\ 5\ 4.19\ \text{mole EG/Kg}\ H_2O\ 5\ 4.19\ \text{m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

11.3 The Structure of the Atom

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air).

Step 1: We can deduce the skeletal structure of the carbonate ion by recognizing that C is less electronegative.

Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 3: Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Chapter Summary

Section 1.1

» The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. The energyof the rays emitted by the radioactive isotoped is characterstic of arsenic and the intensity of the rays establishes how much arsenic is present in a sample.

» The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Section 1.2

» The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

Key Words

Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
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Calimetry, p. 212
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Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206

bcepq_tt

Questions and Problems

bcepq_

The Nature of Energy and Types of Energy

bcepq_

Review Questions

bcepq_ln

5.1 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

5.2 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

bcepq_eq

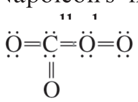
$$CaCO_3(s) + CaO(s) = CO_2(g)$$

5.3 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.4 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.5 The arsenic in Napoleon's hair was detected using a techniq [...] tron activation. When arsenic-75 [...] with high energy neutrons.

bcepq_cd



O C O O

O

5.6 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Problems

5.7 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered Table Per Survey bcepq_tbtt

Component	**Melting Point (˚C)**
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

bcepq_tbcn bcepq_tbtx

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote. bcepq_tbfn

5.121 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered List entry   List entry
List entry   Unnumbered List entry

bcepq_lu

5.122 The arsenic in Napoleon's hair was detected. bcepq_la

(a) As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons.
(b) As-76 isotope.

5.123 The arsenic in Napoleon's hair was detected.

bcepq_tt_a

Special Problems

5.123 The arsenic in Napoleon's hair was detected using a technique called neu bcepq_ln_a tion.

(a) Does a single molecule have a temperature?
(c) Comment on the validity of the previous statements.

15.124 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

Answers to Practice Exercises

3.1 10.81 amu. **3.2** 3.59 moles. **3.3** 2.57 X 10^3g. **3.4** 8.49 X 10^{21} K atoms. **3.5** 32.04 amu. **3.6** 1.66 moles. **3.7** 5.81 X 10^{24} H atoms. **3.8** H: 2.055%; S: 32.69%; O: 65.25%. **3.9** $KMnO_4$ (potassium permanganate). **3.10** 196 g. **3.11** B_2H_6. **3.12** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.13** 235 g. **3.14** 0.769 g. **3.15** (a) 234 g, (b) 234 g. **3.16** (a) 863 g, (b) 93.0%. **3.17** H: 2.055%; S: 32.69%; O: 65.25%. **3.18** $KMnO_4$ (potassium permanganate). **3.19** 196 g. **3.20** B_2H_6. **3.21** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.22** 235 g. **3.23**

eap_nm

Appendix 1

eap_tt

Derivation of the Names of Elements*

eap_tbcn

eap_tbtx

Elements	Symbol	Atomic No.	Atomic Mass	Date of Discovery	Discoverer and Nationality	Derivation
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. aktis, beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.) compound in which it was discovered; derived from L. *alumen,* astringent taste	Alum, the aluminum
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a substance which combines readily; symbol L. *stibium,* mark
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. *aktis,* beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered; derived from L.
alumen,						
						astringent taste
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. *stibium,* mark
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. *aktis,* beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered

eap_tbso

Source: Reprinted with permission from "The Elements and Derivation of Their Names and Symbols," G.P. Dinga, Chemistry 41 (2), 20-22 (1968).

eap_tbfn

* The boiling point of HCN is 26°, but is close enough to qualify as a gas at ordinary atmospheric conditions.

Appendix 2

Unit for the Gas Constant

eap_tx

In this appendix we will see how the gas constant R can be expressed in units J/K mol. Our first step is to derive a realtionship between atm and pascal. We start with:

eap_eq

$$\log 6.7 \text{ X } 10^{24} = 23.17$$

$$\log 6.7 \text{ X } 10^{24} = 23.17$$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithms

eap_ha

The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithms

Common Logorithms

eap_hb

The concept of the logarithms is an extension of the concept of exponents, which is discussed in Chapter 1. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

eap_lutt

eap_lu

Logarithm	**Exponent**
$\log 1 = 0$	$10^0 = 1$
$\log 10 = 1$	$10^1 = 10$
$\log 100 = 2$	$10^2 = 100$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number.

eap_tbsh

eap_tbcn

eap_tbtx

Inorganic Substances				
Substance	(kJ/mol)	(kJ/mol)	(J/K . mol)	Cp
Ag(s)	0	0	42.7	42.7
Ag^1(aq)	105.9	77.1	73.9	73.9
AgCl(s)	2127.0	2109.7	96.1	96.1
Ag(s)	0	0	42.7	42.7
Ag^1(aq)	105.9	77.1	73.9	73.9

GLOSSARY

The number in parentheses is the number of the section in which the term first appears.

A

absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

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absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

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accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

B

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature that uses the absolute zero of temperature as the lowest temperature. (5.3)

bccuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

bsolute temperature scale. A temperature scale that uses the absolute.

ANSWERS

to Even-Numbered Problems

Chapter 1

1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 **1.12** (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
1.4 (a) Zn(s) 1 Cu21(aq) Zn21(aq) 1 Cu(s) **1.12** (a) Physical. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms (e) Physical change. **1.14** (a) K. (b) Cu21(aq) Zn21(aq) 1 Cu(s).
1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 1.12 (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change. (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
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1.4 (a) Hypothesis. (b) Law. (c) Theory 1.12 (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 **1.12** (a) Physical change. (b) Chemical change. (c) [Xe]6s24f145d5 (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B. (e) Cr. (f) B (g) Cr. (h) B
1.4 (a) Hypothesis. (b) Law. (c) Theory **1.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.

Chapter 2

2.4 (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) Zn(*s*) 1 Cu^{21}(*aq*) Zn^{21}(*aq*) 1 Cu(*s*) **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) K. (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Zn(*s*) 1 Cu^{21}(*aq*) Zn^{21}(*aq*) 1 Cu(*s*). (d) Chemical change (e) Physical change. **2.14** (a) K. (b) [Xe]6$s^2$4f^{14}5d^5
2.4 (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) [Xe]6$s^2$4f^{14}5d^5 (d) Chemical change (e) Physical change. **2.14** (a) K. (b) Sn. (c) Cr. (d) B.
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(c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) K. (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory
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Chapter 3

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Chapter 1

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Chapter

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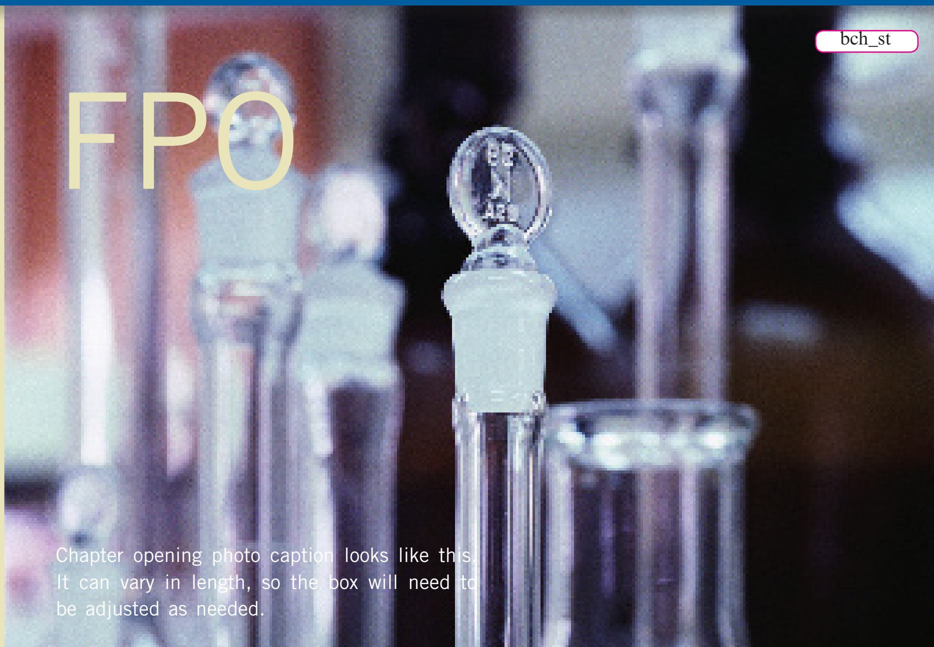
Chemical Bonding in Polyatomic Molecule

Molecular Geometry and Interaction



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Chapter Outline

Chapter Overview

Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of society. Its roots are ancient, but as we will soon see, chemistry is every bit a modern science. We will begin our study of chemistry at the macroscopic level, where we can see and measure the materials of which our world is made. In this chapter we will discuss the scientific method, which provides the framework for research not only in chemistry but in all other sciences as well. Next we will discover how scientists define and characterize matter. Then we will familiarize ourselves withe the systems of measurement used in the laboratory. Finally, we will spend some time learning how to handle numerical results of chemical measurements and solve numerical problems.

Metaly from the Sea

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties.

- If a number is greater than 1, then all the zeros written to the right of the decimal point.
- **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
- Any digit that is not zero is significant. Thus 845 cm has three significant figures, 1.234 kg has four significant figures, and so on.

Chemists distinguish among several subcategories of matter based on composition and properties.

1. If a number is greater than 1, then all the zeros written to the right of the decimal.
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Chemists distinguish among several subcategories of matter based on composition and properties. Chemists distinguish among several subcategories of matter based on composition and properties.

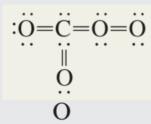
Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

Unnumbered Table Per Survey

Component	Melting Point (˚C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter include substances, mixtures.



Earth's crust, it is cheaper to "mine" the metal from

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

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Pressure Cookers

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Study Hint

If you have a clear idea of what you want to accomplish before you begin to read a chapter. your reading will be more effective. The questions in this chapter outline—as well as those in the subheadings of each section—can serve as a checklist for mea bchfa_tx progress as your read. A clear picture of what questions are going to be addressed and where the answers will be found forms a mental road map to guide you through the chapter. Take a few minutes to study the outline and fix this road map in your mind. It will be time well spent.

11.2 The Relationsip Between Conjugatae Acid-Base Ionization Constants

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air). Thus, everything in the universe has a "chemical" connection we can see and touch.

Summary of Rules for Writing Equilibrium Constant Expressions

A substance is a form of matter that has a definite (constant) composition and distinct properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

bch_df

Mass is a measure of an object's inertia, the property that causes it to resist a change in its motion.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

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Aristole's ideas on motion, although not capable of making quantitative predictions, provided explanations that were widely accepted for many centuries and that fit well with some of our own commonsense thinking.

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

Method 1	Method 2
3.66 + 8.45 = 30.9	3.66 + 8.45 = 30.93
30.9 + 2.11 = 65.2	30.93 + 2.11 = 65.3

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

B_2H_6 diborane
CH_4 methane
SiH_4 silane
NH_3 ammonia

Under certian conditions of pressure and temperature, most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor.

$$CaCO_3(s) + CaO(s) = CO_2(g) \qquad [4.1]$$

The physical properites of a substance often depend on its state. most substances

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Further Readings

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Espenson, J.H.: *Chemical Kinetics and Reaction Mechanisms,* 2d ed., McGraw-Hill, 1995

Eyring, H., D. Henderson, and W. Jost (eds.): *Physical Chemistry: And Advanced Treatise, Academic,* 1967-1975

Frost, W.: *Theory of Unimolecular Reactions, Academic,* 1973.

Franks, F. (ed.); *Water: A Comprehensive Treatise, vols. 1-7, Plenum,* 1972-1982.

Friebolin, H.: *Basic One- and Two-Dimensional NMR Spectroscopy,* 3d ed., Wiley, 1998

Espenson, J.H.: *Chemical Kinetics and Reaction Mechanisms,* 2d ed., McGraw-Hill, 1995

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Friebolin, H.: Basic One- and Two-Dimensional NMR

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second edition

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Design C Chemistry/Physics

The Molecular Nature of Matter and Change

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ftp_au **Brian Laird**

ftp_af *University of Kansas*

ftp_tx With significant contributions by

ftp_au_a **Raymond Chang**

ftp_af_a *Williams College*

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04: 0c, 80m, 80y, 10k

05: 0c, 0m, 24y, 24k

02: 5c, 10m, 40y, 0k

07: 75c, 45m, 50y, 0k

08: 0c, 0m, 8y, 5k

09: 5c, 0m, 0y, 8k

10:80c, 60m, 0y, 0k

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TO DEB, MORGAN, AVA, AND BRYNNA WITH ALL MY LOVE

- David -

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About the **Author**

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Brian Laird was born in Hong Kong and grew up in Shanghai and Hong Kong, China. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing post doctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Professor Laird has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese Language, children's picture books, and a novel for juvenile readers.

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Brief Contents

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Expanded Contents

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Preface

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New and Improved Changes

We define the main goal of this edition is to further improve areas that will facilitate the instructor and aid students in important areas such as organization, art program, readability, and media.

- The chapter on coordination chemistry has been moved to near the end of the book.
- The main goal of this edition is to further improve areas that will faciliate the student to learn better.
- The chapter on coordination chemistry.

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Readability

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Animations

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1. **New title** reflecting the content of this text.
12. The chapter on coordination chemistry.

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Acknowledgments

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June Bronfenbrenner *Anne Arundel Community College–Arnold*

Adedoyin Adeyiga *Bennett College*

June Bronfenbrenner *Anne Arundel Community College–Arnold*

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The main goal of this edition is to further improve areas that will facilitate the instructor.

—*Brian Laird*

Features

Each chapter opening section contains a vibrant photograph to introduce the chapter as well as a clear, concise chapter outline. Then, to spark the student's interest, the chapter text begins on the actual opening page.

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- The chapter on coordination chemistry.

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List of Selected Applications

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Biology/Life Science

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Chemistry

Geology/Earth Science

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To the **Student**

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How to Succeed in Chemistry Class

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Animations

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Chapter Outline

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The Basic Language of Chemistry

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bchop_ha

Chapter Overview

bchop_tx

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FPO

The Chinese characters for chemistry mean "The study of change." bch_fgct_a

11.2 The Relationsip Between Conjugatae Acid-Base Ionization Constants bch_ha

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air). Thus, everything in the universe has a "chemical" connection we can see and touch. bch_tx

Summary of Rules for Writing Equilibrium Constant Expressions bch_hb

A substance is a form of matter that has a definite (constant) composition and distinct properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

a. How many electrons are present in a particular atom? How many electrons are present in a particular atom? bch_la
b. What energies do individual electrons possess? How many electrons are present in a particular atom?

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$ bch_eq

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

Method 1	**Method 2** bch_lutt
3.66 + 8.45 = 30.9	3.66 + 8.45 = 30.93 bch_lu
30.9 + 2.11 = 65.2	30.93 + 2.11 = 65.3

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

B_2H_6 diborane bch_lu_a
CH_4 methane
SiH_4 silane
NH_3 ammonia

Under certian conditions of pressure and temperature, most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor.

bch_eq_a $$CaCO_3(s) + CaO(s) = CO_2(g) \quad [4.1]$$ bch_eq_nm

The physical properites of a substance often depend on its state. most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor. The physical properites of a

bch_tbnm

bch_tbtt **Table 4.1**
Heats of Solution of Some Ionic Compounds

bch_tbcn bch_tbtx

Compound	**ΔH_{soln} (kJ/mol)**
LiCl	–37.1
$CaCl_2$	–82.8
NaCl	4.0
KCl	17.2
NH_4Cl	15.2

bchnt_tt

Physics Today

A gas is a substance that is normally in the gaseous state at ordinary temperatures and pressures; a vapor is the gaseous form of any substance that is a liquid or a solid at normal temperatures and pressures.

bchnt_tx

bch_fgnm **Figure 1.3** (a) The output from an automated DNA sequencing machine. Each lane displays the sequence (indicated in different colors) obtained with a separate DNA sample. (b) Photovoltaic cells. (c) A silicon wafer being processed. (d) The leaf on the left was taken from a tobacco plant that was not genetically engineered but was exposed to tobacco hron worms. The leaf on the right was genetically engineered and is barely attached by the worms. The same technique can be applied to protect the leaves of other types of plants. bch_fgct

substance often depend on its state. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

bch_lb

- If a number is greater than 1, then all the zeros written to the right of the decimal point count as significant figures.
- **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
- Any digit that is not zero is significant. Thus 845 cm has three significant figures, 1.234 kg has four significant figures, and so on.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

bch_ln

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass, and chemical properties.

12. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances

Figure 1.3 Thomson's model of the atom, sometimes descibed as the "plum-pudding" modle, after a traditional English dessert containing raisins. The electrons are embedded in a uniform, positively charged sphere. © Harry Bliss. Originally published in the *New Yorker Magazine.*

bch_fgso

bch_hc

This Is a Third Level Head

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements.

bch_hd

D-Head Runs In The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

bch_fn

†John Dalton (1766–1844). English chemist, mathmetician, and philosopher. In addition to the atomic theory, he also formulated several gas laws and gave the first detailed description of color blindness.

††John Dalton (1766–1844). English chemist, mathmetician, and philosopher.

Metal from the Sea

Magnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties.

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Chemists distinguish among several subcategories of matter based on composition and properties.

1. If a number is greater than 1, then all the zeros written to the right of the decimal.
10. If a number is greater than 1, then all the zeros written to the right of the decimal.

Chemists distinguish among several subcategories of matter based on composition and properties. Chemists distinguish among several subcategories of matter based on composition and properties.

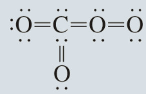
Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

Unnumbered Table Per Survey

Component	Melting Point (°C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter include substances, mixtures.



Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures,

Table 10.1
Some Substances Found as Gasses at 1 atm and 25°C

		Straddle Head Example	
Elements	**Compounds**	**Column**	
H_2 (molecular hydrogen)		HF (hydrogen fluoride)	0.5
N_2 (molecular nitrogen)		HCl (hydrogen chloride)	0.6
O_2 (molecular oxygen) turnover lines		HBr (hydrogen bromide)	1.2

* The boiling point of HCN is 268, but is close enough to qualify as a gas at ordinary atmospheric conditions.
Source: The boiling point of HCN is 268.

elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Chemists distinguish among several subcategories of matter based on composition and properties.

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass.
2. Compounds are composed of atoms of more than one element. In any compound, the ration of the numbers of atoms of any two of the elements.

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

3s $2p_x$ $2p_y$

(a) (b)

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

bchea_tt

bchea_nm

Example 19.1 Calculating Molecular Mass

bchea_tx

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

bchea_ha

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

bchea_la

(a) This is an alpha sublist entry example within an exersice.
(b) This is an alpha sublist entry example within an exersice this is an alpha sublist entry example within an exercise with a runover.

bchea_eq

$$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg } H_2O} \; 5 \; 4.19 \text{ mole EG/Kg } H_2O \; 5 \; 4.19 \text{ m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

Comment 6.07 g is smaller than the molar mass, the answer is reasonable. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water. Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

—Continued

$(NH_2)_2CO$ bch_fgct_b

Continued—

Solution The number of moles of EG in 651 g EG is. To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

bchea_ld

Step 1: We can deduce the skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 3: Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Practice Exercise Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

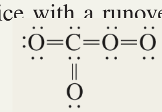
Check Calculate the boiling point and freezing point of a solution containing 478 g of ethylene glycol in 3202 g of water.

bchea_lutt	Reactants	Products
bchea_lu	Al(4)	Al(4)
	O(6)	O(6)

(a) This is an alpha sublist entry example within an exersice.

(b) This is an alpha sublist entry example within an exersice this is an alpha sublist entry example within an exersice with a runover.

bchea_cd



Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances

Example 19.2

Calculate the molecular masses of the following compounds:
(a) sulfur dioxide (SO_2) and (b) caffeine ($C_8H_{10}N_4O_2$).

Strategy To calculate molecular mass, we need to count the number of each type of atom in the molecule and look up its atomic mass in the periodic table.

Solution The number of moles of EG in 651 g EG is:

(a) This is an alpha sublist entry example within an exersice.

(b) This is an alpha sublist entry example within an exersice this is an alpha sublist.

$$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg } H_2O} \text{ 5 } 4.19 \text{ mole EG/Kg } H_2O \text{ 5 } 4.19 \text{ m}$$

Check Because 6.07 g is smaller than the molar mass, the answer is reasonable.

differ from one another in composition and can be identified by their appearance, smell, taste, and other properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.

11.3 The Structure of the Atom

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air).

bch_ld

Step 1: We can deduce the skeletal structure of the carbonate ion by recognizing that C is less electronegative.

Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

Step 3: Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.

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bcesu_tt

Chapter Summary

bcesu_ha

Section 1.1

bcesu_lb

- The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. The energyof the rays emitted by the radioactive isotoped is characterstic of arsenic and the intensity of the rays establishes how much arsenic is present in a sample.
- The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Section 1.2

- The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

bcekt_tt

Key Words

bcekt_tm

Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206

Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
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Calimetry, p. 212
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Chemical energy, p. 206
Closed system, p.207
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Calimetry, p. 212
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Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206
Closed system, p.207
Endothermic process, p. 208
Calimetry, p. 212
Chemical energy, p. 206

bcepq_tt

Questions and Problems

bcepq_ha

The Nature of Energy and Types of Energy

bcepq_hb

Review Questions

bcepq_ln

5.1 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

FPO

5.2 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

bcepq_eq

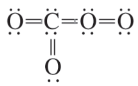
$$CaCO_3(s) + CaO(s) = CO_2(g)$$

5.3 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.4 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

5.5 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons.

bcepq_cd



5.6 The arsenic in Napoleon's hair was detected using a technique called neutron activation.

Problems

5.7 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered Table Per Survey bcepq_tbtt

Component	Melting Point (°C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

bcepq_tbcn bcepq_tbtx

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote. bcepq_tbfn

5.121 When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive.

Unnumbered List entry — List entry
List entry — Unnumbered List entry

bcepq_lu

5.122 The arsenic in Napoleon's hair was detected.

(a) As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons. bcepq_la

(b) As-76 isotope.

5.123 The arsenic in Napoleon's hair was detected.

bcepq_tt_a

Special Problems

5.123 The arsenic in Napoleon's hair was detected using a technique called neutron activation. bcepq_ln_a

(a) Does a single molecule have a temperature?

(c) Comment on the validity of the previous statements.

15.124 The arsenic in Napoleon's hair was detected using a technique called neutron activation. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope. As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

Answers to Practice Exercises

3.1 10.81 amu. **3.2** 3.59 moles. **3.3** 2.57 X 10^3g. **3.4** 8.49 X 10^{21} K atoms. **3.5** 32.04 amu. **3.6** 1.66 moles. **3.7** 5.81 X 10^{24} H atoms. **3.8** H: 2.055%; S: 32.69%; O: 65.25%. **3.9** $KMnO_4$ (potassium permanganate). **3.10** 196 g. **3.11** B_2H_6. **3.12** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.13** 235 g. **3.14** 0.769 g. **3.15** (a) 234 g, (b) 234 g. **3.16** (a) 863 g, (b) 93.0%. **3.17** H: 2.055%; S: 32.69%; O: 65.25%. **3.18** $KMnO_4$ (potassium permanganate). **3.19** 196 g. **3.20** B_2H_6. **3.21** Fe_2O_3 + 3CO 2Fe + $3CO_2$ **3.22** 235 g. **3.23** 0.769 g. **3.24** (a) 234 g, (b) 234 g. **3.24** (a) 863 g, (b) 93.0%.

eap_nm

Appendix 1

eap_nm#

eap_tt

Derivation of the Names of Elements*

eap_tbcn

eap_tbtx

Elements	Symbol	Atomic Atomic No.	Mass	Date of Discovery	Discoverer and Nationality	Derivation
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. aktis, beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.) compound in which it was discovered; derived from L. *alumen,* astringent taste	Alum, the aluminum
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a substance which combines readily; symbol L. *stibium,* mark
Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. *aktis,* beam or ray
Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered; derived from L. *alumen,* astringent taste
Americium	Am	95	(243)	1944	A. Ghiorso (USA) R.A. James (USA) G.T. Seaborg (USA) S.G. Thompson (USA)	The Americas
Antimony	Sb	51	121.8	Ancient		L. *antimonium (anti,* opposite of; *monium,* isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. *stibium,* mark
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Aluminum	Al	13	26.98	1827	F. Woehler (Ge.)	Alum, the aluminum compound in which it was discovered

eap_tbso

eap_tbfn

Source: Reprinted with permission from "The Elements and Derivation of Their Names and Symbols," G.P. Dinga, Chemistry 41 (2), 20-22 (1968).

* The boiling point of HCN is 26°, but is close enough to qualify as a gas at ordinary atmospheric conditions.

Appendix 2

Units for the Gas Constant

eap_tx

In this appendix we will see how the gas constant R can be expressed in units J/K mol. Our first step is to derive a realtionship between atm and pascal. We start with:

eap_eq

$$\log 6.7 \text{ X } 10^{24} = 23.17$$
$$\log 6.7 \text{ X } 10^{24} = 23.17$$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

eap_ha

Logarithms

The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

Logarithms

eap_hb

Common Logorithms

The concept of the logarithms is an extension of the concept of exponents, which is discussed in Chapter 1. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship.

eap_lutt

eap_lu

Logarithm	Exponent
$\log 1 = 0$	$10^{0} = 1$
$\log 10 = 1$	$10^{1} = 10$
$\log 100 = 2$	$10^{2} = 100$

In each case, the logarithm of the numcer can be obtained by inspection. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number. The following are examples that illustrate this realtionship. The common, or base–10, logarithm of any number is the power to which 10 must be raised to equal the number.

eap_tbsh

eap_tbcn

eap_tbtx

Inorganic Substances

Substance	(kJ/mol)	(kJ/mol)	(J/K . mol)	Cp
Ag(s)	0	0	42.7	42.7
Ag^{1}(aq)	105.9	77.1	73.9	73.9
AgCl(s)	2127.0	2109.7	96.1	96.1
Ag(s)	0	0	42.7	42.7
Ag^{1}(aq)	105.9	77.1	73.9	73.9

Glossary

The number in parentheses is the number of the section in which the term first appears.

A

absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)

accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

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absolute temperature scale. A temperature scale that uses the absolute zero. (5.3)

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accuracy. The closeness of a measurement to the true value of the quantity that is measured. (1.8)

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Answers

to Even-Numbered Problems

Chapter 1

1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 **1.12** (a) Physical change. (b) 8.49 + 10K atoms. (c) Physical change. (d) Chemical change (e) Physical change. **1.14** (a) K. (b) Sn. (c) Cr. (d) B.
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Credits

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Chapter 1

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Chapter 2

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Chapter Outline

The Basic Language of Chemistry

Chapter Overview

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Metal from the Sea

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties.

- If a number is greater than 1, then all the zeros written to the right of the decimal point.
- **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
- Any digit that is not zero is significant. Thus 845 cm has three significant figures, 1.234 kg has four significant figures, and so on.

Chemists distinguish among several subcategories of matter based on composition and properties.

1. If a number is greater than 1, then all the zeros written to the right of the decimal.
10. If a number is greater than 1, then all the zeros written to the right of the decimal.

Chemists distinguish among several subcategories of matter based on composition and properties. Chemists distinguish among several subcategories of matter based on composition and properties.

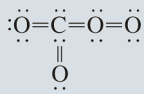
Figure 1.3 Separating iron filings from a heterogeneous mixture. The same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics.

Unnumbered Table Per Survey

Component	Melting Point (˚C)
Bismuth (50%)	271
Cadmium (12.5%)	321
Lead (25%)	328

*Components are shown in percent by mass, and the melting point is that of the pure metal. Use for source or footnote.

Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter include substances, mixtures.



Earth's crust, it is cheaper to "mine" the metal from seawater. The classifications of matter.

Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$

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Pressure Cookers

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- **Potassium Bromide.** The patassioum cation K+ and the bromine anion Br– combine to form the ionic compound potassium bromide.
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Study Hint

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If you have a clear idea of what you want to accomplish before you begin to read a chapter. your reading will be more effective. The questions in this chapter outline—as well as those in the subheadings of each section—can serve as a checklist for measuring your progress as your read. A clear picture of what questions are going to be addressed and where the answers will be found forms a mental road map to guide you through the chapter. Take a few minutes to study the outline and fix this road map in your mind. It will be time well spent.

11.2 The Relationsip Between Conjugatae Acid-Base Ionization Constants

We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air). Thus, everything in the universe has a "chemical" connection we can see and touch.

Summary of Rules for Writing Equilibrium Constant Expressions

A substance is a form of matter that has a definite (constant) composition and distinct properties. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance, smell, taste, and other properties.Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

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Mass is a measure of an object's inertia, the property that causes it to resist a change in its motion.

Chemists distinguish among several subcategories of matter based on composition and properties. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

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Aristole's ideas on motion, although not capable of making quantitative predictions, provided explanations that were widely accepted for many centuries and that fit well with some of our own commonsense thinking.

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and can be identified by their appearance.

Method 1	Method 2
3.66 + 8.45 = 30.9	3.66 + 8.45 = 30.93
30.9 + 2.11 = 65.2	30.93 + 2.11 = 65.3

The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2.

B_2H_6 diborane
CH_4 methane
SiH_4 silane
NH_3 ammonia

Under certian conditions of pressure and temperature, most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor.

$$CaCO_3(s) + CaO(s) = CO_2(g) \qquad \textbf{[4.1]}$$

The physical properites of a substance often depend on its state. most substances cn exist in any one of the three states of matter: solid, liquid, or gas. Water, for example, can be solid ice, liquid water, or steam or eater vapor. The physical properites of a

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Further Readings

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