Image: The Molecular Nature of Matter and Change
 The Molecular Nature of Matter and Change

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second edition



(ftp_tx) With significant contributions by

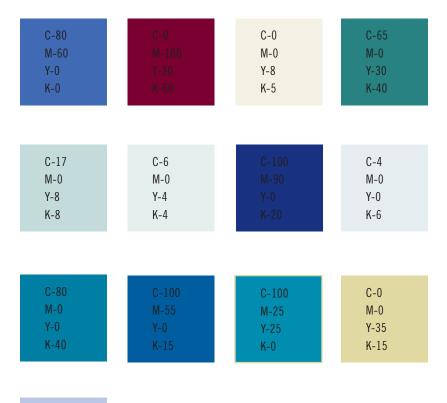


(ftp_af_a) Williams College



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COLOR PALETTE FOR CHEMISTRY/PHYSICS TEMPLATE A



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fcp_tx UNIVERSITY CHEMISTRY

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

- David -

About the Author



faa_au

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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Preface

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(fpr_ha) New and Improved Changes

- fpr_txWe 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.
- fpr_lb » 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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fpr_hb Readability

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Animations

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June Bronfenbrenner Anne Arundel Community College–Arnold

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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.

The main goal of this edition is to further improve areas that will facilitate the instructor and aid students in important areas such as organiza-

To the Student

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fts_ha How to Succeed in Chemistry Class

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fts_hb Commitment of Time and Perseverance

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Getting Organized

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List of Selected Applications

ffm_ha Biology/Life Science



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Chapter



The Basic Language of Chemistry



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

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 measuremeents and solve numerical problems.

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Chapter Outline

- 0.1 Chemistry is the study of matter and change 00
- 0.2 Matter is made of atoms and molecules 00
- 0.3 Compounds are represented by chemical formulas 00
- 0.4 Reactions are described by balanced chemical equations 00
- 0.5 Quantities of atoms and molecules can be described by mass or number 00
- 0.6 Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00
- **Box:** *Major Experimental Technique: Mass Spectrometry* 00

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

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.

- a. How many electrons are present in a particular atom? How many electrons are <u>bch_la</u> present in a particular atom?
- 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.

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

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.

$$(bch_eq_a) \quad CaCO_3(s) + CaO(s) = CO_2(g)$$

$$[4.1] \quad bch_eq_nm$$

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_tbtt	bch_tbnm Table 4.1 Heats of Solution of Some Ionic Compounds			
bch_tbcn	Compo	und	∆H _{soln} (kJ/mol)	
bch_tbtx	LiCl CaCl₂ NaCl KCl NH₄Cl	-37.1 -82.8 ^s 4.0 17.2 r 15.2	exothermic endothermic	

(

bch_eq

FPO

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.

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

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.

- <u>bch_lb</u> » 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.

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

bch fgnm

†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.

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 SE STYLES.

bch_fgct



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

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

bchba_ha

bchba_lb

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

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 distin-

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.

guish among several subcategories of matter based on composition and properties.

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.

$$\ddot{O} = \ddot{C} = \ddot{O} = \dot{O}$$

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

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bchba_tbtx

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bchba_tbfn
bchba_tbso
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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_tbcn Elements Compounds Colur	le Head Example nn
	nn
$\frac{bch_tbtx}{H_2}$ (molecular hydrogen) HF (hy	drogen fluoride) 0.5
N ₂ (molecular nitrogen) HCl (h	ydrogen chloride) 0.6
O ₂ (molecular oxygen) HBr (h turnover lines	ydrogen bromide) 1.2



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

bchba_ln

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.

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	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	$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg H}_2\text{O}} 5 \text{ 4.19 mole EG/Kg H}_2\text{O} 5 \frac{4.19 \text{ m}}{4.19 \text{ m}}$
	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.

FPO

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 Reactant	s 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.

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 (SO₂) 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.

 $\frac{10.50 \text{ mol EG}}{2.505 \text{ kg H}_2\text{O}}$ 5 4.19 mole EG/Kg H₂O 5 4.19 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.

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).

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

Calimetry, p. 212

bcekt_tm

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

Questions and Problems

(bcepq_ha) The Nature of Energy and Types of Energy (bcepq_hb) Review Questions

- bcepq_ln5.1 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.

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

bcepq_eq

- 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_tt_a

Special Problems

- 5.123 The arsenic in Napoleon's hair was detected using a technique called neutron $acti(bcepq_ln_a)$
 - (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

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
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Melting Point (°C)	bcepq_tbcn
271	bcepq_tbtx
321	
328	
	Melting Point (°C) 271 321

*Components are shown in percent by mass, and the melting point is that of the bcepq_tbfn 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 entryList entrybcepq_luList entryUnnumbered List entry

bcepq_la

- 5.122 The arsenic in Napoleon's hair was detected.
 - (a) As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons.

is bonbarded with high energy neutrons, it is

converted to the radioactive As-76 isotope. When

- (b) As-76 isotope.
- 5.123 The arsenic in Napoleon's hair was detected.

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 10^3 g. **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** KMnO₄ (potassium permanganate). **3.10** 196 g. **3.11** B₂H₆. **3.12** Fe₂O₃ + 3CO 2Fe + 3CO₂ **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** KMnO₄ (potassium permanganate). **3.19** 196 g. **3.20** B_2H_6 . **3.21** Fe_2O_3 + 3CO 2Fe + 3CO₂ **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%.

bcepq_cd

eap_nm Appendix 1

Derivation of the Names of Elements*

eap_tbcn	Elements	Symbol	Atomic No.	Atomic Mass	Date of Discovery	Discoverer and Nationality	Derivation
eap_tbtx	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. <i>alumen</i> , 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. <i>alumen</i> , 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. <i>antimonium (anti,</i> opposite of; <i>monium,</i> isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. <i>stibium,</i> 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_tt

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



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

 $\log 6.7 \times 10^{24} = 23.17$ $\log 6.7 \times 10^{24} = 23.17$

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.

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eap_ha
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eap_hb

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.

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

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. 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	Inorganic Substances				
eap_tbcn	Substance	(kJ/mol)	(kJ/mol)	(J/K . mol)	Ср
eap_tbtx	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 7

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

egl_ha A

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 mesaurement to the true value of the quantity that is mea-
- sured. (1.8) **absolute temperature scale.** A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)
- **accuracy.** The closeness of a mesaurement 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 mesaurement to the true value of the quantity that is measured. (1.8)

В

- **bsolute temperature scale.** A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)
- **bccuracy.** The closeness of a mesaurement 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 mesaurement 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 mesaurement to the true value of the quantity that is measured. (1.8)
- **bsolute temperature scale.** A temperature scale that uses the absolute.

Answers a

esa_tt

esa_ha Chapter 1

esa In

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. 1.4 (a) Hypothesis. (b) [Xe]6s24f145d5 1.12 (a) Physical change. (b) Zn(s) 1 Cu21(aq) Zn21(aq) 1 Cu(s). (d) 8.49 + 10K atoms (e) Physical change. 1.14 (a) K. (b) Sn. (c) Cr. (d) B. 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) $Zn(s) \downarrow Cu^{2\downarrow}(aq) Zn^{2\downarrow}(aq)$ 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) $Zn(s) \downarrow Cu^{2 \downarrow}(aq) Zn^{2 \downarrow}(aq) \downarrow Cu(s)$. (d) Chemical change (e) Physical change. **2.14** (a) K. (b) $[Xe]6s^24f^{14}5d^5$ 2.4 (a) Hypothesis. (b) Law. (c) Theory 2.12 (a) Physical change. (b) Chemical change. (c) $[Xe]6s^{2}4f^{14}5d^{5}$ (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) 8.49 + 10K atoms. (c) $Zn(s) \downarrow Cu^{20}(aq) Zn^{20}(aq) \downarrow$ Cu(s) (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (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) 8.49 + 10K atoms. (c) [Xe] $6s^24f^{14}5d^5$ (d) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.4 (a) Zn(s) Ú $Cu^{2\dot{\nu}}(aq) Zn^{2\dot{\nu}}(aq) \dot{\nu} Cu(s) 2.12$ (a) Physical. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.14 (a) K. (b) Sn. (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 **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) Zn(s) Ú $Cu^{2\acute{0}}(aq) Zn^{2\acute{0}}(aq)$ Ú Cu(s) (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) 8.49 + 10K atoms. (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. **2.14** (a) Zn(s) Ú $Cu^{2\acute{0}}(aq)$ Zn^{2⁶}(*aq*) Ú Cu(s).

Chapter 3

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Chapter 2

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Chapter 3

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Chemical Bonding in Polyatomic Molecule

Molecular Geometry and Interaction

bch_st

Chapter Outline

- 4.1 Chemistry is the study of matter and change 00
- 4.2 Matter is made of atoms and molecules 00
- **4.3** Compounds are represented by chemical formulas 00
- **4.4** Reactions are described by balanced chemical equations 00
- 4.5 Quantities of atoms and molecules can be described by mass or number 00
- **4.6** Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00

Box: *Major Experimental Technique: Mass Spectrometry* 00 Chapter opening photo caption looks like this. It can vary in length, so the box will need to be adjusted as needed.

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 measuremeents 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.
- » 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 distin-

FPO

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.

guish among several subcategories of matter based on composition and properties.

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.

$$\ddot{O} = \ddot{C} = \ddot{O} = \dot{O}$$

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.

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

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.

Pressure Cookers

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- » If a number is greater than 1, then all the zeros written to the right of the decimal point. If a number is greater than 1, then all the zeros written to the right of the decimal point. 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 properties. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

- 1. If a number is greater than 1, then all the zeros written to the right of the decimal. If a number is greater than 1, then all the zeros written to the right of the decimal.
- 2. 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. 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. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties.

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 outlineas 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.

bch_df

11.2

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 mat-

Summary of Rules for Writing Equilibrium Constant Expressions

The Relationsip Between Conjugatae Acid-Base

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"

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.

ter include substances, mixtures, elements, and compounds, as well as atoms and

Ionization Constants

molecules, which we will consider in Chapter 2.

connection we can see and touch.

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.

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.

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
- CH₄ methane
- SiH₄ silane
- NH₃ 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.

$$CaCO_{3}(s) + CaO(s) = CO_{2}(g)$$
[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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Design B Chemistry/Physics

The Molecular Nature of Matter and Change



(ftp_af) University of Kansas

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Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto Chapter # Chapter Title

COLOR PALETTE CTP CHEMISTRY TEMPLATE

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

University Chemistry

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About the Cover

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

> > - David -

About the Author



faa_au

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 coau-

thored 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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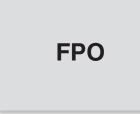
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New and Improved Changes

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.

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- » 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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- 12. The chapter on coordination chemistry.

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Acknowledgments

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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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To the Student

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How to Succeed in Chemistry Class

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Commitment of Time and Perseverance

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Animations

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Getting Organized

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ffm_ha Biology/Life Science

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Geology/Earth Science

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Chapter

The Basic Language of Chemistry

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Chapter Overview

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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.

bopto_tx

Chapter Outline **bopto_tx**)

- 0.1 Chemistry is the study of matter and change 00
- 0.2 Matter is made of atoms and molecules 00
- 0.3 Compounds are represented by chemical formulas 00
- 0.4 Reactions are described by balanced chemical equations 00
- 0.5 Quantities of atoms and molecules can be described by mass or number 00
- 0.6 Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00

Box: *Major Experimental Technique: Mass Spectrometry* 00

1

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 <u>bch_tx</u> 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.

- a. How many electrons are present in a particular atom? How many electrons <u>bch_la</u> are present in a particular atom?
- 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.

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

Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. Substances differ from one another in composition and $\underline{bch_lutt}$ 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	

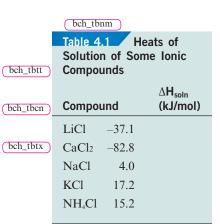
The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and more use, which we will consider in Chapter 2.

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 beck, inquire water, or steam or eater vapor.

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





change."

bch_eq

bch_ha

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.



bch_fgct

bch_fgmm 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.

FPO

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.

- » 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.

bch_lm 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.

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

This Is a Third Level Head

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

bch_fn

bch_hc

bch lb

†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.

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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

Metal from the Sea

bchba_tx

bchba_tt

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

bchba_

bchba_

bchba_lb

bchba_ln

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

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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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

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bchba_ 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.

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

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.

 \ddot{O}

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

bchba_tbfn bchba_tbso

bchba_tbtt

bchba_tbcn

bchba_tbtx

bchba_cd

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-

bch_	Table 10.1 Some Substances Found as Gasses at 1 atm and 25°C				bch_
bch_tbsh	Straddle Head Example				
bch_tbcn	Elements	Compounds	Column		
bch_tbtx	H ₂ (molecula	ar hydrogen)	HF (hydrogen fluoride)	0.5	
	N ₂ (molecula	ar nitrogen)	HCl (hydrogen chloride)	0.6	
	O ₂ (molecula turnover		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-

\uparrow	1	\downarrow	1	\downarrow	
3s	2	p_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	10.50 mol EG 5 4.19 mole EG/Kg H ₂ O 5 4.19 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

FPO

(NH₂),CO

bch_fgct_b

5

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Continued-
```

bchea_ld

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.

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 grycor in 3202 g of water.

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

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

bc

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

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 (SO₂) 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.

 $\frac{10.50 \text{ mol}}{\text{EG}}$ 5 4.19 mole EG/Kg H₂O 5 4.19 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

bch_ld 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

bcesu_ha

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.

bcekt_tt Key Words

Calimetry, p. 212

bcekt_tm

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

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.

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.

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

- 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 in tron activation. When arsenic-75 $\ddot{O}=\ddot{O}=\ddot{O}=\ddot{O}$ with high energy neutrons.

0 C O O

bcepq_tt_a Special Problems

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

0

- (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

Answers to Practice Exercises

3.1 10.81 amu. 3.2 3.59 moles. 3.3 2.57 X 10³g. 3.4 8.49 X 10²¹ K atoms. 3.5 32.04 amu. 3.6 1.66 moles. 3.7 5.81 X 10²⁴ H atoms. 3.8 H: 2.055%; S: 32.69%; O: 65.25%. 3.9 KMnO₄ (potassium permanganate). 3.10 196 g. 3.11 B₂H₆. 3.12 Fe₂O₃

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)	bcepq_tbcn
Bismuth (50%)	271	bcepq_tbtx
Cadmium (12.5%)	321	
Lead (25%)	328	

*Components are shown in percent by mass, and the melting point is that of bcepq_tbfn 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 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.

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 A s - 7 6 is o t o p e . As-76 isotope. When arsenic-75 is bonbarded with high energy neutrons, it is converted to the radioactive As-76 isotope.

+ $3CO 2Fe + 3CO_2$ **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** KMnO₄ (potassium permanganate). **3.19** 196 g. **3.20** B₂H₆. **3.21** Fe₂O₃ + $3CO 2Fe + 3CO_2$ **3.22** 235 g. **3.23**

(bcepq_cd)

bcepq_eq

bcepq_lu

bcepq_la

Appendix 1

Cap_tt Derivation of the Names of Elements*

	Elements	Symbol	Atomic No.	Atomic Mass	Date of Discovery	Discoverer and Nationality	Derivation
eap_tbcn	Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. aktis, beam or ray
eap_tbtx	Aluminum	Al	13	26.98	1827	F. Woehler (Ge.) compound in which it was discovered; derived from L. <i>alumen</i> , 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.
	шитсп,						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. <i>antimonium (anti,</i> opposite of; <i>monium,</i> isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. <i>stibium,</i> 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



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

Unit for the Gas Constant



eap_eq

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:

 $\log 6.7 \times 10^{24} = 23.17$ $\log 6.7 \times 10^{24} = 23.17$

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.

(app lutt	Logarithm	Exponent
eap_lutt	$\log 1 = 0$	$10^0 = 1$
eap_lu	$\log 10 = 1$	$10^1 = 10$
	$\log 100 = 2$	$10^2 = 100$

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. 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	Inorganic Substances							
eap_tbcn	Substance	(kJ/mol)	(kJ/mol)	(J/K . mol)	Ср			
eap_tbtx	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			

eap_hb

eap_ha

GLOSSARY COLL

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

egl_ha egl_tm egl_df

egl_tx

absolute temperature scale. A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3) **accuracy.** The closeness of a mesaurement to the true value of the quantity that is measured. (1.8)

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

- **accuracy.** The closeness of a mesaurement 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 mesaurement 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 tem-
- perature as the lowest temperature. (5.3) **bccuracy.** The closeness of a mesaurement 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 mesaurement 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 mesaurement 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

Chapter 1

esa_ha

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. **1.4** (a) Hypothesis. (b) [Xe]6s24f145d5 1.12 (a) Physical change. (b) Zn(s) = 1 Cu(21(aq)) Zn(21(aq)) = 1 Cu(s). (d) 8.49 + 10K atoms (e) Physical change. 1.14 (a) K. (b) Sn. (c) Cr. (d) B. 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.
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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) $Zn(s) \ 1 \ Cu^{21}(aq) \ Zn^{21}(aq) \ 1 \ Cu(s) \ 2.4$ (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change. (e) Physical change. (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) $Zn(s) \ 1 \ Cu^{21}(aq) \ 2n^{21}(aq) \ 1 \ Cu(s)$. (d) Chemical change (e) Physical change. **2.14** (a) K. (b) [Xe] $6s^24f^{14}5d^5$

2.4 (a) Hypothesis. (b) Law. (c) Theory 2.12 (a) Physical change. (b) Chemical change. (c) $[Xe]6s^24f^{14}5d^5$ (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) 8.49 + 10K atoms. (c) $Zn(s) \perp Cu^{21}(aq) Zn^{21}(aq) \perp$ Cu(s) (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (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) 8.49 + 10K atoms. (c) [Xe] $6s^24f^{14}5d^5$ (d) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.4 (a) Zn(s) 1 $Cu^{21}(aq) Zn^{21}(aq) I Cu(s) 2.12$ (a) Physical. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.14 (a) K. (b) Sn.

(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 **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) Zn(s) 1 Cu²¹(*aq*) Zn²¹(*aq*) 1 Cu(s) (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) 8.49 + 10K atoms. (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. **2.14** (a) Zn(*s*) 1 Cu²¹(*aq*) Zn²¹(*aq*) 1 Cu(*s*).

Chapter 3

3.4 (a) Hypothesis. (b) $[Xe]6s^24f^{14}5d^5$ **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.

B. **3.4** (a) $Zn(s) \ 1 \ Cu^{21}(aq) \ Zn^{21}(aq) \ 1 \ Cu(s) \$ **3.12**(a) Physical.(b) Chemical change. (c) Physical change. (d) Chemicalchange (e) Physical change.**3.14** $(a) <math>Zn(s) \ 1 \ Cu^{21}(aq) \ Zn^{21}(aq)$ 1 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.

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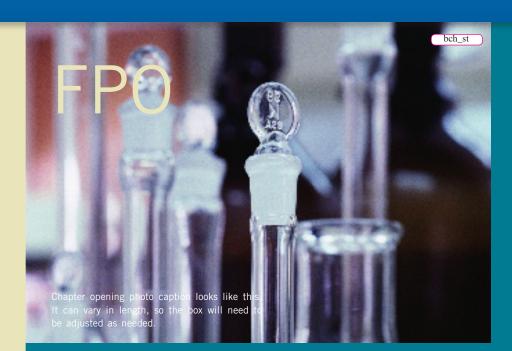
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Chapter



Chemical Bonding in Polyatomic Molecule Molecular Geometry and Interaction



Chapter Outline

- 4.1 Chemistry is the study of matter and change 00
- 4.2 Matter is made of atoms and molecules 00
- **4.3** Compounds are represented by chemical formulas 00
- **4.4** Reactions are described by balanced chemical equations 00
- 4.5 Quantities of atoms and molecules can be described by mass or number 00
- **4.6** Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00

Box: Major Experimental Technique: Mass Spectrometry 00

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.

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.
- 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

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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.

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

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

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

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.

Pressure Cookers

Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

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Chemists distinguish among several subcategories of

matter based on composition properties. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis.

- 1. If a number is greater than 1, then all the zeros written to the right of the decimal. If a number is greater than 1, then all the zeros written to the right of the decimal.
- 2. 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. 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. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Chemists distinguish among several subcategories of matter based on composition and properties. Cagnesium is a valuable, lightweight metal used as a structural mate**11.2** The Relationsip Between Conjugatae

Acid-Base Ionization Constants

"chemical" connection we can see and touch.

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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 outlineas 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.



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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.

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.

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

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

Summary of Rules for Writing Equilibrium Constant Expressions

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 en 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.

$$CaCO_3(s) + CaO(s) = CO_2(g)$$
[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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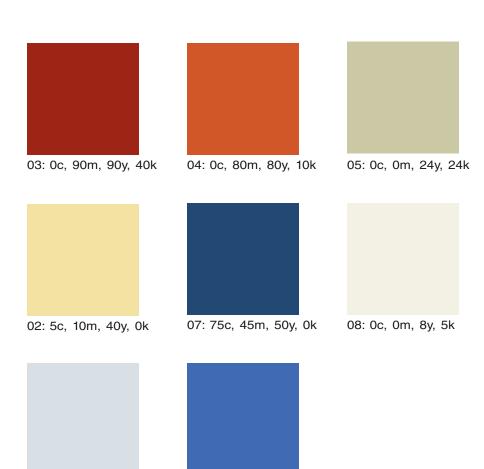
(ftp_tx) With significant contributions by

(ftp_au_a) Raymond Chang

(ftp_af_a) Williams College



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

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

- David -



faa_tt.authors faa_tt 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, faa_tx 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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Preface

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(fpr_ha) New and Improved Changes

- fpr_txWe 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.
- fpr_lb
 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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fpr_hb Readability

fpr_ln

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Animations

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

—Brian Laird

fpr_hc



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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List of Selected Applications

ffm_ha Biology/Life Science

ffm_lu

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To the **Student**

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How to Succeed in Chemistry Class

- fts_tx
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fts_hb Commitment of Time and Perseverance

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Animations fts_hc

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Getting Organized

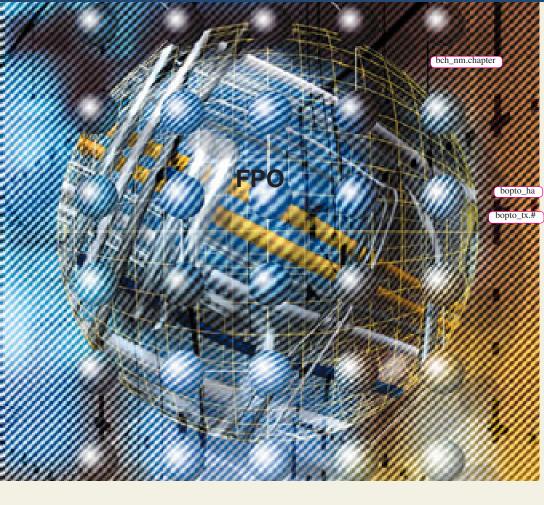
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The Basic Language

bchop_ha Chapter Overview

Elisis am iusci elessectet nim quisci erosto odignisl et in ulputat. Ut dip ex enibh et vel enibh er amconsequat at am, velisiscilit lobor augiatum irit at. Tet ipisisl ex esto dolore dolore magna faci tet doloreet vel delis nos del dolor iriure etum zzriliq uipisl ipis num quam, vullummod tat, cortisse dunt alisi tin voloborem dion vel utpatem nullutating ea aci erosto dui te magna feu faccum quatin ut nulla at, conummy nim dignibh et, volor ipis enissequis adignibh eliquatuer alit non utat. Duis nit, vel delit nulla alisci blaor susto cor suscips uscipisis eugait, corper iureraestrud tat. Ut lum quip estis augiam zzriustrud tie magnit lut aliquatue tat lutem quat. Duiscip ero euismodit wis ent at.



bopto_tx

Chapter Outline

- **0.1** Cheistry is the study of matter and change 00
- **0.2** Matter is made of atoms and molecules 00
- **0.3** Compounds are represented by chemical formulas 00
- 0.4 Reactions are described by balanced chemical e quations 00
- 0.5 Quantities of atoms and can be described by mass or number 00
- **0.6** Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00



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

(bch_fgct_a)

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.

- a. How many electrons are present in a particular atom? How many electrons are <u>bch_la</u> present in a particular atom?
- 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.

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

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.

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

bch_eq

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 4.1Heats of SolutionIonic Compounds	of Some
(bch_tbcn)	Compound mol)	∆H _{soln} (kJ/
bch_tbtx	LiCl	-37.1
	CaCl ₂	-82.8
	NaCl	4.0
	KCl	17.2
	NH ₄ Cl	15.2

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_tt



bch_fgct

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.

FPO

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.

- 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.

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

bch fgnm

†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. **FPO**

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

Metal from the Sea

agnesium 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 ٠ 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 distin-



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.

FPO

guish among several subcategories of matter based on composition and properties.

Unnumbered Table Per Survey

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

*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.

$$\ddot{\mathbf{O}} = \ddot{\mathbf{C}} = \ddot{\mathbf{O}} = \ddot{\mathbf{O}}$$

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 10.1Some Substances Found as Gas	ses 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
01	ose enough to qualify as a gas at ordinary atmos	spheric conditions.
Source: The boiling point of HCN is 268.		

bchba_tbtt bchba_tbcn

bchba_tbfn

bchba_tbso

bchba_tbtx

bchba_cd

4

bchba_tt

bchba tx

bchba_eq

bchba_ha

bchba_lb

bchba_ln

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.



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_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	$\frac{10.50 \text{ mol EG}}{2.505 \text{ kg H}_2\text{O}} 5 \text{ 4.19 mole EG/Kg H}_2\text{O} 5 \frac{4.19 \text{ m}}{4.19 \text{ m}}$
	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

FPO

bch_fgct_b

position.

Continued—

bchea_ld

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.

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

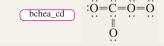
- Step 2: Skeletal structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central position.
- *Step 3:* Structure of the carbonate ion by recognizing that C is less electronegative than). Therefore, it is most likely to occupy a central 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.



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 (SO₂) 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.

 $\frac{10.50 \text{ mol EG}}{2.505 \text{ kg H}_{2}\text{O}} \text{ 5 4.19 mole EG/Kg H}_{2}\text{O 5 4.19 m}$

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.

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).

bcesu_tt

bcesu_lb

Chapter Summary

bcesu_ha 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.

bcekt_tt

bcekt_tm

Calimetry, p. 212
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Key Words

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bcepq_tt

Questions and Problems

(bcepq_ha) The Nature of Energy and Types of Energy

bcepq_hb **Review Questions**

bcepq_In5.1 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.

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

bcepq_eq

bcepq_cd

- 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.



Ö=Ë=Ö=Ö ∎ 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)	bcepq_tbcn
Bismuth (50%)	271	bcepq_tbtx
Cadmium (12.5%)	321	
Lead (25%)	328	

*Components are shown in percent by mass, and the melting point is that of the <u>bcepq_tbfn</u> 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	bcepq_lu
List entry	Unnumbered List entry	

- 5.122 The arsenic in Napoleon's hair was detected.
 - (a) As-76 isotope. When arsenic-75 is bonbarded <u>bcepg_la</u> 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 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 10^3 g. **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** KMnO₄ (potassium permanganate). **3.10** 196 g. **3.11** B₂H₆. **3.12** Fe₂O₃ + 3CO 2Fe +

 $\begin{array}{l} 3CO_2 \ \textbf{3.13} \ 235 \ g. \ \textbf{3.14} \ 0.769 \ g. \ \textbf{3.15} \ (a) \ 234 \ g, \ (b) \\ 234 \ g. \ \textbf{3.16} \ (a) \ 863 \ g, \ (b) \ 93.0\%. \ \textbf{3.17} \ H: \ 2.055\%; \ S: \\ 32.69\%; \ O: \ 65.25\%. \ \textbf{3.18} \ KMnO_4 \ (potassium permanganate). \ \textbf{3.19} \ 196 \ g. \ \textbf{3.20} \ B_2H_6. \ \textbf{3.21} \ Fe_2O_3 + \\ 3CO \ 2Fe \ + \ 3CO_2 \ \textbf{3.22} \ 235 \ g. \ \textbf{3.23} \ 0.769 \ g. \ \textbf{3.24} \ (a) \\ 234 \ g, \ (b) \ 234 \ g. \ \textbf{3.24} \ (a) \ 863 \ g, \ (b) \ 93.0\%. \end{array}$

Appendix 1^{eap_nm#}

eap_tt

Derivation of the Names of Elements*

eap_tbcn			Atomic		Date of	Discoverer and	
eap_tbtx	Elements	Symbol	Atomic No.	Mass	Discovery	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. <i>alumen</i> , 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. <i>antimonium (anti,</i> opposite of; <i>monium,</i> isolated condition), so named because it is a substance which combines readily; symbol L. <i>stibium,</i> 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. <i>alumen</i> , 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. <i>antimonium (anti,</i> opposite of; <i>monium,</i> isolated condition), so named because it is a tangible (metallic) substance which combines readily; ymbol L. <i>stibium,</i> mark
	Actinium	Ac	89	227	1899	A. Debierne (Fr.)	Gr. aktis, beam or ray
(ean theo)	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



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

 $\log 6.7 \times 10^{24} = 23.17$ $\log 6.7 \times 10^{24} = 23.17$

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

eap_hb

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.

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

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						
(kJ/mol)	(kJ/mol)	(J/K . mol)	Ср			
0	0	42.7	42.7			
105.9	77.1	73.9	73.9			
2127.0	2109.7	96.1	96.1			
0	0	42.7	42.7			
105.9	77.1	73.9	73.9			
	(kJ/mol) 0 105.9 2127.0 0	(kJ/mol)(kJ/mol)00105.977.12127.02109.700	(kJ/mol)(kJ/mol)(J/K . mol)0042.7105.977.173.92127.02109.796.10042.7			

Glossary

egl_tt

egl_tx

egl_tm

egl_df

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

egl_ha

- **absolute temperature scale.** A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)
- **accuracy.** The closeness of a mesaurement to the true value of the quantity that is measured. (1.8)
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- **accuracy.** The closeness of a mesaurement to the true value of the quantity that is measured. (1.8)
- **absolute temperature scale.** A temperature scale that uses the absolute zero. (5.3)

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- **accuracy.** The closeness of a mesaurement to the true value of the quantity that is measured. (1.8)
- **absolute temperature scale.** A temperature scale that uses the absolute zero of temperature as the lowest temperature. (5.3)
- **accuracy.** The closeness of a mesaurement 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 mesaurement 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 mesaurement 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 mesaurement to the true value of the quantity that is measured. (1.8)
- **bsolute temperature scale.** A temperature scale that uses the absolute.

esa_st to Even-Numbered Problems

Answers

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. **1.4** (a) Hypothesis. (b) [Xe]6s24f145d5 1.12 (a) Physical change. (b) Zn(s) 1 Cu21(aq) Zn21(aq) 1 Cu(s). (d) 8.49 + 10K atoms (e) Physical change. 1.14 (a) K. (b) Sn. (c) Cr. (d) B. **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) $Zn(s) \downarrow Cu^{2\downarrow}(aq) Zn^{2\downarrow}(aq)$ 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) $Zn(s) \downarrow Cu^{2 \downarrow}(aq) Zn^{2 \downarrow}(aq) \downarrow Cu(s)$. (d) Chemical change (e) Physical change. 2.14 (a) K. (b) $[Xe]6s^24f^{14}5d^5$ 2.4 (a) Hypothesis. (b) Law. (c) Theory 2.12 (a) Physical change. (b) Chemical change. (c) $[Xe]6s^24f^{14}5d^5$ (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) 8.49 + 10K atoms. (c) $Zn(s) \downarrow Cu^{2\downarrow}(aq) Zn^{2\downarrow}(aq) \downarrow$ Cu(s) (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (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) 8.49 + 10K atoms. (c) [Xe] $6s^24f^{14}5d^5$ (d) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.4 (a) Zn(s) Ú $Cu^{2^{i}}(aq) Zn^{2^{i}}(aq) \downarrow Cu(s) 2.12$ (a) Physical. (b) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. 2.14 (a) K. (b) Sn. (c) Cr. (d) B. 2.14 (a) K. (b) Sn. (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 **2.12** (a) Physical change. (b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **2.14** (a) $Zn(s) \circ U Cu^{2\circ}(aq) Zn^{2\circ}(aq) \circ U(s)$ (b) Sn. (c) Cr. (d) B. **2.4** (a) Hypothesis. (b) Law. (c) Theory **2.12** (a) Physical change. (b) 8.49 + 10K atoms. (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) Chemical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. (c) Physical change. (d) 8.49 + 10K atoms. (e) Physical change. **2.14** (a) Zn(s) $\circ U^{2\circ}(aq)$ Zn²⁰(aq) U Cu(s).

Chapter 3

3.4 (a) Hypothesis. (b) $[Xe]6s^24f^{14}5d^5$ **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) $Zn(s) \downarrow Cu^{2 \downarrow}(aq) Zn^{2 \downarrow}(aq) \downarrow Cu(s)$ **3.12**(a) Physical.(b) Chemical change. (c) Physical change. (d) Chemical change (e) Physical change. **3.14** (a) $Zn(s) \downarrow Cu^{2\downarrow}(aq) Zn^{2\downarrow}(aq) \downarrow$ 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) $[Xe]6s^{2}4f^{14}5d^{5}$ **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) $[Xe]6s^24f^{14}5d^5$ (e) Physical change. **3.14** (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) Zn(s) Ú $Cu^{20}(aq) Zn^{20}(aq) \acute{U} Cu(s)$ (e) Physical change. **3.13** (a) $\operatorname{Zn}(s) \circ \operatorname{Cu}^{2\circ}(aq) \operatorname{Zn}^{2\circ}(aq) \circ \operatorname{Cu}(s)$. (c) Physical change. (d) Chemical change (e) Physical change. 3.14 (a) K. (b) Sn. (c) Cr. (d) B. 3.4 (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) $\operatorname{Zn}(s) \circ \operatorname{Cu}^{2\circ}(aq) \operatorname{Zn}^{2\circ}(aq) \circ \operatorname{Cu}(s)$. (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. **3.12** (a) Physical change. (b) Chemical change. (c) Zn(s) Ú $Cu^{2^{(1)}}(aq) Zn^{2^{(1)}}(aq) \cup Cu(s)$ (e) Physical change. **3.13** (a) $\operatorname{Zn}(s) \circ \operatorname{Cu}^{2\circ}(aq) \operatorname{Zn}^{2\circ}(aq) \circ \operatorname{Cu}(s)$. (c) Physical change. (d) Chemical change (e) Physical change. 3.14 (a) K. (b) Sn. (c) Cr. (d) B. 3.4 (a) Hypothesis. (b) Law. (c) Theory **3.12** (a) $\operatorname{Zn}(s) \circ \operatorname{Cu}^{2\circ}(aq) \operatorname{Zn}^{2\circ}(aq) \circ \operatorname{Cu}(s)$. (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.

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ecr_ha

Chapter 1

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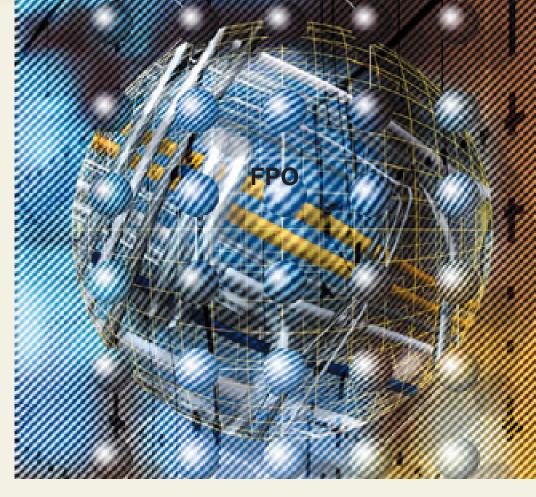
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Chapter Outline

- 0.1 Cheistry is the study of matter and change 00
- 0.2 Matter is made of atoms and molecules 00
- 0.3 Compounds are represented by chemical formulas 00
- 0.4 Reactions are described by balanced chemical e quations 00
- 0.5 Quantities of atoms and can be described by mass or number 00
- **0.6** Stoichiometry is the quantitative study of mass and mole relationships in chemical reactions 00



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 distin-

FPO

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.

guish among several subcategories of matter based on composition and properties.

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.

$$\ddot{O} = \ddot{C} = \ddot{O} = \dot{O}$$

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

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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 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.

bch_df

bch_et

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.

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.

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.

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