

GLOBAL  
EDITION



# Introductory CHEMISTRY

SEVENTH EDITION IN SI UNITS

Nivaldo J. Tro



INTRODUCTORY  
**CHEMISTRY**  
SEVENTH EDITION IN SI UNITS

**Nivaldo J. Tro**

# Introductory Chemistry, eBook, SI Units

## Table of Contents

Cover

Title Page

Copyright

Pearsons Commitment to Diversity, Equity, and Inclusion

About the Author

Contents

Interactive Media Contents

To the Student

To the Instructor

Preface

### Chapter 1. The Chemical World

1.1 Sand and Water

1.2 Chemicals Compose Ordinary Things

1.3 The Scientific Method: How Chemists Think

Everyday Chemistry: Combustion and the Scientific Method

1.4 Analyzing and Interpreting Data

Identifying Patterns in Data

Interpreting Graphs

1.5 A Beginning Chemist: How to Succeed

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

### Chapter 2. Measurement and Problem Solving

2.1 The Metric Mix-up: A \$125 Million Unit Error

2.2 Scientific Notation: Writing Large and Small Numbers

2.3 Significant Figures: Writing Numbers to Reflect Precision

# **Table of Contents**

Counting Significant Figures

Exact Numbers

Chemistry In The Media: The COBE Satellite and Very Precise Measurements That Illuminate  
Our Cosmic Past

## **2.4 Significant Figures in Calculations**

Multiplication and Division

Rounding

Addition and Subtraction

Calculations Involving Both Multiplication/Division and Addition/Subtraction

## **2.5 The Basic Units of Measurement**

The Base Units

Prefix Multipliers

Derived Units

## **2.6 Problem Solving and Unit Conversion**

Converting Between Units

General Problem-Solving Strategy

## **2.7 Solving Multistep Unit Conversion Problems**

## **2.8 Unit Conversion in Both the Numerator and Denominator**

## **2.9 Units Raised to a Power**

Chemistry And Health: Drug Dosage

## **2.10 Density**

Calculating Density

Density as a Conversion Factor

Chemistry And Health: Density, Cholesterol, and Heart Disease

## **2.11 Numerical Problem-Solving Strategies and the Solution Map**

## **Self-Assessment Quiz**

## **Key Terms**

## **Exercises**

## **Answers to Skillbuilder Exercises**

## **Answers to Conceptual Checkpoints**

# **Chapter 3. Matter and Energy**

## **3.1 In Your Room**

## **3.2 What Is Matter?**

## **3.3 Classifying Matter According to Its State: Solid, Liquid, and Gas**

## **3.4 Classifying Matter According to Its Composition: Elements, Compounds, and**

# **Table of Contents**

## Mixtures

3.5 Differences in Matter: Physical and Chemical Properties

3.6 Changes in Matter: Physical and Chemical Changes

Separating Mixtures Through Physical Changes

3.7 Conservation of Mass: There Is No New Matter

3.8 Energy

Chemistry In The Environment: Getting Energy out of Nothing?

Units of Energy

3.9 Energy and Chemical and Physical Change

3.10 Temperature: Random Motion of Molecules and Atoms

3.11 Temperature Changes: Heat Capacity

Everyday Chemistry: Coolers, Camping, and the Heat Capacity of Water

3.12 Energy and Heat Capacity Calculations

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## Chapter 4. Atoms and Elements

4.1 Experiencing Atoms at Tiburon

4.2 Indivisible: The Atomic Theory

4.3 The Nuclear Atom

4.4 The Properties of Protons, Neutrons, and Electrons

Everyday Chemistry: Solid Matter?

4.5 Elements: Defined by Their Numbers of Protons

4.6 Looking for Patterns: The Periodic Law and the Periodic Table

4.7 Ions: Losing and Gaining Electrons

Ions and the Periodic Table

4.8 Isotopes: When the Number of Neutrons Varies

4.9 Atomic Mass: The Average Mass of an Elements Atoms

Chemistry In The Environment: Radioactive Isotopes at Hanford, Washington

Self-Assessment Quiz

Key Terms

Exercises

# **Table of Contents**

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 5. Molecules and Compounds**

5.1 Sugar and Salt

5.2 Compounds Display Constant Composition

5.3 Chemical Formulas: How to Represent Compounds

Polyatomic Ions in Chemical Formulas

Types of Chemical Formulas

5.4 A Molecular View of Elements and Compounds

Atomic Elements

Molecular Elements

Molecular Compounds

Ionic Compounds

5.5 Writing Formulas for Ionic Compounds

Writing Formulas for Ionic Compounds Containing Only Monoatomic Ions

Writing Formulas for Ionic Compounds Containing Polyatomic Ions

5.6 Nomenclature: Naming Compounds

5.7 Naming Ionic Compounds

Naming Binary Ionic Compounds Containing a Metal That Forms Only One Type of Cation

Naming Binary Ionic Compounds Containing a Metal That Forms More Than One Type of Cation

Naming Ionic Compounds Containing a Polyatomic Ion

Everyday Chemistry: Polyatomic Ions

5.8 Naming Molecular Compounds

5.9 Naming Acids

Naming Binary Acids

Naming Oxyacids

5.10 Nomenclature Summary

Ionic Compounds

Molecular Compounds

Acids

5.11 Formula Mass: The Mass of a Molecule or Formula Unit

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

# **Table of Contents**

Answers to Conceptual Checkpoints

## **Chapter 6. Chemical Composition**

6.1 How Much Sodium?

6.2 Counting Nails by the Kilogram

6.3 Counting Atoms by the Gram

Converting between Moles and Number of Atoms

Converting between Grams and Moles of an Element

Converting between Grams of an Element and Number of Atoms

6.4 Counting Molecules by the Gram

Converting between Grams and Moles of a Compound

Converting between Grams of a Compound and Number of Molecules

6.5 Chemical Formulas as Conversion Factors

Converting between Moles of a Compound and Moles of a Constituent Element

Converting between Grams of a Compound and Grams of a Constituent Element

6.6 Mass Percent Composition of Compounds

6.7 Mass Percent Composition from a Chemical Formula

Chemistry And Health: Fluoridation of Drinking Water

6.8 Calculating Empirical Formulas for Compounds

Calculating an Empirical Formula from Experimental Data

6.9 Calculating Molecular Formulas for Compounds

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 7. Chemical Reactions**

7.1 Grade School Volcanoes, Automobiles, and Laundry Detergents

7.2 Evidence of a Chemical Reaction

7.3 The Chemical Equation

7.4 How to Write Balanced Chemical Equations

7.5 Aqueous Solutions and Solubility: Compounds Dissolved in Water

Aqueous Solutions

Solubility

7.6 Precipitation Reactions: Reactions in Aqueous Solution That Form a Solid

# **Table of Contents**

7.7 Writing Chemical Equations for Reactions in Solution: Molecular, Complete Ionic, and Net Ionic Equations

7.8 AcidBase and Gas-Evolution Reactions

AcidBase (Neutralization) Reactions

Gas-Evolution Reactions

Chemistry And Health: Neutralizing Excess Stomach Acid

7.9 OxidationReduction Reactions

7.10 Classifying Chemical Reactions

Classifying Chemical Reactions by What Atoms Do

Classification Flowchart

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 8. Quantities in Chemical Reactions**

8.1 Climate Change: Too Much Carbon Dioxide

8.2 Making Pancakes: Relationships between Ingredients

8.3 Making Molecules: Mole-to-Mole Conversions

8.4 Making Molecules: Mass-to-Mass Conversions

8.5 More Pancakes: Limiting Reactant, Theoretical Yield, and Percent Yield

8.6 Limiting Reactant, Theoretical Yield, and Percent Yield from Initial Masses of Reactants

8.7 Enthalpy: A Measure of the Heat Evolved or Absorbed in a Reaction

Sign of H<sub>rxn</sub> H<sub>rxn</sub>

Everyday Chemistry: Bunsen Burners

Stoichiometry of H<sub>rxn</sub> H<sub>rxn</sub>

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 9. Electrons in Atoms and the Periodic Table**

9.1 Blimps, Balloons, and Models of the Atom



# **Table of Contents**

## 9.2 Light: Electromagnetic Radiation

## 9.3 The Electromagnetic Spectrum

Chemistry And Health: Radiation Treatment for Cancer

## 9.4 The Bohr Model: Atoms with Orbits

## 9.5 The Quantum-Mechanical Model: Atoms with Orbitals

Baseball Paths and Electron Probability Maps

From Orbits to Orbitals

## 9.6 Quantum-Mechanical Orbitals and Electron Configurations

Quantum-Mechanical Orbitals

Electron Configurations: How Electrons Occupy Orbitals

## 9.7 Electron Configurations and the Periodic Table

## 9.8 The Explanatory Power of the Quantum-Mechanical Model

## 9.9 Periodic Trends: Atomic Size, Ionization Energy, and Metallic Character

Atomic Size

Ionization Energy

Chemistry And Health: Pumping Ions: Atomic Size and Nerve Impulses

Metallic Character

## Self-Assessment Quiz

## Key Terms

## Exercises

## Answers to Skillbuilder Exercises

## Answers to Conceptual Checkpoints

# Chapter 10. Chemical Bonding

## 10.1 Bonding Models and AIDS Drugs

## 10.2 Representing Valence Electrons with Dots

## 10.3 Lewis Structures of Ionic Compounds: Electrons Transferred

## 10.4 Covalent Lewis Structures: Electrons Shared

Single Bonds

Double and Triple Bonds

## 10.5 Writing Lewis Structures for Covalent Compounds

Writing Lewis Structures for Polyatomic Ions

Exceptions to the Octet Rule

## 10.6 Resonance: Equivalent Lewis Structures for the Same Molecule

## 10.7 Predicting the Shapes of Molecules

# **Table of Contents**

Representing Molecular Geometries on Paper

Chemistry And Health: Fooled by Molecular Shape

## **10.8 Electronegativity and Polarity: Why Oil and Water Dont Mix**

Electronegativity

Polar Bonds and Polar Molecules

Everyday Chemistry: How Soap Works

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 11. Gases**

### **11.1 Extra-Long Straws**

### **11.2 Kinetic Molecular Theory: A Model for Gases**

### **11.3 Pressure: The Result of Constant Molecular Collisions**

Pressure Units

Pressure Unit Conversion

### **11.4 Boyles Law: Pressure and Volume**

Everyday Chemistry: Airplane Cabin Pressurization

Everyday Chemistry: Extra-long Snorkels

### **11.5 Charless Law: Volume and Temperature**

### **11.6 The Combined Gas Law: Pressure, Volume, and Temperature**

### **11.7 Avogadros Law: Volume and Moles**

### **11.8 The Ideal Gas Law: Pressure, Volume, Temperature, and Moles**

Determining Molar Mass of a Gas from the Ideal Gas Law

Ideal and Nonideal Gas Behavior

### **11.9 Mixtures of Gases**

Partial Pressure and Physiology

Collecting Gases over Water

### **11.10 Gases in Chemical Reactions**

Molar Volume at Standard Temperature and Pressure

Chemistry In The Environment: Air Pollution

Self-Assessment Quiz

Key Terms

Exercises

# **Table of Contents**

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 12. Liquids, Solids, and Intermolecular Forces**

12.1 Spherical Water

12.2 Properties of Liquids and Solids

12.3 Intermolecular Forces in Action: Surface Tension and Viscosity

Surface Tension

Viscosity

12.4 Evaporation and Condensation

Boiling

Energetics of Evaporation and Condensation

Heat of Vaporization

12.5 Melting, Freezing, and Sublimation

Energetics of Melting and Freezing

Heat of Fusion

Sublimation

12.6 Types of Intermolecular Forces: Dispersion, DipoleDipole, Hydrogen Bonding, and IonDipole

Chemistry And Health: Hydrogen Bonding in DNA

Dispersion Force

DipoleDipole Force

Hydrogen Bonding

IonDipole Force

12.7 Types of Crystalline Solids: Molecular, Ionic, and Atomic

Molecular Solids

Ionic Solids

Atomic Solids

12.8 Water: A Remarkable Molecule

Chemistry In The Environment: Water Pollution and the Flint River Water Crisis

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 13. Solutions**

# **Table of Contents**

13.1 Tragedy in Cameroon

13.2 Solutions: Homogeneous Mixtures

13.3 Solutions of Solids Dissolved in Water: How to Make Rock Candy

Solubility and Saturation

Electrolyte Solutions: Dissolved Ionic Solids

How Solubility Varies with Temperature

13.4 Solutions of Gases in Water: How Soda Pop Gets Its Fizz

13.5 Specifying Solution Concentration: Mass Percent

Mass Percent

Using Mass Percent in Calculations

13.6 Specifying Solution Concentration: Molarity

Using Molarity in Calculations

Ion Concentrations

13.7 Solution Dilution

13.8 Solution Stoichiometry

13.9 Freezing Point Depression and Boiling Point Elevation: Making Water Freeze Colder and Boil Hotter

Freezing Point Depression

Everyday Chemistry: Antifreeze in Frogs

Boiling Point Elevation

13.10 Osmosis: Why Drinking Salt Water Causes Dehydration

Chemistry And Health: Solutions in Medicine

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 14. Acids and Bases**

14.1 Sour Patch Kids and International Spy Movies

14.2 Acids: Properties and Examples

14.3 Bases: Properties and Examples

14.4 Molecular Definitions of Acids and Bases

The Arrhenius Definition

The BrønstedLowry Definition

14.5 Reactions of Acids and Bases

# Table of Contents

Neutralization Reactions

Acid Reactions

Everyday Chemistry: What Is in My Antacid?

Base Reactions

14.6 AcidBase Titration: A Way to Quantify the Amount of Acid or Base in a Solution

14.7 Strong and Weak Acids and Bases

Strong Acids

Weak Acids

Strong Bases

Weak Bases

14.8 Water: Acid and Base in One

14.9 The pH and pOH Scales: Ways to Express Acidity and Basicity

Calculating pH from  $[H_3O^+]$

Calculating  $[H_3O^+]$  from pH

The pOH Scale

14.10 Buffers: Solutions That Resist pH Change

Chemistry And Health: Alkaloids

Chemistry And Health: The Danger of Antifreeze

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## Chapter 15. Chemical Equilibrium

15.1 Life: Controlled Disequilibrium

15.2 The Rate of a Chemical Reaction

Collision Theory

How Concentration Affects the Rate of a Reaction

How Temperature Affects the Rate of a Reaction

15.3 The Idea of Dynamic Chemical Equilibrium

15.4 The Equilibrium Constant: A Measure of How Far a Reaction Goes

Writing Equilibrium Constant Expressions for Chemical Reactions

The Significance of the Equilibrium Constant

15.5 Heterogeneous Equilibria: The Equilibrium Expression for Reactions Involving a Solid or a Liquid

# **Table of Contents**

## 15.6 Calculating and Using Equilibrium Constants

Calculating Equilibrium Constants

Using Equilibrium Constants in Calculations

## 15.7 Disturbing a Reaction at Equilibrium: Le Châteliers Principle

## 15.8 The Effect of a Concentration Change on Equilibrium

## 15.9 The Effect of a Volume Change on Equilibrium

Chemistry And Health: How a Developing Fetus Gets Oxygen

## 15.10 The Effect of a Temperature Change on Equilibrium

## 15.11 The Solubility-Product Constant

Using  $K_{sp}$  to Determine Molar Solubility

## 15.12 The Path of a Reaction and the Effect of a Catalyst

How Activation Energies Affect Reaction Rates

Catalysts Lower the Activation Energy

Enzymes: Biological Catalysts

## Self-Assessment Quiz

## Key Terms

## Exercises

## Answers to Skillbuilder Exercises

## Answers to Conceptual Checkpoints

# Chapter 16. Oxidation and Reduction

## 16.1 The End of the Internal Combustion Engine?

## 16.2 Oxidation and Reduction: Some Definitions

## 16.3 Oxidation States: Electron Bookkeeping

Everyday Chemistry: The Bleaching of Hair

## 16.4 Balancing Redox Equations

Chemistry In The Environment: Photosynthesis and Respiration: Energy for Life

## 16.5 The Activity Series: Predicting Spontaneous Redox Reactions

The Activity Series of Metals

Predicting Whether a Metal Will Dissolve in Acid

## 16.6 Batteries: Using Chemistry to Generate Electricity

The Voltaic Cell

Dry-Cell Batteries

LeadAcid Storage Batteries

Fuel Cells

## 16.7 Electrolysis: Using Electricity to Do Chemistry

# **Table of Contents**

## 16.8 Corrosion: Undesirable Redox Reactions

Everyday Chemistry: The Fuel-Cell Breathalyzer

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## Chapter 17. Radioactivity and Nuclear Chemistry

### 17.1 Diagnosing Appendicitis

### 17.2 The Discovery of Radioactivity

### 17.3 Types of Radioactivity: Alpha, Beta, and Gamma Decay

Alpha ( $\alpha$ ) Radiation

Beta ( $\beta$ ) Radiation

Gamma ( $\gamma$ ) Radiation

Positron Emission

### 17.4 Detecting Radioactivity

### 17.5 Natural Radioactivity and Half-Life

Half-Life

Chemistry And Health: Environmental Radon

A Natural Radioactive Decay Series

### 17.6 Radiocarbon Dating: Using Radioactivity to Measure the Age of Fossils and Other Artifacts

Chemistry In The Media: The Shroud of Turin

### 17.7 The Discovery of Fission and the Atomic Bomb

### 17.8 Nuclear Power: Using Fission to Generate Electricity

### 17.9 Nuclear Fusion: The Power of the Sun

### 17.10 The Effects of Radiation on Life

Acute Radiation Damage

Increased Cancer Risk

Genetic Defects

Measuring Radiation Exposure

### 17.11 Radioactivity in Medicine

Isotope Scanning

Radiotherapy

Self-Assessment Quiz

# Table of Contents

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## Chapter 18. Organic Chemistry

18.1 What Do I Smell?

18.2 Vitalism: The Difference between Organic and Inorganic

18.3 Carbon: A Versatile Atom

Chemistry In The Media: The Origin of Life

18.4 Hydrocarbons: Compounds Containing Only Carbon and Hydrogen

18.5 Alkanes: Saturated Hydrocarbons

Chemistry In The Media: Environmental Problems Associated with Hydrocarbon Combustion

18.6 Isomers: Same Formula, Different Structure

18.7 Naming Alkanes

18.8 Alkenes and Alkynes

About Alkenes and Alkynes

Naming Alkenes and Alkynes

18.9 Hydrocarbon Reactions

Alkane Substitution Reactions

Alkene and Alkyne Addition Reactions

18.10 Aromatic Hydrocarbons

Naming Aromatic Hydrocarbons

18.11 Functional Groups

18.12 Alcohols

Naming Alcohols

About Alcohols

18.13 Ethers

Naming Ethers

About Ethers

18.14 Aldehydes and Ketones

Naming Aldehydes and Ketones

About Aldehydes and Ketones

18.15 Carboxylic Acids and Esters

Naming Carboxylic Acids and Esters

About Carboxylic Acids and Esters



# **Table of Contents**

18.16 Amines

18.17 Polymers

Everyday Chemistry: Kevlar: Stronger Than Steel

Self-Assessment Quiz

Key Terms

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

## **Chapter 19. Biochemistry**

19.1 The Human Genome Project

19.2 The Cell and Its Main Chemical Components

19.3 Carbohydrates: Sugar, Starch, and Fiber

Monosaccharides

Disaccharides

Polysaccharides

19.4 Lipids

Fatty Acids

Fats and Oils

Other Lipids

Chemistry And Health: Dietary Fats

19.5 Proteins

19.6 Protein Structure

Everyday Chemistry: Why Straight Hair Gets Longer When It Is Wet

Quaternary Structure

Tertiary Structure

Primary Structure

Secondary Structure

19.7 Nucleic Acids: Molecular Blueprints

19.8 DNA Structure, DNA Replication, and Protein Synthesis

DNA Structure

DNA Replication

Protein Synthesis

Chemistry And Health: Drugs for Diabetes

Self-Assessment Quiz

Key Terms

# **Table of Contents**

Exercises

Answers to Skillbuilder Exercises

Answers to Conceptual Checkpoints

Appendix: Mathematics Review

Answers to Odd-Numbered Exercises

Glossary

Credits

Index

Periodic Table of the Elements

Constants, Factors, and Formulas

Atomic Masses of the Elements