



Name	Symbol	Atomic Number	Atomic Weight	Name	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	(227)*	Mendelevium	Md	101	(258)
Aluminum	Al	13	26.981538	Mercury	Hg	80	200.59
Americium	Am	95	(243)	Molybdenum	Mo	42	95.96
Antimony	Sb	51	121.760	Moscovium	Mc	115	(288)
Argon	Ar	18	39.948	Neodymium	Nd	60	144.242
Arsenic	As	33	74.92160	Neon	Ne	10	20.1797
Astatine	At	85	(210)	Neptunium	Np	93	(237)
Barium	Ba	56	137.327	Nickel	Ni	28	58.6934
Berkelium	Bk	97	(247)	Nihonium	Nh	113	(284)
Beryllium	Be	4	9.012182	Niobium	Nb	41	92.90638
Bismuth	Bi	83	208.98040	Nitrogen	N	7	14.0067
Bohrium	Bh	107	(272)	Nobelium	No	102	(259)
Boron	В	5	10.811	Oganesson	Og	118	(294)
Bromine	Br	35	79.904	Osmium	Os	76	190.23
Cadmium	Cd	48	112.411	Oxygen	O	8	15.9994
Calcium	Ca	20	40.078	Palladium	Pd	46	106.42
Californium	Cf	98	(251)	Phosphorus	P	15	30.97376
Carbon	C	6	12.0107	Platinum	Pt	78	195.094
Cerium	Ce	58	140.116	Plutonium	Pu	94	(244)
Cesium	Cs	55	132.90545	Polonium	Po	84	(209)
Chlorine	Cl	17	35.453	Potassium	K	19	39.0983
Chromium	Cr	24	51.9961	Praseodymium	Pr	59	140.90765
Cobalt	Co	27	58.933195	Promethium	Pm	61	(145)
Copernicium	Cn	112	(285)	Protactinium	Pa	91	231.03588
*	Cu	29	63.546	Radium	Ra	88	(226)
Copper Curium	Cm	96		Radon	Rn	86	. ,
Darmstadtium	Ds		(247)	Rhenium	Re	75	(222)
		110	(281)	Rhodium	Rh	73 45	186.207
Dubnium	Db	105	(268)				102.90550
Dysprosium	Dy	66 99	162.500	Roentgenium Rubidium	Rg	111	(280)
Einsteinium	Es		(252)		Rb	37 44	85.4678
Erbium	Er	68	167.259	Ruthenium	Ru		101.07
Europium	Eu	63	151.964	Rutherfordium	Rf	104	(265)
Fermium	Fm	100	(257)	Samarium	Sm	62	150.36
Flerovium	Fl	114	(289)	Scandium	Sc	21	44.95591
Fluorine	F	9	18.998403	Seaborgium	Sg	106	(271)
Francium	Fr	87	(223)	Selenium	Se	34	78.96
Gadolinium	Gd	64	157.25	Silicon	Si	14	28.0855
Gallium	Ga	31	69.723	Silver	Ag	47	107.8682
Germanium	Ge	32	72.64	Sodium	Na	11	22.98976
Gold	Au	79	196.96657	Strontium	Sr	38	87.62
Hafnium	Hf	72	178.49	Sulfur	S	16	32.065
Hassium	Hs	108	(270)	Tantalum	Ta	73	180.9479
Helium	He	2	4.002602	Technetium	Tc	43	(98)
Holmium	Но	67	164.93032	Tellurium	Te	52	127.60
Hydrogen	Н	1	1.00794	Tennessine	Ts	117	(292)
Indium	In	49	114.818	Terbium	Tb	65	158.92535
Iodine	I	53	126.90447	Thallium	Tl	81	204.3833
Iridium	Ir	77	192.217	Thorium	Th	90	232.0381
Iron	Fe	26	55.845	Thulium	Tm	69	168.93421
Krypton	Kr	36	83.798	Tin	Sn	50	118.710
Lanthanum	La	57	138.9055	Titanium	Ti	22	47.867
Lawrencium	Lr	103	(262)	Tungsten	W	74	183.84
Lead	Pb	82	207.2	Uranium	U	92	238.02891
Lithium	Li	3	6.941	Vanadium	V	23	50.9415
Livermorium	Lv	116	(293)	Xenon	Xe	54	131.293
Lutetium	Lu	71	174.9668	Ytterbium	Yb	70	173.054
Magnesium	Mg	12	24.3050	Yttrium	Y	39	88.90585
Manganese	Mn	25	54.938045	Zinc	Zn	30	65.38
Meitnerium	Mt	109	(276)	Zirconium	Zr	40	91.224

<sup>\*</sup>Values in parentheses are the mass numbers of the most common or longest lived isotopes of radioactive elements.

# **Chemistry, Global Edition**

# **Table of Contents**

Front Cover

Periodic Table of the Elements

Title Page

Copyright Page

**Brief Contents** 

Content

**Preface** 

For Instructors

- 1 Chemical Tools: Experimentation and Measurement
  - 1.1 The Scientific Method: Nanoparticle Catalysts for Fuel Cells
  - 1.2 Measurements: SI Units and Scientific Notation
  - 1.3 Mass and Its Measurement
  - 1.4 Length and Its Measurement
  - 1.5 Temperature and Its Measurement
  - 1.6 Derived Units: Volume and Its Measurement
  - 1.7 Derived Units: Density and Its Measurement
  - 1.8 Derived Units: Energy and Its Measurement
  - 1.9 Accuracy, Precision, and Significant Figures in Measurement
  - 1.10 Significant Figures in Calculations
  - 1.11 Converting from One Unit to Another

INQUIRY? What are the unique properties of nanoscale materials?

Study Guide

Key Terms

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems



#### 2 Atoms, Molecules, and Ions

- 2.1 Chemistry and the Elements
- 2.2 Elements and the Periodic Table
- 2.3 Some Common Groups of Elements and Their Properties
- 2.4 Observations Supporting Atomic Theory: The Conservation of Mass and the Law of Definite Proportions
- 2.5 The Law of Multiple Proportions and Daltons Atomic Theory
- 2.6 Atomic Structure: Electrons
- 2.7 Atomic Structure: Protons and Neutrons
- 2.8 Atomic Numbers
- 2.9 Atomic Weights and the Mole
- 2.10 Measuring Atomic Weight: Mass Spectrometry
- 2.11 Mixtures and Chemical Compounds; Molecules and Covalent Bonds
- 2.12 Ions and Ionic Bonds
- 2.13 Naming Chemical Compounds

INQUIRY? How can measurements of oxygen and hydrogen isotopes in ice cores determine past climates?

Study Guide

**Key Terms** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 3 Mass Relationships in Chemical Reactions

- 3.1 Representing Chemistry on Different Levels
- 3.2 Balancing Chemical Equations
- 3.3 Molecular Weight and Molar Mass
- 3.4 Stoichiometry: Relating Amounts of Reactants and Products
- 3.5 Yields of Chemical Reactions
- 3.6 Reactions with Limiting Amounts of Reactants
- 3.7 Percent Composition and Empirical Formulas
- 3.8 Determining Empirical Formulas: Elemental Analysis
- 3.9 Determining Molecular Weights: Mass Spectrometry



INQUIRY? How is the principle of atom economy used to minimize waste in a chemical synthesis?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 4 Reactions in Aqueous Solution

- 4.1 Solution Concentration: Molarity
- 4.2 Diluting Concentrated Solutions
- 4.3 Electrolytes in Aqueous Solution
- 4.4 Types of Chemical Reactions in Aqueous Solution
- 4.5 Aqueous Reactions and Net Ionic Equations
- 4.6 Precipitation Reactions and Solubility Guidelines
- 4.7 Acids, Bases, and Neutralization Reactions
- 4.8 Solution Stoichiometry
- 4.9 Measuring the Concentration of a Solution: Titration
- 4.10 OxidationReduction (Redox) Reactions
- 4.11 Identifying Redox Reactions
- 4.12 The Activity Series of the Elements
- 4.13 Redox Titrations
- 4.14 Some Applications of Redox Reactions

INQUIRY? How do sports drinks replenish the substances lost in sweat?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

5 Periodicity and the Electronic Structure of Atoms



- 5.1 Wave Properties of Radiant Energy and the Electromagnetic Spectrum
- 5.2 Particlelike Properties of Radiant Energy: The Photoelectric Effect and Plancks Postulate
- 5.3 Atomic Line Spectra and Quantized Energy
- 5.4 Wavelike Properties of Matter: de Broglies Hypothesis
- 5.5 The Quantum Mechanical Model of the Atom: Heisenbergs Uncertainty Principle
- 5.6 The Quantum Mechanical Model of the Atom: Orbitals and Quantum Numbers
- 5.7 The Shapes of Orbitals
- 5.8 Electron Spin and the Pauli Exclusion Principle
- 5.9 Orbital Energy Levels in Multielectron Atoms
- 5.10 Electron Configurations of Multielectron Atoms
- 5.11 Anomalous Electron Configurations
- 5.12 Electron Configurations and the Periodic Table
- 5.13 Electron Configurations and Periodic Properties: Atomic Radii
- INQUIRY? How does knowledge of atomic emission spectra help us build more efficient light bulbs?

Study Guide

**Key Terms** 

Key Equations

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

- 6 Ionic Compounds: Periodic Trends and Bonding Theory
  - 6.1 Electron Configurations of lons
  - 6.2 Ionic Radii
  - 6.3 Ionization Energy
  - 6.4 Higher Ionization Energies
  - 6.5 Electron Affinity
  - 6.6 The Octet Rule
  - 6.7 Ionic Bonds and the Formation of Ionic Solids
  - 6.8 Lattice Energies in Ionic Solids

INQUIRY? How do ionic liquids lead to more environmentally friendly processes?



Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 7 Covalent Bonding and Electron-Dot Structures

- 7.1 Covalent Bonding in Molecules
- 7.2 Strengths of Covalent Bonds
- 7.3 Polar Covalent Bonds: Electronegativity
- 7.4 A Comparison of Ionic and Covalent Compounds
- 7.5 Electron-Dot Structures: The Octet Rule
- 7.6 Procedure for Drawing Electron-Dot Structures
- 7.7 Drawing Electron-Dot Structures for Radicals
- 7.8 Electron-Dot Structures of Compounds Containing Only Hydrogen and Second-Row Elements
- 7.9 Electron-Dot Structures and Resonance
- 7.10 Formal Charges

INQUIRY? How does bond polarity affect the toxicity of organophosphate insecticides?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

- 8 Covalent Compounds: Bonding Theories and Molecular Structure
  - 8.1 Molecular Shapes: The VSEPR Model
  - 8.2 Valence Bond Theory
  - 8.3 Hybridization and sp3 Hybrid Orbitals
  - 8.4 Other Kinds of Hybrid Orbitals
  - 8.5 Polar Covalent Bonds and Dipole Moments



- 8.6 Intermolecular Forces
- 8.7 Molecular Orbital Theory: The Hydrogen Molecule
- 8.8 Molecular Orbital Theory: Other Diatomic Molecules
- 8.9 Combining Valence Bond Theory and Molecular Orbital Theory

INQUIRY? Which is better for human health, natural or synthetic vitamins?

Study Guide

**Key Terms** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

- 9 Thermochemistry: Chemical Energy
  - 9.1 Energy and Its Conservation
  - 9.2 Internal Energy and State Functions
  - 9.3 Expansion Work
  - 9.4 Energy and Enthalpy
  - 9.5 Thermochemical Equations and the Thermodynamic Standard State
  - 9.6 Enthalpies of Chemical and Physical Changes
  - 9.7 Calorimetry and Heat Capacity
  - 9.8 Hesss Law
  - 9.9 Standard Heats of Formation
  - 9.10 Bond Dissociation Energies
  - 9.11 An Introduction to Entropy
  - 9.12 An Introduction to Free Energy

INQUIRY? How do we determine the energy content of biofuels?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

10 Gases: Their Properties and Behavior



- 10.1 Gases and Gas Pressure
- 10.2 The Gas Laws
- 10.3 The Ideal Gas Law
- 10.4 Stoichiometric Relationships with Gases
- 10.5 Mixtures of Gases: Partial Pressure and Daltons Law
- 10.6 The KineticMolecular Theory of Gases
- 10.7 Gas Diffusion and Effusion: Grahams Law
- 10.8 The Behavior of Real Gases
- 10.9 The Earths Atmosphere and the Greenhouse Effect
- 10.10 Greenhouse Gases
- 10.11 Climate Change

INQUIRY? How do inhaled anesthetics work?

Study Guide

Key Terms

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 11 Liquids and Phase Changes

- 11.1 Properties of Liquids
- 11.2 Vapor Pressure and Boiling Point
- 11.3 Phase Changes between Solids, Liquids, and Gases
- 11.4 Energy Changes during Phase Transitions
- 11.5 Phase Diagrams
- 11.6 Liquid Crystals

INQUIRY? How is caffeine removed from coffee?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems



#### Multiconcept Problems

#### 12 Solids and Solid-State Materials

- 12.1 Types of Solids
- 12.2 Probing the Structure of Solids: X-Ray Crystallography
- 12.3 The Packing of Spheres in Crystalline Solids: Unit Cells
- 12.4 Structures of Some Ionic Solids
- 12.5 Structures of Some Covalent Network Solids
- 12.6 Bonding in Metals
- 12.7 Semiconductors
- 12.8 Semiconductor Applications
- 12.9 Superconductors
- 12.10 Ceramics and Composites

INQUIRY? What are quantum dots, and what controls their color?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 13 Solutions and Their Properties

- 13.1 Solutions
- 13.2 Enthalpy Changes and the Solution Process
- 13.3 Predicting Solubility
- 13.4 Concentration Units for Solutions
- 13.5 Some Factors That Affect Solubility
- 13.6 Physical Behavior of Solutions: Colligative Properties
- 13.7 Vapor-Pressure Lowering of Solutions: Raoults Law
- 13.8 Boiling-Point Elevation and Freezing-Point Depression of Solutions
- 13.9 Osmosis and Osmotic Pressure

INQUIRY? How does hemodialysis cleanse the blood of patients with kidney failure?

Study Guide

**Key Terms** 



**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 14 Chemical Kinetics

- 14.1 Reaction Rates
- 14.2 Rate Laws and Reaction Order
- 14.3 Method of Initial Rates: Experimental Determination of a Rate Law
- 14.4 Integrated Rate Law: Zeroth-Order Reactions
- 14.5 Integrated Rate Law: First-Order Reactions
- 14.6 Integrated Rate Law: Second-Order Reactions
- 14.7 Reaction Rates and Temperature: The Arrhenius Equation
- 14.8 Using the Arrhenius Equation
- 14.9 Reaction Mechanisms
- 14.10 Rate Laws for Elementary Reactions
- 14.11 Rate Laws for Overall Reactions
- 14.12 Catalysis
- 14.13 Homogeneous and Heterogeneous Catalysts

INQUIRY? How do enzymes work?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 15 Chemical Equilibrium

- 15.1 The Equilibrium State
- 15.2 The Equilibrium Constant Kc
- 15.3 The Equilibrium Constant Kp
- 15.4 Heterogeneous Equilibria
- 15.5 Using the Equilibrium Constant



- 15.6 Factors That Alter the Composition of an Equilibrium Mixture: Le Châteliers Principle
- 15.7 Altering an Equilibrium Mixture: Changes in Concentration
- 15.8 Altering an Equilibrium Mixture: Changes in Pressure and Volume
- 15.9 Altering an Equilibrium Mixture: Changes in Temperature
- 15.10 The Link between Chemical Equilibrium and Chemical Kinetics

INQUIRY? How does high altitude affect oxygen transport in the body?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

- 16 Aqueous Equilibria: Acids and Bases
  - 16.1 AcidBase Concepts: The BrønstedLowry Theory
  - 16.2 Acid Strength and Base Strength
  - 16.3 Factors That Affect Acid Strength
  - 16.4 Dissociation of Water
  - 16.5 The pH Scale
  - 16.6 Measuring pH
  - 16.7 The pH in Solutions of Strong Acids and Strong Bases
  - 16.8 Equilibria in Solutions of Weak Acids
  - 16.9 Calculating Equilibrium Concentrations in Solutions of Weak Acids
  - 16.10 Percent Dissociation in Solutions of Weak Acids
  - 16.11 Polyprotic Acids
  - 16.12 Equilibria in Solutions of Weak Bases
  - 16.13 Relation Between Ka and Kb
  - 16.14 AcidBase Properties of Salts
  - 16.15 Lewis Acids and Bases

INQUIRY? Has the problem of acid rain been solved?

Study Guide

**Key Terms** 



**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 17 Applications of Aqueous Equilibria

- 17.1 Neutralization Reactions
- 17.2 The Common-Ion Effect
- 17.3 Buffer Solutions
- 17.4 The HendersonHasselbalch Equation
- 17.5 pH Titration Curves
- 17.6 Strong AcidStrong Base Titrations
- 17.7 Weak AcidStrong Base Titrations
- 17.8 Weak BaseStrong Acid Titrations
- 17.9 Polyprotic AcidStrong Base Titrations
- 17.10 Solubility Equilibria for Ionic Compounds
- 17.11 Measuring Ksp and Calculating Solubility from Ksp
- 17.12 Factors That Affect Solubility
- 17.13 Precipitation of Ionic Compounds
- 17.14 Separation of lons by Selective Precipitation
- 17.15 Qualitative Analysis

INQUIRY? What is causing ocean acidification?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

## 18 Thermodynamics: Entropy, Free Energy, and Spontaneity

- 18.1 Spontaneous Processes
- 18.2 Enthalpy, Entropy, and Spontaneous Processes
- 18.3 Entropy and Probability



- 18.4 Entropy and Temperature
- 18.5 Standard Molar Entropies and Standard Entropies of Reaction
- 18.6 Entropy and the Second Law of Thermodynamics
- 18.7 Free Energy and the Spontaneity of Chemical Reactions
- 18.8 Standard Free-Energy Changes for Reactions
- 18.9 Standard Free Energies of Formation
- 18.10 Free-Energy Changes for Reactions under Nonstandard-State Conditions
- 18.11 Free Energy and Chemical Equilibrium
- INQUIRY? Does the formation of highly ordered molecules violate the second law of thermodynamics?

Study Guide

**Key Terms** 

**Key Equations** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 19 Electrochemistry

- 19.1 Balancing Redox Reactions by the Half-Reaction Method
- 19.2 Galvanic Cells
- 19.3 Shorthand Notation for Galvanic Cells
- 19.4 Cell Potentials and Free-Energy Changes for Cell Reactions
- 19.5 Standard Reduction Potentials
- 19.6 Using Standard Reduction Potentials
- 19.7 Cell Potentials under Nonstandard-State Conditions: The Nernst Equation
- 19.8 Electrochemical Determination of pH
- 19.9 Standard Cell Potentials and Equilibrium Constants
- 19.10 Batteries
- 19.11 Corrosion
- 19.12 Electrolysis and Electrolytic Cells
- 19.13 Commercial Applications of Electrolysis
- 19.14 Quantitative Aspects of Electrolysis

INQUIRY? How do hydrogen fuel cells work?



Study Guide **Key Terms Key Equations Practice Test** Conceptual Problems Section Problems Multiconcept Problems 20 Nuclear Chemistry 20.1 Nuclear Reactions and Their Characteristics 20.2 Radioactivity 20.3 Nuclear Stability 20.4 Radioactive Decay Rates 20.5 Dating with Radioisotopes 20.6 Energy Changes during Nuclear Reactions 20.7 Nuclear Fission and Fusion 20.8 Nuclear Transmutation 20.9 Detecting and Measuring Radioactivity INQUIRY? How are radioisotopes used in medicine? Study Guide Key Terms **Key Equations Practice Test** Conceptual Problems Section Problems Multiconcept Problems 21 Transition Elements and Coordination Chemistry 21.1 Electron Configurations 21.2 Properties of Transition Elements 21.3 Oxidation States of Transition Elements 21.4 Coordination Compounds 21.5 Ligands 21.6 Naming Coordination Compounds 21.7 Isomers



21.8 Enantiomers and Molecular Handedness

21.9 Color of Transition Metal Complexes

21.10 Crystal Field Theory

21.11 Bonding in Complexes: Valence Bond Theory

INQUIRY? How does cisplatin kill cancer cells?

Study Guide

**Key Terms** 

**Key Equation** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 22 The Main-Group Elements

22.1 A Review of General Properties and Periodic Trends

22.2 Distinctive Properties of the Second-Row Elements

22.3 Group 1A: Hydrogen

22.4 Group 1A: Alkali Metals and Group 2A: Alkaline Earth Metals

22.5 Group 3A Elements

22.6 Group 4A Elements

22.7 Group 5A Elements

22.8 Group 6A Elements

22.9 Group 7A: The Halogens

22.10 Group 8A: Noble Gases

INQUIRY? What are the barriers to a hydrogen economy?

Study Guide

**Key Terms** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

#### 23 Organic and Biological Chemistry

23.1 Organic Molecules and Their Structures: Consitutional Isomers

23.2 Stereoisomers: Chiral Molecules



23.3 Families of Organic Compounds: Functional Groups

23.4 Carbohydrates: A Biological Example of Isomers

23.5 Valence Bond Theory and Orbital Overlap Pictures

23.6 Lipids: A Biological Example of CisTrans Isomerism

23.7 Formal Charge and Resonance in Organic Compounds

23.8 Conjugated Systems

23.9 Proteins: A Biological Example of Conjugation

23.10 Aromatic Compounds and Molecular Orbital Theory

23.11 Nucleic Acids: A Biological Example of Aromaticity

INQUIRY? Why do enantiomers have different biological responses?

Study Guide

**Key Terms** 

**Practice Test** 

Conceptual Problems

Section Problems

Multiconcept Problems

Appendix A: Mathematical Operations

A.1 Scientific Notation

A.2 Logarithms

A.3 Straight-Line Graphs and Linear Equations

A.4 Quadratic Equations

A.5 Calculus Derivations of Integrated Rate Laws

Appendix B: Thermodynamic Properties at 25 °C

Appendix C: Equilibrium Constants at 25 °C

Appendix D: Standard Reduction Potentials at 25 °C

Appendix E: Properties of Water

Answers to Selected Problems

Glossary

Index

Photo/Text Credits

**Back Cover** 

