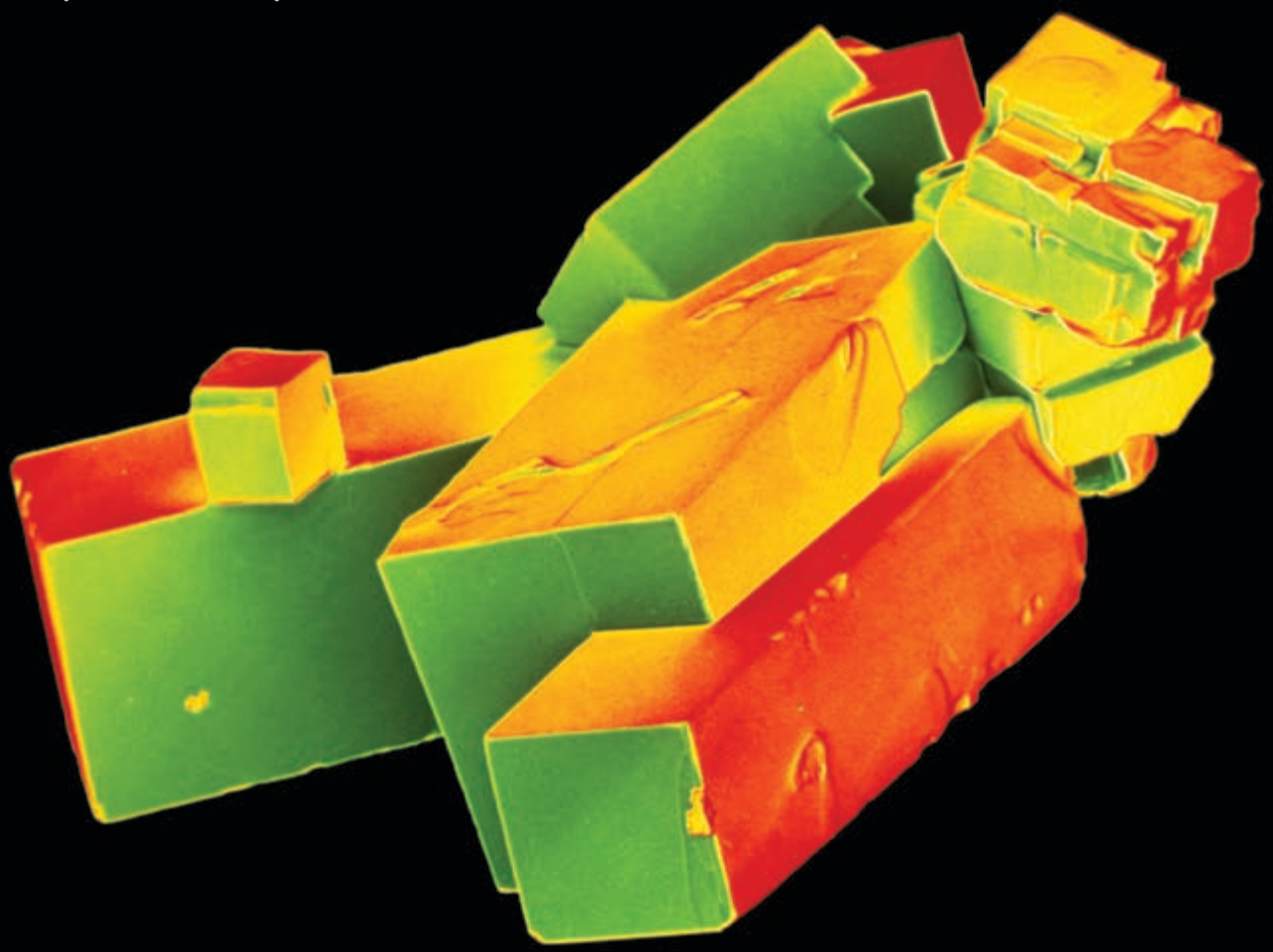
Teacher Edition

HOLT McDOUGAL

Modern Chemistry

Sarquis • Sarquis



HOLT McDOUGAL

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What's New for ©2012...

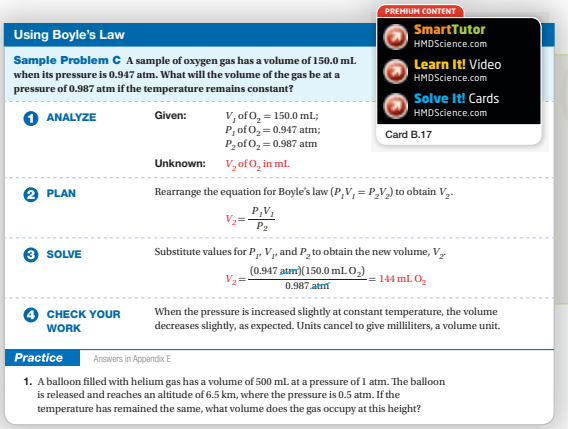
Updated Student & Teacher Edition

- Increased Student Accessibility
- Differentiated Instruction in the Teacher Edition
- New 4-step Instructional Model used to organize the Teacher Edition

now S.T.E.M.

Innovative Technology

- Why It Matters videos
- Virtual Labs
- Animated Chemistry
- Interactive Review Games



Using Boyle's Law

Sample Problem C A sample of oxygen gas has a volume of 150.0 mL when its pressure is 0.947 atm. What will the volume of the gas be at a pressure of 0.987 atm if the temperature remains constant?

PREMIUM CONTENT
SmartTutor HMDScience.com
Learn It! Video HMDScience.com
Solve It! Cards HMDScience.com
Card B.17

1 ANALYZE Given: V_1 of O_2 = 150.0 mL; P_1 of O_2 = 0.947 atm; P_2 of O_2 = 0.987 atm
Unknown: V_2 of O_2 in mL

2 PLAN Rearrange the equation for Boyle's law ($P_1V_1 = P_2V_2$) to obtain V_2.

$$V_2 = \frac{P_1V_1}{P_2}$$

3 SOLVE Substitute values for P_1, V_1, and P_2 to obtain the new volume, V_2.

$$V_2 = \frac{(0.947\ \text{atm})(150.0\ \text{mL}\ O_2)}{0.987\ \text{atm}} = 144\ \text{mL}\ O_2$$

4 CHECK YOUR WORK When the pressure is increased slightly at constant temperature, the volume decreases slightly, as expected. Units cancel to give milliliters, a volume unit.

Practice Answers in Appendix E

1. A balloon filled with helium gas has a volume of 500 mL at a pressure of 1 atm. The balloon is released and reaches an altitude of 6.5 km, where the pressure is 0.5 atm. If the temperature has remained the same, what volume does the gas occupy at this height?

Stronger Problem-Solving Support

- Revised Sample Problems
- Learn It! Video tutorials
- Solve It! Cards

The Standard by which all Chemistry programs are compared

Modern Chemistry presents a balanced and engaging approach to conceptual and problem-solving instruction. Many improvements have been made to the program to make the content accessible to more students.

A Friendlier Student Edition

Critical Thinking

Critical Thinking questions prompt deep thinking in your students.

CRITICAL THINKING
Interpret What is happening to the volume of the gas as the pressure increases?

Highlighted formulas

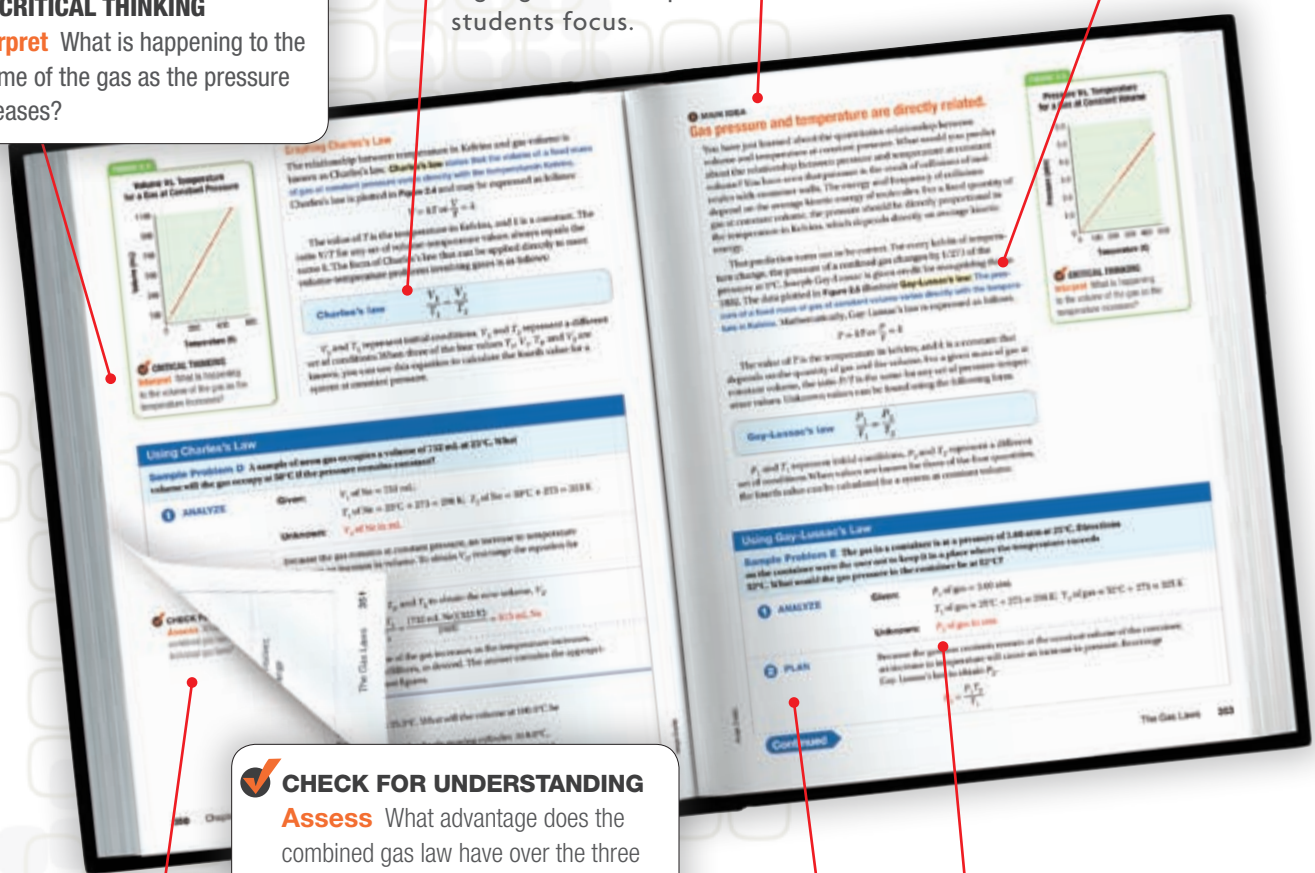
Key formulas have been highlighted to help students focus.

Main Ideas

Chapter content has been organized around main ideas.

In-text definitions

As students study, key vocabulary has been highlighted in context.



CHECK FOR UNDERSTANDING
Assess What advantage does the combined gas law have over the three individual gas laws?

Check for Understanding

These reading comprehension questions help reinforce the important points of the section.

Problem-solving steps

These are organized in a way that is familiar to students.

Highlighted variables

The unknown variables in Sample Problems have been highlighted for greater clarity.

. . . is now more Accessible than ever.

PREMIUM CONTENT

Interactive Review
HMDScience.com

Review Games
Concept Maps

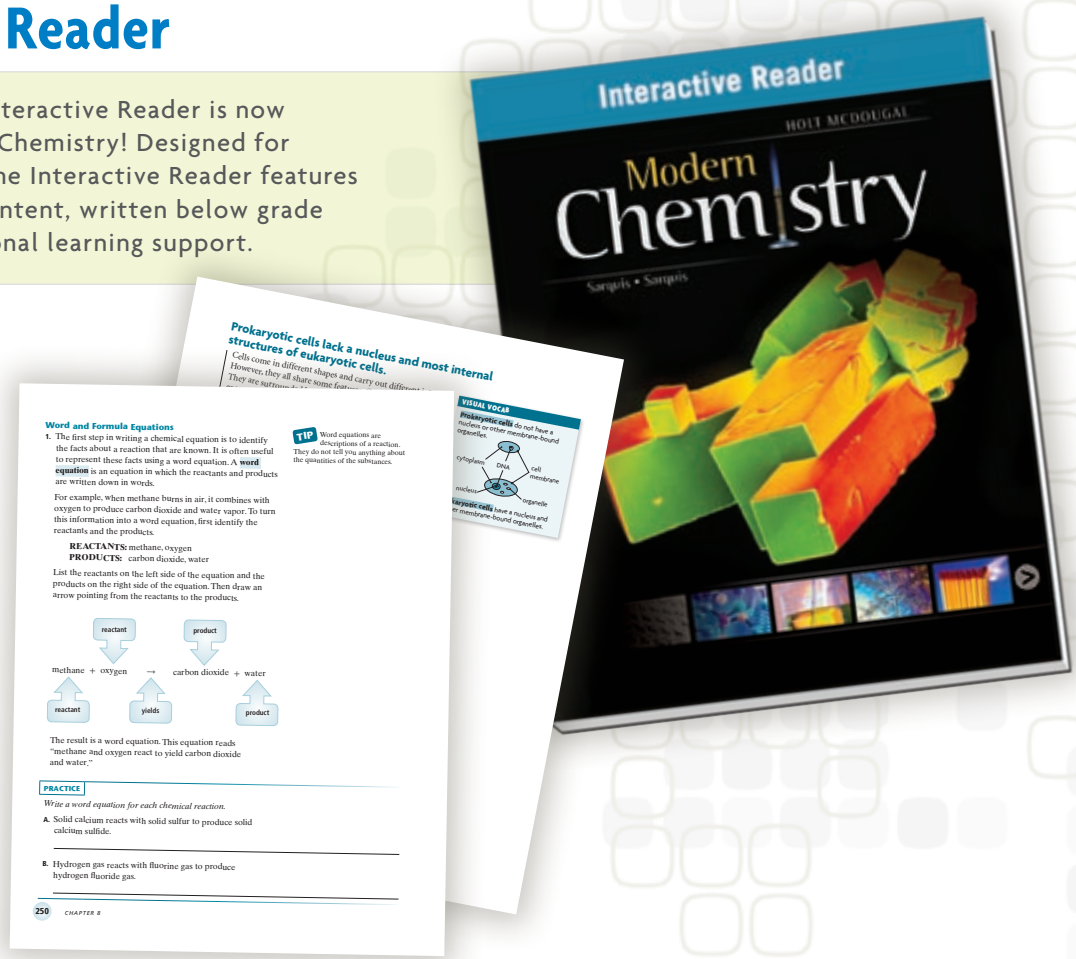
Chapter Summary

Even the chapter summary has been significantly redesigned to be more accessible and useful to students. Features include:

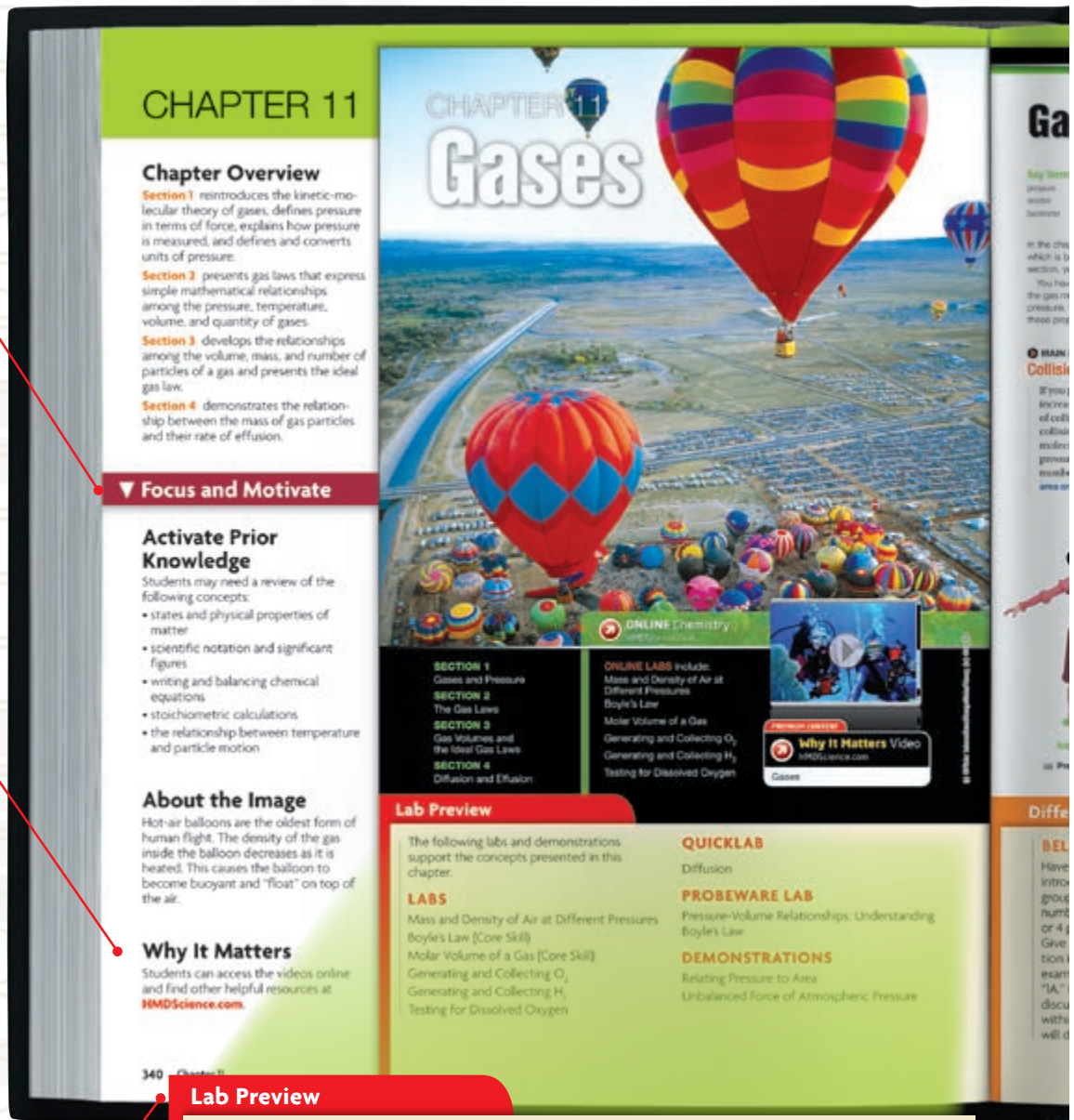
- Section-level summaries
- Section-level key terms
- Interactive Review Games and Concept Map links

Interactive Reader

The hugely popular Interactive Reader is now available for Modern Chemistry! Designed for struggling students, the Interactive Reader features all of the essential content, written below grade level and with additional learning support.



New and Improved Teacher Edition with . . .



New Instructional Model

Enhanced Teacher Edition wrap is organized around an instructional model that includes:

Focus and Motivate

Plan and Prepare

Teach

Assess and Reteach

Why It Matters

Each chapter begins with new **Why It Matters** videos that help students connect chemistry subjects to the world around them.

Labs

The Teacher Edition wrap outlines all program labs that are relevant to the chapter. These labs are all accessed online or on the Lab Generator. **QuickLabs** are also available in the Student Edition.

Lab Preview

The following labs and demonstrations support the concepts presented in this chapter.

LABS

Mass and Density of Air at Different Pressures
Boyle's Law (Core Skill)
Molar Volume of a Gas (Core Skill)
Generating and Collecting O_2
Generating and Collecting H_2
Testing for Dissolved Oxygen

QUICKLAB

Diffusion

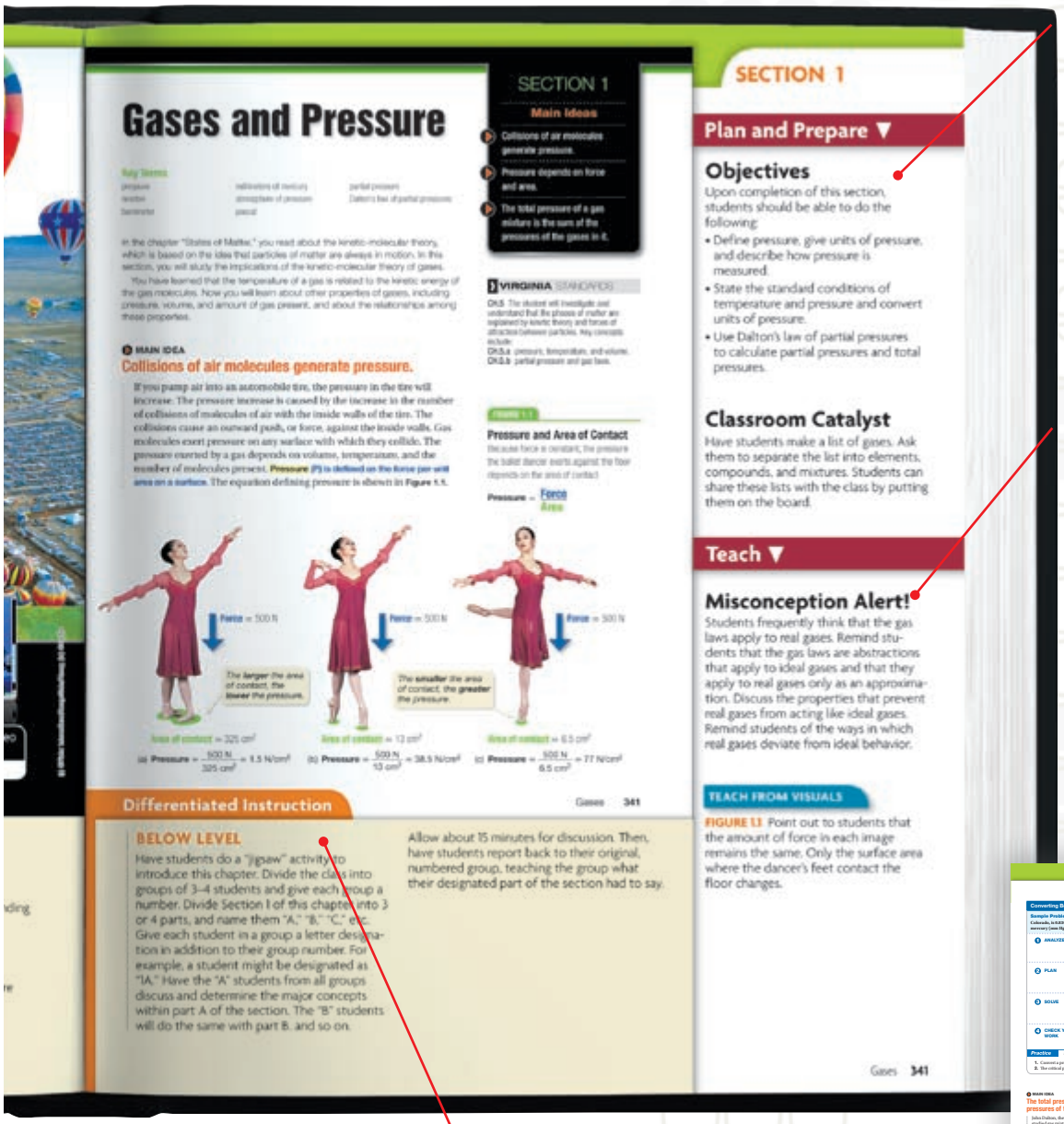
PROBEWARE LAB

Pressure-Volume Relationships: Understanding Boyle's Law

DEMONSTRATIONS

Relating Pressure to Area
Unbalanced Force of Atmospheric Pressure

Stronger instructional support

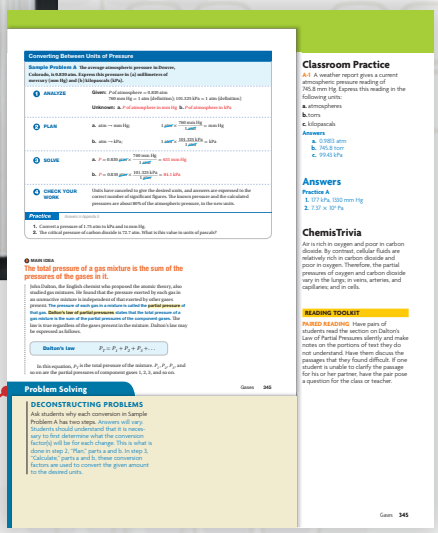


Section Openers

Each section begins with learning objectives and a motivating "Classroom Catalyst" activity.

Strong Teaching Support

Point-of-use teaching support is provided throughout the chapter, including Misconception Alert!, Teach from Visuals, and Reading Toolkit features.



Differentiated Instruction

New differentiated instruction materials have been added to assist teachers with a wide range of student needs. Categories include:

Below Level

English Learners

Pre-AP

Inclusion

Problem-Solving Support

Teachers are provided with additional problem-solving strategies to help students solve chemistry problems.

Technology to inspire and engage

Nothing captures students' interest and facilitates meaningful learning like technology. Many highly effective technology learning tools have been added to ***Modern Chemistry*** to accomplish just that.

Animated Chemistry

Students access chemistry concepts and principles in a meaningful way with dozens of high-quality animations and simulations.

Virtual Labs

Virtual Labs take students beyond the classroom to explore experiments not performed in a typical school laboratory setting.

Interactive Whiteboard Resources

All Online!

Key teaching visuals have been adapted specifically for interactive whiteboard use, allowing teachers to take advantage of this exciting technology.

Interactive Review Games

Nothing encourages students to study and review more than a game! These newly designed online review games help make chemistry more fun than ever.

Available to you online at HMDScience.com

Why It Matters

All Online!

Captivate student interest and boost real-world relevance with these short chapter introductory videos.

PREMIUM CONTENT

Why It Matters Video
HMDScience.com

WebLinks

All Online!

Hand-selected resource links bring the BEST of the internet to the classroom. No longer will you have to spend endless hours scouring the internet for great resources—we've done all the work!

Teaching Visuals

Key illustrations and diagrams from the text are provided in a digital format so that you can display them on a whiteboard or projector.

Interactive Reader Audio

A full audio version of the Interactive Reader makes content more accessible for auditory learners, reluctant readers, and English Learners.

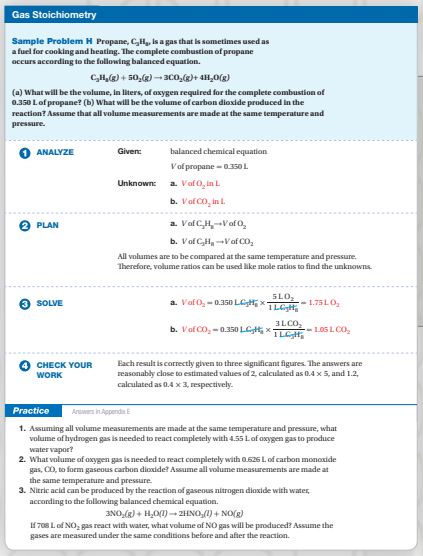
In addition, Modern Chemistry still offers the following popular technology features:

PowerPresentations Use these pre-designed lectures, or edit them to make your own customized presentations.

Chapter Summaries Audio These are available in English and Spanish.

Approach Problem Solving in NEW ways

Problem solving commonly stumps even the best students. ***Modern Chemistry*** has added new problem-solving support resources to help students master the fundamentals of chemistry problem solving.



Gas Stoichiometry

Sample Problem H Propane, C_3H_8, is a gas that is sometimes used as a fuel for cooking and heating. The complete combustion of propane occurs according to the following balanced equation.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

(a) What will be the volume, in liters, of oxygen required for the complete combustion of 0.350 L of propane? (b) What will be the volume of carbon dioxide produced in the reaction? Assume that all volume measurements are made at the same temperature and pressure.

1 ANALYZE — Given: balanced chemical equation; V of propane = 0.350 L. Unknown: a. V of O_2 in L; b. V of CO_2 in L.

2 PLAN — a. V of $C_3H_8 \rightarrow V$ of O_2; b. V of $C_3H_8 \rightarrow V$ of CO_2. All volumes are to be compared at the same temperature and pressure. Therefore, volume ratios can be used like mole ratios to find the unknowns.

3 SOLVE — a. V of $O_2 = 0.350\ \cancel{L\ C_3H_8} \times \frac{5\ L\ O_2}{1\ \cancel{L\ C_3H_8}} = 1.75\ L\ O_2$; b. V of $CO_2 = 0.350\ \cancel{L\ C_3H_8} \times \frac{3\ L\ CO_2}{1\ \cancel{L\ C_3H_8}} = 1.05\ L\ CO_2$

4 CHECK YOUR WORK — Each result is correctly given to three significant figures. The answers are reasonably close to estimated values of 2, calculated as 0.4 × 5, and 1.2, calculated as 0.4 × 3, respectively.

Practice — Answers in Appendix E

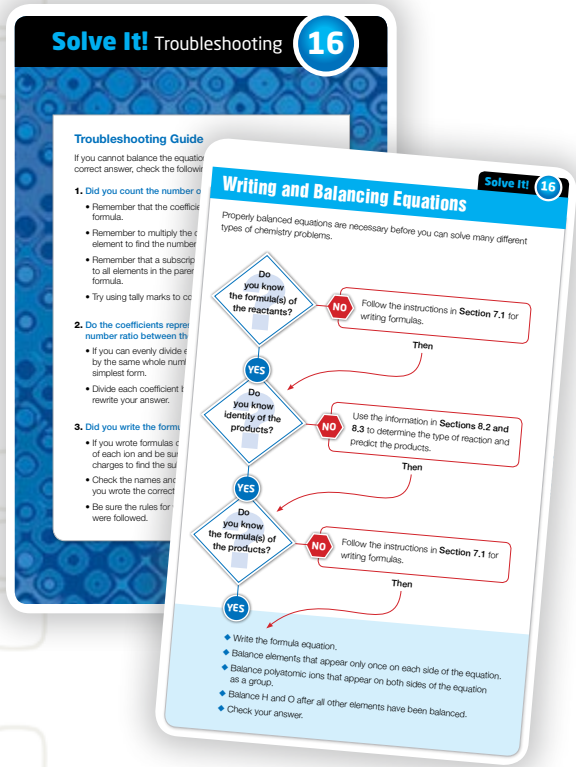
1. Assuming all volume measurements are made at the same temperature and pressure, what volume of hydrogen gas is needed to react completely with 4.55 L of oxygen gas to produce water vapor?
2. What volume of oxygen gas is needed to react completely with 0.626 L of carbon monoxide gas, CO, to form gaseous carbon dioxide? Assume all volume measurements are made at the same temperature and pressure.
3. Nitric acid can be produced by the reaction of gaseous nitrogen dioxide with water, according to the following balanced chemical equation.

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(l) + NO(g)$$

If 708 L of NO_2 gas react with water, what volume of NO gas will be produced? Assume the gases are measured under the same conditions before and after the reaction.

Revised Sample Problems

Major improvements have been made to the textbook Sample Problems to help boost student understanding. These include highlighting unknown variables, improved step references, and more.



Solve It! Troubleshooting 16

Troubleshooting Guide

Solve It! 16

Writing and Balancing Equations

Properly balanced equations are necessary before you can solve many different types of chemistry problems.

Do you know the formula(s) of the reactants? — NO: Follow the instructions in Section 7.1 for writing formulas. Then — YES

Do you know identity of the products? — NO: Use the information in Sections 8.2 and 8.3 to determine the type of reaction and predict the products. Then — YES

Do you know the formula(s) of the products? — NO: Follow the instructions in Section 7.1 for writing formulas. Then — YES

- Write the formula equation.
- Balance elements that appear only once on each side of the equation.
- Balance polyatomic ions that appear on both sides of the equation as a group.
- Balance H and O after all other elements have been balanced.
- Check your answer.

Solve It! Cards

Printable cards help students master the core strategies to solve nearly any chemistry problem.

PREMIUM CONTENT

SolveIt! Cards
HMDScience.com

Learn It! Videos

Videos of master chemistry tutors guide students through the most challenging chemistry problems.

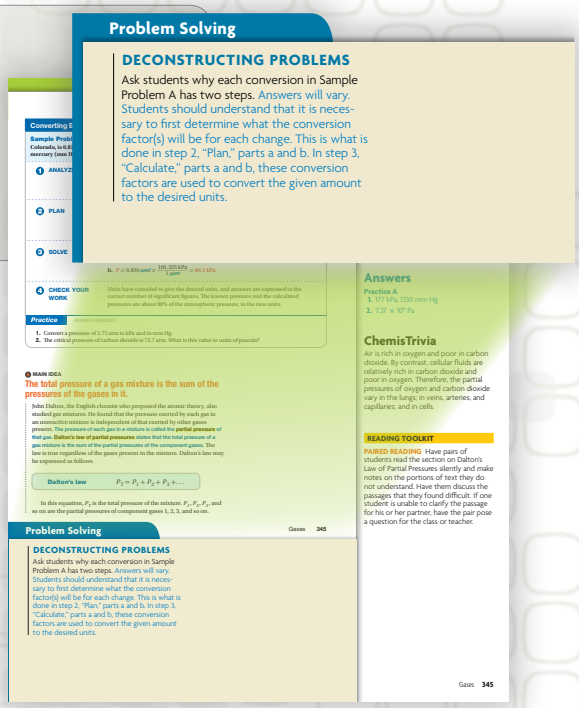
PREMIUM CONTENT

LearnIt! Video
HMDScience.com

with superior Problem-Solving support

TE Problem-Solving Support

The Teacher Edition includes additional problem-solving support strategies to help teachers guide students through a particular set of problems.



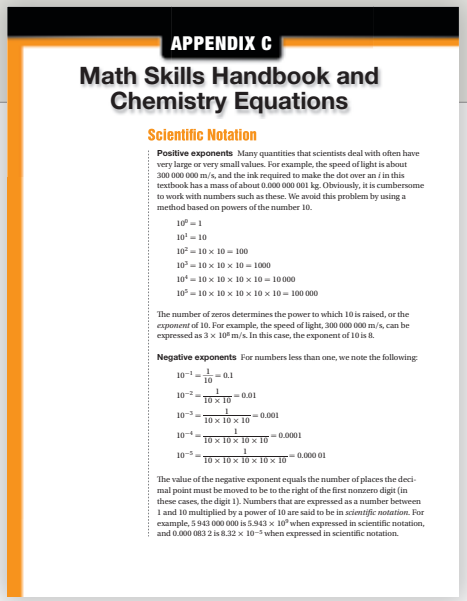
Problem Solving

DECONSTRUCTING PROBLEMS

Ask students why each conversion in Sample Problem A has two steps. Answers will vary. Students should understand that it is necessary to first determine what the conversion factor(s) will be for each change. This is what is done in step 2, "Plan," parts a and b. In step 3, "Calculate," parts a and b, these conversion factors are used to convert the given amount to the desired units.

Math Skills and Equations

A NEW Math Skills Handbook and Chemistry Equations appendix has been added for students who need extra math support.



APPENDIX C

Math Skills Handbook and Chemistry Equations

Scientific Notation

Positive exponents Many quantities that scientists deal with often have very large or very small values. For example, the speed of light is about 300 000 000 m/s, and the ink required to make the dot over an *i* in this textbook has a mass of about 0.000 000 001 kg. Obviously, it is cumbersome to work with numbers such as these. We avoid this problem by using a method based on powers of the number 10.

$10^0 = 1$

$10^1 = 10$

$10^2 = 10 \times 10 = 100$

$10^3 = 10 \times 10 \times 10 = 1000$

$10^4 = 10 \times 10 \times 10 \times 10 = 10\,000$

$10^5 = 10 \times 10 \times 10 \times 10 \times 10 = 100\,000$

The number of zeros determines the power to which 10 is raised, or the *exponent* of 10. For example, the speed of light, 300 000 000 m/s, can be expressed as 3×10^8 m/s. In this case, the exponent of 10 is 8.

Negative exponents For numbers less than one, we note the following:

$10^{-1} = \frac{1}{10} = 0.1$

$10^{-2} = \frac{1}{10 \times 10} = 0.01$

$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$

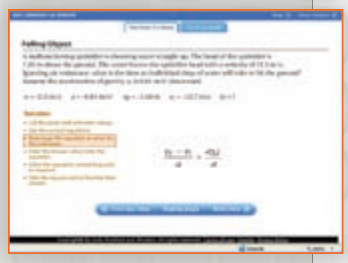
$10^{-4} = \frac{1}{10 \times 10 \times 10 \times 10} = 0.0001$

$10^{-5} = \frac{1}{10 \times 10 \times 10 \times 10 \times 10} = 0.000\,01$

The value of the negative exponent equals the number of places the decimal point must be moved to be to the right of the first nonzero digit (in these cases, the digit 1). Numbers that are expressed as a number between 1 and 10 multiplied by a power of 10 are said to be in *scientific notation*. For example, 5 943 000 000 is 5.943×10^9 when expressed in scientific notation, and 0.000 083 2 is 8.32×10^{-5} when expressed in scientific notation.

Interactive Demonstrations and Sample Problem Sets

Interactive Demonstrations Students hone their problem-solving skills through two modes of interactive problem-solving demonstrations, See How It's Done and Try It Yourself.



Sample Problem Sets Additional practice sets are provided for each type of Sample Problem.

Graphing

Smart Grapher The simple, clean graphing engine can be used to graph any data set. Use it as a stepping stone before exposing your students to more complex or sophisticated graphing tools.

Bringing Inquiry into your classroom with a robust lab suite

All Online!

QuickLabs

QuickLabs allow for hands-on learning with simple, everyday materials and minimal planning.

Virtual Labs

Virtual Labs give students a lab experience without any need for materials, set-up, or advance planning. Many feature lab scenarios that are difficult to perform in the classroom.

Additional Lab Tools

Lab Generator This customizable database of chemistry labs is searchable by topic, difficulty level, duration, or standard.

Materials Lists are available for each chapter.

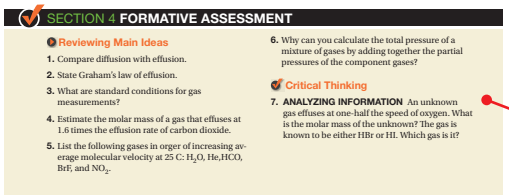
The Right Lab Option for Your Classroom

A broad range of lab types provides a wealth of options for hands-on learning, from core skills to open inquiry.

- **New** S.T.E.M. Labs bring the application of science, technology, engineering, and mathematics into your chemistry classroom.
- **New** Open Inquiry Labs introduce your students to a true inquiry-based lab experience.
- Core Skill Labs teach students how to apply chemistry techniques in the lab.
- Probeware Labs utilize calculator and data-probe techniques.
- Forensics Labs add excitement to your lab program through real-world scenarios.

Quick Labs are found in the textbook and online. All other labs are available online.

Assessing for Mastery

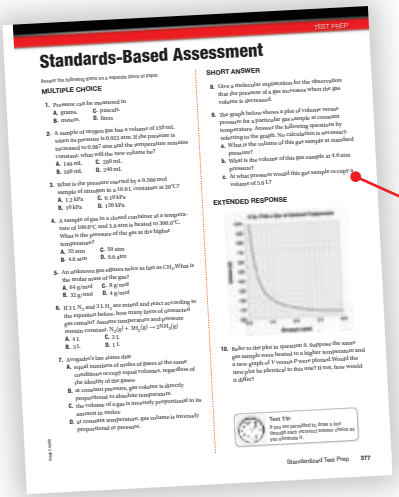

SECTION 4 FORMATIVE ASSESSMENT

Reviewing Main Ideas

1. Compare diffusion with effusion.
2. State Graham's law of effusion.
3. What are standard conditions for gas measurements?
4. Estimate the molar mass of a gas that effuses at 1.6 times the effusion rate of carbon dioxide.
5. List the following gases in orger of increasing average molecular velocity at 25 C: H_2O, He,HCO, BrF, and NO_2.
6. Why can you calculate the total pressure of a mixture of gases by adding together the partial pressures of the component gases?

Critical Thinking

7. ANALYZING INFORMATION An unknown gas effuses at one-half the speed of oxygen. What is the molar mass of the unknown? The gas is known to be either HBr or HI. Which gas is it?


TEST PREP

Standards-Based Assessment

Answer the following items on a separate piece of paper.

MULTIPLE CHOICE

SHORT ANSWER

EXTENDED RESPONSE

Standardized Test Prep 377

Assessment Options

Ongoing Formative Assessment The **Critical Thinking** and **Check for Understanding** questions can be used as formative assessment, to diagnose trouble spots for students as you work through the section content.

Section Formative Assessment Formative assessment, provided with each section in the Student Edition, includes Reviewing Main Ideas and Critical Thinking.

Section Quizzes There are quizzes available online for each section.

Chapter Tests A and B Each chapter has two tests, **General** and **Advanced**, which you can edit directly or customize in **ExamView**. Students can take a version of the Chapter Test online and be directed to resources to help complete their learning.

Alternative Assessment Alternative Assessment features are woven throughout the Teacher Edition wrap.

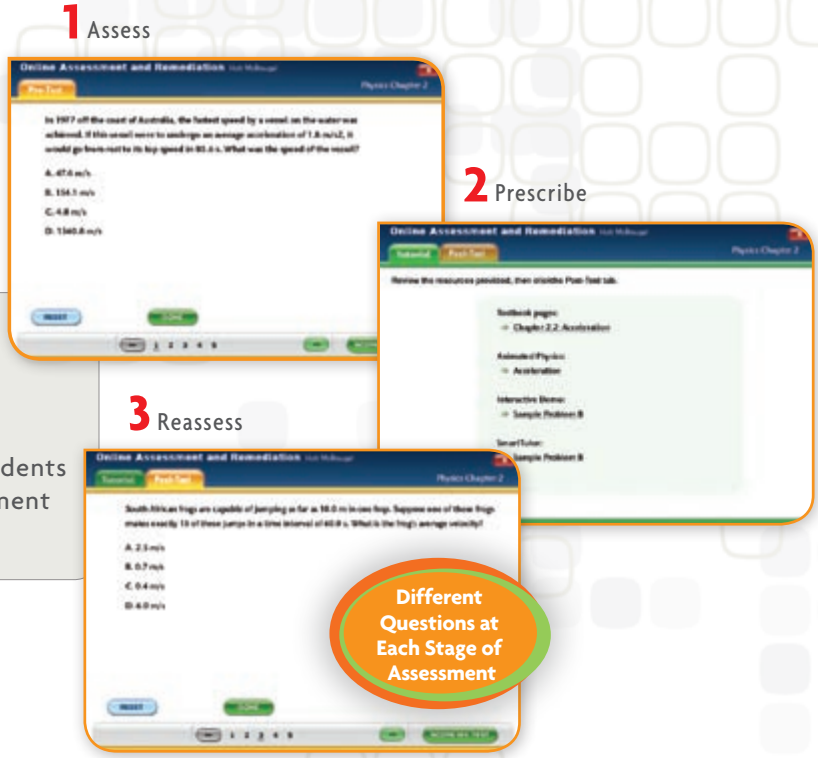
Standards-Based Assessment Every chapter in the Student Edition concludes with a Standards-Based Assessment to prepare students for standardized tests.

ExamView Banks

ExamView Banks are now comprehensive, and include questions from the section quizzes and chapter tests. You can use the questions in these banks with clickers, and can customize your own tests.

Assessment and Remediation

Existing assessment instruments have been repurposed into an online assessment and remediation engine. This engine provides students with prescriptive remediation and re-assessment to determine mastery.



Pacing Guide

Today's chemistry classroom often requires a flexible curriculum. The Pacing Guide below shows a number of ways to adapt the program to your teaching schedule. This Guide can be further adapted, allowing you to mix and match or compress the material so that you can spend more time on select topics, or to allow for special projects and activities.

- **Basic** gives more time for the foundations of chemistry, especially mathematical problem-solving, with less emphasis on some advanced topics from later in the course.
- **General** follows a moderate pace through both the foundational material and the higher-level topics found later in the course.
- **Advanced** moves quickly through foundations of chemistry, to provide additional time for advanced topics.
- **Heavy Lab/Activity** indicates ways to streamline "lecture" time to provide hands-on experience for about a third of the blocks in the school year. (Note: even this approach does not cover all of the labs and activities that are available with the Modern Chemistry program.)

Numbers indicate class periods recommended for the material within each chapter.

	BASIC	GENERAL	ADVANCED	HEAVY LAB/ ACTIVITY
CHAPTER 1 **Matter and Change**	6	6	5	6
Section 1.1 Chemistry Is a Physical Science	1	1	1	1
Section 1.2 Matter and Its Properties	1	1	1	1
Section 1.3 Elements	1	1	1	1
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	1	2
CHAPTER 2 **Measurements and Calculations**	7	7	5	8
Section 2.1 Scientific Method	1	1	1	1
Section 2.2 Units of Measurement	1	1	1	1
Section 2.3 Using Scientific Measurements	2	2	1	1
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	1	2
CHAPTER 3 **Atoms: The Building Blocks of Matter**	8	8	7	7
Section 3.1 The Atom: From Philosophical Idea to Scientific Theory	1	1	1	1
Section 3.2 The Structure of the Atom	2	2	1	1
Section 3.3 Counting Atoms	2	2	2	2
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 4 **Arrangement of Electrons in Atoms**	9	8	7	7
Section 4.1 The Development of a New Atomic Model	1	1	1	1
Section 4.2 The Quantum Model of the Atom	2	2	1	1
Section 4.3 Electron Configurations	3	2	2	2
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 5 **The Periodic Law**	8	8	8	7
Section 5.1 History of the Periodic Table	1	1	1	1
Section 5.2 Electron Configuration and the Periodic Table	2	2	2	1
Section 5.3 Electron Configuration and Periodic Properties	2	2	2	2
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2

Numbers indicate class periods recommended for the material within each chapter.

	BASIC	GENERAL	ADVANCED	HEAVY LAB/ ACTIVITY
CHAPTER 6 Chemical Bonding	**12**	**11**	**11**	**9**
Section 6.1 Introduction to Chemical Bonding	1	1	1	1
Section 6.2 Covalent Bonding and Molecular Compounds	2	2	2	2
Section 6.3 Ionic Bonding and Ionic Compounds	2	2	2	1
Section 6.4 Metallic Bonding	1	1	1	1
Section 6.5 Molecular Geometry	3	2	2	1
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 7 Chemical Formulas and Chemical Compounds	**10**	**9**	**9**	**10**
Section 7.1 Chemical Names and Formulas	2	2	2	2
Section 7.2 Oxidation Numbers	1	1	1	1
Section 7.3 Using Chemical Formulas	2	2	2	2
Section 7.4 Determining Chemical Formulas	2	1	1	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 8 Chemical Equations and Reactions	**8**	**7**	**7**	**8**
Section 8.1 Describing Chemical Reactions	2	2	2	2
Section 8.2 Types of Chemical Reactions	2	1	1	1
Section 8.3 Activity Series of the Elements	1	1	1	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 9 Stoichiometry	**11**	**8**	**8**	**8**
Section 9.1 Introduction to Stoichiometry	3	2	2	2
Section 9.2 Ideal Stoichiometric Calculations	3	2	2	2
Section 9.3 Limiting Reactants and Percentage Yield	2	1	1	1
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 10 States of Matter	**10**	**9**	**10**	**9**
Section 10.1 The Kinetic-Molecular Theory of Matter	1	1	1	1
Section 10.2 Liquids	1	1	1	1
Section 10.3 Solids	1	1	1	1
Section 10.4 Changes of State	3	2	3	1
Section 10.5 Water	1	1	1	0
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	2	2
CHAPTER 11 Gases	**11**	**9**	**10**	**9**
Section 11.1 Gases and Pressure	1	1	1	1
Section 11.2 The Gas Laws	3	2	2	2
Section 11.3 Gas Volumes and the Ideal Gas Law	3	2	3	1
Section 11.4 Diffusion and Effusion	1	1	1	0
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	2	2

Numbers indicate class periods recommended for the material within each chapter.

	BASIC	GENERAL	ADVANCED	HEAVY LAB/ ACTIVITY
CHAPTER 12 Solutions	**10**	**8**	**8**	**9**
Section 12.1 Types of Mixtures	1	1	1	1
Section 12.2 The Solution Process	3	2	2	1
Section 12.3 Concentration of Solutions	3	2	2	2
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	2	2
CHAPTER 13 Ions in Aqueous Solutions and Colligative Properties	**7**	**6**	**6**	**5**
Section 13.1 Compounds in Aqueous Solutions	2	1	1	1
Section 13.2 Colligative Properties of Solutions	2	2	2	1
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 14 Acids and Bases	**8**	**8**	**8**	**7**
Section 14.1 Properties of Acids and Bases	1	1	1	1
Section 14.2 Acid-Base Theories	2	2	2	1
Section 14.3 Acid-Base Reactions	2	2	2	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 15 Acid-Base Titration and pH	**8**	**6**	**6**	**7**
Section 15.1 Aqueous Solutions and the Concept of pH	2	1	1	1
Section 15.2 Determining pH and Titrations	3	2	2	2
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 16 Reaction Energy	**7**	**6**	**7**	**8**
Section 16.1 Thermochemistry	3	2	2	2
Section 16.2 Driving Force of Reactions	1	1	2	1
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	2	2
CHAPTER 17 Reaction Kinetics	**6**	**6**	**6**	**7**
Section 17.1 The Reaction Process	1	1	1	1
Section 17.2 Reaction Rate	2	2	2	1
Lab Experiments	1	1	1	3
Chapter Review and Assessment	2	2	2	2
CHAPTER 18 Chemical Equilibrium	**6**	**8**	**9**	**8**
Section 18.1 The Nature of Chemical Equilibrium	1	1	1	1
Section 18.2 Shifting Equilibrium	1	1	2	1
Section 18.3 Equilibria of Acids, Bases, and Salts	0	2	2	1
Section 18.4 Solubility Equilibrium	1	1	1	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2

Numbers indicate class periods recommended for the material within each chapter.

	BASIC	GENERAL	ADVANCED	HEAVY LAB/ ACTIVITY
CHAPTER 19 **Oxidation-Reduction Reactions**	9	7	7	7
Section 19.1 Oxidation and Reduction	2	1	1	1
Section 19.2 Balancing Redox Equations	3	2	2	1
Section 19.3 Oxidizing and Reducing Agents	1	1	1	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 20 **Electrochemistry**	6	6	6	7
Section 20.1 Introduction to Electrochemistry	1	1	1	1
Section 20.2 Voltaic Cells	1	1	1	1
Section 20.3 Electrolytic Cells	1	1	1	1
Lab Experiments	1	1	1	2
Chapter Review and Assessment	2	2	2	2
CHAPTER 21 **Nuclear Chemistry**	10	9	9	7
Section 21.1 The Nucleus	1	1	1	1
Section 21.2 Radioactive Decay	3	2	2	1
Section 21.3 Nuclear Radiation	2	2	2	1
Section 21.4 Nuclear Fission and Nuclear Fusion	1	1	1	1
Lab Experiments	1	1	1	1
Chapter Review and Assessment	2	2	2	2
CHAPTER 22 **Organic Chemistry**	0	8	9	8
Section 22.1 Organic Compounds	0	1	1	1
Section 22.2 Hydrocarbons	0	2	2	1
Section 22.3 Functional Groups	0	1	1	1
Section 22.4 Organic Reactions	0	1	2	1
Lab Experiments	0	1	1	2
Chapter Review and Assessment	0	2	2	2
CHAPTER 23 **Biological Chemistry**	0	9	9	9
Section 23.1 Carbohydrates and Lipids	0	2	2	1
Section 23.2 Amino Acids and Proteins	0	2	2	1
Section 23.3 Metabolism	0	1	1	1
Section 23.4 Nucleic Acids	0	1	1	1
Lab Experiments	0	1	1	3
Chapter Review and Assessment	0	2	2	2
Total	177	177	177	177

Safety in Your Laboratory

Direct students to the section "Safety in the Chemistry Laboratory" in the *Student Edition* front-matter pages. This section includes a key to the safety icons used within the laboratory program.

Risk Assessment

MAKING YOUR LABORATORY A SAFE PLACE TO WORK AND LEARN

Concern for safety must begin before any activity in the classroom and before students enter the lab. A careful review of the facilities should be a basic part of preparation for each school term. You should investigate the physical environment, identify any safety risks, and inspect your work areas for compliance with safety regulations.

The review of the lab should be thorough, and all safety issues must be addressed immediately. Keep a file of your review, and add to the list each year. This will allow you to continue to raise the standard of safety in your lab and classroom.

Many classroom experiments, demonstrations, and other activities are classics that have been used for years. This familiarity may lead to a comfort that can obscure inherent safety concerns. Review all experiments, demonstrations, and activities for safety concerns before presenting them to the class. Identify and eliminate potential safety hazards.

1. **Identify the Risks**
   Before introducing any activity, demonstration, or experiment to the class, analyze it and consider what could possibly go wrong. Carefully review the list of materials to make sure they are safe. Inspect the equipment in your lab or classroom to make sure it is in good working order. Read the procedures to make sure they are safe. Record any hazards or concerns you identify.
2. **Evaluate the Risks**
   Minimize the risks you identified without sacrificing learning. Remember that no activity you perform in the lab or classroom is worth risking injury. Thus, extremely hazardous activities, or those that violate your school's policies, must be eliminated. For activities that present smaller risks, analyze each risk carefully to determine its likelihood. If the pedagogical value of the activity does not outweigh the risks, the activity must be eliminated.
3. **Select Controls to Address Risks**
   Even low-risk activities require controls to eliminate or minimize the risks. Make sure that in devising controls you do not substitute an equally or more hazardous alternative. Some control methods include the following:
   - Explicit verbal and written warnings may be added or posted.
   - Equipment may be rebuilt or relocated, have parts replaced, or be replaced entirely by safer alternatives.
   - Risky procedures may be eliminated.
   - Activities may be changed from student activities to teacher demonstrations.
4. **Implement and Review Selected Controls**
   Controls do not help if they are forgotten or not enforced. The implementation and review of controls should be as systematic and thorough as the initial analysis of safety concerns in the lab and laboratory activities.

SOME SAFETY RISKS AND PREVENTATIVE CONTROLS

The following list describes several possible safety hazards and controls that can be implemented to resolve them. This list is not complete, but it can be used as a starting point to identify hazards in your laboratory.

IDENTIFIED RISK	PREVENTATIVE CONTROL
Facilities and equipment	
Lab tables are in disrepair, room is poorly lighted and ventilated, faucets and electrical outlets do not work or are difficult to use because of their location.	Work surfaces should be level and stable. There should be adequate lighting and ventilation. Water supplies, drains, and electrical outlets should be in good working order. Any equipment in a dangerous location should not be used; it should be relocated or rendered inoperable.
Wiring, plumbing, and air circulation systems do not work or do not meet current specifications.	Specifications should be kept on file. Conduct a periodic review of all equipment, and document compliance. Damaged fixtures must be labeled as such and must be repaired as soon as possible.
Eyewash fountains and safety showers are presented, but no one knows anything about their specifications.	Ensure that eyewash fountains and safety showers meet the requirements of the ANSI standard (Z358.1).
Eyewash fountains are checked and cleaned once at the beginning of the school year. No records are kept of routine checks and maintenance on the safety showers and eyewash fountains.	Flush eyewash fountains for 5 minutes every month to remove any bacteria or other organisms from the pipes. Test safety showers (measure flow in gallons per min.) and eyewash fountains every 6 months and keep records of the test results.
Labs are conducted in multipurpose rooms, and equipment from other courses remains accessible.	Only items necessary for a given activity should be available to students. All equipment should be locked away when not in use.
Students are permitted to enter or work in the lab without teacher supervision.	Lock all laboratory rooms whenever teacher is not present. Supervising teachers must be trained in lab safety and emergency procedures.
Safety equipment and emergency procedures	
Fire and other emergency drills are infrequent, and no records or measurements are made of the results of the drills.	Always carry out critical reviews of fire or other emergency drills. Be sure that plans include alternate routes. Don't wait until an emergency to find the flaws in your plans.
Emergency evacuation plans do not include instructions for securing the lab in the event of an evacuation during a lab activity.	Plan actions in case of emergency: establish what devices should be turned off, which escape route to use, and where to meet outside the building.
Fire extinguishers are in out-of-the-way locations, not on the escape route.	Place fire extinguishers near escape routes so that they will be of use during an emergency.
Fire extinguishers are not maintained. Teachers are not trained to use them.	Document regular maintenance of fire extinguishers. Train supervisory personnel in the proper use of extinguishers. Instruct students not to use an extinguisher but to call for a teacher.

IDENTIFIED RISK	PREVENTATIVE CONTROL
Safety equipment and emergency procedures (continued)	
Teachers in labs and neighboring classrooms are not trained in CPR or first aid.	Teachers should receive training for first aid safety. The American Red Cross and other groups offer training. Certifications should be kept current with refresher courses.
Teachers are not aware of their legal responsibilities in case of an injury or accident.	Review your faculty handbook for your responsibilities regarding safety in the classroom and laboratory. Contact the legal counsel for your school district to find out the extent of their support and any rules, regulations, or procedures you must follow.
Emergency procedures are not posted. Emergency numbers are kept only at the switchboard or main office. Instructions are given verbally only at the beginning of the year.	Emergency procedures should be posted at all exits and near all safety equipment. Emergency numbers should be posted at all phones, and a script should be provided for the caller to use. Emergency procedures must be reviewed periodically, and students should be reminded of them at the beginning of each activity.
Spills are handled on a case-by-case basis and are cleaned up with whatever materials happen to be on hand.	Have the appropriate equipment and materials available for cleaning up; replace them before expiration dates. Make sure students know to alert you to spilled chemicals, blood, and broken glass.
Work habits and environment	
Safety gear is used only for activities involving chemicals or hot plates.	Aprons and goggles should be worn in the lab at all times. Long hair, loose clothing, and loose jewelry should be secured.
There is no dress code established for the laboratory; students are allowed to wear sandals or open-toed shoes.	Open-toed shoes should never be worn in the laboratory. Do not allow any footwear in the lab that does not cover feet completely.
Students are required to wear safety gear but teachers and visitors are not.	Everyone must wear safety gear while in the lab. Keep extra equipment on hand for visitors.
Safety is emphasized at the beginning of the term but is not mentioned later in the year.	Safety must be the first priority in all lab work. Students should be warned of risks and instructed in emergency procedures for each activity.
There is no assessment of students' knowledge and attitudes regarding safety.	Conduct frequent safety quizzes. Only students with perfect scores should be allowed to work in the lab.
You work alone during your preparation period to organize the day's labs.	Never work alone in a science laboratory or in a storage area.
Safety inspections are conducted irregularly and are not documented. Teachers and administrators are unaware of what documentation will be necessary in case of a lawsuit.	Safety reviews should be frequent and regular. All reviews should be documented, and improvements must be implemented immediately. Contact legal counsel for your district to make sure your procedures will protect you in case of a lawsuit.

IDENTIFIED RISK	PREVENTATIVE CONTROL
Purchasing, storing, and using chemicals	
The storeroom is too crowded, so you decide to keep some equipment on the lab benches.	Do not store reagents or equipment on lab benches. Keep shelves organized. Never place reactive chemicals (in bottles, beakers, flasks, wash bottles, etc.) near the edges of a lab bench.
You prepare solutions from concentrated stock to save money.	Reduce risks by ordering diluted instead of concentrated substances.
You purchase plenty of chemicals to be sure that you won't run out or to save money.	Purchase chemicals in class-size quantities. Do not purchase or have on hand more than one year's supply of each chemical.
You don't generally read labels on chemicals when preparing solutions for a lab, because you already know about a chemical.	Read each chemical label for stated hazards. Know the precautions and first aid procedures that apply to all chemicals and reagents for the specified lab. Make sure the chemical's label also contains this information, in case someone else has to deal with that chemical in an emergency.
You never read the Material Safety Data Sheets (MSDSs) that come with your chemicals.	Always read the Material Safety Data Sheet (MSDS) for a chemical before using it and follow the precautions described. File and organize MSDSs for all chemicals where they can be found easily in case of an emergency.
The main stockroom contains chemicals that haven't been used for years.	Do not leave unused chemicals on lab shelves for more than one week, or in the stockroom for more than one year. Dispose of, or use up, any leftover chemicals.
No extra precautions are taken when flammable liquids are dispensed from their containers.	When transferring flammable liquids from bulk containers, ground the container, and before transferring to a smaller metal container, ground both containers.
Students are told to put their broken glass and solid chemical wastes in the trash can.	Have separate containers for trash, for broken glass, and for different categories of hazardous chemical wastes.
You store chemicals alphabetically instead of by hazard class. Chemicals are stored without consideration of possible emergencies (fire, earthquake, flood, etc.), which could compound the hazard.	Use MSDSs to determine which chemicals are incompatible. Store chemicals by the hazard class indicated on the MSDS. Store chemicals that are incompatible with common fire-fighting media like water (such as alkali metals) or carbon dioxide (such as alkali and alkaline-earth metals) under conditions that eliminate the possibility of a reaction with water or carbon dioxide if it is necessary to fight a fire in the storage area.
Corrosives are kept above eye level, out of reach from any unauthorized person.	Always store corrosive chemicals on shelves below eye level. Remember, fumes from many corrosives can destroy metal cabinets and shelving.
Chemicals are kept on the stockroom floor on the days that they will be used so that they are easy to find.	Never store chemicals or other materials on floors or in the aisles of the laboratory or storeroom, even for a few minutes.

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Modern Chemistry

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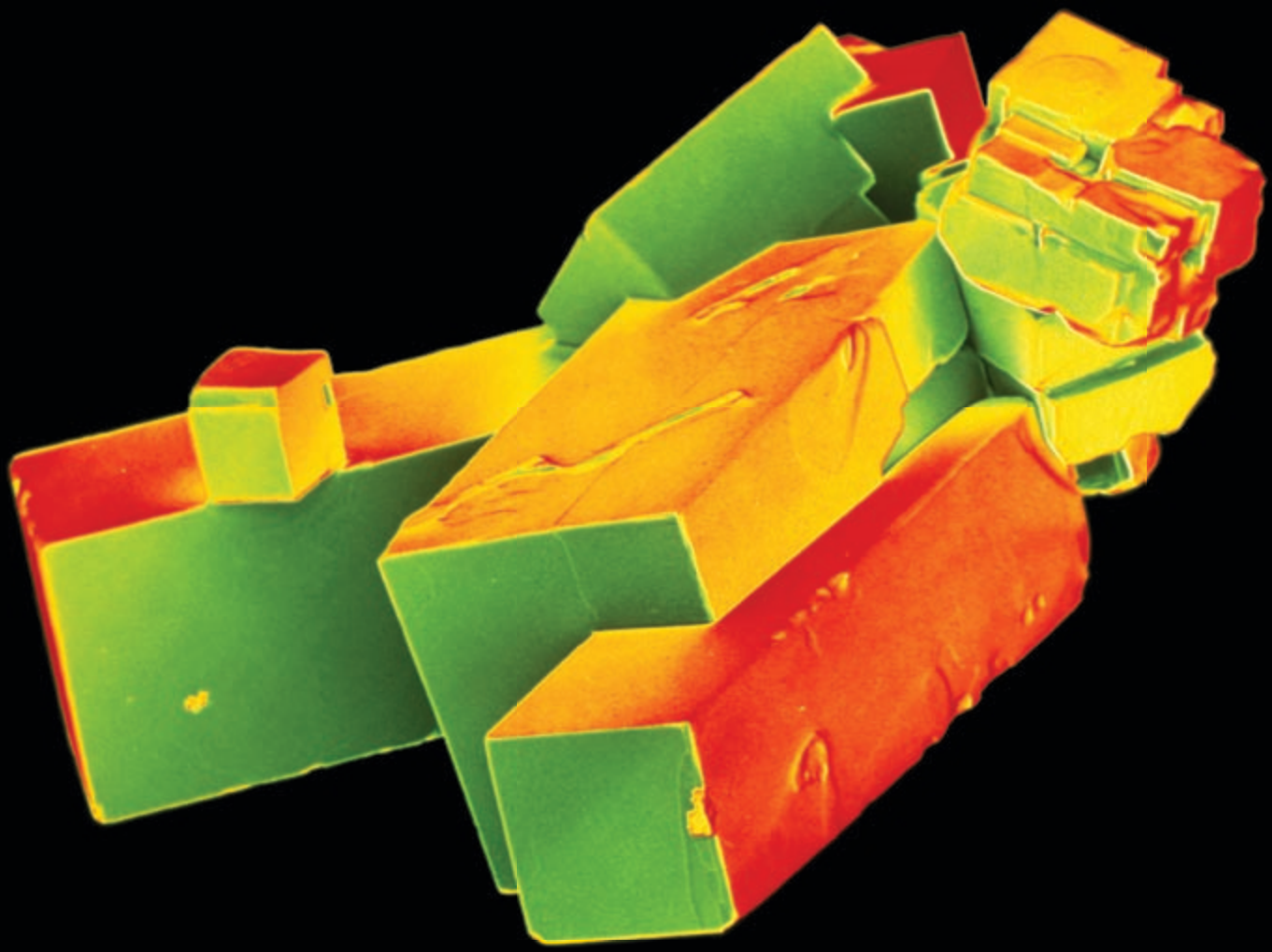

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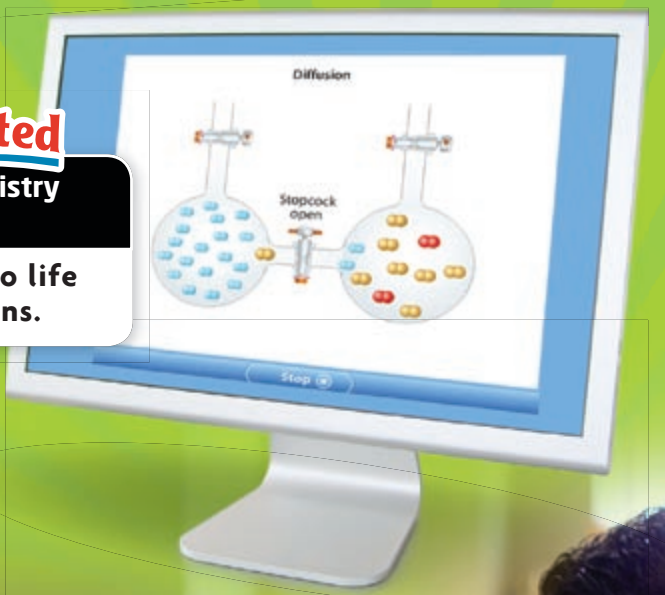

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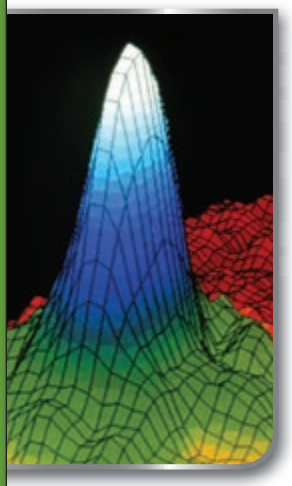

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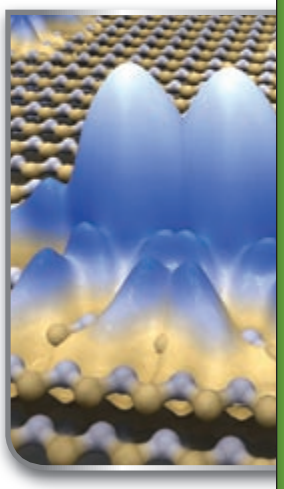

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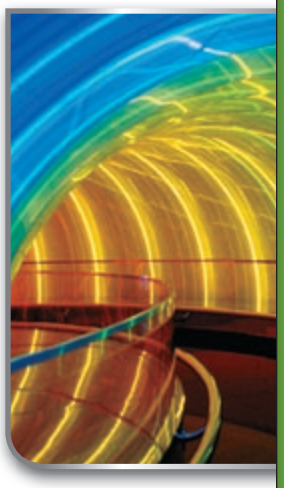

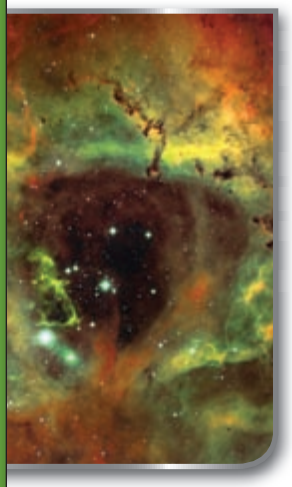

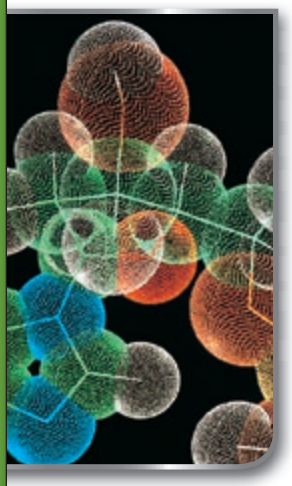

SAMPLE PROBLEMS AND MATH TUTORS

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Chemistry EXPLORERS

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CAREERS IN CHEMISTRY

WHY IT MATTERS

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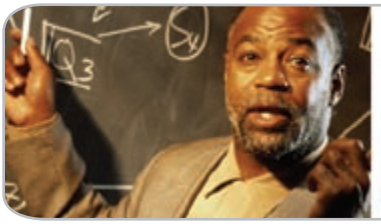

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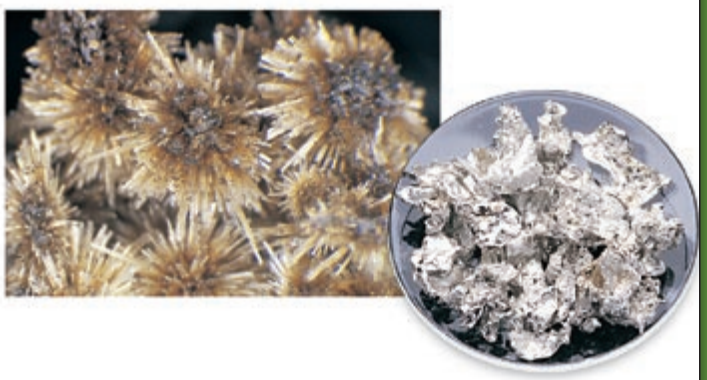


SAFETY IN THE CHEMISTRY LABORATORY

Any chemical can be dangerous if it is misused. Always follow the instructions for the experiment. Pay close attention to the safety notes. Do not do anything differently unless told to do so by your teacher.

Chemicals, even water, can cause harm. The challenge is to know how to use chemicals correctly. To make sure you are using chemicals correctly, follow the rules stated below, pay attention to your teacher's directions, and obey the cautions on chemical labels and in an experiment's procedure.

Specific experiments will use a system of Safety Symbols to highlight specific types of precautions. No matter what Safety Symbols an experiment may contain, the following safety rules apply any time you are in the lab.

BEFORE YOU BEGIN

1. **Read the entire activity before entering the lab.** Be familiar with the instructions before beginning an activity. Do not start an activity until you have asked your teacher to explain any parts of the activity that you do not understand.

2. **Student-designed procedures or inquiry activities must be approved by your teacher before you attempt the procedures or activities.**

3. **Wear the right clothing for lab work.** Before beginning work, roll up loose sleeves, and put on any required personal protective equipment as directed by your teacher. If your hair is longer than where the bottom of a shirt collar would be, tie your hair back. Avoid loose clothing or any kind of jewelry that could knock things over, catch on fire, get caught in moving parts, contact electrical connections, or absorb chemical solutions. In addition, chemical fumes may react with and ruin some jewelry, such as pearl jewelry. Wear pants rather than shorts or skirts. Nylon and polyester fabrics burn and melt more readily than cotton does. Protect your feet from chemical spills and falling objects. Do not wear open-toed shoes, sandals, or canvas shoes in the lab. Do not apply cosmetics in the lab. Some hair care products and nail polish are highly flammable.

4. **Do not wear contact lenses in the lab.** Even though you will be wearing safety goggles, chemicals could get between contact lenses and your eyes and could cause irreparable eye damage. If your doctor requires that you wear contact lenses instead of glasses, then you should wear eye-cup safety goggles—similar to goggles worn for underwater swimming—in the lab. Ask your doctor or your teacher how to use eye-cup safety goggles to protect your eyes.

5. **Know the location and usage of all safety and emergency equipment used in the lab.** Know proper fire-drill procedures and the location of all fire exits. Ask your teacher where the nearest eyewash stations, safety blankets, safety shower, fire extinguisher, first-aid kit, and chemical spill kit are located. Be sure that you know how to operate the equipment safely.

WHILE YOU ARE WORKING

6. **Always wear a lab apron and safety goggles.** Wear these items even if you are not working on an activity. Labs contain chemicals that can damage your clothing, skin, and eyes. Keep the strings of your lab apron tied. If your safety goggles cloud up or are uncomfortable, ask your teacher for help. Lengthening the strap slightly or washing the goggles with soap and warm water may relieve the problem.

7. **NEVER work alone in the lab.** Work in the lab only when supervised by your teacher. Do not leave assembled equipment unattended.

8. **Perform only activities specifically assigned by your teacher and no others.** Use only materials and equipment listed in the activity or authorized by your teacher. Steps in a procedure should be performed only as described in the activity or as approved by your teacher.

9. **Keep your work area neat and uncluttered.** Have only books and other materials that are needed to conduct the activity in the lab. Keep backpacks, purses, and other items in your desk, locker, or other designated storage areas.

10. **Always heed safety symbols and cautions listed in activities, listed on handouts, posted in the room, provided on chemical labels, and given verbally by your teacher.** Be aware of the potential hazards of the required materials and procedures, and follow all precautions indicated.

11. **Be alert, and walk with care in the lab.** Be aware of others near you and your equipment.

12. **Do not take food, drinks, chewing gum, or tobacco products into the lab.**

13. **Use extreme caution when working with hot plates and other heating devices.** Keep your head, hands, hair, and clothing away from the flame or heating area. Remember that metal surfaces connected to the heated area will become hot by conduction. Use tongs when heating containers and never hold or touch them. Gas burners should be lit only with a spark lighter, not with matches. Make sure that all heating devices and gas valves are turned off before you leave the lab. Never leave a heating device unattended when it is in use. Metal, ceramic, and glass items may not look hot when they are. Allow all items to cool before storing.

14. **Remember glass breaks easy and can cause serious cuts.** Check the condition of any glassware before and after using it. Inform your teacher of any broken, chipped, or cracked glassware, because it should not be used. Handle all glassware with care. To protect your hands, wear heavy cloth gloves or wrap toweling around the glass and the tubing, stopper, or cork, and gently push in the glass. Do not pick up broken glass with your bare hands. Dispose of broken glass appropriately.

15. **Exercise caution when working with electrical equipment.** Do not use electrical equipment with frayed or twisted wires. Be sure that your hands are dry before using electrical equipment. Do not let electrical cords dangle from work stations. Dangling cords can cause you to trip and can cause an electrical shock. The area under and around electrical equipment should be dry; cords should not lie in puddles of spilled liquid. In dryer weather, be careful of static electrical discharges that may occur when you touch metal objects. Not only can these hurt, but also they can sometimes short out electrical circuits.

16. **Do not fool around in the lab.** Take your lab work seriously, and behave appropriately in the lab. Lab equipment and apparatus are not toys; never use lab time or equipment for anything other than the intended purpose. Be aware of the safety of your classmates as well as your safety at all times.

WORKING WITH CHEMICALS

17. **NEVER taste chemicals or allow them to contact your skin.** Keep your hands away from your face and mouth, even if you are wearing gloves.

18. **Do not inhale fumes directly.** When instructed to smell a substance, use your hand to wave the fumes toward your nose, and inhale gently.

19. **Read chemical labels.** Follow the instructions and safety precautions stated on the labels.

20. **If you are working with flammable liquids, use only small amounts.** Be sure no one else is using a lit Bunsen burner or is planning to use one when you are working with flammable liquids, because the fumes can ignite.

21. **For all chemicals, take only what you need.** However, if you do happen to take too much and have some left over, DO NOT put it back in the bottle. If somebody accidentally puts a chemical into the wrong bottle, the next person to use it will have a contaminated sample. Ask your teacher what to do with any leftover chemicals.

22. **NEVER take any chemicals out of the lab.** (This is another one that you should already know. You probably know the remaining rules also, but read them anyway.)

EMERGENCY PROCEDURES

23. **Follow standard fire-safety procedures.** If your clothing catches on fire, do not run; STOP—DROP—AND ROLL. If another student's clothes catch on fire, keep them from running and wrap them in the fire blanket provided in your lab to smother the flames. While doing so, call to your teacher. In case of fire, alert your teacher and leave the lab according to instructions.

24. **Report any accident, incident, or hazard— no matter how trivial—to your teacher immediately.** Any incident involving bleeding, burns, fainting, nausea, dizziness, chemical exposure, or ingestion should also be reported immediately to the school nurse or to a physician. If you have a close call, tell your teacher so that you and your teacher can find a way to prevent it from happening again.

25. **Report all spills to your teacher immediately.** Call your teacher rather than trying to clean a spill yourself. Your teacher will tell you whether it is safe for you to clean up the spill; if it is not safe, your teacher will know how to clean up the spill.

26. **If you spill a chemical on your skin, wash the chemical off in the sink and call your teacher.** If you spill a solid chemical onto your clothing, brush it off carefully without scattering it onto somebody else, and call your teacher. If you get liquid on your clothing, wash it off right away by using the faucet at the sink, and call your teacher. Rinse your skin for 10-15 minutes. If the spill is on your pants or something else that will not fit under the sink faucet, use the safety shower. Remove the pants or other affected clothing while you are under the shower, and call your teacher. (It may be temporarily embarrassing to remove pants or other clothing in front of your classmates, but failure to flush the chemical off your skin could cause permanent damage.)

27. **If you get a chemical in your eyes, walk immediately to the eyewash station, turn it on, and lower your head so your eyes are in the running water.** Hold your eyelids open with your thumbs and fingers, and roll your eyeballs around. You have to flush your eyes continuously for at least 15 minutes. Call your teacher while you are doing this.

WHEN YOU ARE FINISHED

28. **Clean your work area at the conclusion of each lab period as directed by your teacher.** Broken glass, chemicals, and other waste products should be disposed of in separate, special containers. Dispose of waste materials as directed by your teacher. Put away all material and equipment according to your teacher's instructions. Report any damaged or missing equipment or materials to your teacher.

29. **Wash your hands with soap and hot water after each lab period.** To avoid contamination, wash your hands at the conclusion of each lab period, and before you leave the lab.

A FINAL REMINDER

30. **Whether or not the lab instructions remind you, ALL OF THESE RULES APPLY ALL OF THE TIME!**

SAFETY SYMBOLS

To highlight specific types of precautions, the following symbols are used throughout the lab program. Remember that no matter what safety symbols you see in the textbook, all 30 of the lab safety rules previously described should be followed at all times.

EYE PROTECTION

- Wear safety goggles in the lab at all times.
- Know how to use the eyewash station. If chemicals get into your eyes, flush your eyes (including under the eyelids) with running water at the eyewash station for at least 15 minutes. Use your thumb and fingers to hold your eyelids open and, roll your eyeball around. While doing so, ask another student to notify your teacher.

CLOTHING PROTECTION

- Wear an apron or lab coat at all times in the lab.
- Tie back long hair, secure loose clothing, and remove loose jewelry so that they do not knock over equipment or come into contact with hazardous materials.

HAND SAFETY

- Wear protective gloves when working with chemicals.
- Use a hot mitt or tongs to handle equipment that may be hot.

GLASSWARE SAFETY

- Inspect glassware before use; do not use chipped or cracked glassware.
- Never place glassware, containers of chemicals, or anything else near the edges of a lab bench or table.

CHEMICAL SAFETY

- Never return unused chemicals to the original container. Take only what you need.
- Label the beakers and test tubes you use with the chemicals they contain.
- Never transfer substances by sucking on a pipet or straw; use a suction device.
- Do not mix any chemicals unless specifically instructed to do so by your teacher.
- If a chemical spills on the floor or lab bench, tell your teacher, and wait for instructions before cleaning it up yourself.

CAUSTIC SUBSTANCE SAFETY

- Do not pour water into a strong acid or base. The mixture can produce heat and can splatter.

HEATING SAFETY

- Avoid using open flames. If possible, work only with hot plates having an on/off switch and an indicator light.
- When heating a chemical in a test tube, point the open end of the test tube away from yourself and others.

HYGIENE CARE

- Keep your hands away from your face and mouth while you work in the lab.
- Do not eat or drink any food from laboratory containers.
- Wash your hands thoroughly before you leave the lab.

WASTE DISPOSAL

- Help protect our environment by following the instructions for proper disposal.

SAFETY USING MSDS

Do you help with the housekeeping at home? Do you clean your bathtub? Do you use a commercial product intended just for that purpose? Or bleach, or powdered cleanser? It is important to know that you should never mix bleach and powdered cleanser together—doing so results in a chemical reaction that releases poisonous chlorine gas. The vapor from the reaction could do very serious damage to your lungs.

One important thing that you can take away from chemistry class is how to safely use all of the many chemicals in the world around you. Most of us don't think much about chemical safety when we're in our own homes, or in a place that we think of as "safe," like a school. However, hazardous chemicals are sometimes found in the most ordinary places.

WHAT IS AN MSDS?

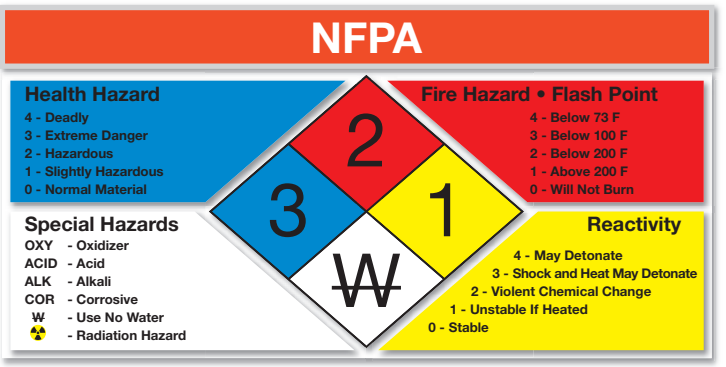
Because there are dangerous chemicals all around us, chemical manufacturers are required to provide an *MSDS* for all their products sold in the United States. MSDS stands for Material Safety Data Sheet. Such sheets are lists of safety information and procedures for handling chemicals. These can range from household products like vinegar, soap, and baking soda, to some extremely powerful and dangerous chemicals. They are based on guidelines from the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA). A hypothetical example of an MSDS is provided on the next page. It's for a compound you probably know very well.

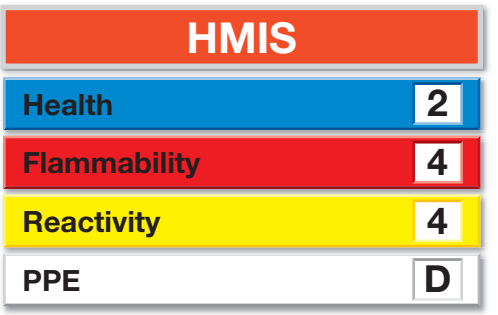
WHAT KINDS OF INFORMATION DOES AN MSDS GIVE?

There are many different types of information on an MSDS. Some of the information is meant for emergency responders, like firefighters and emergency medical professionals. There are, however, many things in an MSDS that you need to know to be successful with your chemistry laboratory experiments. These sheets should be kept handy at all times when using chemicals. It's also important to read your lab experiment in advance and look up the MSDS for any chemicals to be used. Study the hypothetical example of an MSDS on the following page. Does this seem like a dangerous chemical? Do you recognize the chemical?

WHAT DO THE COLORED LOGOS ON AN MSDS MEAN?

OSHA requires all chemical manufacturers to label hazardous substances with specific types of information. Many companies use either the National Fire Prevention Association (NFPA) format or the Hazardous Materials Information Systems (HMIS) format. An example of each logo is shown below. The logos use the same color and number designations, but slightly different ways of presenting them. A zero indicates that no hazard exists, while a 4 indicates an extreme hazard. Always look for hazard labels on bottles of chemicals before you use the chemicals.





SAMPLE MSDS (HYPOTHETICAL)

MEGACHEM CORPORATION, INC.

222 Oxygen Ave, City, State, 55555 (555) 555-5555

MATERIAL SAFETY DATA SHEET (MSDS)

MSDS #: 6.00 Revised: X/XX/XXXX

SECTION 1 Product Identification

Dihydrogen monoxide

SECTION 2 Composition and Ingredients

Dihydrogen monoxide
Synonyms: hydrogen oxide; agua; water
CAS No. N/A
Red: Fire/Explosive: 0 **Blue:** Health: 2
Yellow: Reactivity: 1 **White:** Special: OXY

SECTION 3 Physical and Chemical Properties

Boiling point (760 mm Hg): 100°C (212°F)
Melting point: 0°C (32°F)
Specific gravity (H_2O = 1): 1
Vapor pressure - 100°C (212°F) 760 mm Hg - 0°C (32°F) 17.5 mm Hg
Solubility in water (% by wt.): 100%
% Volatiles by volume: 100%
Evap. rate: 750-3000 mm/yr (as measured by U.S. Weather Service)
Appearance and Odor: Clear liquid; No odor

SECTION 4 Hazards Identification

Clear, colorless, odorless liquid.
Inhalation can result in asphyxiation.
High temperature fumes can cause severe burns to exposed body areas.
Prolonged skin immersion may result in digital vasoconstriction.
In solid form, can cause decreased resistance to hypothermia.

SECTION 5 First Aid Measures

Seek medical attention for further treatment following first aid.
If inhaled, remove to fresh air; if not effective, apply artificial respiration and oxygen.
Inhalation may result in injury or death.
If skin contact is prolonged, cease immersion immediately; use soft, absorptive materials to dry affected areas.

SECTION 6 Fire Fighting and Explosion Measures

Flash Point: Not applicable
Auto-ignition Temperature: Not applicable
Flammable limits in air (% by Vol.): Not applicable
Extinguishing Media: Do not use water to extinguish, this will only increase difficulty.
Special fire fighting procedures: Not applicable
Unusual Fire and Explosion Hazard: Explosive vaporization can occur in sealed containers after rapidly increasing temperature.

SECTION 7 Accidental Spill or Release Measures

Restrict unprotected individuals from area.
Use absorptive materials to contain and soak up spill.
No neutralizing chemicals required.

SECTION 8 Personal Protection and Exposure Measures

Avoid prolonged contact with eyes, skin, or clothing, particularly at temperatures above 100°C or below 0°C.
Wear chemical-splash goggles and chemical-resistant apron when working at high temperatures.
Insulated garments/gloves must be worn during exposure to solid or vaporous forms at temperatures above 100°C or below 0°C, respectively.
Exposure guidelines: Not available

SECTION 9 Handling and Storage

Do not store in metal containers for prolonged periods.
Do not heat in closed container that is not pressure-sealed.
Do not store in open container for prolonged periods, as compound will evaporate.
Compound expands when freezing.
Do not inhale liquid.
Contact with many soluble compounds will result in complete dissolution.

SECTION 10 Stability and Reactivity

Conditions contributing to instability: Generally stable except when exposed to high temperatures or electrical current.
Incompatibility: Rapid temperature increase can occur when added to strong acids or bases. Reaction with sodium metal can result in fire or explosion.
Hazardous decomposition products: Hydrogen - Highly flammable and explosive gas.
Oxygen - Supports rapid combustion.
Conditions contributing to hazardous polymerization: None
Forms solutions readily.

SECTION 11 Toxicological Information

Acute effects: Harmful liquid if inhaled or skin contact in excess of 100°C
Chronic effects: Oxidation of metals
Target organs: Respiratory system
Commonly found in tumor cells.
Accumulates in vesicles formed from contact with compound at temperatures exceeding 100°C.

SECTION 12 Ecological Information

Organism exposure to either extreme amounts of compound or prolonged evaporation of compound may result in injury or death.

SECTION 13 Transportation Information

Shipping name: Dihydrogen monoxide; Liquid
Hazard class: Not regulated

SECTION 14 Disposal Information

May be safely disposed of down sink or drain.
Disposal of excessive amounts may be subject to local, state, or federal regulations.

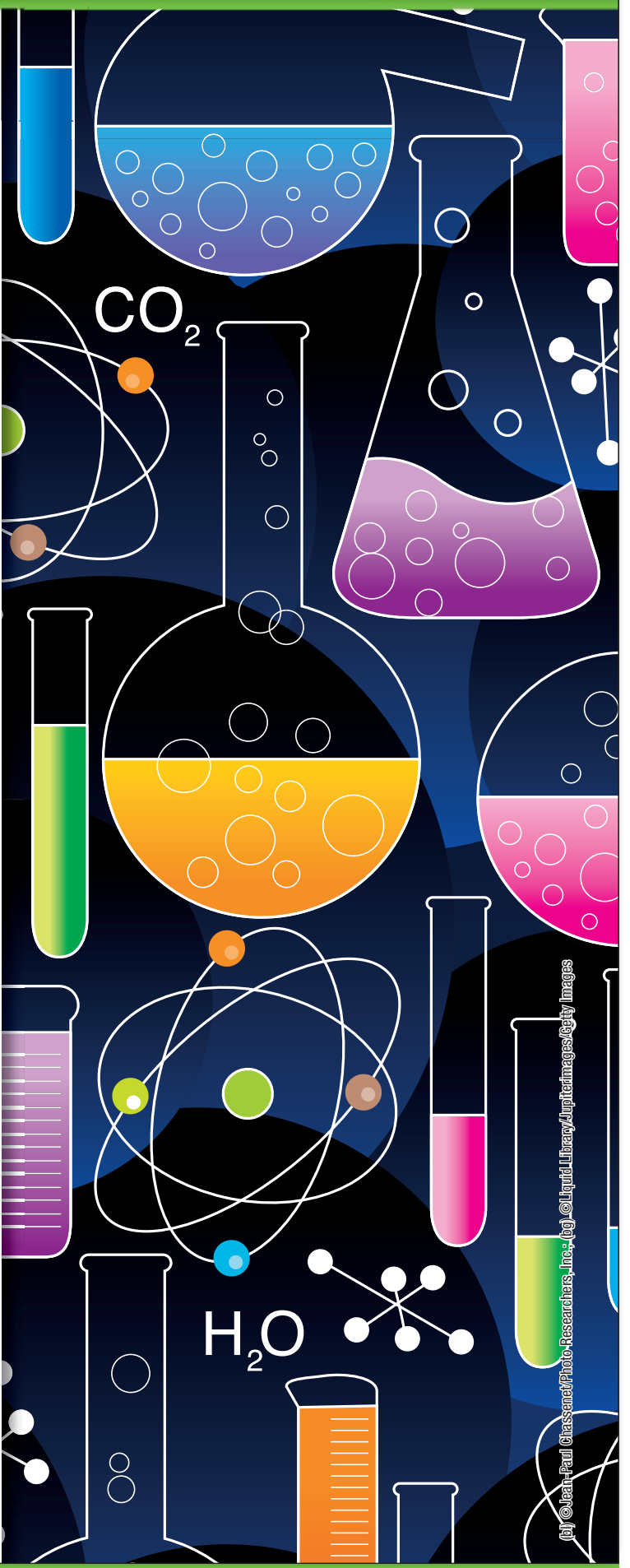
SECTION 15 Regulatory Information

Not regulated

SECTION 16 Other

This Material Safety Data Sheet (MSDS) is provided as a guideline only. MegaChem Corp., Inc. does not accept or assume any responsibility or liability for use, handling, storage, transportation, or disposal of this product, as these are beyond the control of MegaChem Corp., Inc. FOR THESE REASONS MEGACHEM CORPORATION, INC. EXPRESSLY DISAVOWS ALL KNOWLEDGE OR LIABILITY FOR LOSS, DAMAGE, OR EXPENSES RESULTING FROM THIS PRODUCT.

STUDY SKILLS HANDBOOK



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Secrets for Success in Chemistry

Some people are gifted scholars and naturally pick up the skills that enable them to be successful in their studies. Most of us, however, have to *learn* the study habits that will help us succeed. No two people learn in exactly the same way, so each of us has to find what works best for us.

You may have heard teachers use terms like *visual, auditory,* and *kinesthetic* when talking about learning styles. These terms are a fancy way of saying that a person learns best when *seeing* something, *hearing* something, or *doing* something hands-on. Most people actually learn in multiple styles, although they may favor one method over others.

The last thing you probably want to hear is that you have to study. You are not alone. Not many people actually *like* to study. What a surprise! You may have asked, "Why do I even need to take chemistry? I'm not going to be a scientist." The answer to that question is that you need chemistry because *everything* is chemistry. Every single thing around you, including you, is made up of atoms, molecules, and chemical compounds. Everything a person does has something to do with chemistry, from deciding what cleanser scrubs the bathtub best, to choosing what motor oil makes the car run smoothly in winter, or what toothpaste gives the whitest smile. With all these decisions that depend on chemistry, wouldn't you like to know more about it?

Chemistry is a subject that builds on the knowledge that you start accumulating from the first day of class. Imagine what it would be like if you tried writing a novel before learning the entire alphabet. The farther behind you fall at the beginning, the more likely you are to have trouble understanding things the rest of the course. So, the best thing to do is to get it right the first time!

You may have asked, "Why do I even need to take chemistry? I'm not going to be a scientist." The answer to that question is that *everything* is chemistry.

A textbook is one of the many tools you will use in order to be successful in class. This handbook will provide a number of additional useful tips, tricks, and skills—you might say study *secrets*—that can help you a lot in chemistry. However, they only help if you actually *use* them!

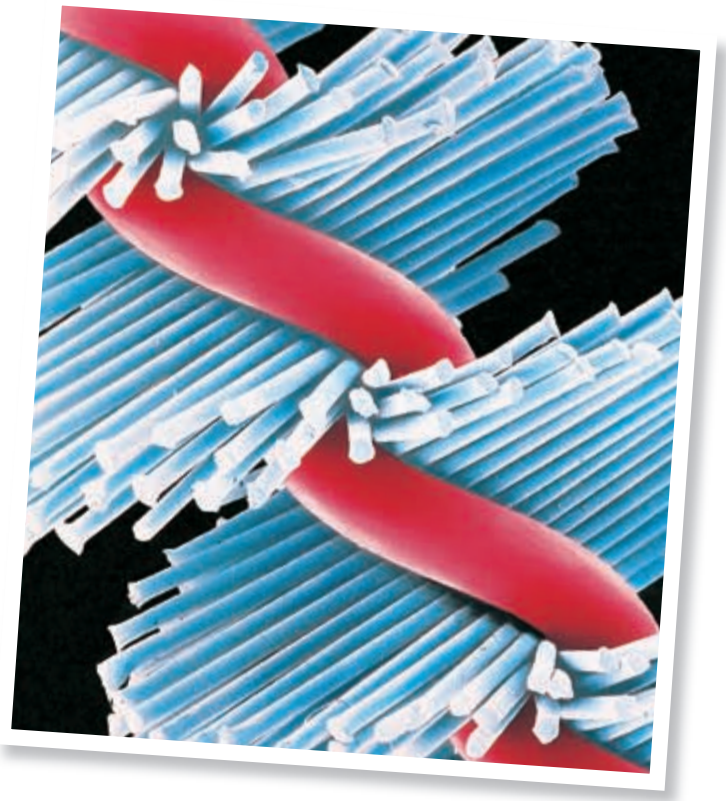
SECRET 1: READ THE BOOK.

No matter how useful your chemistry book may be for holding up the shelf in your locker, it is virtually impossible to pass the class if you don't take it out, open it up, and actually see what is inside. It was not meant to be just a heavy burden in your backpack. It was written to help you to learn chemistry. Here are some tips to put it to the best use:

1. Read the assigned pages *before* you come to class. That way, you'll have a better idea of what the lecture is about.
2. Keep some note cards with you when you read. When you have a question, write it down on one side of a card. When you find the answer or your teacher explains it to you, write the answer on the other side of the card. You may even add diagrams or sketches that help to explain things. There you have it! An instant flashcard! Now you have a useful study tool to help you review a concept that you had a little trouble understanding.
3. Find a good place to study. Some people will tell you to find a quiet place, free from distractions, and that is what works best for them. If you're like many people, though, if a place is *too* quiet, you will *look* for distractions. Look at this realistically. If you study in front of the television, you *will* watch the television. If you study in a room where there are *video games*, and you happen to love video games, you will be distracted. However, there is nothing wrong with some quiet music while you study, if it helps you relax.
4. Use the Main Ideas in the section openers as a guide. These show you what is most important for you to focus on in each chapter. If you have looked at those carefully, you're one step ahead of the game.

SECRET 2: PAY ATTENTION IN CLASS.

The more actively you take part in things, the less bored and sleepy you will be. Sleep at night or on your vacation.



SECRET 3: WORK THE SAMPLE AND PRACTICE PROBLEMS.

For better or worse, problem-solving is a big part of chemistry. Practicing problem-solving skills will be a major part of successfully passing the class.

1. The Sample Problems in the textbook will take you step-by-step through the process, teaching you how to solve them as you go.
2. The solutions to these problems are given in the book. Try covering them up, and then using them to check your work when you finish.
3. The Practice Problems given right after the Sample Problems are there to reinforce what you just learned. The more you do something, the more it will stay in your memory. Practice is what helps you actually *learn* something, rather than just temporarily memorizing it for a test and then forgetting it when you need it later.
4. The problems in the Chapter Review are similar to the Sample Problems. If you can apply the things you learned in the Sample and Practice Problems to the ones in the Review, then you really know the concepts.

5. Plugging numbers into a calculator can be a great tool, but when something goes wrong, it's hard to see where you might have made a mistake. Use the four step problem-solving format: *Analyze, Plan, Solve,* and *Check Your Work*. These will organize your work and help you to better understand the process of solving the problem.

6. If you work on a problem for 15 minutes or more and are still having trouble with it, make note of it so that you can ask your teacher or a friend who understands it for help. Then move on. Otherwise, you may just become frustrated and give up.

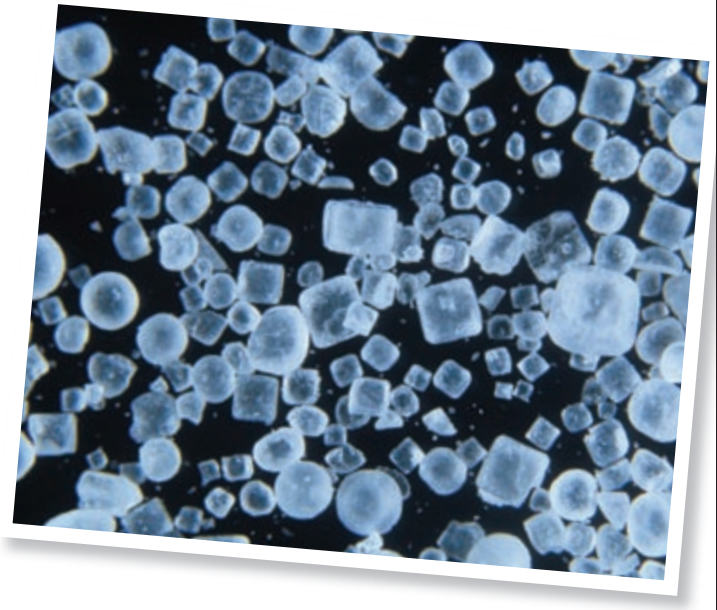
7. Always check your answer to see if it makes sense. Is the number realistic when you look back at what you were asked to find? Does your final answer have the correct unit of measurement? Were you supposed to convert something from one unit to another somewhere along the way? Taking a few moments to check these things will not only make you sure that you have the correct answer, it will also help you keep from making the same mistakes over and over again.

8. Write a problem on one side of a note card and the solution on the other. Use the problem cards to periodically practice solving that type of problem.

SECRET 4: DO YOUR HOMEWORK.

You would be amazed at the difference it makes in your chemistry grade when you actually *do* your homework and turn it in on time. And it's important that you do *your own* homework. Friends may seem wonderful when they let you copy their homework in the morning, but they are not doing you any favors. If *they* did the work, *you* have not learned anything. Would you want to go to a doctor who copied someone else's work in school? Would you want to fly in an airplane designed by an engineer who had received all the answers from a friend? Think about it.

1. As soon as possible after class, review your notes, and do your homework. This is the best time, when things are still fairly fresh in your mind. If you wait too long, what you learned in class will fade away. You also will be tired and thus more likely to become frustrated and give up. At this time in your life, one of the most important things you can do is to make the most of your education. It will definitely pay off in your future.



2. Define the key terms, even if they have not been assigned. Take your note-cards and put a term on one side and the definition on the other side. If the key term refers to a scientific equation, put the term on one side of the card and the equation on the other side.

SECRET 5: TAKE NOTES IN CLASS.

Paying attention in class is great, but it is not enough! Very few people have perfect recall, and you can't expect to remember everything. If you don't take notes as you go along, you will forget things. Unless your teacher requires you to take notes in a specific way, there are a number of techniques you can try. Try several and see which one works best for you.

1. Bring paper and pen or pencil. It's pretty hard to take notes without them and your friends eventually will get tired of loaning them to you.

2. Bring your book and follow along in the chapter as your teacher lectures. Add page numbers to your notes so that you can find things again later.

3. Use highlighting markers or colored pens to differentiate between different types of information. It will help keep your notes more organized, and it makes note-taking a little more interesting.

4. Add diagrams or simple sketches to illustrate a concept. This will help you understand it better and also remember it later on, especially if you are mainly a visual learner.
5. It is impossible to write down every single thing a teacher says. If you try to do this, you'll just fall behind and aggravate the teacher and your peers by constantly asking them to wait or to repeat things. Focus on the main ideas and add the details later.
6. Use abbreviations and develop your own short-hand way of writing. Don't put in every *if, and, the,* or *but.*
7. Review your notes as soon as possible after class. Definitely do it within 24 to 48 hours; otherwise, it will fade from your mind. Use your note cards and write down questions that arise as you review. Ask the teacher about them the next time you are in class. Again, now you have a flashcard!
8. Create a note-taking co-op with your classmates. Each person can make copies of their notes and share them. Others may have picked up on concepts that you missed, and you may have notes that others missed. Together, you can have it all.
9. With your teacher's permission, record the lecture. Listen to the recording later and fill in any gaps in your class notes. Label recordings so that you know what subject each covers.
10. See the descriptions of Simple Outlines and Cornell Notes in this Handbook for additional note-taking suggestions.

SECRET 6: START PREPARING FOR A TEST THE DAY YOU START A TOPIC.

Just because you may have been able to wait until the night before the test to study in the past, skim through the chapter quickly, and then pass the test, doesn't mean it will work for you forever. Each year there is more to learn, and the concepts are at a higher level of understanding. If you don't review and practice things as you go along, there will be too much material by the time of the test. You also will not have the time to get enough help.

1. Break it down! It is easier to do a big task in small pieces. Look through your notes for 10 to 15 minutes and read a few pages of the chapter each night. By doing this, you will not have to learn new material the night before an exam.

2. Ask the teacher for specific things you need to memorize for the test. Don't try to memorize everything. If you have consistently reviewed the material, you will be more likely to remember it. If you haven't looked at it since the day you first saw it, you will have too much to re-learn the night before the exam.

3. Use your flashcards. These address topics that you had questions about, and going over them will help you remember those questions. Again, don't think it's a waste of your time to make flashcards. Simply making the flashcards will help you better remember material, even if you don't look at them ever again.

4. Study with a friend and test one another with the flashcards. You could try to set some goals to make things more interesting. For example, see which one of you could answer the questions or do the problems on ten flashcards in a row first. This could make studying more fun.

5. Do the review questions in the book, even if they weren't assigned. Test questions often come from the Section and Chapter Reviews. If you do them a few days in advance of the test, you can check with the teacher for the answers to see what you need to spend more time on.

6. Take online quizzes. They are often made up of questions in the test bank and may well reappear on the test. These can help you to pinpoint areas where you're having trouble, so you can get help.

7. Some people, especially if they are in a note-taking co-op, find it beneficial to rewrite and reorganize their notes before a test, to make studying easier. In many cases, this can also refresh your memory and be a review in itself.

8. Get enough sleep. At your age, when you sleep is when your body is growing, building new bone and muscle, and doing general maintenance and repair. You actually require *more* than 8 hours of sleep a day while these things are going on. If you don't let your body and your brain rest, build, and repair, *things won't work right.*

9. Eat right. Your car won't run if it doesn't get the right fuel, and your body won't either. Save the junk food for a reward after the test. You'll certainly deserve it after all the hard work you've put into studying.

SECRET 7: BE PRACTICAL WHEN YOU TAKE A TEST.

There are skills that can help you be more successful when you take the test. Some of them are common sense things that your mom probably told you a million times until you stopped listening. Pay close attention to the phrase *common sense.* Common means that a lot of people know about it (not just your mom) and it will benefit you to pay attention.

1. When test day comes, bring a pen and/or pencil to class. Teachers don't accept answers transmitted by telepathy.

2. Ask the teacher if you may use scratch paper to work problems out.

3. If it's permitted, bring a calculator to help speed up doing the math on problems. But don't let it take the place of a step-by-step approach, because you might miss an important step. Calculators are only as good as the data you put into them.

4. Dress comfortably. Although the school is unlikely to allow you to wear your pajamas in class, you're bound to have a favorite pair of jeans and shirt that don't scratch, pinch, ride up, or cause other discomfort.

5. Once you are given the test, look over the whole thing first, before you start.

6. Read the directions. Some teachers occasionally like to give tests that have directions like the following, just to see if you are paying attention: "Sign your name on your paper, wait two minutes, then turn it in. Grin at everyone as you walk back to your seat. Do this and you'll get an A."

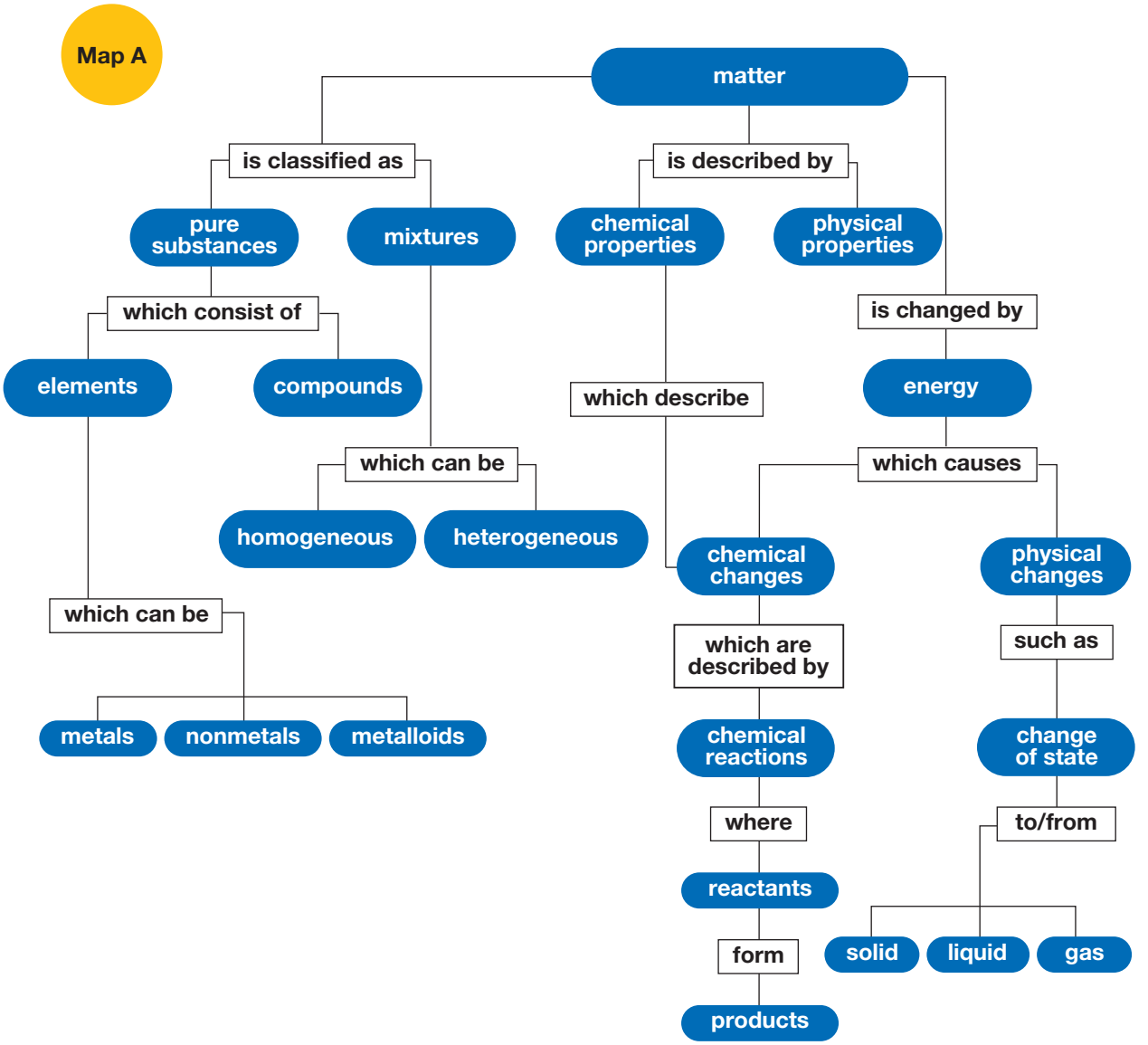
7. Start with the questions you're sure you know the answers to, then go back and work on the harder ones. Doing the easier questions first may spark your memory and help you to answer the ones you skipped.

8. Remember your problem-solving skills and check to make sure your answers make sense.

Concept Maps

Making concept maps can help you decide what material in a chapter is important and how to efficiently learn that material. A concept map presents key ideas, meanings, and relationships for the concepts being studied. It can be thought of as a visual road map of the chapter. Learning happens efficiently when you use concept maps because you work with only the key ideas and how they fit together.

The concept map shown as **Map A** was made from vocabulary terms in the chapter, "Matter and Change." Vocabulary terms are generally labels for concepts, and concepts are generally nouns. In a concept map, linking words are used to form propositions that connect concepts and give them meaning in context. For example, on the map below, "matter is described by physical properties" is a proposition.



Studies show that people are better able to remember materials presented visually. In a concept map, you can see the relationships among many ideas.

The more concept maps you make, the better you will become at constructing them. Soon you may find that organizing them becomes second nature. You may even develop your own system of shapes, lines, and colors to emphasize different types of information contained in your concept maps. For example, you may decide to place all vocabulary terms in ovals, main ideas in squares, and clarifying examples in triangles. You could draw solid lines between concepts and terms that are very related and dotted lines between those that are only slightly related.

The great thing about concept maps is that they allow you the freedom to organize material in a way that makes sense to you.

To Make a Concept Map

1. **List all the important concepts.** We'll use some concepts from Section 2 of the chapter "Matter and Change."

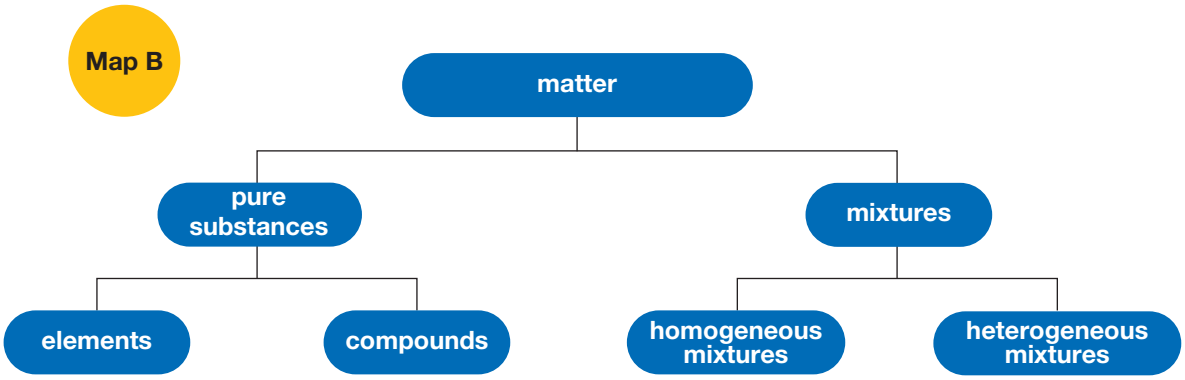
matter	mixture
compound	pure substance
element	
homogeneous mixture	
heterogeneous mixture	

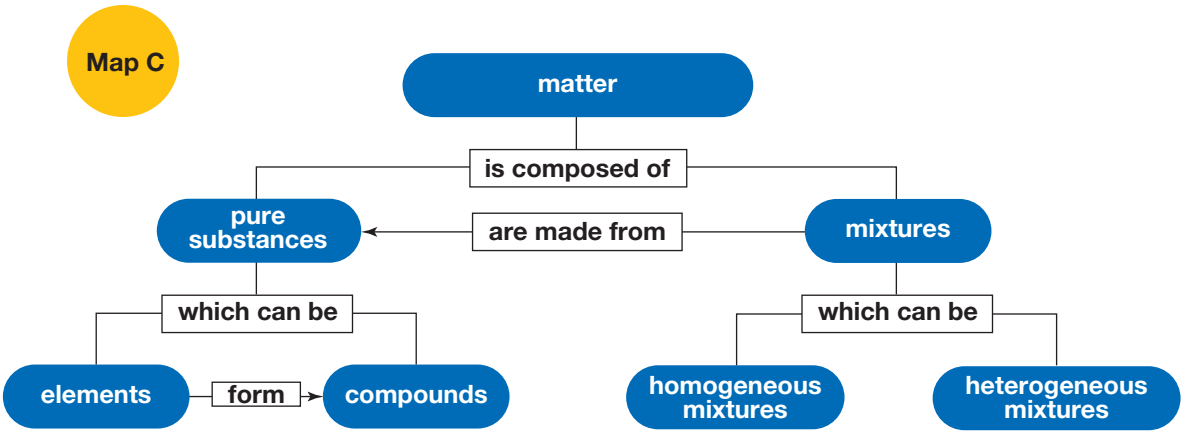
From this list, group similar concepts together. For example, one way to group these concepts would be into two groups—one that is related to mixtures and one that is related to pure substances.

mixture	pure substance
heterogeneous mixture	compound
homogeneous mixture	element

2. **Select a main concept for the map.**
We will use *matter* as the main concept for this map.

3. **Build the map by placing the concepts according to their importance under the main concept, *matter.***
One way of arranging the concepts is shown in **Map B.** (This map is continued on the next page.)





4. Add linking words to give meaning to the arrangement of concepts.

When adding the links, be sure that each proposition makes sense. To distinguish concepts from links, place your concepts in circles, ovals, or rectangles, as shown in the maps. Then make cross-links. Cross-links are made of propositions and lines connecting concepts across the map. Links that apply in only one direction are indicated with an arrowhead.

Map C is a finished map covering the main ideas listed in Step 1. Making maps might seem difficult at first, but the process forces you to think about the meanings and relationships among the concepts. If you do not understand those relationships, you can get help early on.

Practice mapping by making concept maps about topics you know. For example, if you know a lot about a particular sport, such as basketball, or if you have a particular hobby, such as playing a musical instrument, you can use that topic to make a practice map. By perfecting your skills with information that you know very well, you will begin to feel more confident about making maps from the information in a chapter.

Remember, the time you devote to mapping will pay off when it is time to review for an exam.

PRACTICE

1. Classify each of the following as either a concept or linking word(s).

a. classification _____

b. is classified as _____

c. forms _____

d. is described by _____

e. reaction _____

f. reacts with _____

g. metal _____

h. defines _____

2. Write three propositions from the information in **Map A.**

_____

_____

_____

3. List two cross-links shown on **Map C.**

_____

_____

_____

Simple Outlines

Outlining is a skill that is useful in many different subject areas. An outline can help you quickly identify the major concepts of a topic, along with key supporting details or examples. Your textbook layout was designed to help you set up a simple outline. Each section has a title, main ideas, and examples that support the main ideas. Under each example are additional details that help to explain the concept more fully.

Here is a simple outline based on the sections in the chapter "Matter and Change:"

I. Chemistry Is a Physical Science

II. Matter and Its Properties

III. Elements

Adding in the Main Ideas, subheadings, definitions, examples, and supporting information from the textbook can easily make this outline more detailed. A sample from the beginning of the section is shown below.

I. Chemistry is a Physical Science (Section Title)

A. Chemistry is the study of matter and its processes. (Main Idea)

B. There are several branches of chemistry. (Main Idea)

1. organic chemistry
2. inorganic chemistry
3. physical chemistry
4. analytical chemistry
5. biochemistry

Cornell Notes

The Cornell note-taking system was developed in the 1950's by Walter Pauk, while he was teaching at Cornell University. The method is now widely recommended and is used by schools and colleges all over the world due to its effectiveness as a study tool. Make things easier by setting up or printing out a note-taking template in advance.

Here is a template that can be used for taking notes with the Cornell system:

Current Topic	**Heading** **Unit Title** (1")
Cues *Can Be:* • *Main Ideas and Key Terms* • *Study questions about items in notes* • *Page numbers, section numbers, references, or other clues to finding more information* *Complete this column within 24 hours of taking notes.*	**Notes** • *Take notes with whatever method you are most comfortable.* • *Add diagrams, concept maps, or simple sketches.* • *Review as soon as possible after class.* • *When studying, cover this column up, and use the cue questions or prompts to quiz yourself. Then, uncover this side to check your answers.* *Complete this column during class.*
2.5"	6"
Summary *2-3 sentences describing the topic* *Complete this section within 24 hours of taking notes.* (2")	

K/W/L Strategy

The K/W/L strategy stands for "what I *Know*—what I *Want* to know—what I *Learned*." You start by brainstorming about the subject matter before reading the assigned material. Relating new ideas and concepts to those you have learned previously will help you better understand and apply the new knowledge you obtain. The main ideas throughout your textbook are ideal for using the K/W/L strategy.

1. **Read the main ideas.** You may also want to scan additional headings, highlighted terms, and equations before reading.
2. **Divide a sheet of paper into three columns, and label the columns "What I Know," "What I Want to Know," and "What I Learned."**
3. **Brainstorm what you know about the information in the objectives, and write these ideas in the first column.** Because this chart is designed primarily to help you integrate your own knowledge with new information, it is not necessary to write complete sentences.
4. **Think about what you want to know about the information in the objectives, and write these ideas in the second column.** Include information from both the section objectives and any other objectives your teacher has given you.
5. **While reading the section or afterwards, use the third column to write down the information you learned.** While reading, pay close attention to any information about the topics you wrote in the "What I Want to Know" column. If you do not find all of the answers you are looking for, you may need to reread the section or reference a second source. Be sure to ask your teacher if you still cannot find the information after reading the section a second time. It is also important to review your brainstormed ideas when you have completed reading the section. Compare your ideas in the first column with the information you wrote down in the third column.

   If you find that some of your brainstormed ideas are incorrect, cross them out. It is extremely important to identify and correct any misconceptions you had prior to reading before you begin studying for your test.

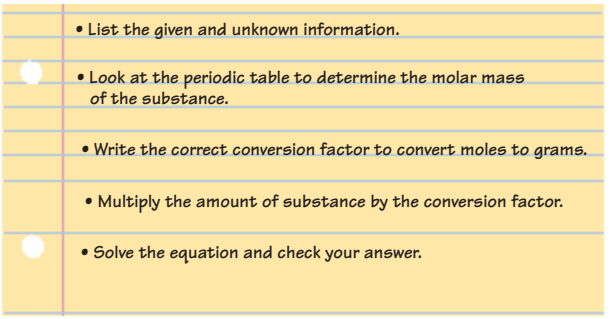
   The example below shows a K/W/L strategy a student may have written while studying about the different types of matter.

What I Know	What I Want to Know	What I Learned
• a gas has no definite shape or volume • a liquid has no definite shape, but has definite volume • a solid has definite shape and volume • a mixture is a combination of substances • a pure substance has only one component	• how gas, liquid, and solid states depend on the movements of particles • how mixtures and pure substances are different at the particle level	• molecules in solid and liquid states are close together, but are far apart in gas state • molecules in solid state have fixed positions, but molecules in liquid and gas states can flow • mixtures are combinations of pure substances • pure substances have fixed compositions and definite properties

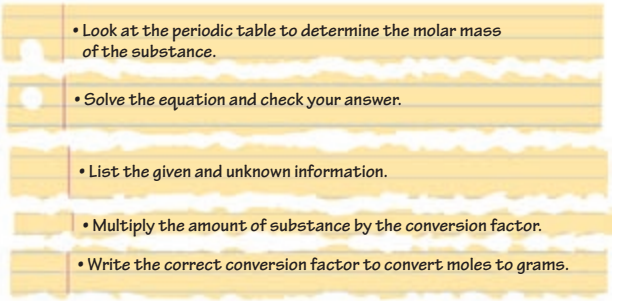
Sequencing / Pattern Puzzles

You can use pattern puzzles to help you remember sequential information. Pattern puzzles are not just a tool for memorization. They also promote a greater understanding of a variety of chemical processes, from the steps in solving a mass-mass stoichiometry problem to the procedure for making a solution of specified molarity.

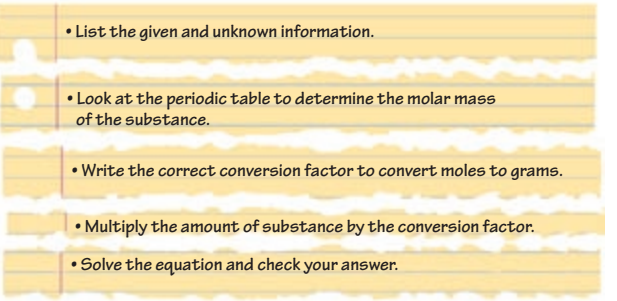
1. **Write down the steps of a process in your own words.** For an example, we will use the process for converting the amount of a substance in moles to mass in grams. (See Sample Problem B in the chapter, "Atoms: The Building Blocks of Matter.") On a sheet of notebook paper, write down one step per line, and do not number the steps. Also, do not copy the process straight from your textbook. Writing the steps in your own words promotes a more thorough understanding of the process. You may want to divide longer steps into two or three shorter steps.



2. **Cut the sheet of paper into strips with only one step per strip of paper.** Shuffle the strips of paper so that they are out of sequence. Alternatively, you can write each step on a separate note card, and then shuffle the note cards.



3. **Place the strips (or note cards) in their proper sequence.** Confirm the order of the process by checking your text or your class notes.



Pattern puzzles are especially helpful when you are studying for your chemistry tests. Before tests, use your puzzles to practice sequencing and to review the steps of chemistry processes. You and a classmate can also take turns creating your own pattern puzzles of different chemical processes and putting each other's puzzles in the correct sequence. Studying with a classmate in this manner will help make studying fun and will enable you to help each other.

Other Learning Strategies

BRAINSTORMING

Brainstorming is a strategy that helps you recognize and evaluate the knowledge you already have before you start reading. It works well individually or in groups. When you brainstorm, you start with a central term or idea, then quickly list all the words, phrases, and other ideas that you think are related to it.

Because there are no "right" or "wrong" answers, you can use the list as a basis for classifying terms, developing a general explanation, or speculating about new relationships. For example, you might brainstorm a list of terms related to the word *element.* The list might include gold, metals, chemicals, silver, carbon, oxygen, and water. As you read the textbook, you might decide that some of the terms you listed are not elements. Later, you might use that information to help you distinguish between elements and compounds.

BUILDING / INTERPRETING VOCABULARY

Using a dictionary to look up the meanings of prefixes and suffixes as well as word origins and meanings helps you build your vocabulary and interpret what you read. If you know the meaning of prefixes like kilo- (one thousand) and milli- (one thousandth), you have a good idea what kilograms, kilometers, milligrams, and millimeters are and how they are different.

Knowledge of prefixes, suffixes, and word origins can help you understand the meaning of new words. For example, if you know the suffix -protic comes from the same word as proton, it will help you understand what monoprotic and polyprotic acids are.

READING HINTS

Reading hints help you identify and bookmark important charts, tables, and illustrations for easy reference. For example, you may want to use a self-adhesive note to bookmark the periodic table in your book so you can easily locate it and use it for reference as you study different aspects of chemistry and solve problems involving elements and compounds.

INTERPRETING GRAPHIC SOURCES OF INFORMATION

Charts, tables, photographs, diagrams, and other illustrations are graphic, or visual, sources of information. The labels and captions, together with the illustrations, help you make connections between the words and the ideas presented in the text.

READING RESPONSE LOGS

Keeping a reading response log helps you interpret what you read and gives you a chance to express your reactions and opinions about what you have read. Draw a vertical line down the center of a piece of paper. In the left-hand column, write down or make notes about passages you read to which you have reactions, thoughts, feelings, questions, or associations. In the right-hand column, write what those reactions, thoughts, feelings, questions, or associations are.

COMPARING AND CONTRASTING

Comparing and contrasting is a strategy that helps you note similarities and differences between two or more objects or events. When you determine similarities, you are comparing. When you determine differences, you are contrasting.

You can use comparing and contrasting to help you classify objects or properties, differentiate between similar concepts, and speculate about new relationships. For example, as you read the chapter, "Matter and Change," you might begin to make a table in which you compare and contrast metals, nonmetals, and metalloids. As you continue to learn about these substances you can add to your table, giving you a better understanding of the similarities and differences among elements.

IDENTIFYING CAUSE AND EFFECT

Identifying causes and effects as you read helps you understand the material and builds logical reasoning skills. An effect is an event or the result of some action. A cause is the reason the event or action occurred. Signal words, such as *because, so, since, therefore, as a result,* and *depends on,* indicate a cause-and-effect relationship. You can use arrows to show cause and effect. For example, you might write this cause-and-effect relationship as you read the chapter on gases: At constant pressure, increase in temperature (cause) → increase in gas volume (effect).

MAKING A PREDICTION GUIDE

A prediction guide is a list of statements about which you express your opinions and then try to justify them based on your current knowledge. After reading the material, you re-evaluate your opinions in light of what you learned. Using prediction guides helps you assess your knowledge, identify assumptions you may have that could lead to mistaken conclusions, and form an idea of expected results. Here are some suggestions for how to make a prediction guide.

1. **Start with the statements your teacher writes on the board or you find listed in your textbook.** For example, look at the five statements from Dalton's atomic theory in your textbook, in the chapter "Atoms: The Building Blocks of Matter."
2. **Decide whether you think each statement is true or false.** Discuss the reasons why you think so and write it all down. If someone disagrees with your conclusion, write down the reasons why.
3. **After reading the section or listening to a lecture, re-evaluate your opinion of each statement.** Discuss why your opinion changed or remained the same. Find passages in the text that account for the change of reinforcement of your opinions. For example, you might have agreed with all five statements from Dalton's theory before reading the text. Then, after reading about atoms and subatomic particles, you might have changed your opinion about the first statement.

COOPERATIVE LEARNING TECHNIQUES

READING WITH A PARTNER

Reading with a partner can help you understand what you read and point out where you need more study.

1. **First read the text silently by yourself and take notes.** Use self-adhesive notes to mark those parts of the text that you do not understand. For example, you might have difficulty with some of the material about quantum numbers, while another student might not understand electron configurations.
2. **Work with a partner to discuss the passages each of you marked.** Take turns listening and trying to clarify the difficult passages for each other. Together, study the related tables and illustrations and explain how they relate to the text.
3. **Work together to formulate questions for class discussion or for your teacher to answer.** Make note of the complications you both encountered and bring questions to your teacher.

USING L.I.N.K.

The L.I.N.K. strategy stands for **L**ist, **I**nquire, **N**otes, **K**now. It is similar to the K/W/L strategy, but you work as a class or in groups.

1. **Brainstorm all the words, phrases, and ideas associated with a term your teacher provides.** Volunteers can keep track of contributions on the board or on a separate sheet of paper.
2. **Have your teacher direct you in a class or group discussion about the words and ideas listed.** Now is the time to ask your teacher and other students for clarification of the listed ideas.
3. **At the end of the discussion, make notes about everything you can remember.** Look over your notes to see if you have left anything out.
4. **See what you now know about the given concept based on the discussion.** Consider if what you now know is different from what you previously believed.

SUMMARIZING/PAIRED SUMMARIZING

A summary is a brief statement of main ideas or important concepts. Making a summary of what you have read provides you with a way to review what you have learned, see what information needs further clarification, and make connections to material previously studied. Paired summarizing helps strengthen your ability to read, listen, and understand. It is especially useful when a section of text has several subdivisions, each dealing with different concepts.

1. **First read the material silently by yourself.**
2. **Then you and your partner take turns being the "listener" and the "speaker."** The speaker summarizes the material for the listener, who does not interrupt until the speaker has finished. If necessary, the speaker may consult the text, and the listener may ask for clarification. The listener then states any inaccuracies or omissions made by the speaker.
3. **Work together to refine the summary.** Make sure the summary states the important ideas in a clear and concise manner.

DISCUSSING IDEAS

Discussing ideas with someone else before you read is a strategy that can help you broaden your knowledge base and decide what concepts to focus on. Discussing ideas after you have read a section or chapter can help you check your understanding, clarify difficult concepts, and speculate about new ideas.