MODERN CHEMISTRY®

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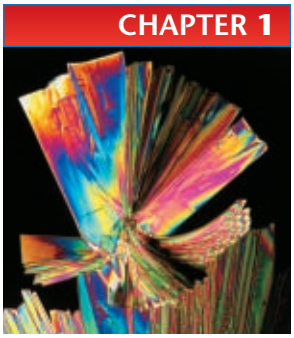

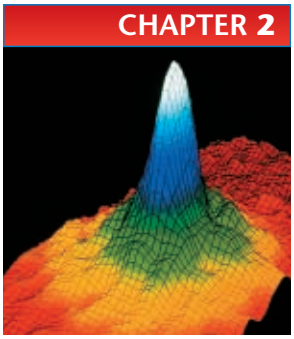

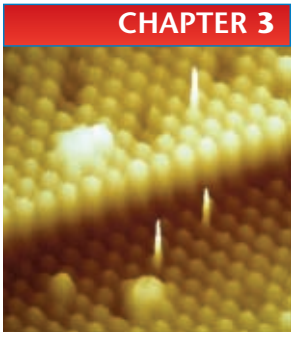

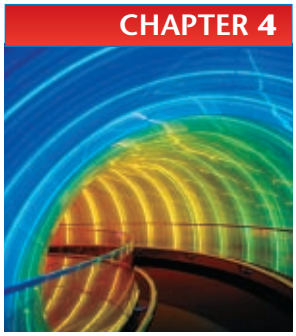

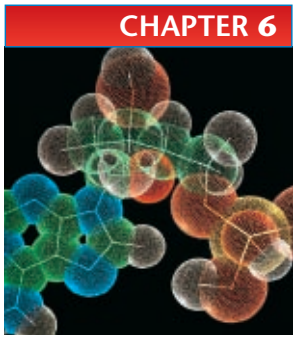

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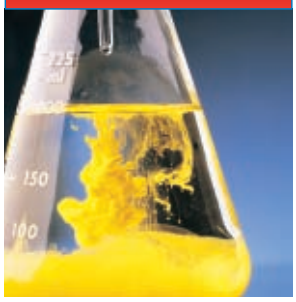

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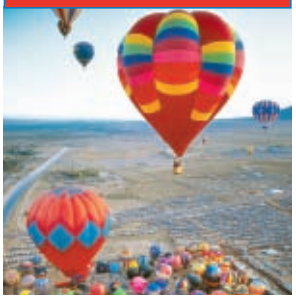

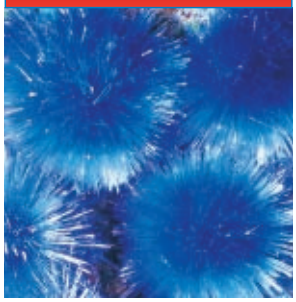

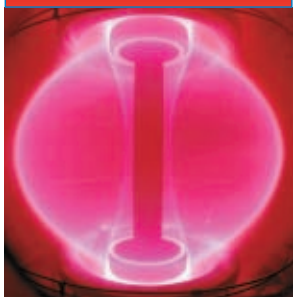

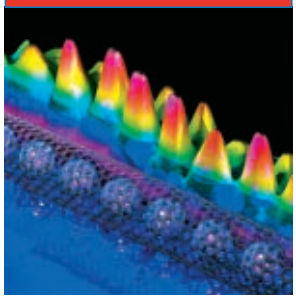

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extension

Go to **go.hrw.com** for full-length articles.

CAREERS in Chemistry

Chemistry in Action

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 follow cautions on chemical labels and in the experiments.

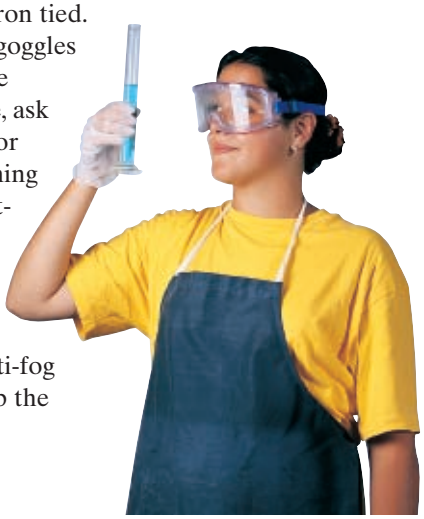
Specific experiments will use a system of Safety Symbols to highlight specific types of precautions. No matter what Safety Symbols an experiment may contain, the following safety rules apply any time you are in the lab.

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, tie back long hair, roll up loose sleeves, and put on any required personal protective equipment as directed by your teacher. Remove your wristwatch and any necklaces or jewelry that could get caught in moving parts. Avoid or confine loose clothing that could knock things over, catch on fire, get caught in moving parts, contact electrical connections, or absorb chemical solutions. 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. In addition, chemical fumes may react with and ruin some jewelry, such as pearl jewelry. 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 of <u>all safety and emergency equipment</u> 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, washing the goggles with soap and warm water, or using an anti-fog spray may help the problem.



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

8. **Perform only activities specifically assigned by your teacher.** Do not attempt any procedure without your teacher's direction. 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.** Do not store or eat food in 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 do not necessarily look hot when they are hot. Allow all items to cool before storing them.

14. **Remember how easily glass can break and cause a serious cut.** 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. Never force glass tubing into rubber tubing, stoppers or wooden corks. 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 in a specially designated disposal container.

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.

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; WALK to the safety shower, stand under it, and turn it on. While doing so, call to your teacher. In case of fire, alert your teacher and leave the lab.

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. 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 bulb.
- 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.

How to Use Your Textbook

Your Roadmap for Success with *Modern Chemistry*

Get Organized

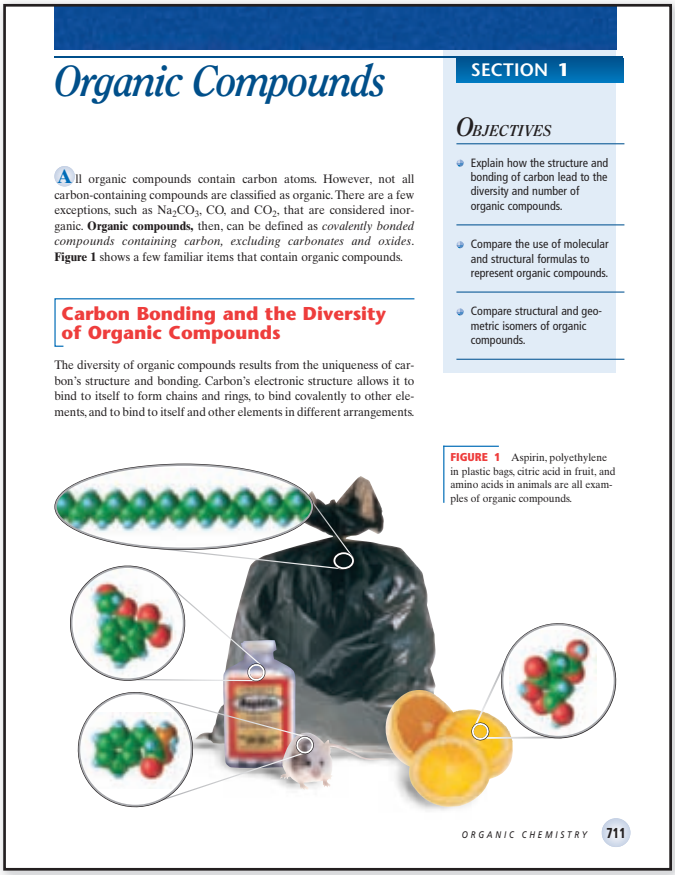
Keep a science notebook so that you are ready to take notes when your teacher reviews material in class. Keep your assignments in this notebook so that you can review them when studying for the chapter test.

STUDY TIP **Appendix B,** located in the back of the book, describes a number of Study Skills that can help you succeed in chemistry, including several approaches to note taking.

Read for Meaning

Read the **Objectives** at the beginning of each section because they will tell you what you'll need to learn. **Key Terms** are boldfaced in each chapter. Use the glossary to locate definitions quickly. After reading each chapter, turn to the **Chapter Highlights** page. Then, review the list of key terms and read the brief summaries of the chapter's main ideas. You may want to do this even before you read the chapter.

STUDY TIP If you don't understand a definition, reread the page on which the term is introduced. The surrounding text should help make the definition easier to understand.



Organic Compounds

SECTION 1

OBJECTIVES

- Explain how the structure and bonding of carbon lead to the diversity and number of organic compounds.
- Compare the use of molecular and structural formulas to represent organic compounds.
- Compare structural and geometric isomers of organic compounds.

All organic compounds contain carbon atoms. However, not all carbon-containing compounds are classified as organic. There are a few exceptions, such as Na_2CO_3, CO, and CO_2, that are considered inorganic. **Organic compounds,** then, can be defined as *covalently bonded compounds containing carbon, excluding carbonates and oxides*. **Figure 1** shows a few familiar items that contain organic compounds.

Carbon Bonding and the Diversity of Organic Compounds

The diversity of organic compounds results from the uniqueness of carbon's structure and bonding. Carbon's electronic structure allows it to bind to itself to form chains and rings, to bind covalently to other elements, and to bind to itself and other elements in different arrangements.

FIGURE 1 Aspirin, polyethylene in plastic bags, citric acid in fruit, and amino acids in animals are all examples of organic compounds.

ORGANIC CHEMISTRY 711

Be Resourceful, Use the Web

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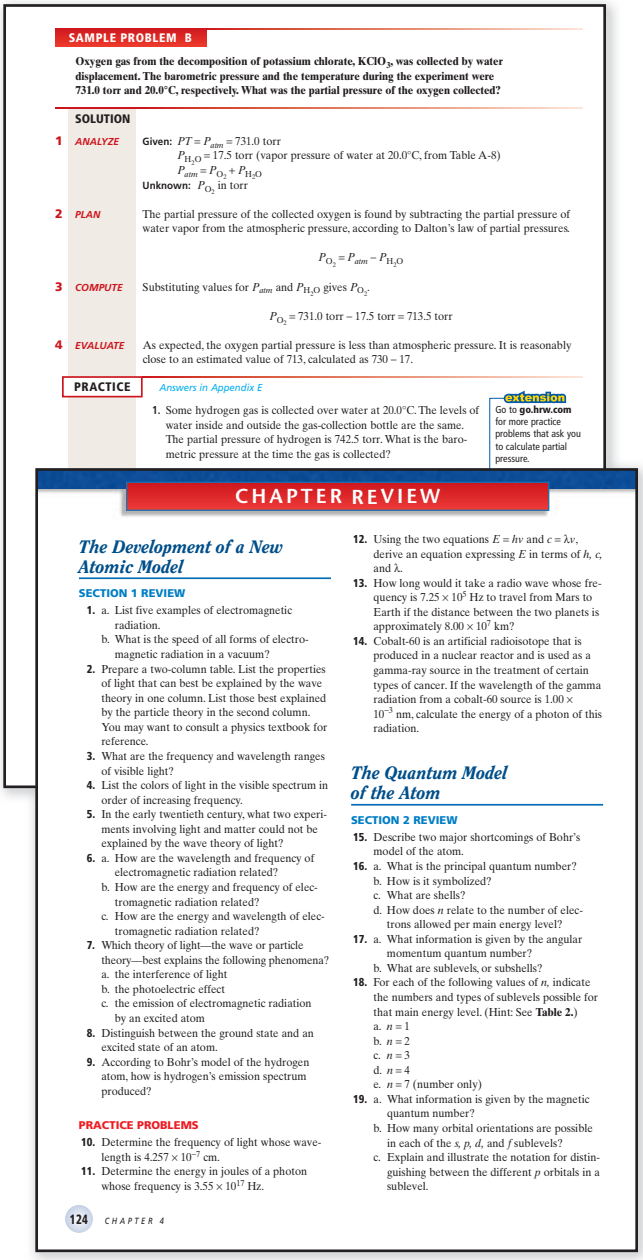
Visit go.hrw.com

Find resources and reference materials that go with your textbook. Visit **go.hrw.com,** and type in the keywords found in your textbook to access the available resources.



SAMPLE PROBLEM B

Oxygen gas from the decomposition of potassium chlorate, $KClO_3$, was collected by water displacement. The barometric pressure and the temperature during the experiment were 731.0 torr and 20.0°C, respectively. What was the partial pressure of the oxygen collected?

SOLUTION

1 ANALYZE

Given: $PT = P_{atm} = 731.0$ torr
$P_{H_2O} = 17.5$ torr (vapor pressure of water at 20.0°C, from Table A-8)
$P_{atm} = P_{O_2} + P_{H_2O}$
Unknown: P_{O_2} in torr

2 PLAN

The partial pressure of the collected oxygen is found by subtracting the partial pressure of water vapor from the atmospheric pressure, according to Dalton's law of partial pressures.

$$P_{O_2} = P_{atm} - P_{H_2O}$$

3 COMPUTE

Substituting values for P_{atm} and P_{H_2O} gives P_{O_2}.

$$P_{O_2} = 731.0 \text{ torr} - 17.5 \text{ torr} = 713.5 \text{ torr}$$

4 EVALUATE

As expected, the oxygen partial pressure is less than atmospheric pressure. It is reasonably close to an estimated value of 713, calculated as 730 – 17.

PRACTICE *Answers in Appendix E*

1. Some hydrogen gas is collected over water at 20.0°C. The levels of water inside and outside the gas-collection bottle are the same. The partial pressure of hydrogen is 742.5 torr. What is the barometric pressure at the time the gas is collected?

extension
Go to **go.hrw.com** for more practice problems that ask you to calculate partial pressure.

CHAPTER REVIEW

The Development of a New Atomic Model

SECTION 1 REVIEW

1. a. List five examples of electromagnetic radiation.
   b. What is the speed of all forms of electromagnetic radiation in a vacuum?
2. Prepare a two-column table. List the properties of light that can best be explained by the wave theory in one column. List those best explained by the particle theory in the second column. You may want to consult a physics textbook for reference.
3. What are the frequency and wavelength ranges of visible light?
4. List the colors of light in the visible spectrum in order of increasing frequency.
5. In the early twentieth century, what two experiments involving light and matter could not be explained by the wave theory of light?
6. a. How are the wavelength and frequency of electromagnetic radiation related?
   b. How are the energy and frequency of electromagnetic radiation related?
   c. How are the energy and wavelength of electromagnetic radiation related?
7. Which theory of light—the wave or particle theory—best explains the following phenomena?
   a. the interference of light
   b. the photoelectric effect
   c. the emission of electromagnetic radiation by an excited atom
8. Distinguish between the ground state and an excited state of an atom.
9. According to Bohr's model of the hydrogen atom, how is hydrogen's emission spectrum produced?

PRACTICE PROBLEMS

10. Determine the frequency of light whose wavelength is 4.257×10^{-7} cm.
11. Determine the energy in joules of a photon whose frequency is 3.55×10^{17} Hz.
12. Using the two equations $E = h\nu$ and $c = \lambda\nu$, derive an equation expressing E in terms of h, c, and λ.
13. How long would it take a radio wave whose frequency is 7.25×10^5 Hz to travel from Mars to Earth if the distance between the two planets is approximately 8.00×10^7 km?
14. Cobalt-60 is an artificial radioisotope that is produced in a nuclear reactor and is used as a gamma-ray source in the treatment of certain types of cancer. If the wavelength of the gamma radiation from a cobalt-60 source is 1.00×10^{-3} nm, calculate the energy of a photon of this radiation.

The Quantum Model of the Atom

SECTION 2 REVIEW

15. Describe two major shortcomings of Bohr's model of the atom.
16. a. What is the principal quantum number?
    b. How is it symbolized?
    c. What are shells?
    d. How does n relate to the number of electrons allowed per main energy level?
17. a. What information is given by the angular momentum quantum number?
    b. What are sublevels, or subshells?
18. For each of the following values of n, indicate the numbers and types of sublevels possible for that main energy level. (Hint: See **Table 2.**)
    a. $n = 1$
    b. $n = 2$
    c. $n = 3$
    d. $n = 4$
    e. $n = 7$ (number only)
19. a. What information is given by the magnetic quantum number?
    b. How many orbital orientations are possible in each of the s, p, d, and f sublevels?
    c. Explain and illustrate the notation for distinguishing between the different p orbitals in a sublevel.

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Work the Problems

Sample Problems, Math Tutors, and **Practice Problems** build your reasoning and problem-solving skills by guiding you through example problems.

Prepare for Tests

Section Reviews and **Chapter Reviews** test your knowledge of the main points of the chapter. Critical Thinking items challenge you to think about the material in different ways and in greater depth. The **Standardized Test Prep** that is located after each Chapter Review helps you sharpen your test-taking abilities.

STUDY TIP Reread the Objectives and Chapter Highlights when studying for a test to be sure you know the material.

Use the Appendix

Your **Appendix** contains a variety of resources designed to enhance your learning experience. The **Elements Handbook** provides additional information about the elements. **Appendix A** has tables which include essential problem-solving information. **Appendix D** provides more practice problems.

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