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<td>Study Guide for Content Mastery, p. 6</td>
</tr>
</tbody>
</table>

**Key to National Science Content Standards:** UCP = Unifying Concepts and Processes, A = Science as Inquiry, B = Physical Science, C = Life Science, D = Earth and Space Sciences, E = Science and Technology, F = Science in Personal and Social Perspectives, G = History and Nature of Science

Refer to pages 4T–5T of the Teacher Guide for an explanation of the National Science Content Standards correlations.
Resource Manager

**Materials List**

**ChemLab** (pages 18–19)
- large rubber band, 500-g mass, ring stand, clamp, hair dryer, meterstick

**Discovery Lab** (page 3)
- large kitchen matches, laboratory balance, stopwatch or clock

**MiniLab** (page 15)
- petri dish (2), 25-mL graduated cylinder, whole milk, water, vegetable oil, food coloring (4 different colors), toothpicks (2), dishwashing detergent

**Demonstration** (pages 10–11)
- 0.05 g potassium permanganate (KMnO₄), 1 g sodium hydrogen sulfite (NaHSO₃), 1 g barium chloride dihydrate (BaCl₂·2H₂O), 400-mL beakers (3), small test tubes (2), water

**Preparation of Solutions**

For a review of solution preparation, see page 46T of the Teacher Guide.

Quantities are for a class of 30 students.

**Demonstration** (pages 10–11)
- **potassium permanganate solution** Dissolve 3 or 4 small crystals, about 0.05 gram, of potassium permanganate (KMnO₄) in 250 mL water. **CAUTION:** The solution is toxic.
- **barium chloride solution** Add 1 gram of barium chloride dihydrate (BaCl₂·2H₂O) to 1 mL water in a small test tube. **CAUTION:** The solution is toxic.
- **sodium hydrogen sulfite solution** Add 1 gram sodium hydrogen sulfite (NaHSO₃) to 1 mL water in a small test tube. **CAUTION:** The solution is toxic.

**Assessment Resources**
- Chapter Assessment, pp. 1–6
- MindJogger Videoquizzes
- Alternate Assessment in the Science Classroom
- TestCheck Software
- Solutions Manual, Chapter 1
- Supplemental Problems, Chapter 1
- Performance Assessment in the Science Classroom
- Chemistry Interactive CD-ROM, Chapter 1 quiz

**Additional Resources**
- Spanish Resources
- Guided Reading Audio Program, Chapter 1
- Cooperative Learning in the Science Classroom
- Lab and Safety Skills in the Science Classroom
- Lesson Plans
- Block Scheduling Lesson Plans
- Texas Lesson Plans
- Texas Block Scheduling Lesson Plans
Level 1 activities should be appropriate for students with learning difficulties.

Level 2 activities should be within the ability range of all students.

Level 3 activities are designed for above-average students.

ELL activities should be within the ability range of English Language Learners.

Cooperative Learning activities are designed for small group work.

These strategies represent student products that can be placed into a best-work portfolio.

These strategies are useful in a block scheduling format.

The following multimedia for this chapter are available from Glencoe.

**VIDEOTAPE/DVD**
- MindJogger Videoquizzes, Chapter 1

**VIDEODISC**
- Cosmic Chemistry
  - *Greenhouse Effect*, Movie
  - *Ozone Studies*, Movie
  - *Nylon*, Movie
  - *Dr. Jekyll and Mr. Hyde*, Movie
  - *Lab Safety*, Movie

**CD-ROM**
- *Chemistry: Matter and Change*
  - *Magic of Chemistry*, Demonstration

Look for the following icons for strategies that emphasize different learning modalities.

**Kinesthetic**
- Meeting Individual Needs, pp. 5, 7

**Visual-Spatial**
- Reteach, pp. 5, 9; Portfolio, p. 16

**Interpersonal**
- Meeting Individual Needs, p. 15; Reinforcement, p. 16

**Intrapersonal**
- Chemistry Journal, pp. 5, 12, 14; Extension, p. 11; Meeting Individual Needs, p. 12

**Linguistic**
- Chemistry Journal, p. 8

**Logical-Mathematical**
- Quick Demo, p. 10

**Portfolio Assessment**
- Portfolio, TWE, p. 16
- Assessment, TWE, pp. 4, 17

**Performance Assessment**
- Assessment, TWE, p. 13
- Problem-Solving Lab, TWE, p. 8
- ChemLab, TWE, p. 19
- MiniLab, SE, p. 15
- MiniLab, TWE, p. 15
- Demonstration, TWE, p. 11
- ChemLab, SE, pp. 18–19
- Discovery Lab, SE, p. 3

**Knowledge Assessment**
- Assessment, TWE, pp. 6, 9
- Section Assessment, SE, pp. 6, 9, 13, 17
- Chapter Assessment, SE, pp. 22–23

**Skill Assessment**
- Assessment, TWE, p. 11
Chapter 1
Introduction to Chemistry

What You’ll Learn
- You will describe the relationship between chemistry and matter.
- You will recognize how scientific methods can be used to solve problems.
- You will distinguish between scientific research and technology.

Why It’s Important
- You, and all the objects around you, are composed of matter. By studying matter and the way it changes, you will gain an understanding of your body and all the “stuff” you see and interact with in your everyday life.

The four nebulae shown here contain a stew of elements. The red color in two of the nebulae is emitted by hydrogen atoms. The Horsehead Nebula can be seen on the right. The fourth nebula is the bluish structure below the horse’s head. The round, bright object on the left is the star, Zeta Orionis.

Visit the Chemistry Web site at science.glencoe.com to find links about chemistry and matter.

Chemistry Online

Using the Photo
Ask students what is involved when a star explodes. Lead them to understand that the event involves matter and energy and how they interact. Tell them that this interaction is what chemistry is all about—matter and energy and how they relate to each other.

Chapter Themes
The following themes from the National Science Education Standards are covered in this chapter. Refer to page 4T of the Teacher Guide for an explanation of the correlations:
- Systems, order, and organization (UCP.1)
- Evidence, models, and explanation (UCP.2)
- Change, constancy, and measurement (UCP.3)

DISCOVERY LAB
Purpose
Students will observe a chemical reaction and relate their observations to definitions of matter and chemistry.

Safety and Disposal
Caution students to use care around an open flame. Have them place used matches in a flameproof container or in a container of water.

Teaching Strategies
- Ask students what evidence they observe that a change in matter is taking place. Answers might include change in appearance or odor or a gas and energy are given off.
- Use the odor produced by this experiment to introduce a discussion of air pollution. This lab can be used to introduce the ozone problem discussed in this chapter.

Expected Results
The match loses mass in each trial. The data from trial 1 should agree closely with the data from trial 2.

Analysis
The change in mass occurs because solids are changed into the gases that are released during the reaction.
1.1 The Stories of Two Chemicals

Take a moment to look around you. Where did all the “stuff” you see come from? All the stuff in the universe is made from building blocks formed in stars such as the ones shown in the photo on the opposite page. And, as you learned in the DISCOVERY LAB, this stuff changes form.

Scientists are naturally curious. They continually ask questions about and seek answers to all that they observe in the universe. One of the areas in which scientists work is the branch of science called chemistry. Your introduction to chemistry will begin with two unrelated discoveries that now form the basis of one of the most important environmental issues of our time.

The Ozone Layer

You are probably aware of some of the damaging effects of ultraviolet radiation from the Sun if you have ever suffered from a sunburn. Overexposure to ultraviolet radiation also is harmful to plants and animals, lowering crop yields and disrupting food chains. Living things can exist on Earth because ozone, a chemical in Earth’s atmosphere, absorbs most of this radiation before it reaches Earth’s surface. A chemical is any substance that has a definite composition. Ozone is a substance that consists of three particles of oxygen.

Before presenting the lesson, display Section Focus Transparency 1 on the overhead projector and have students answer the accompanying questions using Section Focus Transparency Master 1.
Ask students why the majority of ozone would be formed over the equator. **Ozone formation in the stratosphere** depends on the energy from UV rays from the sun striking and breaking up oxygen. The direct rays at the equator have more energy than the slanted rays that strike other parts of Earth.

**Earth’s atmosphere** As you can see in Figure 1-1, Earth’s atmosphere consists of layers. The lowest layer is called the troposphere and contains the air we breathe. The troposphere is where the clouds shown in Figure 1-2 occur and where airplanes fly. All of Earth’s weather occurs in the troposphere.

The stratosphere is the layer above the troposphere. It extends from about 15 to 50 kilometers (km) above Earth’s surface. The ozone that protects Earth is located in the stratosphere. About 90% of Earth’s ozone is spread out in a layer that surrounds and protects our planet.

**Ozone formation** How does ozone enter the stratosphere? Ozone is formed when oxygen gas is exposed to ultraviolet radiation in the upper regions of the stratosphere. Particles of oxygen gas are made of two smaller oxygen particles. The energy of the radiation breaks the gas particles into oxygen particles, which then interact with oxygen gas to form ozone. Figure 1-3 illustrates this process. Ozone also can absorb radiation and break apart to reform oxygen gas. Thus, there tends to be a balance between oxygen gas and ozone levels in the stratosphere.

Ozone was first identified and measured in the late 1800s, so its presence has been studied for a long time. It was of interest to scientists because air currents in the stratosphere move ozone around Earth. Ozone forms over the equator where the rays of sunlight are the strongest and then flows toward the poles. Thus, ozone makes a convenient marker to follow the flow of air in the stratosphere.

In the 1920s, G.M.B. Dobson began measuring the amount of ozone in the atmosphere. Although ozone is formed in the higher regions of the stratosphere, most of it is stored in the lower stratosphere, where it can be measured by instruments on the ground or in balloons, satellites, and rockets. Dobson measured levels of stratospheric ozone of more than 300 Dobson units (DU). His measurements serve as a basis for comparison with recent measurements.

During 1981–1983, a research group from the British Antarctic Survey was monitoring the atmosphere above Antarctica. They measured surprisingly low levels of ozone, readings as low as 160 DU, especially during the Antarctic spring in October. They checked their instruments and repeated their measurements. In October 1985, they reported a confirmed decrease in the amount of ozone in the stratosphere and concluded that the ozone layer was thinning.

**Skin Tones**

Darker skin tones offer more protection from harmful UV rays in sunlight. Therefore, where rays from the sun are strong near the equator, skin tones have evolved to be darker. UV rays are less intense in areas farther from the equator, so skin tones are lighter there.

Although the Inuit people live far north of the equator, their skin tones are darker than would be expected because snow reflects UV light. The Inuit need darker skin to protect them from the increased levels of UV light they receive from reflection.

**Quick Demo**

Bring in a globe and an electric lamp. Ask students to identify the equator, where ozone is produced in the greatest quantity. Show students how the light rays strike Earth directly at the equator. Have a student volunteer confirm that more energy is felt where light rays strike directly than where they strike at an angle. Also show how convection currents caused by unequal heating of the atmosphere flow ozone from the equator to the poles.

**Reinforcement**

Ask students why the majority of ozone would be formed over the equator. Ozone formation in the stratosphere depends on the energy from UV rays from the sun striking and breaking up oxygen. The direct rays at the equator have more energy than the slanted rays that strike other parts of Earth.

**GLENCOE TECHNOLOGY**

**VIDEODISC**

**Cosmic Chemistry**

Disc 4, Side 8

Movie: Greenhouse Effect
1:00 min

Examination of this climatic chemical phenomenon

Movie: Ozone Studies 1:17 min

Chemical changes in the ozone layer

**Figure 1-1**

Earth’s atmosphere consists of several layers. The layer nearest Earth is the troposphere. The stratosphere is above the troposphere.

**Figure 1-2**

The troposphere extends to a height of about 15 km. Cumulonimbus clouds, or thunderheads, produce thunder, lightning, and rain.

**Figure 1-3**

The stratosphere extends to a height of about 15 km. Cumulonimbus clouds, or thunderheads, produce thunder, lightning, and rain.
Although the thinning of the ozone layer is often called the ozone hole, it is not actually a hole. You can think of it as being similar to the old sock in Figure 1-4a in which the material of the heel is wearing thin. You might be able to see your skin through the thinning sock. So although the ozone is still present in the atmosphere, the protective layer is much thinner than normal. This fact has alarmed scientists who never expected to find such low levels. Measurements made from balloons, high-altitude planes, and satellites have supported the measurements made from the ground, as the satellite map in Figure 1-4b shows. What could be causing the ozone hole?

Chlorofluorocarbons

The story of the second chemical in this chapter begins in the 1920s. Refrigerators, which used toxic gases such as ammonia as coolants, were just beginning to be produced large scale. Because ammonia fumes could escape from the refrigerator and harm the members of a household, chemists began to search for safer coolants. Thomas Midgley, Jr. synthesized the first chlorofluorocarbon in 1928. A chlorofluorocarbon (CFC) is a chemical that consists of chlorine, fluorine, and carbon. There are several different chemicals that are classified as CFCs. They are all made in the laboratory and do not occur naturally. CFCs are nontoxic and stable. They do not readily react with other chemicals. At the time, they seemed to be ideal coolants for refrigerators. By 1935, the first self-contained home air-conditioning units and eight million new refrigerators in the United States used CFCs as coolants. In addition to their use as refrigerants, CFCs also were used in plastic foams and as propellants in spray cans.

Concept Development

Have a local mechanic or air conditioning specialist speak to the class on the safeguards that currently exist to keep harmful chemicals from affecting the atmosphere. Ask him or her to clarify that chemicals that are shown to be harmful to the environment can be either eliminated or replaced with a chemical that is less harmful.

Discussion

Ask students what comes to mind when the term chemical is used. Often, the term has a negative connotation. Emphasize that chemicals are all around them and that they could not exist without them. Some chemicals can be harmful, but others are not only helpful, but essential.

3 Assess

Check for Understanding

What is the normal level of ozone in the stratosphere? 300 DU What was the lowest level that scientists found over the Antarctic in the early 1980s? 160 DU Have students explain why scientists were alarmed at these findings. L2

Re教

Visual-Spatial Bring in a thin sock or item of clothing. Demonstrate that the material is still present, but it is thinner than normal and allows more light to pass through. Have students explain how this model is similar to the ozone hole. L1 ELL

Chemistry CD-ROM

Go to the Chemistry Interactive CD-ROM to find additional resources for this chapter.
Now think of all the refrigerators in your neighborhood, in your city, across the country, and around the world. Think of the air conditioners in homes, schools, office buildings, and cars that also used CFCs. Add to your mental list all of the aerosol cans and plastic foam cups and food containers used each day throughout the world. If all of these products contained or were made with CFCs, imagine the quantities of these chemicals that could be released into the environment in a single day.

Scientists first began to notice the presence of CFCs in the atmosphere in the 1970s. They decided to measure the amount of CFCs in the stratosphere and found that quantities in the stratosphere increased year after year. This increase is shown in Figure 1-5. But, it was thought that CFCs did not pose a threat to the environment because they are so stable. Two separate occurrences had been noticed and measured: the protective ozone layer in the atmosphere was thinning, and increasingly large quantities of useful CFCs were drifting into the atmosphere. Could there be a connection between the two occurrences? Before you learn the answer to this question, you need to understand some of the basic ideas of chemistry and know how chemists— and most scientists, for that matter—solve problems.

---

**Assessment**

**Knowledge** Provide students with two lists. One list contains the layers of the atmosphere, listed in random order. The other list contains one characteristic of each layer. The characteristics should relate to the chemistry of the layer. Ask students to match each layer to its characteristic.

---

**Section 1.1 Assessment**

1. Why is ozone important in the atmosphere?
2. Where is ozone formed and stored?
3. What are CFCs? How are they used?
4. **Thinking Critically** Why do you think ozone is formed over the equator? What is the connection between sunlight and ozone formation?
5. **Comparing and Contrasting** What general trend in ozone concentration is shown in the graph at the right? How does the data for the years 1977–1987 on this graph compare to the same time span on the graph in Figure 1-5? What do you notice?
Matter, the stuff of the universe, has many different forms. You are made of matter. There is matter in the bed, blankets, and sheets on which you sleep as well as in the clothes you wear. There is matter in the food you eat, and in medications and vitamins you may take. You have learned that ozone is a chemical that occurs naturally in the environment, whereas CFCs do not. Although both chemicals are invisible gases, they, too, are matter.

**Chemistry: The Central Science**

Chemistry is the study of matter and the changes that it undergoes. A basic understanding of chemistry is central to all sciences—biology, physics, Earth science, ecology, and others. Chemistry also is central to our everyday lives, as Figure 1-6 illustrates. It will continue to be central to discoveries made in science and technology in the twenty-first century.

**Objectives**

- Define chemistry and matter.
- Compare and contrast mass and weight.
- Explain why chemists are interested in a submicroscopic description of matter.

**Vocabulary**

- chemistry
- matter
- mass
- weight

**Figure 1-6**

High-tech fabrics that don’t hinder athletic performance, water, fertilizers, pesticides, food, grocery items, clothing, building materials, hair care products, plastics, and even the human body are made of chemicals.

**Quick Demo**

Light the candle used in the Quick Demo on page 3. Discuss the burning of the candle in terms of matter. Chemistry involves the study of the composition of matter, such as the wax in the candle and the oxygen in the air, and changes in matter, such as the changes that occur in the wax as it burns.
Matter and its Characteristics
You recognize matter in the everyday objects you are familiar with, such as those shown in Figure 1-6. But, how do you define matter? Matter is anything that has mass and takes up space. Mass is a measurement that reflects the amount of matter. It is easy to see that your textbook has mass and takes up space. Is air matter? You can’t see it and you can’t always feel it. However, when you inflate a balloon, it expands to make room for the air. The balloon gets heavier. Thus, air must be matter. Is everything made of matter? The thoughts and ideas that “fill” your head are not matter; neither are heat, light, radio waves, nor magnetic fields. What else can you name that is not matter?

Mass and weight When you go to the supermarket to buy a pound of vegetables, you place them on a scale like the one shown in Figure 1-7 to find their weight. Weight is a measure not only of the amount of matter but also of the effect of Earth’s gravitational pull on that matter. This force is not exactly the same everywhere on Earth and actually becomes less as you move away from Earth’s surface at sea level. You may not notice a difference in the weight of a pound of vegetables from one place to another, but subtle differences do exist.

It might seem more convenient for scientists to simply use weight instead of mass. You might wonder why it is so important to think of matter in terms of mass. Scientists need to be able to compare the measurements that they make in different parts of the world. They could identify the gravitational force every time they weigh something but that is not practical or convenient. This is why they use mass as a way to measure matter independent of gravitational force.

What you see and what you don’t What can you observe about the outside of your school building or a skyscraper downtown? You know that there is more than meets the eye to such a building. There are beams inside the walls that give the building structure, stability, and function. Consider another

Problem-solve LAB
Purpose Students will examine, compare, and analyze scientific models.
Process Skills Using scientific illustrations, observing and inferring, comparing and contrasting
Teaching Strategies Bring a soccer ball to class and have students compare the pattern shown in it to the structure of a buckyball.
Analysis The carbon atoms are on the outside of the molecule. Each carbon atom is connected to three other carbon atoms.
Thinking Critically
The figure shows the formation of ozone from oxygen. The particles are too small and the process too fast to be shown in a photograph. The colored particles represent oxygen atoms.

Assessment Performance Have molecular model kits or gumdrops and toothpicks available for interested students to use to model molecules. Use the Performance Task Assessment List for Model in PASC, p. 51.

Problem-solving LAB

Chemical Models
Making Models Until the mid-1980s, scientists thought there were only two forms of carbon, each with a unique structure: diamond and graphite. As with many scientific discoveries, another form of carbon came as a surprise. Buckminsterfullerene, also called the buckyball, was found while researching interstellar matter. Scientists worked with various models of carbon structures until they determined that 60 carbons were most stable when joined together in a shape that resembles a soccer ball.

Analysis
Examine the structure in the diagram. Where are the carbon atoms? How many carbons is each carbon connected to? Identify the pentagons and hexagons on the faces of the buckyball.

Thinking Critically
Go back to Figure 1-3 to see an example of another model that chemists use. What process does the figure show? Explain why this information could not be shown in a photograph. What do the colored particles represent? Use Table C-1 in Appendix C to help you in your identification.

3 Assess Check for Understanding
Ask students to define chemical and chemistry. A chemical is any substance that has a definite composition. Chemicals make up matter. Chemistry is the study of matter and the changes it undergoes.

| Linguistic | Have students write about how they think they would feel to be in an environment without gravity. How would lack of gravity affect their weight? Would they still fit the definition of matter? Yes, they have mass and take up space. Use this scenario to differentiate mass and weight. | L2 |
example. When you bend your arm at the elbow, you observe that your hand comes toward your shoulder. Muscles that you cannot see under the skin contract and relax to move your arm.

Much of matter and its behavior is macroscopic; that is, you do not need a microscope to see it. You will learn in Chapter 3 that the tremendous variety of stuff around you can be broken down into more than 100 types of matter called elements, and that elements are made up of particles called atoms. Atoms are so tiny that they cannot be seen even with optical microscopes. Thus, atoms are submicroscopic. They are so small that 100 million million atoms could fit onto the period at the end of this sentence.

The structure, composition, and behavior of all matter can be explained on a submicroscopic level. All that we observe about matter depends on atoms and the changes they undergo. Chemistry seeks to explain the submicroscopic events that lead to macroscopic observations. One way this can be done is by making a model, a visual representation of a submicroscopic event. Figure 1-3 is such a model. The problem-solving lab on the opposite page gives you practice interpreting a simple chemical model.

Branches in the field of chemistry Because there are so many types of matter, there are many areas of study in the field of chemistry. Chemistry is traditionally broken down into the five branches listed in Table 1-1. Additional areas of chemistry include theoretical chemistry, which focuses on why and how chemicals interact, and environmental chemistry, which deals with the role chemicals play in the environment.

<table>
<thead>
<tr>
<th>Branch</th>
<th>Area of emphasis</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic chemistry</td>
<td>Most carbon-containing chemicals</td>
<td>Pharmaceuticals, plastics</td>
</tr>
<tr>
<td>Inorganic chemistry</td>
<td>In general, matter that does not contain carbon</td>
<td>Minerals, metals and nonmetals, semiconductors</td>
</tr>
<tr>
<td>Physical chemistry</td>
<td>The behavior and changes of matter and the related energy changes</td>
<td>Reaction rates, reaction mechanisms</td>
</tr>
<tr>
<td>Analytical chemistry</td>
<td>Components and composition of substances</td>
<td>Food nutrients, quality control</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>Matter and processes of living organisms</td>
<td>Metabolism, fermentation</td>
</tr>
</tbody>
</table>

Section 1.2 Assessment

6. Define matter.
7. Compare and contrast mass and weight.
8. Why does chemistry involve the study of the changes in the world at a submicroscopic level?
9. **Thinking Critically** Explain why a scientist must be cautious when a new chemical that has many potential uses is synthesized.
10. **Using Numbers** If your weight is 120 pounds and your mass is 54 kilograms, how would those values change if you were on the moon? The gravitational force on the moon is 1/6 the gravitational force on Earth.
Section Focus

Before presenting the lesson, display Section Focus Transparency 3 on the overhead projector and have students answer the accompanying questions using Section Focus Transparency Master 3.

2 Teach

Quick Demo

Logical-Mathematical
Ask groups of four students each to develop a list of the steps they would use to make a peanut butter and jelly sandwich. Then, have each group list their steps on the chalkboard, and have the class compare lists. Even though each group ends up with the same product, the methods used may vary. Have students relate this analogy to the development and use of scientific methods.

Demonstration

The Magic of Chemistry

Purpose

Students observe that one substance can be changed into another substance having different properties.

Materials

KMnO₄ (0.05 g); NaHSO₃ (1 g); BaCl₂ · 2H₂O (1 g); 400-mL beakers (3); small test tubes (2)

Safety Precautions

Disposal Filter the solution through filter paper. Dispose of the solid in a landfill approved to receive chemical waste.

Procedure

Before the demo, dissolve three or four small crystals of KMnO₄ in 250 mL of water in a beaker. In a test tube, add 1 g NaHSO₃ to 1 mL of water. In a second test tube, add 1 g BaCl₂ · 2H₂O to 1 mL of water. See page 2C for prepa-

Objectives

- Identify the common steps of scientific methods.
- Compare and contrast types of data.
- Compare and contrast types of variables.
- Describe the difference between a theory and a scientific law.

Vocabulary

scientific method qualitative data quantitative data hypothesis experiment independent variable dependent variable control conclusion model theory scientific law

A Systematic Approach

Scientists approach their work in a similar way. Each scientist tries to understand his or her world based on a personal point of view and individual creativity. Often, the work of many scientists is combined in order to gain new insight. It is helpful if all scientists use common procedures as they conduct their experiments.

A scientific method is a systematic approach used in scientific study, whether it is chemistry, biology, physics, or other sciences. It is an organized process used by scientists to do research, and it provides a method for scientists to verify the work of others. An overview of the typical steps of a scientific method is shown in Figure 1-9. The steps are not used as a checklist to be done in the same order each time. Therefore, all scientists must describe their methods when they publish their results. If other scientists cannot confirm the results after repeating the method, then doubt arises over the validity of the reported results.

Observation You make observations throughout your day in order to make decisions. Scientific study usually begins with simple observation. An observation is the act of gathering information. Quite often, the types of observations scientists first make are qualitative data—information that describes color, odor, shape, or some other physical characteristic. In general, anything that relates to the five senses is qualitative: how something looks, feels, sounds, tastes, or smells.

Observe Figure 1-8 shows students working together on an experiment in the laboratory. You know that each person in the group probably has a different idea about how to do the project and a different part of the project that interests him or her the most. Having many different ideas about how to solve a problem is one of the benefits of many people working together. Communicating ideas effectively to one another and combining individual contributions to form a solution can be difficulties encountered in group work.

Figure 1-8

During your chemistry course, you will have opportunities to use scientific methods to perform investigations and solve problems.

10 Chapter 1
Chemists frequently gather another type of data. For example, they can measure temperature, pressure, volume, the quantity of a chemical formed, or how much of a chemical is used up in a reaction. This numerical information is called **quantitative data**. It tells you how much, how little, how big, how tall, or how fast. What kind of qualitative and quantitative data can you gather from Figure 1-10?

**Hypothesis**

Let’s return to the stories of two chemicals that you read about earlier. Even before quantitative data showed that ozone levels were decreasing in the stratosphere, scientists observed that CFCs were found there. Chemists Mario Molina and F. Sherwood Rowland were curious about how long CFCs could exist in the atmosphere.

Molina and Rowland examined the interactions that can occur among various chemicals in the troposphere. They determined that CFCs were stable there for long periods of time. But they also knew that CFCs drift up into the stratosphere. They formed a hypothesis that CFCs break down in the stratosphere due to interactions with ultraviolet light from the Sun. In addition, the calculations they made led them to hypothesize that a chlorine particle produced by this interaction would break down ozone.

A **hypothesis** is a tentative explanation for what has been observed. Molina and Rowland’s hypothesis stated what they believed to be happening, even though there was no formal evidence at that point to support the statement.

**Experiments**

A hypothesis means nothing unless there are data to support it. Thus, forming a hypothesis helps the scientist focus on the next step in a scientific method, the experiment. An **experiment** is a set of controlled observations that test the hypothesis. The scientist must carefully plan and set up one or more laboratory experiments in order to change and test one variable at a time. A variable is a quantity or condition that can have more than one value.

Suppose your chemistry teacher asks your class to design an experiment in which to test the hypothesis that table salt dissolves faster in hot water than in water at room temperature (20°C).

Discussion of solutions. **CAUTION:** The solutions are toxic. Place the NaHSO₃ solution in a beaker labeled 1 and the BaCl₂ solution in a beaker labeled 2. To start the demonstration, show students the “wine” (KMnO₄ solution). Pour the “wine” into beaker 1. Pour the “water” that results into beaker 2.

**Results**

The “wine” turns into “water,” and the “water” is then changed into “milk.”

Discussing the chemistry of this demo will be of little value at this time. Explain that a chemist learns how to change one substance into another substance having different properties.

**Analysis**

1. Were your observations of these changes qualitative or quantitative data? **Qualitative data; students’ sense of sight was used to observe color changes.**
Students often don’t understand what a scientific theory is. Many people use the term theory to explain something in the world around them or human behavior. What they call a theory might be a hypothesis.

Uncover the Misconception
Have students work in groups to distinguish between a fact and a prediction. Conclusions should include that a fact has been tested and found to be reliable. A prediction might be based on information, but is yet to be supported. Relate these terms to theory and hypothesis.

Demonstrate the Concept
With students, develop an events chain concept map that shows the hierarchy of the terms theory, hypothesis, experiments, observations. Concept maps should show that a theory requires numerous hypotheses, which are supported by experiments that include observations.

Assess New Knowledge
Ask students to describe a common “theory.” Help them see that simple statements based on observations are often really hypotheses.

In-Text Question
Page 12  Does either one contain acid?  no

Because temperature is the variable that you plan to change, it is an independent variable. Your group determines that a given quantity of salt completely dissolves within 1 minute at 40°C but that the same quantity of salt dissolves only after 3 minutes at 20°C. Thus, temperature affects the rate at which the salt dissolves. This rate is called a dependent variable because its value changes in response to a change in the independent variable. Although your group can determine the way the independent variable changes, it has no control over the way the dependent variable changes.

What other factors could you vary in your experiment? Would the amount of salt you try to dissolve make a difference? The amount of water you use? Would stirring the mixture affect your results? The answer can be yes to all of these questions. You must plan your experiment so that these variables are the same at each temperature, or you will not be able to tell clearly what caused your results. In a well-planned experiment, the independent variable should be the only condition that affects the experiment’s outcome. A constant is a factor that is not allowed to change during the experiment. The amount of salt, water, and stirring must be constant at each temperature.

In many experiments, it is valuable to have a control, that is, a standard for comparison. In the above experiment, the room-temperature water is the control. The rate of dissolving at 40°C is compared to the rate at 20°C. Figure 1-12 shows a different type of control. A chemical indicator has been added to each of three test tubes. Acid is added to the middle test tube, and the indicator turns yellow. This test tube can be used as a control. Compare the other two test tubes with the control. Does either one contain acid?

The interactions described between CFCs and ozone in Molina and Rowland’s hypothesis take place high overhead. Many variables are involved. For example, there are different gases present in the stratosphere. Thus, it would be difficult to determine which gases, or possibly if all gases, are decreasing ozone levels. winds, variations in ultraviolet light, and other factors could change the outcome of any experiment on any given day making comparisons difficult. Sometimes it is easier to simulate conditions in a laboratory where the variables can be more easily controlled.

An experiment may generate a large amount of data. These data must be carefully and systematically analyzed. Because the concept of data analysis is so important, you will learn more about it in the next chapter.

Conclusion
Scientists take the data that have been analyzed and apply them to the hypothesis to form a conclusion. A conclusion is a judgment based on the information obtained. A hypothesis can never be proven. Therefore, to say

Gifted
Intrapersonal Have gifted students find articles in a recently published scientific journal on a research topic of interest. Have them identify each step of the scientific method used in the research described in the article.

Qualitative and Quantitative
Intrapersonal Have students describe themselves using qualitative and quantitative data. Examples of qualitative data should use as many senses as possible: color of hair, tall or short, color of eyes, etc. Qualitative data may include their height or length of hair.
that the data support a hypothesis is to give only a tentative “thumbs up” to the idea that the hypothesis may be true. If further evidence does not support it, then the hypothesis must be discarded or modified. The majority of hypotheses are not supported, but the data may still yield new information.

Molina and Rowland formed a hypothesis about the stability of CFCs in the stratosphere. They gathered data that supported their hypothesis and developed a model in which the chlorine formed by the breakdown of CFCs would react over and over again with ozone. You must realize by now a model is a visual, verbal, and/or mathematical explanation of experimental data.

A model can be tested and used to make predictions. Molina and Rowland’s model predicted the formation of chlorine and the depletion of ozone, as shown in Figure 1-13. Another research group found evidence of interactions between ozone and chlorine when taking measurements in the stratosphere, but they did not know the source of the chlorine. Molina and Rowland’s model predicted a source of the chlorine. They came to the conclusion that ozone in the stratosphere could be destroyed by CFCs and that they had enough support for their hypothesis to publish their discovery.

Theory A theory is an explanation that has been supported by many, many experiments. You have heard of Einstein’s theory of relativity or the atomic theory. A theory states a broad principle of nature that has been supported over time. All theories are still subject to new experimental data and can be modified. Also, theories often lead to new conclusions.

A theory is considered successful if it can be used to make predictions that are true. In 1985, the announcement by the British Antarctic Survey that the amount of ozone in the stratosphere was decreasing lent Molina and Rowland’s hypothesis—that chlorine from CFCs could destroy ozone—further support.

Scientific law Sometimes, many scientists come over and over again to the same conclusion about certain relationships in nature. They find no exceptions. For example, you know that no matter how many times skydivers leap from a plane, they always wind up back on Earth’s surface. Sir Isaac Newton was so certain that an attractive force exists between all objects that he proposed his law of universal gravitation.

Newton’s law is a scientific law and, as such, a relationship in nature that is supported by many experiments. It is up to scientists to develop further hypotheses and experimentation to explain why these relationships exist.

Section 1.3 Assessment

11. What is a scientific method? What are its steps?
12. You are asked to study the effect of temperature on the volume of a balloon. The balloon’s size increases as it is warmed. What is the independent variable? Dependent variable? What factor is held constant? How would you construct a control?
13. Critique Molina and Rowland’s hypothesis of ozone depletion as to its strengths and weaknesses.
14. Jacques Charles described the direct relationship between temperature and volume of all gases at constant pressure. Should this be called Charles’s law or Charles’s theory? Explain.
15. Thinking Critically Why must Molina and Rowland’s data in the laboratory be supported by measurements taken in the stratosphere?
16. Interpreting Data A report in the media states that a specific diet will protect individuals from cancer. However, no data are reported to support this statement. Is this statement a hypothesis or a conclusion?

1.3 Scientific Methods

3 Assess

Check for Understanding

Ask students to explain the difference between a hypothesis and a theory. A hypothesis is a statement about what is believed to be happening, without evidence. A theory is formed over time and is confirmed by verification of many hypotheses by experiments.

Reteach

Have students clarify the difference between a theory and a scientific law. A theory is a statement that provides an explanation based on supported hypotheses. A scientific law describes something known to happen without error, such as gravity, but doesn’t explain how it happens.

Extension

Bring in a newspaper or journal article about a development in environmental chemistry. Have students identify the steps of a scientific method used as well as any controls and variables used.

Assessment

Performance Cut out large pieces of paper and write a vocabulary word from this section on each. Have students place these papers in the order they are used in a scientific method. Some words may be subsets of specific steps. Accept any order that students can justify. Use the Performance Task Assessment List for Events Chain in PASC, p. 91.
Every day in the media, whether it’s TV, newspapers, magazines, or the Internet, you are bombarded with the results of scientific investigations. Many deal with the environment, medicine, or health. As a consumer, you are asked to evaluate the results of scientific research and development. How do scientists use qualitative and quantitative data to solve different types of scientific problems?

### Types of Scientific Investigations

**Pure research** seeks to gain knowledge for the sake of knowledge itself. Molina and Rowland conducted research on CFCs and their interactions with ozone as pure research, motivated by curiosity. No environmental evidence at the time indicated that there was a correlation to their model in the stratosphere. Their research only showed that CFCs could speed the breakdown of ozone in a laboratory setting.

When the ozone hole was reported in 1985, scientists had made measurements of CFC levels in the stratosphere that supported the hypothesis that CFCs could be responsible for the depletion of ozone. The pure research done only for the sake of knowledge became applied research. **Applied research** is research undertaken to solve a specific problem. Scientists continue to monitor the amount of CFCs in the atmosphere and the annual changes in the amount of ozone in the stratosphere. Applied research also is being done to find replacement chemicals for the CFCs that are now banned. Read the **Chemistry and Society** feature at the end of this chapter to learn about research into the human genome. What type of research does it describe?

**Chance discoveries** Sometimes, when a scientist plans research with a specific goal in mind, he or she will conduct experiments and reach a conclusion that is expected. Sometimes, however, the conclusion reached is far different from what was expected. Some truly wonderful discoveries in science have been made unexpectedly.

The discovery of nylon is one example. In 1928, E.I. DuPont de Nemours and Company appointed a young, 32-year-old chemist from Harvard, Wallace Carothers, as the director of its new research center. The goal was to create artificial fibers similar to cellulose and silk. In 1930, Julian Hill, a member of Carothers’ team, dipped a hot glass rod in a mixture of solutions and unexpectedly pulled out long fibers such as the one shown in Figure 1-14. Carothers pursued the development of these fibers as a synthetic silk that could withstand high temperatures and eventually developed nylon in 1934. Nylon’s first use was in a toothbrush with nylon bristles. During World War II, nylon was used as a replacement for silk in parachutes. Nylon is used extensively today in textiles and some kinds of plastics.

### Students in the Laboratory

In your study of chemistry, you will learn many facts about matter. You also will do experiments in which you will be able to form and test hypotheses, gather and analyze data, and draw conclusions.

When you work in the chemistry laboratory, you are responsible for your safety and the safety of the people working nearby. **Table 1-2** on page 16 lists some safety rules that you must use as a guide each time you enter the lab.
Chemists and all other scientists use these safety rules. Before you do the miniLAB at the bottom of this page or the CHEMLAB at the end of this chapter, read the procedures carefully. Which safety rules in Table 1-2 apply?

Figure 1-14

Strands of nylon can be pulled from the top layer of solutions. After its discovery, nylon was used mainly for war materials and was unavailable for home use until after World War II.

miniLAB

Developing Observation Skills

Observing and Inferring A chemist’s ability to make careful and accurate observations is developed early. The observations often are used to make inferences. An inference is an explanation or interpretation of observations.

Materials petri dish (2), graduated cylinder, whole milk, water, vegetable oil, four different food colorings, toothpick (2), dishwashing detergent

Procedure

1. Add water to a petri dish to a height of 0.5 cm. Add 1 mL of vegetable oil.
2. Dip the end of a toothpick in liquid dishwashing detergent.
3. Touch the tip of the toothpick to the water at the center of the petri dish. Record your detailed observations.
4. Add whole milk to a second petri dish to a height of 0.5 cm.
5. Place one drop of each of four different food colorings in four different locations on the surface of the milk, as shown in the photo. Do not put a drop of food coloring in the center.
6. Repeat steps 2 and 3.

Analysis

1. What did you observe in step 3?
2. What did you observe in step 6?
3. Oil, the fat in milk, and grease belong to a class of chemicals called lipids. What can you infer about the addition of detergent to dishwater?

Expected Results

When the toothpick touches the milk, the detergent temporarily destroys the surface tension. The colors move to the outside of the dish. The detergent emulsifies any fat in the milk. Convectionlike currents are established, causing the colors to move from the outside toward the center.

Analysis

1. The oil moved away from the detergent.
2. The colors moved to the outside of the dish.
3. It helps remove grease and oil from items being washed.

Assessment

Performance Have different lab groups test milk samples that have different fat content and then compare their observations. Use the Performance Task Assessment List for Carrying Out a Strategy and Collecting Data in PASC, p. 25.

English Language Learners

Interpersonal Have a student explain the difference between pure and applied research and chance discovery to an English-language-learning student. The student can use figures in the textbook to help him or her explain.
**Applying Chemistry**

Ask students if the discovery of CFCs was pure research, applied research, or chance discovery. It was applied research to find another source of refrigerants.

**Reinforcement**

**Interpersonal** Divide students into groups of four. Give each group several safety tips from Table 1-2. Have them create a quick skit to demonstrate potential dangers and lab safety.

**Concept Development**

As the instructor, walk into the lab demonstrating poor lab safety, such as wearing loose clothing and chewing gum. Have students identify as many rules you are breaking as they can. Have a prize, such as a special pair of lab goggles, for the student or group who identifies the greatest number of broken rules. Emphasize that although this example can be humorous, lab safety is a serious issue.

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**Table 1-2**

<table>
<thead>
<tr>
<th>Safety in the Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Study your lab assignment before you come to the lab. If you have any questions, be sure to ask your teacher for help.</td>
</tr>
<tr>
<td>2. Do not perform experiments without your teacher’s permission. Never work alone in the laboratory.</td>
</tr>
<tr>
<td>3. Use the table on the inside front cover of this textbook to understand the safety symbols. Read all CAUTION statements.</td>
</tr>
<tr>
<td>4. Safety goggles and a laboratory apron must be worn whenever you are in the lab. Gloves should be worn whenever you use chemicals that cause irritations or can be absorbed through the skin. Long hair must be tied back. See the photo below.</td>
</tr>
<tr>
<td>5. Do not wear contact lenses in the lab, even under goggles. Lenses can absorb vapors and are difficult to remove in case of an emergency.</td>
</tr>
<tr>
<td>6. Avoid wearing loose, draping clothing and dangling jewelry. Bare feet and sandals are not permitted in the lab.</td>
</tr>
<tr>
<td>7. Eating, drinking, and chewing gum are not allowed in the lab.</td>
</tr>
<tr>
<td>8. Know where to find and how to use the fire extinguisher, safety shower, fire blanket, and first-aid kit.</td>
</tr>
<tr>
<td>9. Report any accident, injury, incorrect procedure, or damaged equipment to your teacher.</td>
</tr>
<tr>
<td>10. If chemicals come in contact with your eyes or skin, flush the area immediately with large quantities of water. Immediately inform your teacher of the nature of the spill.</td>
</tr>
</tbody>
</table>
| 11. Handle all chemicals carefully. Check the labels of all bottles before removing the contents. Read the label three times:
  - Before you pick up the container.
  - When the container is in your hand.
  - When you put the bottle back. |
| 12. Do not take reagent bottles to your work area unless instructed to do so. Use test tubes, paper, or beakers to obtain your chemicals. Take only small amounts. It is easier to get more than to dispose of excess. |
| 13. Do not return unused chemicals to the stock bottle. |
| 14. Do not insert droppers into reagent bottles. Pour a small amount of the chemical into a beaker. |
| 15. Never taste any chemicals. Never draw any chemicals into a pipette with your mouth. |
| 16. Keep combustible materials away from open flames. |
| 17. Handle toxic and combustible gases only under the direction of your teacher. Use the fume hood when such materials are present. |
| 18. When heating a substance in a test tube, be careful not to point the mouth of the test tube at another person or yourself. Never look down the mouth of a test tube. |
| 19. Do not heat graduated cylinders, burettes, or pipettes with a laboratory burner. |
| 20. Be careful with hot apparatus or glassware. Hot glass looks the same as cool glass. |
| 21. Dispose of broken glass, unused chemicals, and products of reactions only as directed by your teacher. |
| 22. Know the correct procedure for preparing acid solutions. Always add the acid slowly to the water. |
| 23. Keep the balance area clean. Never place chemicals directly on the pan of a balance. |
| 24. After completing an experiment, clean and put away your equipment. Clean your work area. Make sure the gas and water are turned off. Wash your hands with soap and water before you leave the lab. |

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**Lab Safety**

**Visual-Spatial** Have student groups create posters or a bulletin board that emphasizes safe lab procedures. Be sure the products reflect what the safe behavior is and why it should be used.

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**Chemistry TEKS**

Pages 14–17

1(A), 2(B), 2(E), 3(C), 3(E)
Benefits of Chemistry

It is easy to understand the purpose of applied research because it addresses a specific problem. It also is easier to see its immediate benefit. Yet, when a sudden, unexpected event occurs in the world, whether it’s the ozone hole or the AIDS epidemic, the first line of defense is to look at the pure research that has already been conducted.

The products that we use to make our lives easier and more comfortable are the result of technological applications of pure and applied research. Technology is the practical use of scientific information. It is concerned with making improvements in human life and the world around us. As Figure 1-15 shows, advances in technology can benefit us in many ways.

**Figure 1-15**

Nuclear power and artificial limbs and joints are just a few of the technological advances that have improved human life.

---

**Section 1.4 Assessment**

17. Compare and contrast pure research and applied research.

18. What is technology? Is technology a product of pure research or applied research? Explain.

19. Explain why it is important to read each CHEM-LAB and miniLAB before you come to class.

20. **Thinking Critically** Explain the reason behind each of the following.
   a. Wear goggles and an apron in the lab even if you are only an observer.
   b. Report all accidents to your teacher.
   c. Do not return unused chemicals to the stock bottle.

21. **Interpreting Scientific Diagrams** What safety precautions should you take when you see the following safety symbols?
   - 🚨
   - 🌫️
   - ⚠️
   - 🧵

---

**3 Assess**

**Check for Understanding**

Ask students whether they think research on the Human Genome Project is pure or applied. If students are unfamiliar with the project, have them read the Chemistry and Society on page 20 of this text. **Answers will vary but might include that it is pure research for knowledge of what’s in the genome. Some students might say it is applied because of its use in gene therapy and cures for genetic diseases.**

**Reteach**

Emphasize that pure research is often a foundation for applied research. Pure research can create compounds or increase knowledge that scientists may not know how to use for years. However, when that knowledge or material is needed, it is readily available.

**Extension**

Ask students to bring in newspaper or magazine articles about scientific research and explain to the class how that research applies to their lives. Examples may include a new drug or treatment for a disease that affects someone they know or new technology that affects the environment.

---

**Portfolio**

Have students summarize articles brought in by some of the other students for the Extension above. Have students place the summaries into their portfolios.
Pre-Lab 1. Heat is the transfer of energy from a warmer object to a cooler object. If an object feels warm to your finger, your finger is cooler than the object and energy is being transferred from the object to your finger. In what direction does the energy flow if an object feels cooler to you? 2. Your forehead is very sensitive to hot and cold. How can you use this fact to detect whether an object is giving off or absorbing heat? 3. Read the entire CHEMLAB. It is important to know exactly what you are going to do during all chemistry experiments so you can use your laboratory time efficiently and safely. What is the problem that this experiment is going to explore? 4. What typical steps in a scientific method will you use to explore the problem? Write down the procedure that you will use in each experiment that you design. Be sure to include all safety precautions. 5. You will need to record the data that you collect during each experiment. Prepare data tables that are similar to the one below.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Objectives</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>What happens when you heat a stretched rubber band?</td>
<td>• Observe the properties of a stretched and a relaxed rubber band. • Form a hypothesis about the effect of heat on a stretched rubber band. • Design an experiment to test your hypothesis. • Collect and analyze data. • Draw conclusions based on your analysis.</td>
<td>large rubber band 500-g mass ring stand clamp hair dryer meter stick or ruler</td>
</tr>
</tbody>
</table>

Safety Precautions • Frequently observe the rubber band for any splits. Discard if rubber band is defective. • The hair dryer can become hot, so handle it with care.

Preparation 1. from the warmer object (your finger) to the cooler one (the object) 2. The sensitive skin on the forehead tells that an object is giving off heat if it feels warm on your forehead and absorbing heat if it feels cool. 3. What happens when you heat a stretched rubber band? 4. Check student procedures to assure they follow a correct scientific method. 5. See Expected Results.

Expected Results Observations should reflect that a rubber band gives off heat when it stretches, absorbs heat when it contracts, and contracts when heated. 1. The rubber band feels warm. Energy was lost by the rubber band and gained by the forehead. 2. The rubber band feels cooler. Heat is gained by the rubber band and lost by the forehead. 3. When heated, a stretched rubber band contracts. 4. Most students would hypothesize that the rubber band would stretch when heated. The actual result refuted the hypothesis. The rubber band became shorter.

CHEMLAB 1

The Rubber Band Stretch

Galileo Galilei (1564–1642) was an Italian philosopher, astronomer, and mathematician. Galileo pioneered the use of a systematic method of observation, experimentation, and analysis as a way to discover facts about nature. Modern science has its roots in Galileo’s 17th-century work on the art of experimentation. This chapter introduced you to how scientists approach their work. In this CHEMLAB, you will have a chance to design a scientific method to study something you have observed many times before—the stretching of a rubber band.

Materials
- large rubber band
- 500-g mass
- ring stand
- clamp
- hair dryer
- meter stick or ruler

Problem
What happens when you heat a stretched rubber band?

Objectives
- Observe the properties of a stretched and a relaxed rubber band.
- Form a hypothesis about the effect of heat on a stretched rubber band.
- Design an experiment to test your hypothesis.
- Collect and analyze data.
- Draw conclusions based on your analysis.

Materials
- large rubber band
- 500-g mass
- ring stand
- clamp
- hair dryer
- meter stick or ruler

Expected Results
- The rubber band feels warmer. Energy was lost by the rubber band and gained by the forehead.

Analyze and Conclude
1. The rubber band feels warm. Energy was lost by the rubber band and gained by the forehead.
2. The rubber band feels cooler. Heat is gained by the rubber band and lost by the forehead.
3. When heated, a stretched rubber band contracts.
4. Most students would hypothesize that the rubber band would stretch when heated. The actual result refuted the hypothesis. The rubber band became shorter.
Procedure

1. Obtain one large rubber band. Examine the rubber band for any splits or cracks. If you find any defects, discard it and obtain a new one.

2. Record detailed observations of the unstretched rubber band.

3. Design your first experiment to observe whether heat is given off or absorbed by a rubber band as it is stretched. Have your instructor approve your plan.

4. Do repeated trials of your experiment until you are sure of the results. **CAUTION:** Do not bring the rubber band near your face unless you are wearing goggles.

5. Design a second experiment to observe whether heat is given off or absorbed by a rubber band as it contracts after being stretched. Have your instructor approve your plan.

6. Do repeated trials of your experiment until you are sure of the results.

7. Use your observations in steps 2, 4, and 6 to form a hypothesis and make a prediction about what will happen to a stretched rubber band when it is heated.

8. Use the remaining items in the list of materials to design a third experiment to test what happens to a stretched rubber band as it is heated. Have your instructor approve your plan. Be sure to record all observations before, during, and after heating.

Cleanup and Disposal

1. Return the rubber band to your instructor to be reused by other classes.

2. Allow the hair dryer to cool before putting it away.

Analyze and Conclude

1. **Observing and Inferring** What results did you observe in step 4 of the procedure? Was energy gained or lost by the rubber band? By your forehead? Explain.

2. **Observing and Inferring** What results did you observe in step 6 of the procedure? Was energy gained or lost by the rubber band? By your forehead? Explain.

3. **Applying** Many substances expand when they are heated. Did the rubber band behave in the same way? How do you know?

4. **Drawing a Conclusion** Did the result of heating the stretched rubber band in step 8 confirm or refute your hypothesis? Explain.

5. **Making Predictions** What would happen if you applied ice to the stretched rubber band?

6. **Error Analysis** Compare your results and conclusion with those of your classmates. What were your independent and dependent variables? Did you use a control? Did all of the lab teams measure the same variables? Were the data that you collected qualitative or quantitative? Does this make a difference when reporting your data to others? Do your results agree? Why or why not?

Real-World Chemistry

1. Water expands when frozen. When ice melts, the water takes up less volume.

2. The materials that make up the bridge expand in warm weather and contract in cold weather. Bridge materials will crack if nothing is done to allow the bridge to expand and contract.

Performance

Design an experiment like the one done in Procedure step 8, but cool the rubber band instead of heating it. Use the Performance Task Assessment List for Designing an Experiment in PASC, p. 23.

Assessment

Resource Manager

ChemLab and MiniLab Worksheets, pp. 2–4 L2

Internet Address Book

Note Internet addresses that you find useful in the space below for quick reference.
The Human Genome Project

From eye and skin color to the potential for developing disease, humans display remarkable and endless variety. Much of this variety is controlled by the human genome: the complete “instruction manual” found in the nucleus of all cells that is used to define a specific organism. Decoding and understanding these instructions is the goal of the Human Genome Project (HGP). The United States Department of Energy and the National Institutes of Health coordinated the project that began in 1990. Private industry also is involved. The HGP fosters cooperation as well as competition among researchers in a project that could hasten advances in treatment of human genetic conditions such as cancer and heart disease.

A common goal, a common approach

The year 2003 marks the fiftieth anniversary of Watson and Crick’s discovery of the structure of DNA. Chemicals called nitrogen bases connect the twisted strands that make up DNA. There are roughly three billion pairs of these bases in the human genome. Determining the sequence, or order, in which these base pairs occur was one common goal of researchers working on the HGP. Biologists, chemists, physicists, computer specialists, and engineers across the country approach the task from different angles. Use of scientific methods was the unifying theme in all of this work.

Prior to the HGP, researchers around the world used scientific methods to work independently on the mammoth task of decoding the human genome. Without coordination, however, the data they collected were analyzed and stored using different databases and were shared only through scientific journals and conferences. Those working on the HGP used common methods for gathering and analyzing data. Results were shared through databases that are rapidly available through the World Wide Web, enhancing communication, cooperation, and the flow of information. Because of this cooperation, a rough map of the human genome was completed several years ahead of schedule. Much work still remains to be done, however, and results will have to be shared by researchers working on the project.

Looking toward the future

The Human Genome Project is spurring medical advances. But this powerful knowledge also raises important issues. For example, if a person’s genome map shows a predisposition for a certain illness, should an employer or insurance company be informed? While the HGP is opening exciting doors, the associated ethical, legal, and societal issues must be acknowledged and addressed.

Investigating the Issue

1. Communicating Ideas Research some of the ethical, legal, and societal issues being raised by genome research. Write a brief essay giving your opinion about how one or more of these issues could be addressed.

2. Debating the Issue The race to sequence the human genome took place in both the public and private sectors. Find information about several companies that worked independently on genome research. Is it ethical for them to sell this information, or should it be freely shared with others?

Investigating the Issue

1. Students will have varying opinions on issues such as whether testing for genetic compatibility should be required prior to marriage; who should receive information about the results of genetic tests, including employers and insurance companies; and what is done if genetic testing shows a predisposition for developing certain illnesses.

2. Students will have a variety of reactions to a company’s right to research, organize, and sell information it acquires using its own funds.
CHAPTER 1
STUDY GUIDE

Summary
1.1 The Stories of Two Chemicals
- The building blocks of the matter in the universe formed in the stars.
- A chemical is any substance that has a definite composition.
- Ozone is a chemical that forms a protective layer in Earth’s atmosphere.
- Ozone is formed in the stratosphere when ultraviolet radiation from the Sun strikes oxygen gas.
- Thinning of the ozone layer over Antarctica is called the ozone hole.
- CFCs are synthetic chemicals made of chlorine, fluorine, and carbon.
- CFCs were used as refrigerants and as propellants in aerosol cans.
- CFCs can drift into the stratosphere.

1.2 Chemistry and Matter
- Chemistry is the study of matter and the changes that it undergoes.
- Matter is anything that has mass and takes up space.
- Mass is a measure of the amount of matter.
- Weight is a measure not only of an amount of matter but also the effect of Earth’s gravitational pull on that matter.
- There are five traditional branches of chemistry: organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry, and biochemistry.

1.3 Scientific Methods
- Typical steps of a scientific method include observation, hypothesis, experiments, data analysis, and conclusion.
- Qualitative data describe an observation; quantitative data use numbers.
- An independent variable is a variable that you change in an experiment.
- A dependent variable changes in response to a change in the independent variable.
- A theory is a hypothesis that has been supported by many experiments.
- A scientific law describes relationships in nature.

1.4 Scientific Research
- Scientific methods can be used in pure research for the sake of knowledge, or in applied research to solve a specific problem.
- Laboratory safety is the responsibility of anyone who conducts an experiment.
- Many of the conveniences we enjoy today are technological applications of chemistry.

Vocabulary
- applied research (p. 14)
- chemistry (p. 7)
- conclusion (p. 12)
- control (p. 12)
- dependent variable (p. 12)
- experiment (p. 11)
- hypothesis (p. 11)
- independent variable (p. 12)
- mass (p. 8)
- matter (p. 8)
- model (p. 13)
- pure research (p. 14)
- qualitative data (p. 10)
- quantitative data (p. 11)
- scientific law (p. 13)
- scientific method (p. 10)
- technology (p. 17)
- theory (p. 13)
- weight (p. 8)

Using the Vocabulary
To reinforce chapter vocabulary, have students write a sentence using each term.

Review Strategies
- Have students define chemistry, chemical, matter, mass, and weight.
- Have students summarize the steps of a scientific method, giving examples of each step.
- Have students explain safe practices in the laboratory.

Reviewing Chemistry is a component of the Teacher Classroom Resources package that was prepared by The Princeton Review. Use the Chapter 1 review materials in this book to review the chapter with your students.

Portfolio Options
Review the portfolio options that are provided throughout the chapter. Encourage students to select one product that demonstrates their best work for the chapter. Have students explain what they have learned and why they chose this example for placement into their portfolios. Additional portfolio options may be found in the Challenge Problems booklet of the Teacher Classroom Resources.

Chemistry TEKS
Pages 20–21
3(A)
Concept Mapping

22. Complete the concept map using the following terms: stratosphere, oxygen gas, CFCs, ozone, ultraviolet radiation.

Mastering Concepts

23. any substance with a definite composition
24. 90% in the stratosphere
25. Chemical reactions in the atmosphere form ozone from oxygen and oxygen from ozone. Ozone protects Earth from UV rays.
26. refrigerants, foams, propellants for spray products
27. the study of matter and the changes it undergoes
28. An understanding of chemistry is central to all sciences and to our everyday lives.
29. Weight depends on gravitational force and changes as the gravitational force changes. Mass remains the same.
30. Analytical chemistry studies the composition of substances; environmental chemistry studies the environmental impact of chemicals.
31. Qualitative data, such as color or shape, are observed with the five senses. Quantitative data, such as mass or length, are measurements.
32. A control is a standard used for comparison.
33. A hypothesis is a tentative explanation about what has been observed. A theory is an explanation that has been supported by many experiments. A scientific law describes a relationship in nature.

Thinking Critically

35. Compare and Contrast Why is CFC depletion of the ozone layer a theory and not a scientific law?
36. Classifying CFCs break down to form chemicals that react with ozone. Is this a macroscopic or a microscopic observation?
37. Communicating Ideas Scientists often learn as much from an incorrect hypothesis as they do from one that is correct. Explain.
38. Designing an Experiment How would you design an experiment to evaluate the effectiveness of a “new and improved” chemical fertilizer on bean plants? Be sure to describe your hypothesis, procedure, variables, and control.
39. Inferring A newscaster reports, “The air quality today is poor. Visibility is only a quarter mile. Pollutants in the air are expected to rise above 0.085 parts per million (ppm) in the next eight hour average. Spend as little time outside today as possible if you suffer from asthma or other breathing problems.” Which of these statements are qualitative and which are quantitative?
40. Comparing and Contrasting Match each of the following research topics with the branch of chemistry that would study it: water pollution, the digestion of food in the human body, the composition of a new textile fiber, metals to make new coins, a treatment for diabetes.

Writing in Chemistry

41. Based on your beginning knowledge of chemistry, describe the research into depletion of the ozone layer by CFCs in a timeline.
42. Learn about the most recent measures taken by countries around the world to reduce CFCs in the atmosphere since the Montreal Protocol. Write a short report describing the Montreal Protocol and more recent environmental measures to reduce CFCs.
43. Name a technological application of chemistry that you use everyday. Prepare a booklet about its discovery and development.

Cumulative Review

In chapters 2 through 26, this heading will be followed by questions that review your understanding of previous chapters.

34. Pure research might examine the properties of water. Applied research might ask what chemicals should be added to drinking water to promote health, such as fluoride to promote healthy tooth formation. Technology might include creating filters to filter harmful contaminants out of water or machines to purify it.
Use these questions and the text-taking tip to prepare for your standardized test.

1. Matter is defined as anything that _____.
   a. exists in nature
   b. is solid to the touch
   c. is found in the universe
   d. has mass and takes up space

2. Mass is preferred as a measurement over weight for all of the following reasons EXCEPT _____.
   a. it has the same value everywhere on Earth
   b. it is independent of gravitational forces
   c. it becomes less in outer space, farther from Earth
   d. it is a constant measure of the amount of matter

3. Which of the following is an example of pure research?
   a. creating synthetic elements to study their properties
   b. producing heat-resistant plastics for use in household ovens
   c. finding ways to slow down the rusting of iron ships
   d. searching for fuels other than gasoline to power cars

4. When working with chemicals in the laboratory, which of the following is something you should NOT do?
   a. Read the label of chemical bottles before using their contents.
   b. Pour any unused chemicals back into their original bottles.
   c. Use lots of water to wash skin that has been splashed with chemicals.
   d. Take only as much as you need of shared chemicals.

Interpreting Tables and Graphs

Use the table and graph to answer questions 5–7.

5. What must be a constant during the experiment?
   a. temperature
   b. mass of CO₂ dissolved in each sample
   c. amount of beverage in each sample
   d. independent variable

6. Assuming that all of the experimental data are correct, what is a reasonable conclusion for this experiment?
   a. Greater amounts of CO₂ dissolve in a liquid at lower temperatures.
   b. The different samples of beverage contained the same amount of CO₂ at each temperature.
   c. The relationship between temperature and solubility seen with solids is the same as the one seen with CO₂.
   d. CO₂ dissolves better in a liquid at higher temperatures.

7. The scientific method used by this student showed that _____.
   a. the hypothesis is supported by the experimental data
   b. the observation accurately describes what occurs in nature
   c. the experiment is poorly planned
   d. the hypothesis should be thrown out

Thinking Critically

35. It has been supported by many experiments but still relies on further experiments for support. It does not describe a law of nature that always occurs, such as gravity.

36. Microscopic because it cannot be seen with human eyes

37. Data obtained testing an incorrect hypothesis provides useful information.

38. The hypothesis might say that the new fertilizer increases the number of beans produced by each bean plant. The procedure might be to have three groups of bean plants, one group with no fertilizer, one group with the unimproved fertilizer, and the other group with the new fertilizer. The independent variable would be the use of fertilizer. The dependent variable would be the number of beans produced by each plant. The control would be the plants that received no fertilizer.

39. The qualitative statements are that air quality is poor and that people should spend little time outside. Quantitative statements include that visibility is only a quarter mile and that the pollutants will rise above 0.085 ppm in the next eight-hour average.

40. Answers will vary but might include environmental, biochemistry, and organic, analytical, inorganic, and biochemistry, respectively.