## Chapter 1 Organizer: Introduction to Chemistry

### BIG Idea
Chemistry is a science that is central to our lives.

### Section Objectives | National Standards | State/Local Standards | Resources to Assess Mastery
--- | --- | --- | ---
**Section 1.1**
1. Define substance.
2. Explain the formation and importance of ozone.
3. Describe the development of chlorofluorocarbons.

UCP.1, UCP.2; A.1, A.2; B.3, B.6; E.2; F.4, F.5, F.6; G.2, G.3

**Entry-Level Assessment**
Focus Transparency 1

**Progress Monitoring**
Formative Assessment, pp. 5, 6, 7
Reading Check, pp. 5, 7
Graph Check, p. 8
Section Assessment, p. 8

**Section 1.2**
1. Compare and contrast mass and weight.
2. Explain why chemists are interested in a submicroscopic description of matter.
3. Identify the area of emphasis for various branches of chemistry.

UCP.1, UCP.2; A.1; B.2; G.1, G.2

**Entry-Level Assessment**
Focus Transparency 2

**Progress Monitoring**
Formative Assessment, p. 11
Reading Check, p. 10
Section Assessment, p. 11

**Section 1.3**
1. Identify the common steps of scientific methods.
2. Compare and contrast types of data.
3. Identify types of variables.
4. Describe the difference between a theory and a scientific law.

UCP.1, UCP.2; A.2; G.1, G.2

**Entry-Level Assessment**
Focus Transparency 3

**Progress Monitoring**
Formative Assessment, pp. 12, 13, 16
Reading Check, pp. 13, 14
Section Assessment, p. 16

**Section 1.4**
1. Compare and contrast pure research, applied research, and technology.
2. Apply knowledge of laboratory safety.

UCP.1, UCP.2; A.1, A.2; B.2, B.6; E.2; F.1, F.4, F.6; G.1, G.2, G.3

**Entry-Level Assessment**
Focus Transparency 4

**Progress Monitoring**
Formative Assessment, pp. 19, 22
Reading Check, p. 20
Graph Check, p. 20
Section Assessment, p. 22

**Summative Assessment**
Chapter Assessment, p. 26
*ExamView® Assessment Suite CD-ROM*
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### Leveled Resources

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<td><strong>OL</strong></td>
<td><strong>ChemLab</strong>, p. 24: test tubes with stoppers, test tube rack, grease pencil, 25-mL graduated cylinder, distilled water, dropper, beaker, Water Sample 1, Water Sample 2, dish detergent, metric ruler 45 min</td>
<td><strong>What's CHEMISTRY Got To Do With It? DVD</strong></td>
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<td><strong>COOP LEARN</strong></td>
<td><strong>LabManager™ CD-ROM</strong></td>
<td><strong>Interactive Classroom DVD</strong></td>
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<td><strong>(Scaffolded)</strong></td>
<td><strong>COOP LEARN</strong></td>
<td><strong>Lab and Safety Skills in the Science Classroom</strong></td>
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<td><strong>Science Notebook 1.2</strong></td>
<td><strong>ChemLab</strong>, p. 24: test tubes with stoppers, test tube rack, grease pencil, 25-mL graduated cylinder, distilled water, dropper, beaker, Water Sample 1, Water Sample 2, dish detergent, metric ruler 45 min</td>
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<td><strong>OL</strong></td>
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<td><strong>FAST FILE Chapter Resources:</strong></td>
<td><strong>OL</strong></td>
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<td><strong>BL</strong></td>
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<td>Teaching Transparency 2</td>
<td><strong>EL</strong></td>
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<td><strong>COOP LEARN</strong></td>
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BIG Idea

Chemistry and Life  To introduce this chapter’s Big Idea, lead students in a discussion of chemistry that occurs around them every day. Ask students to give an example of chemistry that is occurring in the classroom not related to lab experiments. Accept all reasonable responses. Possible answers: respiration, digestion, and various examples of heat transfer. Ask students to give examples of chemistry that occur in their homes. Accept all reasonable responses. Possible answers: cooking food, burning candles, and boiling water.

Use the Photo

Chemistry in the Home  Ask students to look at the photo of the cabin. Ask students to suggest examples of additional chemical reactions that might occur inside a cabin or inside their own home. Possible answers: cooking food, burning natural gas, fuel oil, or propane for heat, or burning candles.

ChemFacts

- Many of the processes that occur around you are the result of chemistry in action.
- Chemists study chemical reactions, such as why heat and light are given off when a log burns.
- The rusting of a nail, or other iron object, is another example of a chemical process that chemists might study.

Interactive Classroom

This DVD-ROM is an editable Microsoft® PowerPoint® presentation that includes:
- a premade presentation for every chapter
- additional diagnostic, formative, chapter, and Standardized Test Practice questions
- animations
- image bank
- transparencies
- links to glencoe.com
LAUNCH Lab

Where did the mass go?

When an object burns, the mass of what remains is less than the original object. What happens to the mass of the object?

Procedure

1. Read and complete the lab safety form.
2. Use a laboratory balance to measure the mass of a candle. Record this measurement, and record detailed observations about the candle.
3. Place the candle on a burn-resistant surface, such as a lab table. Carefully strike a match and light the candle. Use a stopwatch or a clock with a second hand to measure the time. Allow the candle to burn for 5 min. Then, blow out the flame. Record your observations.
   WARNING: Do not place matches in the sink.
4. Allow the candle to cool. Measure and record the mass of the extinguished candle.
5. Place the extinguished candle in a container designated by your instructor.

Analysis

1. Summarize your observations of the candle as it was burning and after the flame was extinguished.
2. Evaluate Where is the matter that appears to have been lost?

Inquiry Can the amount of matter “lost” vary? Plan an investigation to determine what factors might contribute to a different outcome.

Analysis

1. Sample Summary: A small amount of smoke came from the candle and the candle got smaller as it burned. After it burned, the candle looked smaller than it did before it burned.
2. It changed to a gas and it was released into the room.

Inquiry Yes, the amount of matter lost is a variable. Possible factors that might contribute to a different outcome are the chemical composition of the candle, the chemical composition of the wick, and the diameter of the candle.

LAUNCH Lab

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

Safety Precautions Approve lab safety forms before work begins. Warn students to use care around an open flame.

Disposal Have students place used matches in a flameproof container or in a container of water.

Teaching Strategies

• Ask students what evidence they observe that indicates a change in matter is occurring. Answers might include a change in appearance or odor produced, or gas and energy produced.
• 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 candle loses mass after it is burned.

Analysis

1. Sample Summary: A small amount of smoke came from the candle and the candle got smaller as it burned. After it burned, the candle looked smaller than it did before it burned.
2. It changed to a gas and it was released into the room.

Inquiry Yes, the amount of matter lost is a variable. Possible factors that might contribute to a different outcome are the chemical composition of the candle, the chemical composition of the wick, and the diameter of the candle.
Section 1.1

1 Focus

Focus Transparency

Before presenting the lesson, project Section Focus Transparency 1 and have students answer the accompanying questions.

Chemistry Around You

Ask students to recall the last time someone baked something, such as cake, bread, or cookies, at their houses. Ask students if chemistry was involved. Yes, several chemical reactions usually occur when something is baked, such as the chemical reaction when baking powder is mixed with water and a gas is produced, or the chemical reaction when baking soda is mixed with buttermilk and a gas is produced. Ask students if chemistry is involved when an MP3 player is turned on. Yes, a chemical reaction occurs in the battery. Hold up a calculator, and ask students what type of chemistry takes place during the manufacturing of the calculator. Possible answers: Chemistry is used during the manufacturing process for the case and for the chips that perform the calculations.

2 Teach

Concept Development

Chemicals

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

Objectives

- Define substance.
- Explain the formation and importance of ozone.
- Describe the development of chlorofluorocarbons.

Review Vocabulary

matter: anything that has mass and takes up space

New Vocabulary

chemistry

substance

A Story of Two Substances

MAIN Idea

Chemistry is the study of everything around us.

Real-World Reading Link

Have you ever moved a piece of furniture to a new location, only to discover that the new location won’t work? Sometimes, moving furniture creates a new problem, such as a door will not open all the way or an electric cord will not reach an outlet. Solving a problem only to find that the solution creates a new problem also occurs in science.

Why study chemistry?

Take a moment to observe your surroundings and Figure 1.1. Where did all the “stuff” come from? All the stuff in the universe, including everything in the photos, is made from building blocks formed in stars. Scientists call these building blocks matter.

As you begin your study of chemistry—the study of matter and the changes that it undergoes—you are probably asking yourself, “Why is chemistry important to me?” The answer to this question can be illustrated by real-life events that involve two discoveries. One discovery involves something that you probably use every day—refrigeration. If you go to school in an air-conditioned building or if you protect your food from spoilage by using a refrigerator, this discovery is important to you. The other discovery involves energy from the Sun. Because you eat food and spend time outdoors, this discovery is also important to you. These two seemingly unrelated discoveries became intertwined in an unexpected way—as you will soon learn.

Figure 1.1

Everything in the universe, including particles in space and things around you, is composed of matter.

Chemistry Journal

Chemistry

Ask students to write a few paragraphs in their chemistry journal describing what they would like to learn in chemistry class and what they expect to learn. Refer to these paragraphs later in the year to see if their expectations were met.
The Ozone Layer

If you have ever had a sunburn, you have experienced the damaging effects of ultraviolet radiation from the Sun. Overexposure to ultraviolet radiation is harmful to both plants and animals. Increased levels of a type of ultraviolet radiation called UVB can cause cataracts and skin cancer in humans, lower crop yields in agriculture, and disrupted food chains in nature.

Living organisms have evolved in the presence of UVB, and cells have some ability to repair themselves when exposed to low levels of UVB. However, some scientists believe that when UVB levels reach a certain point, the cells of living organisms will no longer be able to cope, and many organisms will die.

Earth’s atmosphere Living organisms on Earth exist because they are protected from high levels of UVB by ozone. Ozone, which is made up of oxygen, is a substance in the atmosphere that absorbs most harmful radiation before it reaches Earth’s surface. A substance, which is also known as a chemical, is matter that has a definite and uniform composition.

About 90% of Earth’s ozone is spread out in a layer that surrounds and protects our planet. As you can see in Figure 1.2, Earth’s atmosphere consists of several layers. The lowest layer is called the troposphere and contains the air we breathe. The troposphere is where clouds 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 10 to 50 kilometers (km) above Earth’s surface. The ozone layer that protects Earth is located in the stratosphere.

Figure 1.2 Earth’s atmosphere consists of several layers. The protective ozone layer is located in the stratosphere.

Real-World Chemistry
The Ozone Layer

Sunscreen To offer some protection from harmful UV radiation, sunscreen can be applied to the skin. Sunscreen helps prevent sunburn and skin cancer. Health professionals recommend the use of sunscreen anytime that you are outdoors and exposed to the Sun’s ultraviolet radiation.

Vocabulary

Word origin
Ozone comes from the Greek word ozon, which means to smell.

Assessment

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

Reading Check Explain the benefits of ozone in the atmosphere.

Chemistry Project

UV-B and Living Organisms Divide students into small groups, and have them research the effects of increased UV-B radiation on living organisms. Students should prepare an oral presentation with visual aids to present to the rest of the class. OL COOP LEARN
Reinforcement

Ozone Formation  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.

Ozone formation  How does ozone enter the stratosphere? When oxygen gas ($O_2$) is exposed to ultraviolet radiation in the upper regions of the stratosphere, ozone ($O_3$) is formed. Molecules of oxygen gas are made of two smaller oxygen particles. The energy of the radiation breaks the oxygen gas into individual oxygen particles (O), which then interact with $O_2$ to form $O_3$. Figure 1.3 illustrates this process. Ozone can also 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, British scientist G.M.B. Dobson (1889–1976) 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. Ozone can be measured in the lower stratosphere by instruments on the ground or in balloons, satellites, and rockets. Dobson’s measurements helped scientists determine the normal amount of ozone that should be in the stratosphere. Three hundred Dobson units (DU) is considered the normal amount of ozone in the stratosphere. Instruments, like those shown in Figure 1.4, monitor the amount of ozone present in the stratosphere today.

Cultural Diversity

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, human skin tones have evolved to be darker. UV rays are less intense in areas farther from the equator, so human 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.
Between 1981 and 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. Figure 1.5 shows how the thinning ozone layer looked in October 1990.

Although the thinning of the ozone layer is often called the ozone hole, it is not a hole. The ozone is still present in the atmosphere. However, 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. What could be causing the ozone hole?

### Chlorofluorocarbons

The story of the second substance in this chapter begins in the 1920s. Large-scale production of refrigerators, which at first used toxic gases such as ammonia as coolants, was just beginning. 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 chlorofluorocarbons in 1928. A chlorofluorocarbon (CFC) is a substance that consists of chlorine, fluorine, and carbon. Several different substances 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 substances. 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 were also used in plastic foams and as propellants in spray cans.

**Reading Check** Explain why scientists thought CFCs were safe for the environment.

### Concept Development

**Coolants** Have a local mechanic or air conditioning specialist speak to the class about the safeguards that currently exist to keep harmful coolants from affecting the atmosphere. Ask him or her to clarify that refrigerants shown to be harmful to the environment can be either eliminated or replaced with a coolant that is less harmful.

### Visual Learning

**Figure 1.5** Have students look at Figure 1.5 and describe in detail what the image shows. Discuss the image as a class to make sure that all students understand the image.

### Reading Check

CFCs do not readily react with other substances; therefore, scientists thought the molecules were stable.

### Assessment

**Knowledge** Ask students where chemistry is used in their everyday lives. Answers might include the fuel used to power their cars or heat their homes, the clothing they wear, and the food they eat. OL EL

### Chemistry Journal

**Thomas Midgely** Have students research Thomas Midgley, Jr. Then, have them write a short biographical summary of his life. OL

### Differentiated Instruction

**Visually Impaired** Have sighted students work with visually-impaired students to create a three-dimensional, tactile model of the layers of the atmosphere. Have the sighted student explain the location of the troposphere and stratosphere and the process of ozone formation and storage. OL EL COOP LEARN

### Careers in Chemistry

**Environmental Chemist** An environmental chemist uses tools from chemistry and other sciences to study how chemicals interact with the physical and biological environment. This includes identifying the sources of pollutants such as ozone and their effects on living organisms. For more information on chemistry careers, visit glencoe.com.
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 by these findings. OL EL

Reteach

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. EL EL

Extension

Discuss with students how the processes used to manufacture products change over time. Include in the discussion the role chemistry has in these changes. Mention the development of refrigerants as discussed in the text. Bring to class a cardboard milk container and a plastic milk jug. Ask students to describe the advantages and disadvantages of each type of container. The cardboard will decompose over time; the plastic will not. Both can be recycled. Milk will stay fresher in the plastic. AL

Scientists first began to detect 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. By 1990, the concentration of CFCs had reached an all-time high, as shown in Figure 1.6. However, it was widely thought that CFCs did not pose a threat to the environment because they are so stable, and consequently many scientists were not alarmed.

Scientists had noticed and measured two separate phenomena: the protective ozone layer in the atmosphere was thinning, and increasingly large quantities of 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—solve scientific problems.
Section 1.2

Chemistry and Matter

**MAIN Idea** Branches of chemistry involve the study of different kinds of matter.

**Real-World Reading Link** If you consider that everything around you is matter, you will realize that chemists study a huge variety of things.

**Matter and its Characteristics**

Matter, the stuff of the universe, has many different forms. Everything around you, like the things in Figure 1.7, is matter. Some matter occurs naturally, such as ozone, and other substances are not natural, such as CFCs, which you read about in Section 1.1.

You might realize that everyday objects are composed of matter, but how do you define matter? Recall that matter is anything that has mass and takes up space. Also recall that **mass** is a measurement that reflects the amount of matter. You know that your textbook has mass and takes up space, but is air matter? You cannot see it and you cannot 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 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** Have you ever used a bathroom scale to measure your 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 might not notice a difference in your weight from one place to another, but subtle differences do exist.

**Differentiated Instruction**

**Visually Impaired** Have visually impaired students choose several objects, such as their textbooks, and describe them. Characteristics might include that they have weight and shape. Help students understand these properties as mass and volume. Blow up a balloon. Have students touch it to “feel” the mass and volume of air contained in the balloon.

**Chemistry Project**

**Space Travel** Have students research how astronauts perform common tasks, such as working with tools and eating, in the weightlessness of space. Have students prepare a short report detailing their findings.

**Section 1.2 • Chemistry and Matter**

**1 Focus**

Before presenting the lesson, project **Section Focus Transparency** 2 and have students answer the accompanying questions.

**MAIN Idea**

**Branches of Chemistry** Write the term biochemistry on the board. Ask students what they think a biochemist would study. The chemistry of life Write the term environmental chemistry on the board. Have students infer what an environmental chemist studies.

Point out to students that the study of chemistry is broad and includes many areas. Many chemists specialize and focus their studies on a narrow part of chemistry.

**2 Teach**

**In-Text Question** Answers might include feelings, emotions, microwaves, and sound.

**Caption Question** Fig. 1.7 Mass is a measure of the amount of matter. It is independent of gravity. Weight is the effect of gravity on matter.

**Quick Demo**

**Chemistry and Matter** Light a candle used in the Launch Lab. 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.
Concept Development

Matter Bring to class cubes of different shapes, sizes, and materials. You could use wood, plastic, paper, and foam blocks. Ask students to compare and contrast the blocks. Ask students if the blocks are matter, and have them justify their answers. All are matter because they have mass and take up space. They differ in that each type of block contains a different type and amount of matter. OL

GLENCOE Technology

Virtual Labs CD-ROM Chemistry: Matter and Change Demonstration: Magic of Chemistry

Caption Question Fig. 1.8 The concept of atoms is difficult to understand because the unaided human eye cannot see them. Models help chemists “see” atoms and study them.

Reading Check Possible answers: car model and train model.

Foldables

Vocabulary

SCIENCE USAGE V. COMMON USAGE

Weight

Science usage: the measure of the amount of matter in and the gravitational force exerted on an object

The weight of an object is the product of its mass and the local acceleration of gravity.

Common usage: the relative heaviness of an object

The puppy grew so quickly it doubled its weight in a matter of weeks.

Figure 1.8 Scientists use models to visualize complex ideas, such as the materials and structure used to build office buildings. They also use models to test a concept, such as a new airplane design, before it is mass produced. Infer why chemists use models to study atoms.

Foldables Incorporate information from this section into your Foldable.

Chemistry Journal

Weightlessness 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 would have mass and take up space. Use this scenario to differentiate mass and weight. OL
Chemistry: The Central Science

Recall from Section 1.1 that 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. 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 branches that focus on specific areas, such as those listed in Table 1.1. Although chemistry is divided into specific areas of study, many of the areas overlap. For example, as you can see from Table 1.1, an organic chemist might study plastics, but an industrial chemist or a polymer chemist could also focus on plastics.

<table>
<thead>
<tr>
<th>Table 1.1</th>
<th>Some Branches of Chemistry</th>
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<tbody>
<tr>
<td>Branch</td>
<td>Area of Emphasis</td>
</tr>
<tr>
<td>Organic chemistry</td>
<td>most carbon-containing chemicals</td>
</tr>
<tr>
<td>Inorganic chemistry</td>
<td>in general, matter that does not contain carbon</td>
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<tr>
<td>Physical chemistry</td>
<td>the behavior and changes of matter and the related energy changes</td>
</tr>
<tr>
<td>Analytical chemistry</td>
<td>components and composition of substances</td>
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<tr>
<td>Biochemistry</td>
<td>matter and processes of living organisms</td>
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<tr>
<td>Environmental chemistry</td>
<td>matter and the environment</td>
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<td>Industrial chemistry</td>
<td>chemical processes in industry</td>
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<td>Polymer chemistry</td>
<td>polymers and plastics</td>
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<td>Theoretical chemistry</td>
<td>chemical interactions</td>
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<tr>
<td>Thermochemistry</td>
<td>heat involved in chemical processes</td>
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Chemistry and Matter

8. The study of chemistry is a broad field, so chemists specialize in small areas.
9. Mass is constant and is not affected by gravity. Weight varies with gravity.
10. The changes you see with your eyes begin with changes at the submicroscopic level.
11. Models enable chemists to understand difficult concepts that they cannot normally see.
12. Possible answers: Aircraft models allow scientists to test their designs before money is spent on the aircraft. Computer models of chemical processes allow chemists to test processes before manufacturing facilities are built. Car models allow scientists to test certain features, such as wind resistance, before a car is built.
13. Your mass would be the same, but your weight would be 1/6 your weight on Earth.
14. You would weigh less as you ascend because the acceleration due to gravity would be offset by the upward acceleration due to the elevator. You would not be in a free-fall situation in a descending elevator, so your weight would be the same in the descending elevator as it is on the ground. The difference in altitude would be negligible.
**Section 1.3**

**1 Focus**

**Focus Transparency**
Before presenting the lesson, project Section Focus Transparency 3 and have students answer the accompanying questions.

**MAIN Idea**

**Scientific Methods** Ask students to give examples of questions that scientists might want to answer. Possible question: How fuel efficient is a car prototype? Write a few of the questions on the board. Have students propose ways in which scientists might find the answer(s) to each question. Possible answer: build a model and test it.

**2 Teach**

**Assessment Skill** Ask students to draw the steps of a scientific method as a flow chart. Under each heading, have them write a one-sentence description of that step.

**Caption Question Fig. 1.10** Qualitative: one substance is blue and the other substance is green; quantitative: the flask contains 500 mL and the graduated cylinder contains 100 mL.

**Reading Check** Hypotheses are not proven facts. They are educated guesses, and they are subject to change when new data or evidence is available.

**Demonstration**

**The Magic of Chemistry**

**Purpose**

to demonstrate 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. Pour liquids down a drain.

**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 of NaHSO₃ to 1 mL of water. In a second test tube, add 1 g BaCl₂·2H₂O to 1 mL of water. WARNING: 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 KMnO₄ solution. Pour the KMnO₄ solution into beaker 1. Pour the resulting solution into beaker 2.

**Results**

The red solution turns into a clear solution, and the clear solution is then changed into a milky-colored solution. The chemistry of this
Hypothesis

Recall the stories of the two substances that you read about in Section 1.1. Even before quantitative data showed that ozone levels were decreasing in the stratosphere, scientists observed CFCs 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 upward 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 chlorine 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.

**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. Often, the types of observations scientists make first 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.

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 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**
Recall the stories of the two substances that you read about in Section 1.1. Even before quantitative data showed that ozone levels were decreasing in the stratosphere, scientists observed CFCs 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 upward 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 chlorine 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.

**Procedure**

1. Read and complete the lab safety form.
2. Add water to a petri dish to a height of 0.5 cm. Use a graduated cylinder to measure 1 mL of vegetable oil, then add it to the petri dish.
3. Dip the end of a toothpick into liquid dishwasher detergent.
4. Touch the tip of the toothpick to the water at the center of the petri dish. Record your detailed observations.

5. Add whole milk to a second petri dish to a height of 0.5 cm.
6. Place one drop each of four different food colorings in four different locations on the surface of the milk. Do not put a drop of food coloring in the center.
7. Repeat Steps 3 and 4.

**Analysis**

1. Describe what you observed in Step 4.
2. Describe what you observed in Step 7.
3. Infer Oil, the fat in milk, and grease belong to a class of substances called lipids. What can you infer about the addition of detergent to dishwasher?
4. Explain why observations skills were important in this chemistry lab.

**Expected Result**

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. Convection-like 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.
4. If observations are not made carefully, there might not be enough information to explain or infer what is occurring.

**Reading Check**

Infer why a hypothesis is tentative.

**Assessment**

**Knowledge** Ask students how this lab illustrates why it is important not to taste anything in the lab even if it looks like a familiar food or drink. Products in the lab might look like a familiar food, but it could be a toxic substance. It is important to never taste anything in the lab.

**Performance** Have different lab groups test milk samples that have different fat content and have students compare their observations.

**Mini Lab**

**Develop Observation Skills**

Why are observation skills important in chemistry? Observations are often used to make inferences. An inference is an explanation or interpretation of observations.

**Procedure**

1. Read and complete the lab safety form.
2. Add water to a petri dish to a height of 0.5 cm. Use a graduated cylinder to measure 1 mL of vegetable oil, then add it to the petri dish.
3. Dip the end of a toothpick into liquid dishwasher detergent.
4. Touch the tip of the toothpick to the water at the center of the petri dish. Record your detailed observations.

5. Add whole milk to a second petri dish to a height of 0.5 cm.
6. Place one drop each of four different food colorings in four different locations on the surface of the milk. Do not put a drop of food coloring in the center.
7. Repeat Steps 3 and 4.

**Analysis**

1. Describe what you observed in Step 4.
2. Describe what you observed in Step 7.
3. Infer Oil, the fat in milk, and grease belong to a class of substances called lipids. What can you infer about the addition of detergent to dishwater?
4. Explain why observations skills were important in this chemistry lab.

**Expected Result**

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. Convection-like currents are established, causing the colors to move from the outside toward the center.

**Analysis**

1. The oil moved away from the detergent.
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3. It helps remove grease and oil from items being washed.
4. If observations are not made carefully, there might not be enough information to explain or infer what is occurring.

**Assessment**

**Knowledge** Ask students how this lab illustrates why it is important not to taste anything in the lab even if it looks like a familiar food or drink. Products in the lab might look like a familiar food, but it could be a toxic substance. It is important to never taste anything in the lab.

**Performance** Have different lab groups test milk samples that have different fat content and have students compare their observations.
Experiments A hypothesis is meaningless 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 use the materials shown in Figure 1.11 to design an experiment to test the hypothesis that table salt dissolves faster in hot water than in water at room temperature (20°C). 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 min at 40°C, but that the same quantity of salt dissolves after 3 min 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 in which the independent variable changes, it has no control over the way the dependent variable changes.

Reading Check Explain the difference between a dependent and an independent variable.

Other factors 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 to all of these questions might be yes. 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. Figure 1.12 shows a different type of control. A chemical indicator has been added to each of three test tubes. An acidic solution is in the test tube on the left, and the indicator turns red. The test tube in the middle contains water and the indicator is yellow. The test tube on the right contains a basic solution and the indicator turns blue.
Controlling variables 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 several gases present in the stratosphere. Thus, it would be difficult to determine which gases, or if all gases, are causing 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.

Conclusion An experiment might generate a large amount of data. Scientists take the data, analyze it, and check it against the hypothesis to form a conclusion. A conclusion is a judgment based on the information obtained. A hypothesis can never be proven. Therefore, when the data support a hypothesis, this only indicates that the hypothesis might 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 might still yield new and useful 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.

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 they had enough support for their hypothesis to publish their discovery. They won the Nobel Prize in 1995.

**Differentiated Instruction**

**Below Level** Pair below-level students with other students that understand the chemical reaction taking place in Figure 1.13. Have the below-level student explain the reaction to the other student, and have the other student correct any misconceptions that the below-level student might have.

**Chemistry Project**

**Biographies** Divide the class into small groups. Have each group choose one of the scientists discussed in this chapter and research his or her life. Have each group prepare a short presentation for the class.

**RUBRIC** available at glencoe.com

**Identify Misconceptions**

Students often do not 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 or just an idea or prediction.

**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*, and *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 hypotheses. OL EL COOP LEARN
3 Assess
Check for Understanding
Ask students to explain the difference between qualitative data and quantitative data. Qualitative data is observed with the senses, such as color and odor. Quantitative data is numerical information, such as 3 m or 5 mL. OL EL

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 does not explain how it happens. OL EL

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

Assessment
Cut out large pieces of paper and write a vocabulary term from this section on each piece. Have students place these papers in the order they are used in a scientific method. Some words might be subsets of specific steps. Accept any order that students can justify. OL EL

Section 1.3 Assessment

Section Summary
- Scientific methods are systematic approaches to problem solving.
- Qualitative data describe an observation; quantitative data use numbers.
- Independent variables are changed in an experiment. Dependent variables change in response to the independent variable.
- A theory is a hypothesis that is supported by many experiments.

15. MAIN Explain why scientists do not use a standard set of steps for every investigation they conduct.
16. Differentiate Give an example of quantitative and qualitative data.
17. Evaluate 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? The dependent variable? What factor is held constant? How would you construct a control?
18. Distinguish 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.
19. Explain Good scientific models can be tested and used to make predictions. What did Molina and Rowland’s model of the interactions of CFCs and ozone in the atmosphere predict would happen to the amount of ozone in the stratosphere as the level of CFCs increased?

Theory and Scientific Law
A theory is an explanation of a natural phenomenon based on many observations and investigations over time. You might 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 subject to new experimental 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.

Sometimes, many scientists come to the same conclusion about certain relationships in nature and they find no exceptions to these relationships. For example, you know that no matter how many times skydivers, like those shown in Figure 1.14, leap from a plane, they always return to 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—a relationship in nature that is supported by many experiments. It is up to scientists to develop further hypotheses and experiments to explain why these relationships exist.

Figure 1.14 It does not matter how many times skydivers leap from a plane; Newton’s law of universal gravitation applies every time.

15. MAIN Explain why scientists do not use a standard set of steps for every investigation they conduct.
16. Differentiate Give an example of quantitative and qualitative data.
17. Evaluate 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? The dependent variable? What factor is held constant? How would you construct a control?
18. Distinguish 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.
19. Explain Good scientific models can be tested and used to make predictions. What did Molina and Rowland’s model of the interactions of CFCs and ozone in the atmosphere predict would happen to the amount of ozone in the stratosphere as the level of CFCs increased?
Section 1.4

**Objectives**
- Compare and contrast pure research, applied research, and technology.
- Apply knowledge of laboratory safety.

**Review Vocabulary**
- synthetic: something that is human-made and does not necessarily occur in nature

**New Vocabulary**
- pure research
- applied research

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**Scientific Research**

**MAIN Idea** Some scientific investigations result in the development of technology that can improve our lives and the world around us.

**Real-World Reading Link** Much of the information that scientists obtain through basic research is used to solve a specific problem or need. For example, X rays were discovered by scientists who were conducting basic research on electrical discharge through gases. Later, it was discovered that X rays could be used to diagnose medical problems.

**Types of Scientific Investigations**

Every day in the media—through TV, newspapers, magazines, or the Internet—the public is 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?

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

By the time 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 early 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, as shown in **Figure 1.15**. Applied research is also being conducted to find replacement chemicals for the CFCs that are now banned.

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**Chemistry Journal**

**Research or Discovery** Have students clip a newspaper article describing a scientific study. Ask them to discuss whether this example is pure research, applied research, or a chance discovery.

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**2 Teach**

**Quick Demo**

**Pure Research** Bring in samples of nylon cloth and nylon cord. Nylon is a good example of a synthetic compound that has many uses. Explain that many such applications are chance discoveries that are byproducts of pure research.

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**In-Text Question** Possible answer: Qualitative data might be used to determine which color of an organism is the best defense against a predator. Quantitative data might be used to determine the solution concentration that produces the highest yield of product in a chemical process.
The ChemLab located at the end of the chapter can be used at this point in the lesson.

Apply Chemistry
CFCs  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.

Content Background
Hook-and-Loop Fasteners  The design of hook-and-loop fastener tape is based on nature. After a walk in the countryside, Swiss inventor, George de Mestral, was interested in finding out why cockleburs cling to his clothing so tenaciously. With the aid of a microscope, Mestral discovered that the cocklebur was covered in tiny hooks and his clothing had tiny loops on the surface. He began searching for a material that could be used to duplicate nature’s design. By accident, Mestral discovered that nylon, sewn under ultraviolet light, formed tiny hooks. The first hook-and-loop fastener tape was mass produced in France in the 1950s.

Chance discoveries  Often, a scientist conducts experiments and reaches a conclusion that is far different from what was predicted. Some truly wonderful discoveries in science have been made unexpectedly. You might be familiar with the two examples described below.

Connection to Biology  Alexander Fleming is famous for making several accidental discoveries. In one accidental discovery, Fleming found that one of his plates of *Staphylococcus* bacteria had been contaminated by a greenish mold, later identified as *Penicillium*. He observed it carefully and saw a clear area around the mold where the bacteria had died. In this case, a chemical in the mold—penicillin—was responsible for killing the bacteria.

The discovery of nylon is another example of an accidental discovery. In 1930, Julian Hill, an employee of E.I. DuPont de Nemours and Company, dipped a hot glass rod in a mixture of solutions and unexpectedly pulled out long fibers similar to those shown in Figure 1.16. Hill and his colleagues pursued the development of these fibers as a synthetic silk that could withstand high temperatures. They eventually developed nylon in 1934. During World War II, nylon was used as a replacement for silk in parachutes. Today, nylon is used extensively in textiles and some kinds of plastics. It is also used to make hook-and-loop tape, as shown in Figure 1.16.

Students in the Laboratory
In your study of chemistry, you will learn many facts about matter. You will also do investigations and 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 people working nearby. Often, many people are working in a small space during a lab, so it is important that everyone practice safe laboratory procedures. Table 1.2 lists some safety rules that you should follow each time you enter the lab. Chemists and all other scientists use these safety rules as well.
Table 1.2  
Safety in the Laboratory

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Study your lab assignment before you come to the lab. If you have any questions, ask your teacher for help.</td>
</tr>
<tr>
<td>2.</td>
<td>Do not perform experiments without your teacher’s permission. Never work alone in the laboratory. Know how to contact help, if necessary.</td>
</tr>
<tr>
<td>3.</td>
<td>Use the table on the inside front cover of this textbook to understand the safety symbols. Read and adhere to all <strong>WARNING</strong> statements.</td>
</tr>
<tr>
<td>4.</td>
<td>Wear safety goggles and a laboratory apron whenever you are in the lab. Wear gloves whenever you use chemicals that cause irritations or can be absorbed through the skin. If you have long hair, you must tie it back.</td>
</tr>
<tr>
<td>5.</td>
<td>Do not wear contact lenses in the lab, even under goggles. Lenses can absorb vapors and are difficult to remove during an emergency.</td>
</tr>
<tr>
<td>6.</td>
<td>Avoid wearing loose, draping clothing and dangling jewelry. Wear only closed-toe shoes in the lab.</td>
</tr>
<tr>
<td>7.</td>
<td>Keep food, beverages, and chewing gum out of the lab. Never eat in the lab.</td>
</tr>
<tr>
<td>8.</td>
<td>Know where to find and how to use the fire extinguisher, safety shower, fire blanket, first-aid kit, and gas and electrical power shutoffs.</td>
</tr>
<tr>
<td>9.</td>
<td>Immediately clean up spills on the floor and keep all walkways clear of objects, such as backpacks, to prevent accidental falls or tripping. Report any accident, injury, incorrect procedure, or damaged equipment to your teacher.</td>
</tr>
<tr>
<td>10.</td>
<td>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>
<tr>
<td>11.</td>
<td>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, and when you put the bottle back.</td>
</tr>
<tr>
<td>12.</td>
<td>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.</td>
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<tr>
<td>13.</td>
<td>Do not return unused chemicals to the stock bottle.</td>
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<tr>
<td>14.</td>
<td>Do not insert droppers into reagent bottles. Pour a small amount of the chemical into a beaker.</td>
</tr>
<tr>
<td>15.</td>
<td>Never taste any chemicals. Never draw any chemicals into a pipette with your mouth.</td>
</tr>
<tr>
<td>16.</td>
<td>Keep combustible materials away from open flames.</td>
</tr>
<tr>
<td>17.</td>
<td>Handle toxic and combustible gases only under the direction of your teacher. Use the fume hood when such materials are present.</td>
</tr>
<tr>
<td>18.</td>
<td>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 into the mouth of a test tube.</td>
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<tr>
<td>19.</td>
<td>Do not heat graduated cylinders, burettes, or pipettes with a laboratory burner.</td>
</tr>
<tr>
<td>20.</td>
<td>Use caution and proper equipment when handling a hot apparatus or glassware. Hot glass looks the same as cool glass.</td>
</tr>
<tr>
<td>21.</td>
<td>Dispose of broken glass, unused chemicals, and products of reactions only as directed by your teacher.</td>
</tr>
<tr>
<td>22.</td>
<td>Know the correct procedure for preparing acid solutions. Always add the acid to the water slowly.</td>
</tr>
<tr>
<td>23.</td>
<td>Keep the balance area clean. Never place chemicals directly on the pan of a balance.</td>
</tr>
<tr>
<td>24.</td>
<td>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.</td>
</tr>
</tbody>
</table>

**Chemistry Project**

**Lab Safety** 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. **OL EL**
**Enrichment**

**Time Line**  Divide the class into small groups. Assign each group the task of researching significant events or milestones that occurred during their assigned time period in the areas of ozone depletion, CFC accumulation in the atmosphere, and new CFCs or replacement chemicals on the market that are more environmentally friendly. Consider dividing the class into the following time periods: 1970–1975; 1976–1981; 1982–1987; 1988–2003; 2003–present. Have students write the date and a short description of the event or milestone on a sheet of paper. Use the papers to create a time line of events and display the time line on a classroom wall. **OL COOP LEARN**

**Graph Check**  about 1989

**Reading Check**  When temperatures drop below $-78^\circ\mathrm{C}$, stratospheric ice clouds promote the production of chemically active chlorine and bromine. When temperatures begin to warm in the spring, the chemically active chlorine and bromine react with the ozone. These chemical reactions consume much of the ozone creating a hole over Antarctica.

**The Story Continues**

Now, back to the two substances that you have been reading about. A lot has happened since the 1970s, when Molina and Rowland hypothesized that CFCs broke down stratospheric ozone. The National Oceanic and Atmospheric Administration (NOAA) and many other groups are actively collecting historic and current data on CFCs in the atmosphere and ozone concentrations in the stratosphere. Through applied research, scientists determined that not only do CFCs react with ozone, but a few other substances react as well. Carbon tetrachloride and methyl chloroform are two additional substances that harm the ozone, as well as substances that contain bromine.

**The Montreal Protocol**  Because ozone depletion is an international concern, nations have banded together to try to solve this problem. In 1987, leaders from many nations met in Montreal, Canada, and signed the Montreal Protocol. By signing this agreement, nations agreed to phase out the use of these compounds and place restrictions on how they should be used in the future. As you can see from Figure 1.17, the global use of CFCs began to decline after the Montreal Protocol was signed. However, the graph shows that the amount of CFCs measured over Antarctica did not decline immediately.

**Graph Check**  Identify when CFCs in Antarctica began to level off after national leaders signed the Montreal Protocol.

**The ozone hole today**  Scientists have also learned that the ozone hole forms each year over Antarctica during the spring. Stratospheric ice clouds form over Antarctica when temperatures there drop below $-78^\circ\mathrm{C}$. These clouds produce changes that promote the production of chemically active chlorine and bromine. When temperatures begin to warm in the spring, this chemically active chlorine and bromine react with ozone, causing ozone depletion. This ozone depletion causes the ozone hole to form over Antarctica. Some ozone depletion also occurs over the Arctic, but temperatures do not remain low for as long, which means less ozone depletion in the Arctic.

**Reading Check**  Explain what triggers the formation of the ozone hole over Antarctica.

**Chemistry Project**

**Ozone Layer**  Divide students into small groups and have them research the current status of the ozone layer. Have students prepare an oral presentation that includes visual aids and present it to the class. **OL COOP LEARN**
**Figure 1.18** The ozone hole over Antarctica reached its maximum level of thinning in September 2005. The color-key below shows what the colors represent in this colorized satellite image.

**Compare** How do these ozone levels compare with what is considered normal?

Scientists are not sure when the ozone layer will begin to recover. Originally, scientists predicted that it would begin to recover in 2050. However, new computer models predict that it will not begin to recover until 2068. The exact date of its recovery is not as important as the fact that it will recover given time.

**Vocabulary**

**Academic Vocabulary**

Recover

to bring back to normal

It takes several days to recover from the flu.

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**DATA ANALYSIS LAB**

**Interpret Graphs**

**How do ozone levels vary throughout the year in Antarctica?** The National Oceanic and Atmospheric Administration (NOAA) continues to monitor the concentration of ozone in the stratosphere over Antarctica.

**Think Critically**

1. **Describe** the trend in the data for total ozone and temperature at the 20–24 km layer.
2. **Evaluate** how the 2004 data compare with the 2005 data.
3. **Identify** the month during which the ozone levels were the lowest.
4. **Assess** Do these data points back up what you learned in this chapter about ozone depletion? Explain your answer.

**Data and Observations**

This graph displays data that the NOAA collected in 2004 and 2005 over Antarctica. The darker lines represent 2005 data.

**Caption Question Fig. 1.18**

The normal is 300 DU, so 110 to 200 DU is below normal.
**3 Assess**

**Check for Understanding**

Ask students if research on new refrigerants that are not harmful to the environment is pure research or applied research. **It is applied research because it is conducted to solve a problem.**

**Reteach**

Emphasize that pure research is often a foundation for applied research. Pure research can create compounds or increase knowledge that scientists might 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 might include a new drug or treatment for a disease that affects someone they know or a new technology that affects the environment.

** Assessment**

**Knowledge**

Have students summarize the articles used in the Extension feature.

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**The Benefits of Chemistry**

Chemists are an important part of the team of scientists that solve many of the problems or issues that we face today. Chemists are not only involved in resolving the ozone depletion problem. They are also involved in finding cures or vaccines for diseases, such as AIDS and influenza. Almost every situation that you can imagine involves a chemist, because everything in the universe is made of matter.

**Figure 1.19** shows some of the advances in technology that are possible because of the study of matter. The car on the left is powered by compressed air. When the compressed air is allowed to expand, it pushes the pistons that move the car. Because the car is powered by compressed air, no pollutants are released. The photo on the right shows a tiny submarine that is made by computer-aided lasers. This submarine, which is only 4 mm long, might be used for detecting and repairing defects in the human body.

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**Section 1.4 Assessment**

**Section Summary**

- Scientific methods can be used in pure research or in applied research.
- Some scientific discoveries are accidental, and some are the result of diligent research in response to a need.
- Laboratory safety is the responsibility of everyone in the laboratory.
- Many of the conveniences we enjoy today are technological applications of chemistry.

**Assessment**

20. **Main Idea** Name three technological products that have improved our lives or the world around us.
21. Compare and contrast pure research and applied research.
22. Classify Is technology a product of pure research or applied research? Explain.
23. Summarize the reason behind each of the following.
   a. Wear goggles and an apron in the lab even if you are only an observer.
   b. Do not return unused chemicals to the stock bottle.
   c. Do not wear contact lenses in the laboratory.
   d. Avoid wearing loose, draping clothing and dangling jewelry.
24. Interpret Scientific Diagrams What safety precautions should you take when the following safety symbols are listed?

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20. Possible answers: computer, internal combustion engine, and vaccinations.
21. Pure research is done for the sake of knowledge. Applied research is done to solve a specific problem.
22. Technology can be the product of either one. It can be a product of pure research when scientists realize their discovery has a practical application. It can also be a product of applied research when scientists perform research to solve a particular problem.
23. a. Harmful substances can get in your eyes and on your clothing if you are performing an experiment or just watching it being performed.
   b. The chemicals might be contaminated, and you do not want to contaminate the stock bottle.
   c. Contact lenses can absorb gases that can damage your eyes, and they are difficult to remove during an emergency situation.
   d. It is easy to drag these items through chemicals and across flames, which might create a hazardous situation.
24. Protect your hands from hot or cold objects; protect yourself from possible hazardous fumes; protect yourself from substances that can irritate your skin, mucous membranes, or respiratory tract; substances are flammable, do not have an open flame in the lab.
Purpose
Students will learn about the reactive properties of atomic oxygen and how it can be used to repair damaged works of art.

Background
Because atomic oxygen is more reactive than molecular oxygen, it can be used to remove soot and other impurities from paintings. The oxygen can be applied using a hand-held device, or the entire painting can be placed in a chamber flooded with atomic oxygen.

Atomic oxygen does not replace other art restoration techniques. While many paint pigments will not react with atomic oxygen, some, such as lead, become discolored when treated with oxygen.

Teaching Strategies
• Develop a list of materials that can cause stains and another list of materials used to clean stains. Have students investigate the chemistry of stains and cleaners.
• Discuss some of the difficulties involved in restoring works of art.
• How long might paintings be expected to last? Discuss some of the causes of damage to art works and ways this damage might be minimized.

In the Field

Career: Art Restorer
Painting Restoration

Art does not last forever. It is damaged by events such as people sneezing on it, touching it, or by smoke during a fire. The repair of damage to artwork is the job of art restorers. Art repair is not always an easy task, because the materials used to correct the damage can also damage the artwork.

Help from above Oxygen makes up 21% of Earth’s atmosphere. Near the ground, almost all the oxygen exists as oxygen gas (O₂). However, high in the atmosphere, ultraviolet light from the Sun splits oxygen gas into atomic oxygen (O). While oxygen gas is chemically reactive, atomic oxygen is even more reactive. It can damage spacecraft in orbit, which is why NASA actively studies the reactions between atomic oxygen and other substances.

Oxygen and art Atomic oxygen is especially reactive with the element carbon—the main substance found in soot from a fire. When NASA scientists treated the soot-damaged painting shown in Figure 1 with atomic oxygen, the carbon in the soot reacted with oxygen to produce gases that floated away.

Figure 1 The photo on the left shows soot damage to an oil painting. The photo on the right shows the painting after oxygen treatment. Removal of a small amount of glossy binder was the only damage to the painting during the treatment.

The kiss Another successful restoration was the Andy Warhol painting called The Bathtub. It was damaged when a lipstick-wearing viewer kissed the canvas, as shown in Figure 2. Most conventional restoration techniques would have driven the lipstick deeper into the painting, leaving a permanent pink stain. When atomic oxygen was applied to the stain, the pink color vanished.

On the surface Because atomic oxygen acts only on what it touches, paint layers below the soot or other surface impurities are unaffected. If you compare the image on the left with the image on the right in Figure 1, you will notice that the soot was removed, but the painting was not harmed. This is in contrast to more conventional treatments, in which organic solvents are used to remove the soot. These solvents often react with the paint as well as the soot.

Figure 2 This lipstick stain could not be removed using conventional techniques. However, atomic oxygen removed the stain without damage to the painting.

Figure 2

Research The articles should contain information similar to what is in the feature about how atomic oxygen is used in art restoration. Student articles should also contain additional information that students find when doing their research.
**CHEMLAB**

See the ChemLab worksheet in your FAST FILE.

**RUBRIC** available at glencoe.com

### Forensics: Identify the Water Source

**Background:** The contents of tap water vary from community to community. Water is classified as hard or soft based on the amount of calcium or magnesium in the water, measured in milligrams per liter (mg/L). Imagine a forensics lab has two samples of water. One sample comes from Community A, which has soft water. The other sample comes from Community B, which has hard water.

**Question:** From which community did each water sample originate?

**Materials**
- test tubes with stoppers (3)
- test-tube rack
- grease pencil
- graduated cylinder (25-mL)
- distilled water
- dropper
- beaker (250-mL)
- Water sample 1
- Water sample 2
- dish detergent
- metric ruler

**Safety Precautions**

**Procedure**

1. Read and complete the lab safety form.
2. Prepare a data table like the one shown. Then, use a grease pencil to label three large test tubes: D (for distilled water), 1 (for Sample 1), and 2 (for Sample 2).
3. Use a graduated cylinder to measure out 20 mL of distilled water. Pour the water into Test Tube D.
4. Place Test Tubes 1 and 2 next to Test Tube D and make a mark on each test tube that corresponds to the height of the water in Test Tube D.
5. Obtain 50 mL of Water Sample 1 in a beaker from your teacher. Slowly pour the water sample into Test Tube 1 until you reach the marked height.
6. Obtain 50 mL of Water Sample 2 in a beaker from your teacher. Slowly pour Water Sample 2 into Test Tube 2 until you reach the marked height.
7. Add one drop of dish detergent to each test tube. Stopper the tubes tightly. Then, shake each sample for 30 s to produce suds. Use a metric ruler to measure the height of the suds.
8. Use some of the soapy solutions to remove the grease marks from the test tubes.

**Data Table**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Height of Suds</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**Classification of Water Hardness**

<table>
<thead>
<tr>
<th>Classification</th>
<th>mg of Calcium or Magnesium /L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td>0–60</td>
</tr>
<tr>
<td>Moderate</td>
<td>61–120</td>
</tr>
<tr>
<td>Hard</td>
<td>121–180</td>
</tr>
<tr>
<td>Very hard</td>
<td>&gt;180</td>
</tr>
</tbody>
</table>

**Analyze and Conclude**

1. Answers will depend on which sample is soft water and which is hard water. The soft water produces the most suds. The hard water produces the least suds.
2. According to the background introduction, the soft water came from Community A. The hard water came from Community B.
3. $7.3 \text{ mg Mg/0.05 L} = 147 \text{ mg Mg/L}$; hard
4. Independent variable, volume of water samples and amount of detergent; dependent variable, amount of suds produced; No, there was not a control in this experiment. Distilled water could have been used as a control because it does not have minerals dissolved in it. Comparison of results will vary
5. The volume of the liquids and the detergent could be measured with more precision.

**Inquiry Extension**

**Investigate**

There are a number of products that claim to soften water. Visit a grocery store or home improvement store to find these products and design an experiment to test their claims.

**LabManager™**

Customize this lab with the LabManager™ CD-ROM.
Chemistry is the study of everything around us. 

**Key Concepts**
- Chemistry is the study of matter.
- Chemicals are also known as substances.
- Ozone is a substance that forms a protective layer in Earth's atmosphere.
- CFCs are synthetic substances made of chlorine, fluorine, and carbon that are thinning the ozone layer.

**Section 1.2 Chemistry and Matter**

**Key Concepts**
- Models are tools that scientists, including chemists, use.
- Macroscopic observations of matter reflect the actions of atoms on a submicroscopic scale.
- There are several branches of chemistry, including organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry, and biochemistry.

**Section 1.3 Scientific Methods**

**Key Concepts**
- Scientific methods are systematic approaches to problem solving.
- Qualitative data describe an observation; quantitative data use numbers.
- Independent variables are changed in an experiment. Dependent variables change in response to the independent variable.
- A theory is a hypothesis that is supported by many experiments.

**Section 1.4 Scientific Research**

**Key Concepts**
- Scientific methods can be used in pure research or applied research.
- Some scientific discoveries are accidental, and some are the result of diligent research in response to a need.
- Laboratory safety is the responsibility of everyone in the laboratory.
- Many of the conveniences we enjoy today are technological applications of chemistry.

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**What's CHEMISTRY Got To Do With It?**
- **DVD** Isotope Tracers

**Vocabulary PuzzleMaker**
For additional practice with vocabulary, have students access the Vocabulary PuzzleMaker online at glencoe.com.
### Section 1.1

#### Mastering Concepts

25. Substance—any substance with a definite composition; chemistry—the study of matter and the changes it undergoes.

26. 90% in the stratosphere

27. carbon, fluorine, and chlorine

28. refrigerants, foams, propellants for spray products

29. increased usage of CFCs

30. because chemists study matter, and matter is found throughout the universe

#### Mastering Problems

31. 2 units; 3 units; 9 units

32. 27.2%

### Section 1.2

#### Mastering Concepts

33. An understanding of chemistry is central to all sciences and to our everyday lives.

34. Weight; weight is calculated using the acceleration due to gravity; mass is independent of gravity.

35. Analytical chemistry studies the composition of substances; environmental chemistry studies the environmental impact of chemicals.

#### Mastering Problems

36. Your weight would be less in Denver because the acceleration due to gravity is less in Denver than in New Orleans.

37. 1,000,000,000,000

38. \( x = 128 \text{ g} \)

### Section 1.3

#### Mastering Concepts

39. Qualitative data, such as color or shape, are determined with the five senses. Quantitative data, such as mass or length, are measurements.

40. A control is a standard used for comparison.

41. 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.

#### Mastering Concepts

42. temperature; amount of sugar dissolved; amount of water

43. a. quantitative
   b. qualitative
   c. qualitative

44. The hypothesis should be rewritten based on the new information and the new hypothesis should be tested.

#### Mastering Problems

45. 1 particle \( O_3 / 1 \) particle \( O_2 = x \) particles \( O_2 / 24 \) particles \( O_3 ; x = 24 \) particles \( O_3 \)

### Section 1.4

#### Mastering Concepts

46. a. before you come to the lab
   b. chewing gum out of the lab
   c. fire extinguisher, safety shower, fire blanket, and first-aid kit

#### Mastering Concepts

47. a. Study your lab assignment
   b. Keep food, beverages, and
   c. Know where to find and how to use the
Mastering Problems

47. If your lab procedure instructs you to add two parts acid to each one part of water and you start with 25 mL of water, how much acid will you add, and how will you add it?

Think Critically

48. Compare and Contrast 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, and a treatment for AIDS.

49. Interpret Scientific Diagrams Decide whether each of the diagrams shown below is displaying qualitative or quantitative data.

   a. Types of Apples Grown in Bioscience Greenhouse

   
   ![Apple Types Diagram]

   b. Data: Characteristics of Product Formed

<table>
<thead>
<tr>
<th>Color</th>
<th>white</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal Form</td>
<td>needles</td>
</tr>
<tr>
<td>Odor</td>
<td>none</td>
</tr>
</tbody>
</table>

50. Classify CFCs break down to form chemicals that react with ozone. Is this a macroscopic or a microscopic observation?

51. Infer A newscaster reports, “The air quality today is poor. Visibility is only 1.7 km. 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?

Cumulative Review

In Chapters 2 through 24, this heading will be followed by questions that review your understanding of previous chapters.

Additional Assessment

52. Ozone Depletion Based on your knowledge of chemistry, describe the research into depletion of the ozone layer by CFCs in a timeline.

53. CFC Reduction Research 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.

54. Technology Name a technological application of chemistry that you use everyday. Prepare a booklet about its discovery and development.

Document-Based Questions

Ozone Depletion The area of low-ozone varies over the Arctic as well as over the Antarctic. NOAA collects data and monitors low-ozone area at both poles.

Figure 1.23 shows the average areas of unusually low ozone concentration in the north pole region from February to March of each year from 1991 to 2005.


55. In what year or years was the low-ozone area the largest? The smallest?

56. What is the average area from 2000–2005? How does that compare to the average area from 1995–2000?

Think Critically

48. Possible answers: water pollution, environmental chemistry; the digestion of food, biochemistry; textile fibers, polymer chemistry; metal coins, inorganic chemistry; AIDS treatment, biochemistry.

49. a. qualitative data
   b. quantitative

50. microscopic observation

51. The qualitative statements are that air quality is poor and that people should spend little time outside. Quantitative statements include that visibility is only 1.7 km and that the pollutants will rise above 0.085 ppm in the next eight-hour average.

Additional Assessment

* RUBRIC available at glencoe.com

52. Answers will vary but should include increased use of CFCs and the decrease in the ozone layer, including the effects of the depletion of life on Earth.

53. Answers will vary but should include the measures taken by the United States to limit the use and control of the disposal of CFCs. Answers should also include the measures taken by several other countries.

54. Check student booklets for accuracy. Be sure students explain clearly how the application is related to chemistry.
Standardized Test Practice

Cumulative

Multiple Choice

1. When working with chemicals in the laboratory, which 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.

2. What must be a constant during the experiment?
   A. temperature
   B. mass of CO$_2$ dissolved in each sample
   C. amount of beverage in each sample
   D. independent variable

3. Assuming that all of the experimental data are correct, what is a reasonable conclusion for this experiment?
   A. Greater amounts of CO$_2$ dissolve in a liquid at lower temperatures.
   B. The different samples of beverage contained the same amount of CO$_2$ at each temperature.
   C. The relationship between temperature and solubility seen with solids is the same as the one seen with CO$_2$.
   D. CO$_2$ dissolves better at higher temperatures.

4. 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.

5. The independent variable in this experiment is
   A. the number of samples tested.
   B. the mass of CO$_2$ measured.
   C. the type of beverage used.
   D. the temperature of the beverage.

6. Which 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

7. In this experiment testing the effects of soda on students’ heart rates, which student serves as the control?
   A. Student 1
   B. Student 2
   C. Student 3
   D. Student 4
8. Give examples of qualitative data that are true for the element sodium.

9. Give examples of quantitative data that are true for the element copper.

10. A student in your class announces that he has a theory to explain why he scored poorly on a quiz. Is this a proper use of the term theory? Explain your answer.

Extended Response

11. Explain why scientists use mass for measuring the amount of a substance instead of using weight.

Consider the following experiment as you answer Questions 12 and 13.

A chemistry student is investigating how particle size affects the rate of dissolving. In her experiment, she adds a sugar cube, sugar crystals, or crushed sugar to each of three beakers of water, stirs the mixtures for 10 seconds, and records how long it takes the sugar to dissolve in each beaker.

12. Identify the independent and dependent variables in this experiment. How can they be distinguished?

13. Identify a feature of this experiment that should be kept constant. Explain why it is important to include keep this feature constant.

NEED EXTRA HELP?

If You Missed Question . . . 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Review Section . . . 1.2 1.2 1.4 1.4 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.4 1.4 1.4 1.4

SAT Subject Test: Chemistry

14. A scientist from which field of chemistry investigates a new form of packaging material that breaks down rapidly in the environment?
   A. biochemistry
   B. theoretical chemistry
   C. environmental chemistry
   D. inorganic chemistry
   E. physical chemistry

Use the safety symbols below to answer Questions 15–18. Some choices may be used more than once; others will not be used at all.

15. Safety goggles should be worn whenever you are working in the lab.
16. Use chemicals in rooms with proper ventilation in case of strong fumes.
17. Wear proper protective clothing to prevent stains and burns.
18. Objects may be extremely hot or extremely cold; use hand protection.
19. Which statement is NOT true about mass?
   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.
   E. It is found in all matter.

Extended Response

11. Because weight is affected by gravity, it can change depending on its location on Earth. Mass measures the amount of matter in a substance regardless of the effect of gravity on the substance, which makes it a more reliable measurement when comparing measurements made in different parts of the world.

12. The dependent variable is the amount of time required for dissolving, while the independent variable is how much the sugar is crushed before it is added. The dependent variable can be identified because it is the factor that the researcher is changing, while the dependent variable is the outcome of the experiment that is being measured.

13. Answers will vary but can include temperature of water, volume of water, or mass of sugar added. It is important to keep these features constant in order for the different trials to be compared appropriately. If too many factors change in an experiment, the researcher cannot identify what effect each individual factor has on the outcome of the experiment.

SAT Subject Test: Chemistry

14. C
15. C
16. E
17. D
18. B
19. C