A CALL CAME IN TO 911 FROM A MAN WHO arrived home from work to find his wife lying on the floor of their home. When the police arrived, they pronounced the woman dead. The victim's body was lying on the floor of the living room. There was no blood at the scene, but the police did find a glass on the side table that contained a small amount of liquid. In an adjacent laundry room, the police found a half-empty bottle of antifreeze, which contains the toxic compound ethylene glycol. The bottle, glass, and liquid were bagged and sent to the forensic laboratory.

In another 911 call, a man was found lying on the grass outside his home. Blood was present on his body, and some bullet casings were found on the grass. Inside the victim’s home, a weapon was recovered. The bullet casings and the weapon were bagged and sent to the forensic laboratory.

Sarah and Mark, forensic scientists, use scientific procedures and chemical tests to examine the evidence from law enforcement agencies. Sarah analyzes blood, stomach contents, and the unknown liquid from the first victim’s home. She will look for the presence of drugs, poisons, and alcohol. Her lab partner, Mark, analyzes the fingerprints on the glass. He will also match the characteristics of the bullet casings to the weapon that was found at the second crime scene.

CAREER Forensic Scientist
Most forensic scientists work in crime laboratories that are part of city or county legal systems where they analyze bodily fluids and tissue samples collected by crime scene investigators. In analyzing these samples, forensic scientists identify the presence or absence of specific chemicals within the body to help solve the criminal case. Some of the chemicals they look for include alcohol, illegal or prescription drugs, poisons, arson debris, metals, and various gases such as carbon monoxide. In order to identify these substances, a variety of chemical instruments and highly specific methodologies are used. Forensic scientists analyze samples from criminal suspects, athletes, and potential employees. They also work on cases involving environmental contamination and animal samples for wildlife crimes. Forensic scientists usually have a bachelor's degree that includes courses in math, chemistry, and biology.

CLINICAL UPDATE Forensic Evidence Helps Solve the Crime
In the forensic laboratory, Sarah analyzes the victim's stomach contents and blood for toxic compounds. You can view the results of the tests on the forensic evidence in the CLINICAL UPDATE Forensic Evidence Helps Solve the Crime, page 19, and determine if the victim ingested a toxic level of ethylene glycol (antifreeze).
1.1 Chemistry and Chemicals

**LEARNING GOAL** Define the term chemistry and identify substances as chemicals.

Now that you are in a chemistry class, you may be wondering what you will be learning. What questions in science have you been curious about? Perhaps you are interested in what hemoglobin does in the blood or how aspirin relieves a headache. Just like you, chemists are curious about the world we live in.

What does hemoglobin do in the body? Hemoglobin consists of four polypeptide chains, each containing a heme group with an iron atom that binds to oxygen \( \text{O}_2 \) in the lungs. From the lungs, hemoglobin transports oxygen to the tissues of the body where it is used to provide energy. Once the oxygen is released, hemoglobin binds to carbon dioxide \( \text{CO}_2 \) for transport to the lungs where it is released.

Why does aspirin relieve a headache? When a part of the body is injured, substances called prostaglandins are produced, which cause inflammation and pain. Aspirin acts to block the production of prostaglandins, reducing inflammation and pain. Chemists in the medical field develop new treatments for diabetes, genetic defects, cancer, AIDS, and other diseases. For the chemist in the forensic laboratory, the nurse in the dialysis unit, the dietitian, the chemical engineer, or the agricultural scientist, chemistry plays a central role in understanding problems and assessing possible solutions.

**Chemistry**

Chemistry is the study of the composition, structure, properties, and reactions of matter. Matter is another word for all the substances that make up our world. Perhaps you imagine that chemistry takes place only in a laboratory where a chemist is working in a white coat and goggles. Actually, chemistry happens all around you every day and has an impact on everything you use and do. You are doing chemistry when you cook food, add bleach to your laundry, or start your car. A chemical reaction has taken place when silver tarnishes or an antacid tablet fizzes when dropped into water. Plants grow because chemical reactions convert carbon dioxide, water, and energy to carbohydrates. Chemical reactions take place when you digest food and break it down into substances that you need for energy and health.

**Chemicals**

A chemical is a substance that always has the same composition and properties wherever it is found. All the things you see around you are composed of one or more chemicals. Chemical processes take place in chemistry laboratories, manufacturing plants, and pharmaceutical labs as well as every day in nature and in our bodies. Often the terms chemical and substance are used interchangeably to describe a specific type of matter.

Every day, you use products containing substances that were developed and prepared by chemists. Soaps and shampoos contain chemicals that remove oils on your skin and scalp. In cosmetics and lotions, chemicals are used to moisturize, prevent deterioration of the product, fight bacteria, and thicken the product. Perhaps you wear a ring or watch made of gold, silver, or platinum. Your breakfast cereal is probably fortified with iron, calcium, and phosphorus, whereas the milk you drink is enriched with vitamins A and D. When you brush your teeth, the substances in toothpaste clean your teeth, prevent plaque formation, and stop tooth decay. Some of the chemicals used to make toothpaste are listed in Table 1.1.

**Table 1.1 Chemicals Commonly Used in Toothpaste**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium carbonate</td>
<td>Used as an abrasive to remove plaque</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>Prevents loss of water and hardening of toothpaste</td>
</tr>
<tr>
<td>Sodium lauryl sulfate</td>
<td>Used to loosen plaque</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>Makes toothpaste white and opaque</td>
</tr>
<tr>
<td>Sodium fluorophosphate</td>
<td>Prevents formation of cavities by strengthening tooth enamel with fluoride</td>
</tr>
<tr>
<td>Methyl salicylate</td>
<td>Gives toothpaste a pleasant wintergreen flavor</td>
</tr>
</tbody>
</table>
PRACTICE PROBLEMS

1.1 Chemistry and Chemicals

LEARNING GOAL Define the term chemistry and identify substances as chemicals.

In every chapter, odd-numbered exercises in the Practice Problems are paired with even-numbered exercises. The answers for the magenta, odd-numbered Practice Problems are given at the end of each chapter. The complete solutions to the odd-numbered Practice Problems are in the Study Guide and Student Solutions Manual.

1.1 Write a one-sentence definition for each of the following:
   a. chemistry
   b. chemical

1.2 Ask two of your friends (not in this class) to define the terms in problem 1.1. Do their answers agree with the definitions you provided?

Clinical Applications

1.3 Obtain a bottle of multivitamins and read the list of ingredients. What are four chemicals from the list?

1.4 Obtain a box of breakfast cereal and read the list of ingredients. What are four chemicals from the list?

1.5 Read the labels on some items found in your medicine cabinet. What are the names of some chemicals contained in those items?

1.6 Read the labels on products used to wash your dishes. What are the names of some chemicals contained in those products?

1.2 Scientific Method: Thinking Like a Scientist

LEARNING GOAL Describe the activities that are part of the scientific method.

When you were very young, you explored the things around you by touching and tasting. As you grew, you asked questions about the world in which you live. What is lightning? Where does a rainbow come from? Why is the sky blue? As an adult, you may have wondered how antibiotics work or why vitamins are important to your health. Every day, you ask questions and seek answers to organize and make sense of the world around you.

When the late Nobel Laureate Linus Pauling described his student life in Oregon, he recalled that he read many books on chemistry, mineralogy, and physics. “I mulled over the properties of materials: why are some substances colored and others not, why are some minerals or inorganic compounds hard and others soft?” He said, “I was building up this tremendous background of empirical knowledge and at the same time asking a great number of questions.” Linus Pauling won two Nobel Prizes: the first, in 1954, was in chemistry for his work on the nature of chemical bonds and the determination of the structures of complex substances; the second, in 1962, was the Peace Prize.

The Scientific Method

The process of trying to understand nature is unique to each scientist. However, the scientific method is a process that scientists use to make observations in nature, gather data, and explain natural phenomena.

1. Observations The first step in the scientific method is to make observations about nature and ask questions about what you observe. When an observation always seems to be true, it may be stated as a law that predicts that behavior and is often measurable. However, a law does not explain that observation. For example, we can use the Law of Gravity to predict that if we drop our chemistry book it would fall on the table or the floor but this law does not explain why our book falls.

2. Hypothesis A scientist forms a hypothesis, which gives a possible explanation of an observation or a law. The hypothesis must be stated in such a way that it can be tested by experiments.

3. Experiments To determine if a hypothesis is true or false, experiments are done to find a relationship between the hypothesis and the observations. The results of the experiments may confirm the hypothesis. However, if the experiments do not confirm the hypothesis, it is modified or discarded. Then new experiments will be designed to test the hypothesis.

4. Conclusion/Theory When the results of the experiments are analyzed, a conclusion is made as to whether the hypothesis is true or false. When experiments give consistent results, the hypothesis may be stated to be true. Even then, the hypothesis continues...
to be tested and, based on new experimental results, may need to be modified or replaced. If many additional experiments by a group of scientists continue to support the hypothesis, it may become a scientific theory, which gives an explanation for the initial observations.

**CHEMISTRY LINK TO HEALTH**

**Early Chemist: Paracelsus**

For many centuries, chemistry has been the study of changes in matter. From the time of the ancient Greeks to the sixteenth century, alchemists described matter in terms of four components of nature: earth, air, fire, and water. By the eighth century, alchemists believed that they could change metals such as copper and lead into gold and silver. Although these efforts failed, the alchemists provided information on the chemical reactions involved in the extraction of metals from ores. The alchemists also designed some of the first laboratory equipment and developed early laboratory procedures. These early efforts were some of the first observations and experiments using the scientific method.

Paracelsus (1493–1541) was a physician and an alchemist who thought that alchemy should be about preparing new medicines. Using observation and experimentation, he proposed that a healthy body was regulated by a series of chemical processes that could be unbalanced by certain chemical compounds and rebalanced by using minerals and medicines. For example, he determined that inhaled dust caused lung disease in miners. He also thought that goiter was a problem caused by contaminated water, and he treated syphilis with compounds of mercury. His opinion of medicines was that the right dose makes the difference between a poison and a cure. Paracelsus changed alchemy in ways that helped establish modern medicine and chemistry.

**Using the Scientific Method in Everyday Life**

You may be surprised to realize that you use the scientific method in your everyday life. Suppose you visit a friend in her home. Soon after you arrive, your eyes start to itch and you begin to sneeze. Then you observe that your friend has a new cat. Perhaps you form the hypothesis that you are allergic to cats. To test your hypothesis, you leave your friend’s home. If the sneezing stops, perhaps your hypothesis is correct. You test your hypothesis further by visiting another friend who also has a cat. If you start to sneeze again, your experimental results support your hypothesis and you come to the conclusion that you are allergic to cats. However, if you continue sneezing after you leave your friend’s home, your hypothesis is not supported. Now you need to form a new hypothesis, which could be that you have a cold.

**SAMPLE PROBLEM 1.1 Scientific Method**

**TRY IT FIRST**

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

**a.** During an assessment in the emergency room, a nurse writes that the patient has a resting pulse of 30 beats/min.
**b.** Repeated studies show that lowering sodium in the diet leads to a decrease in blood pressure.
**c.** A nurse thinks that an incision from a recent surgery that is red and swollen is infected.

**SOLUTION**

**a.** observation  **b.** conclusion  **c.** hypothesis
1.3 Studying and Learning Chemistry

LEARNING GOAL  Identify strategies that are effective for learning. Develop a study plan for learning chemistry.

Here you are taking chemistry, perhaps for the first time. Whatever your reasons for choosing to study chemistry, you can look forward to learning many new and exciting ideas.

Strategies to Improve Learning and Understanding

Success in chemistry utilizes good study habits, connecting new information with your knowledge base, rechecking what you have learned and what you have forgotten, and retrieving what you have learned for an exam. Let’s take a look at ways that can help you...
study and learn chemistry. Suppose you were asked to indicate if you think each of the following common study habits is helpful or not helpful:

<table>
<thead>
<tr>
<th>Helpful</th>
<th>Not helpful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing practice</td>
<td>Highlighting</td>
</tr>
<tr>
<td>Studying different ideas at the same time</td>
<td>Underlining</td>
</tr>
<tr>
<td>Retesting a few days later</td>
<td>Reading the chapter many times</td>
</tr>
<tr>
<td>Memorizing the key words</td>
<td>Cramming</td>
</tr>
</tbody>
</table>

Learning something requires us to place new information in our long-term memory, which allows us to remember those ideas for an exam, a process called retrieval. Thus, our evaluation of study habits depends on their value in helping us to recall knowledge. The study habits that are not very helpful in retrieval include highlighting, underlining, reading the chapter many times, memorizing key words, and cramming. If we want to recall new information, we need to connect it with prior knowledge that we can retrieve. This can be accomplished by developing study habits that involve a lot of practice testing ourselves on how to retrieve new information. We can determine how much we have learned by going back a few days later and retesting. Another useful learning strategy is to study different ideas at the same time, which allows us to connect those ideas and how to differentiate them. Although these study habits may take more time and seem more difficult, they help us find the gaps in our knowledge and connect new information with what we already know. In the long run, you retain and retrieve more information, making your study for exams less stressful.

### Tips for Using New Study Habits for Successful Learning

1. **Do not keep rereading text or notes.** Reading the same material over and over will make that material seem familiar but does not mean that you have learned it. You need to test yourself to find out what you do and do not know.

2. **Ask yourself questions as you read.** Asking yourself questions as you read requires you to interact continually with new material. For example, you might ask yourself how the new material is related to previous material, which helps you make connections. By linking new material with long-term knowledge, you make pathways for retrieving new material.

3. **Self-test by giving yourself quizzes.** Using problems in the text or sample exams, practice taking tests frequently.

4. **Study at a regular pace rather than cramming.** Once you have tested yourself, go back in a few days and practice testing and retrieving information again. We do not recall all the information when we first read it. By frequent quizzing and retesting, we identify what we still need to learn. Sleep is also important for strengthening the associations between newly learned information. Lack of sleep may interfere with retrieval of information as well. So staying up all night to cram for your chemistry exam is not a good idea. Success in chemistry is a combined effort to learn new information and then to retrieve that information when you need it for an exam.

5. **Study different topics in a chapter and relate the new concepts to concepts you know.** We learn material more efficiently by relating it to information we already know. By increasing connections between concepts, we can retrieve information when we need it.

### ENGAGE

**Why is self-testing helpful for learning new concepts?**
1.3 Studying and Learning Chemistry

Features in This Text That Help You Study and Learn Chemistry

This text has been designed with study features to complement your individual learning style. On the inside of the front cover is a periodic table of the elements. On the inside of the back cover are tables that summarize useful information needed throughout your study of chemistry. Each chapter begins with *Looking Ahead*, which outlines the topics in the chapter. *Key Terms* are bolded when they first appear in the text, and are summarized at the end of each chapter. They are also listed and defined in the comprehensive *Glossary and Index*, which appears at the end of the text.

*Key Math Skills* and *Core Chemistry Skills* that are critical to learning chemistry are indicated by icons in the margin, and summarized at the end of each chapter.

Before you begin reading, obtain an overview of a chapter by reviewing the topics in *Looking Ahead*. As you prepare to read a Section of the chapter, look at the Section title and turn it into a question. Asking yourself questions about new topics builds new connections to material you have already learned. For example, for Section 1.1, “Chemistry and Chemicals,” you could ask, “What is chemistry?” or “What are chemicals?” At the beginning of each Section, a *Learning Goal* states what you need to understand and a *Review* box lists the Key Math Skills and Core Chemistry Skills from previous chapters that relate to new material in the chapter. As you read the text, you will see *Engage* features in the margin, which remind you to pause your reading and test yourself with a question related to the material.

Several *Sample Problems* are included in each Chapter. The *Try It First* feature reminds you to work the problem before you look at the Solution. The *Analyze the Problem* feature includes *Given*, the information you have; *Need*, what you have to accomplish; and *Connect*, how you proceed. It is helpful to try to work a problem first because it helps you link what you know to what you need to learn. This process will help you develop successful problem-solving techniques. Many Sample Problems include a *Solution Guide* that shows the steps you can use for problem solving. Work the associated *Study Check* and compare your answer to the one provided.

At the end of each chapter Section, you will find a set of *Practice Problems* that allows you to apply problem solving immediately to the new concepts. Throughout each

---

**SAMPLE PROBLEM 1.2 Strategies for Learning Chemistry**

**TRY IT FIRST**

Predict which student will obtain the best exam score.

a. A student who reads the chapter four times.

b. A student who reads the chapter two times and works all the problems at the end of each Section.

c. A student who reads the chapter the night before the exam.

**SOLUTION**

b. A student who reads the chapter two times and works all the problems at the end of each Section has interacted with the content in the chapter using self-testing to make connections between concepts and practicing retrieving information learned previously.

**STUDY CHECK 1.2**

What is another way that student b in Sample Problem 1.2 could improve his or her retrieval of information?

**ANSWER**

Student b in Sample Problem 1.2 could also wait two or three days and practice working the problems in each Section again to determine how much he or she has learned. Retesting strengthens connections between new and previously learned information for longer lasting memory and more efficient retrieval.
Section. Test suggestions remind you to solve the indicated Practice Problems as you study. The Clinical Applications in the Practice Problems relate the content to health and medicine. The problems are paired, which means that each of the odd-numbered problems is matched to the following even-numbered problem. At the end of each chapter, the answers to all the odd-numbered problems are provided. If the answers match yours, you most likely understand the topic; if not, you need to study the Section again.

Throughout each chapter, boxes titled Chemistry Link to Health and Chemistry Link to the Environment help you relate the chemical concepts you are learning to real-life situations. Many of the figures and diagrams use macro-to-micro illustrations to depict the atomic level of organization of ordinary objects, such as the atoms in aluminum foil. These visual models illustrate the concepts described in the text and allow you to “see” the world in a microscopic way. Interactive Video suggestions illustrate content as well as problem solving.

At the end of each chapter, you will find several study aids that complete the chapter. Chapter Reviews provide a summary in easy-to-read bullet points and Concept Maps visually show the connections between important topics. Understanding the Concepts are problems that use art and models to help you visualize concepts and connect them to your background knowledge. Additional Practice Problems and Challenge Problems provide additional exercises to test your understanding of the topics in the chapter. Answers to all of the odd-numbered problems complete the chapter allowing you to compare your answers to the ones provided.

After some chapters, problem sets called Combining Ideas test your ability to solve problems containing material from more than one chapter.

Many students find that studying with a group can be beneficial to learning. In a group, students motivate each other to study, fill in gaps, and correct misunderstandings by teaching and learning together. Studying alone does not allow the process of peer correction. In a group, you can cover the ideas more thoroughly as you discuss the reading and problem solve with other students.

Making a Study Plan
As you embark on your journey into the world of chemistry, think about your approach to studying and learning chemistry. You might consider some of the ideas in the following list. Check those ideas that will help you successfully learn chemistry. Commit to them now. Your success depends on you.

My study plan for learning chemistry will include the following:

- ________ reading the chapter before class
- ________ going to class
- ________ reviewing the Learning Goals
- ________ keeping a problem notebook
- ________ reading the text
- ________ working the Test problems as I read each Section
- ________ answering the Engage questions
- ________ trying to work the Sample Problem before looking at the Solution
- ________ working the Practice Problems at the end of each Section and checking answers
- ________ studying different topics at the same time
- ________ organizing a study group
- ________ seeing the professor during office hours
- ________ reviewing Key Math Skills and Core Chemistry Skills
- ________ attending review sessions
- ________ studying as often as I can
LEARNING GOAL
Review math concepts used in chemistry: place values, positive and negative numbers, percentages, solving equations, and interpreting graphs.

During your study of chemistry, you will work many problems that involve numbers. You will need various math skills and operations. We will review some of the key math skills that are particularly important for chemistry. As we move through the chapters, we will also reference the key math skills as they apply.
CHAPTER 1 Chemistry in Our Lives

Identifying Place Values

For any number, we can identify the place value for each of the digits in that number. These place values have names such as the ones place (first place to the left of the decimal point) or the tens place (second place to the left of the decimal point). A premature baby has a mass of 2518 g. We can indicate the place values for the number 2518 as follows:

<table>
<thead>
<tr>
<th>Digit</th>
<th>Place Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>thousands</td>
</tr>
<tr>
<td>5</td>
<td>hundreds</td>
</tr>
<tr>
<td>1</td>
<td>tens</td>
</tr>
<tr>
<td>8</td>
<td>ones</td>
</tr>
</tbody>
</table>

We also identify place values such as the tenths place (first place to the right of the decimal point) and the hundredths place (second place to the right of the decimal point). A silver coin has a mass of 6.407 g. We can indicate the place values for the number 6.407 as follows:

<table>
<thead>
<tr>
<th>Digit</th>
<th>Place Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>ones</td>
</tr>
<tr>
<td>4</td>
<td>tenths</td>
</tr>
<tr>
<td>0</td>
<td>hundredths</td>
</tr>
<tr>
<td>7</td>
<td>thousandths</td>
</tr>
</tbody>
</table>

Note that place values ending with the suffix *ths* refer to the decimal places to the right of the decimal point.

SAMPLE PROBLEM 1.4 Identifying Place Values

**TRY IT FIRST**

A bullet found at a crime scene has a mass of 15.24 g. What are the place values for each of the digits in the mass of the bullet?

**SOLUTION**

<table>
<thead>
<tr>
<th>Digit</th>
<th>Place Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>tens</td>
</tr>
<tr>
<td>5</td>
<td>ones</td>
</tr>
<tr>
<td>2</td>
<td>tenths</td>
</tr>
<tr>
<td>4</td>
<td>hundredths</td>
</tr>
</tbody>
</table>

**STUDY CHECK 1.4**

A bullet found at a crime scene contains 0.925 g of lead. What are the place values for each of the digits in the mass of the lead?

**ANSWER**

<table>
<thead>
<tr>
<th>Digit</th>
<th>Place Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>tenths</td>
</tr>
<tr>
<td>2</td>
<td>hundredths</td>
</tr>
<tr>
<td>5</td>
<td>thousandths</td>
</tr>
</tbody>
</table>
Using Positive and Negative Numbers in Calculations

**A positive number** is any number that is greater than zero and has a positive sign (+). Often the positive sign is understood and not written in front of the number. For example, the number +8 can also be written as 8. A **negative number** is any number that is less than zero and is written with a negative sign (−). For example, a negative eight is written as −8.

### Multiplication and Division of Positive and Negative Numbers

When two positive numbers or two negative numbers are multiplied, the answer is positive (+).

\[
2 \times 3 = +6 \\
(-2) \times (-3) = +6
\]

When a positive number and a negative number are multiplied, the answer is negative (−).

\[
2 \times (-3) = -6 \\
(-2) \times 3 = -6
\]

The rules for the division of positive and negative numbers are the same as the rules for multiplication. When two positive numbers or two negative numbers are divided, the answer is positive (+).

\[
\frac{6}{3} = 2 \\
\frac{-6}{-3} = 2
\]

When a positive number and a negative number are divided, the answer is negative (−).

\[
\frac{-6}{3} = -2 \\
\frac{6}{-3} = -2
\]

### Addition of Positive and Negative Numbers

When positive numbers are added, the sign of the answer is positive.

\[
3 + 4 = 7 \quad \text{The + sign (}+7\text{) is understood.}
\]

When negative numbers are added, the sign of the answer is negative.

\[
(-3) + (-4) = -7
\]

When a positive number and a negative number are added, the smaller number is subtracted from the larger number, and the result has the same sign as the larger number.

\[
12 + (-15) = -3
\]

### Subtraction of Positive and Negative Numbers

When two numbers are subtracted, change the sign of the number to be subtracted and follow the rules for addition shown above.

\[
12 - (+5) = 12 - 5 = 7 \\
12 - (-5) = 12 + 5 = 17 \\
-12 - (-5) = -12 + 5 = -7 \\
-12 - (+5) = -12 - 5 = -17
\]

### Calculator Operations

On your calculator, there are four keys that are used for basic mathematical operations. The change sign [+/-] key is used to change the sign of a number.

To practice these basic calculations on the calculator, work through the problem going from the left to the right doing the operations in the order they occur. If your calculator has a change sign [+/-] key, a negative number is entered by pressing the number and then pressing the change sign [+/-] key. At the end, press the equals [=] key or ANS or ENTER.

**ENGAGE**

Why does (−5) + 4 = −1, whereas (−5) + (−4) = −9?

**TEST**

Try Practice Problems 1.17 and 1.18
CHAPTER 1
Chemistry in Our Lives

Calculating Percentages
To determine a percentage, divide the parts by the total (whole) and multiply by 100%. For example, if an aspirin tablet contains 325 mg of aspirin (active ingredient) and the tablet has a mass of 545 mg, what is the percentage of aspirin in the tablet?

\[
\frac{325 \text{ mg aspirin}}{545 \text{ mg tablet}} \times 100\% = 59.6\% \text{ aspirin}
\]

When a value is described as a percentage (%), it represents the number of parts of an item in 100 of those items. If the percentage of red balls is 5, it means there are 5 red balls in every 100 balls. If the percentage of green balls is 50, there are 50 green balls in every 100 balls.

\[
\begin{align*}
5\% \text{ red balls} &= \frac{5 \text{ red balls}}{100 \text{ balls}} \\
50\% \text{ green balls} &= \frac{50 \text{ green balls}}{100 \text{ balls}}
\end{align*}
\]

SAMPLE PROBLEM 1.5 Calculating a Percentage

TRY IT FIRST
A bullet found at a crime scene may be used as evidence in a trial if the percentage of metals is a match to the composition of metals in a bullet from the suspect’s ammunition. If a bullet found at a crime scene contains 13.9 g of lead, 0.3 g of tin, and 0.9 g of antimony, what is the percentage of each metal in the bullet? Express your answers to the ones place.

SOLUTION
Total mass \( = 13.9 \text{ g} + 0.3 \text{ g} + 0.9 \text{ g} = 15.1 \text{ g} \)

Percentage of lead
\[
\frac{13.9 \text{ g}}{15.1 \text{ g}} \times 100\% = 92\% \text{ lead}
\]

Percentage of tin
\[
\frac{0.3 \text{ g}}{15.1 \text{ g}} \times 100\% = 2\% \text{ tin}
\]

Percentage of antimony
\[
\frac{0.9 \text{ g}}{15.1 \text{ g}} \times 100\% = 6\% \text{ antimony}
\]
Solving Equations

In chemistry, we use equations that express the relationship between certain variables. Let’s look at how we would solve for \( x \) in the following equation:

\[
2x + 8 = 14
\]

Our overall goal is to rearrange the items in the equation to obtain \( x \) on one side.

1. **Place all like terms on one side.** The numbers 8 and 14 are like terms. To remove the 8 from the left side of the equation, we subtract 8. To keep a balance, we need to subtract 8 from the 14 on the other side.

\[
2x + 8 - 8 = 14 - 8
\]

\[
2x = 6
\]

2. **Isolate the variable you need to solve for.** In this problem, we obtain \( x \) by dividing both sides of the equation by 2. The value of \( x \) is the result when 6 is divided by 2.

\[
\frac{2x}{2} = \frac{6}{2}
\]

\[
x = 3
\]

3. **Check your answer.** Check your answer by substituting your value for \( x \) back into the original equation.

\[
2(3) + 8 = 14
\]

\[
6 + 8 = 14
\]

\[
14 = 14 \quad \text{Your answer } x = 3 \text{ is correct.}
\]

**Summary:** To solve an equation for a particular variable, be sure you perform the same mathematical operations on both sides of the equation.

- If you eliminate a symbol or number by subtracting, you need to subtract that same symbol or number on the opposite side.
- If you eliminate a symbol or number by adding, you need to add that same symbol or number on the opposite side.
- If you cancel a symbol or number by dividing, you need to divide both sides by that same symbol or number.
- If you cancel a symbol or number by multiplying, you need to multiply both sides by that same symbol or number.

When we work with temperature, we may need to convert between degrees Celsius and degrees Fahrenheit using the following equation:

\[
T_F = 1.8(T_C) + 32
\]
To obtain the equation for converting degrees Fahrenheit to degrees Celsius, we subtract 32 from both sides.

\[
T_F = 1.8(T_C) + 32
\]

\[
T_F - 32 = 1.8(T_C) + 32 - 32
\]

\[
T_F - 32 = 1.8(T_C)
\]

To obtain \( T_C \) by itself, we divide both sides by 1.8.

\[
\frac{T_F - 32}{1.8} = \frac{1.8(T_C)}{1.8} = T_C
\]

**SAMPLE PROBLEM 1.6 Solving Equations**

**TRY IT FIRST**

Solve the following equation for \( V_2 \):

\[
P_1V_1 = P_2V_2
\]

**SOLUTION**

\[
P_1V_1 = P_2V_2
\]

To solve for \( V_2 \), divide both sides by the symbol \( P_2 \).

\[
\frac{P_1V_1}{P_2} = \frac{P_2V_2}{P_2}
\]

\[
V_2 = \frac{P_1V_1}{P_2}
\]

**STUDY CHECK 1.6**

Solve the following equation for \( m \):

\[
\text{heat} = m \times \Delta T \times SH
\]

**ANSWER**

\[
m = \frac{\text{heat}}{\Delta T \times SH}
\]

**Interpreting Graphs**

A graph represents the relationship between two variables. These quantities are plotted along two perpendicular axes, which are the \( x \) axis (horizontal) and \( y \) axis (vertical).

**Example**

In the graph Volume of a Balloon Versus Temperature, the volume of a gas in a balloon is plotted against its temperature.

**Title**

Look at the title. What does it tell us about the graph? The title indicates that the volume of a balloon was measured at different temperatures.

**Vertical Axis**

Look at the label and the numbers on the vertical (y) axis. The label indicates that the volume of the balloon was measured in liters (L). The numbers, which are chosen to include the low and high measurements of the volume of the gas, are evenly spaced from 22.0 L to 30.0 L.
Horizontal Axis
The label on the horizontal (x) axis indicates that the temperature of the balloon was measured in degrees Celsius (°C). The numbers are measurements of the Celsius temperature, which are evenly spaced from 0 °C to 100 °C.

Points on the Graph
Each point on the graph represents a volume in liters that was measured at a specific temperature. When these points are connected, a line is obtained.

Interpreting the Graph
From the graph, we see that the volume of the gas increases as the temperature of the gas increases. This is called a direct relationship. Now we use the graph to determine the volume at various temperatures. For example, suppose we want to know the volume of the gas at 50 °C. We would start by finding 50 °C on the x axis and then drawing a line up to the plotted line. From there, we would draw a horizontal line that intersects the y axis and read the volume value where the line crosses the y axis as shown on the graph above.

SAMPLE PROBLEM 1.7 Interpreting a Graph

TRY IT FIRST
A nurse administers Tylenol to lower a child’s fever. The graph shows the body temperature of the child plotted against time.

a. What is measured on the vertical axis?
b. What is the range of values on the vertical axis?
c. What is measured on the horizontal axis?
d. What is the range of values on the horizontal axis?

SOLUTION
a. body temperature, in degrees Celsius
b. 37.0 °C to 39.4 °C
c. time, in minutes, after Tylenol was given
d. 0 min to 30 min

STUDY CHECK 1.7

a. Using the graph in Sample Problem 1.7, what was the child’s temperature 15 min after Tylenol was given?
b. How many minutes elapsed before the temperature decreased to 38.0 °C?

ANSWER
a. 37.6 °C  b. 8 min

TEST
Try Practice Problems 1.23 and 1.24
PRACTICE PROBLEMS

1.4 Key Math Skills for Chemistry

LEARNING GOAL Review math concepts used in chemistry: place values, positive and negative numbers, percentages, solving equations, and interpreting graphs.

1.15 What is the place value for the bold digit?
   a. 7.3288
   b. 16.1234
   c. 4675.99

1.16 What is the place value for the bold digit?
   a. 97.5689
   b. 375.88
   c. 46.1000

1.17 Evaluate each of the following:
   a. \(15 - (-8) = \) _____
   b. \(-8 + (-22) = \) _____
   c. \(4 \times (-2) + 6 = \) _____

1.18 Evaluate each of the following:
   a. \(-11 - (-9) = \) _____
   b. \(34 + (-55) = \) _____
   c. \(-56 \div 8 = \) _____

Clinical Applications

1.19 a. A clinic had 25 patients on Friday morning. If 21 patients were given flu shots, what percentage of the patients received flu shots? Express your answer to the ones place.
   b. An alloy contains 56 g of pure silver and 22 g of pure copper. What is the percentage of silver in the alloy? Express your answer to the ones place.
   c. A collection of coins contains 11 nickels, 5 quarters, and 7 dimes. What is the percentage of dimes in the collection? Express your answer to the ones place.

1.20 a. At a local hospital, 35 babies were born. If 22 were boys, what percentage of the newborns were boys? Express your answer to the ones place.
   b. An alloy contains 67 g of pure gold and 35 g of pure zinc. What is the percentage of zinc in the alloy? Express your answer to the ones place.
   c. A collection of coins contains 15 pennies, 14 dimes, and 6 quarters. What is the percentage of pennies in the collection? Express your answer to the ones place.

1.21 Solve each of the following for \(a\):
   a. \(4a + 4 = 40\)
   b. \(\frac{a}{6} = 7\)

1.22 Solve each of the following for \(b\):
   a. \(2b + 7 = b + 10\)
   b. \(3b - 4 = 24 - b\)

Use the following graph for problems 1.23 and 1.24:

![Graph: Time for Cooling of Tea Versus Temperature]

1.23 a. What does the title indicate about the graph?
   b. What is measured on the vertical axis?
   c. What is the range of values on the vertical axis?
   d. Does the temperature increase or decrease with an increase in time?

1.24 a. What is measured on the horizontal axis?
   b. What is the range of values on the horizontal axis?
   c. What is the temperature of the tea after 20 min?
   d. How many minutes were needed to reach a temperature of 45 °C?

1.5 Writing Numbers in Scientific Notation

LEARNING GOAL Write a number in scientific notation.

In chemistry, we often work with numbers that are very large and very small. We might measure something as tiny as the width of a human hair, which is about 0.000 008 m. Or perhaps we want to count the number of hairs on the average human scalp, which is about 100 000 hairs. In this text, we add spaces between sets of three digits when it helps make the places easier to count. However, we will see that it is more convenient to write large and small numbers in scientific notation.

A number written in scientific notation has two parts: a coefficient and a power of 10. For example, the number 2400 is written in scientific notation as \(2.4 \times 10^3\). The coefficient, 2.4,
Humans have an average of $1 \times 10^5$ hairs on their scalps. Each hair is about $8 \times 10^{-6}$ m wide.

is obtained by moving the decimal point to the left to give a number that is at least 1 but less than 10. Because we moved the decimal point three places to the left, the power of 10 is a positive 3, which is written as $10^3$. When a number greater than 1 is converted to scientific notation, the power of 10 is positive.

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2400$</td>
<td>$2.4 \times 10^3$</td>
</tr>
</tbody>
</table>

In another example, $0.000\, 86$ is written in scientific notation as $8.6 \times 10^{-4}$. The coefficient, 8.6, is obtained by moving the decimal point to the right. Because the decimal point is moved four places to the right, the power of 10 is a negative 4, written as $10^{-4}$. When a number less than 1 is written in scientific notation, the power of 10 is negative.

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.000, 86$</td>
<td>$8.6 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

**TABLE 1.2** gives some examples of numbers written as positive and negative powers of 10. The powers of 10 are a way of keeping track of the decimal point in the number. **TABLE 1.3** gives several examples of writing measurements in scientific notation.

**TABLE 1.2** Some Powers of 10

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Multiples of 10</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10, 000$</td>
<td>$10 \times 10 \times 10 \times 10$</td>
<td>$1 \times 10^4$</td>
</tr>
<tr>
<td>$1, 000$</td>
<td>$10 \times 10 \times 10$</td>
<td>$1 \times 10^3$</td>
</tr>
<tr>
<td>$100$</td>
<td>$10 \times 10$</td>
<td>$1 \times 10^2$</td>
</tr>
<tr>
<td>$10$</td>
<td>$10$</td>
<td>$1 \times 10^1$</td>
</tr>
<tr>
<td>$1$</td>
<td>$1$</td>
<td>$1 \times 10^0$</td>
</tr>
<tr>
<td>$0.1$</td>
<td>$\frac{1}{10}$</td>
<td>$1 \times 10^{-1}$</td>
</tr>
<tr>
<td>$0.01$</td>
<td>$\frac{1}{10} \times \frac{1}{10} = \frac{1}{100}$</td>
<td>$1 \times 10^{-2}$</td>
</tr>
<tr>
<td>$0.001$</td>
<td>$\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = \frac{1}{1000}$</td>
<td>$1 \times 10^{-3}$</td>
</tr>
<tr>
<td>$0.0001$</td>
<td>$\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = \frac{1}{10000}$</td>
<td>$1 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

A chickenpox virus has a diameter of $3 \times 10^{-7}$ m.
### TABLE 1.3 Some Measurements Written as Standard Numbers and in Scientific Notation

<table>
<thead>
<tr>
<th>Measured Quantity</th>
<th>Standard Number</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of gasoline used in the United States each year</td>
<td>550 000 000 000 L</td>
<td>$5.5 \times 10^{11}$ L</td>
</tr>
<tr>
<td>Diameter of Earth</td>
<td>12 800 000 m</td>
<td>$1.28 \times 10^{7}$ m</td>
</tr>
<tr>
<td>Average volume of blood pumped in 1 day</td>
<td>8500 L</td>
<td>$8.5 \times 10^{3}$ L</td>
</tr>
<tr>
<td>Time for light to travel from the Sun to Earth</td>
<td>500 s</td>
<td>$5 \times 10^{2}$ s</td>
</tr>
<tr>
<td>Mass of a typical human</td>
<td>68 kg</td>
<td>$6.8 \times 10^{1}$ kg</td>
</tr>
<tr>
<td>Mass of stirrup bone in ear</td>
<td>0.003 g</td>
<td>$3 \times 10^{-3}$ g</td>
</tr>
<tr>
<td>Diameter of a chickenpox (Varicella zoster) virus</td>
<td>0.000 000 3 m</td>
<td>$3 \times 10^{-7}$ m</td>
</tr>
<tr>
<td>Mass of bacterium (mycoplasma)</td>
<td>0.000 000 000 000 000 1 kg</td>
<td>$1 \times 10^{-19}$ kg</td>
</tr>
</tbody>
</table>

### SAMPLE PROBLEM 1.8 Writing a Number in Scientific Notation

#### TRY IT FIRST
Write each of the following in scientific notation:

- **a.** 3500
- **b.** 0.000 016

#### SOLUTION GUIDE

<table>
<thead>
<tr>
<th>ANALYZE THE PROBLEM</th>
<th>Given</th>
<th>Need</th>
<th>Connect</th>
</tr>
</thead>
<tbody>
<tr>
<td>standard number</td>
<td>scientific notation</td>
<td>coefficient is at least 1 but less than 10</td>
<td></td>
</tr>
</tbody>
</table>

#### a. 3500

**Step 1** Move the decimal point to obtain a coefficient that is at least 1 but less than 10. For a number greater than 1, the decimal point is moved to the left three places to give a coefficient of 3.5.

**Step 2** Express the number of places moved as a power of 10. Moving the decimal point three places to the left gives a power of 3, written as $10^3$.

**Step 3** Write the product of the coefficient multiplied by the power of 10.

$$3.5 \times 10^3$$

#### b. 0.000 016

**Step 1** Move the decimal point to obtain a coefficient that is at least 1 but less than 10. For a number less than 1, the decimal point is moved to the right five places to give a coefficient of 1.6.

**Step 2** Express the number of places moved as a power of 10. Moving the decimal point five places to the right gives a power of negative 5, written as $10^{-5}$.

**Step 3** Write the product of the coefficient multiplied by the power of 10.

$$1.6 \times 10^{-5}$$

### STUDY CHECK 1.8
Write each of the following in scientific notation:

- **a.** 425 000
- **b.** 0.000 000 86

#### ANSWER

- **a.** $4.25 \times 10^5$
- **b.** $8.6 \times 10^{-7}$
Scientific Notation and Calculators

You can enter a number in scientific notation on many calculators using the EE or EXP key. After you enter the coefficient, press the EE or EXP key and enter the power 10. To enter a negative power of 10, press the +/- key or the - key, depending on your calculator.

<table>
<thead>
<tr>
<th>Number to Enter</th>
<th>Procedure</th>
<th>Calculator Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4 \times 10^6$</td>
<td>$4 \text{EE or EXP } 6$</td>
<td>$406$ or $4\times10^6$ or $4E06$</td>
</tr>
<tr>
<td>$2.5 \times 10^{-4}$</td>
<td>$2.5 \text{EE or EXP } +/- 4$</td>
<td>$2.5\times10^{-4}$ or $2.5\times10^{-4}$ or $2.5E-04$</td>
</tr>
</tbody>
</table>

When a calculator answer appears in scientific notation, the coefficient is shown as a number that is at least 1 but less than 10, followed by a space or E and the power of 10. To express this display in scientific notation, write the coefficient value, write $\times10$, and use the power of 10 as an exponent.

<table>
<thead>
<tr>
<th>Calculator Display</th>
<th>Expressed in Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7.52 \text{E04}$ or $7.52\times10^4$ or $7.52\text{E04}$</td>
<td>$7.52 \times 10^4$</td>
</tr>
<tr>
<td>$5.8 \text{E-02}$ or $5.8\times10^{-2}$ or $5.8\text{E-02}$</td>
<td>$5.8 \times 10^{-2}$</td>
</tr>
</tbody>
</table>

On many calculators, a number is converted into scientific notation using the appropriate keys. For example, the number 0.000 52 is entered, followed by pressing the 2nd or 3rd function key and the SCI key. The scientific notation appears in the calculator display as a coefficient and the power of 10.

$0.000 \text{ } 52 \text{ } \text{2nd or 3rd function key SCI} = 5.2 \times 10^{-4}$

**ENGAGE**

Describe how you enter a number in scientific notation on your calculator.

**PRACTICE PROBLEMS**

1.5 Writing Numbers in Scientific Notation

**LEARNING GOAL** Write a number in scientific notation.

1.25 Write each of the following in scientific notation:
   - a. 55 000
   - b. 480
   - c. 0.000 005
   - d. 0.001 4
   - e. 0.0072
   - f. 670 000

1.26 Write each of the following in scientific notation:
   - a. 180 000 000
   - b. 0.000 006
   - c. 750
   - d. 0.15
   - e. 0.024
   - f. 1500

1.27 Which number in each of the following pairs is larger?
   - a. $7.2 \times 10^3$ or $8.2 \times 10^2$
   - b. $4.5 \times 10^{-3}$ or $3.2 \times 10^{-2}$
   - c. $1 \times 10^3$ or $1 \times 10^{-4}$
   - d. 0.005 2 or $6.8 \times 10^{-2}$

1.28 Which number in each of the following pairs is smaller?
   - a. $4.9 \times 10^{-3}$ or $5.5 \times 10^{-9}$
   - b. 1250 or $3.4 \times 10^2$
   - c. 0.000 000 4 or $5.0 \times 10^2$
   - d. $2.50 \times 10^2$ or $4 \times 10^5$

**CLINICAL UPDATE**

Forensic Evidence Helps Solve the Crime

Using a variety of laboratory tests, Sarah finds ethylene glycol in the victim’s blood. The quantitative tests indicate that the victim had ingested 125 g of ethylene glycol.

Sarah determines that the liquid in a glass found at the crime scene was ethylene glycol that had been added to an alcoholic beverage. Ethylene glycol is a clear, sweet-tasting, thick liquid that is odorless and mixes with water. It is easy to obtain since it is used as antifreeze in automobiles and in brake fluid. Because the initial symptoms of ethylene glycol poisoning are similar to being intoxicated, the victim is often unaware of its presence.
Chemistry is the study of the composition, structure, properties, and reactions of matter.
A chemical is any substance that always has the same composition and properties wherever it is found.

Mark determines that fingerprints on the glass containing the ethylene glycol were those of the victim’s husband. This evidence along with the container of antifreeze found in the home led to the arrest and conviction of the husband for poisoning his wife.

Clinical Applications
1.29 A container was found in the home of the victim that contained 120 g of ethylene glycol in 450 g of liquid. What was the percentage of ethylene glycol? Express your answer to the ones place.

1.30 If the toxic quantity is 1.5 g of ethylene glycol per 1000 g of body mass, what percentage of ethylene glycol is fatal?

CHAPTER REVIEW
1.1 Chemistry and Chemicals
LEARNING GOAL Define the term chemistry and identify substances as chemicals.
• Chemistry is the study of the composition, structure, properties, and reactions of matter.
• A chemical is any substance that always has the same composition and properties wherever it is found.

1.2 Scientific Method: Thinking Like a Scientist
LEARNING GOAL Describe the activities that are part of the scientific method.
• The scientific method is a process of explaining natural phenomena beginning with making observations, forming a hypothesis, and performing experiments.
• After repeated successful experiments, a hypothesis may become a theory.
1.3 Studying and Learning Chemistry

LEARNING GOAL. Identify strategies that are effective for learning. Develop a study plan for learning chemistry.

- A plan for learning chemistry utilizes the features in the text that help develop a successful approach to learning chemistry.
- By using the Learning Goals, Reviews, Analyze the Problems, and Try It First in the chapter and working the Sample Problems, Study Checks, and the Practice Problems at the end of each Section, you can successfully learn the concepts of chemistry.

1.4 Key Math Skills for Chemistry

LEARNING GOAL. Review math concepts used in chemistry: place values, positive and negative numbers, percentages, solving equations, and interpreting graphs.

1.5 Writing Numbers in Scientific Notation

LEARNING GOAL. Write a number in scientific notation.

- A number written in scientific notation has two parts, a coefficient and a power of 10.
- When a number greater than 1 is converted to scientific notation, the power of 10 is positive.
- When a number less than 1 is written in scientific notation, the power of 10 is negative.

KEY TERMS

- **chemical**: A substance that has the same composition and properties wherever it is found.
- **chemistry**: The study of the composition, structure, properties, and reactions of matter.
- **conclusion**: An explanation of an observation that has been validated by repeated experiments that support a hypothesis.
- **experiment**: A procedure that tests the validity of a hypothesis.
- **hypothesis**: An unverified explanation of a natural phenomenon.
- **observation**: Information determined by noting and recording a natural phenomenon.
- **scientific method**: The process of making observations, proposing a hypothesis, and testing the hypothesis; after repeated experiments validate the hypothesis, it may become a theory.
- **scientific notation**: A form of writing large and small numbers using a coefficient that is at least 1 but less than 10, followed by a power of 10.
- **theory**: An explanation for an observation supported by additional experiments that confirm the hypothesis.

KEY MATH SKILLS

The chapter Section containing each Key Math Skill is shown in parentheses at the end of each heading.

### Identifying Place Values (1.4)

- The place value identifies the numerical value of each digit in a number.

**Example:** Identify the place value for each of the digits in the number 456.78.

<table>
<thead>
<tr>
<th>Digit</th>
<th>Place Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>hundreds</td>
</tr>
<tr>
<td>5</td>
<td>tens</td>
</tr>
<tr>
<td>6</td>
<td>ones</td>
</tr>
<tr>
<td>7</td>
<td>tenths</td>
</tr>
<tr>
<td>8</td>
<td>hundredths</td>
</tr>
</tbody>
</table>

### Using Positive and Negative Numbers in Calculations (1.4)

- A **positive number** is any number that is greater than zero and has a positive sign (+). A **negative number** is any number that is less than zero and is written with a negative sign (−).
- When two positive numbers are added, multiplied, or divided, the answer is positive.
- When two negative numbers are multiplied or divided, the answer is positive. When two negative numbers are added, the answer is negative.
- When a positive and a negative number are multiplied or divided, the answer is negative.
- When a positive and a negative number are added, the smaller number is subtracted from the larger number and the result has the same sign as the larger number.
- When two numbers are subtracted, change the sign of the number to be subtracted then follow the rules for addition.
Example: Evaluate each of the following:

a. \(-8 - 14 = \_____
\)

b. \(6 \times (-3) = \_____
\)

Answer: a. \(-22
\)

b. \(-18
\)

### Calculating Percentages (1.4)

- A percentage is the part divided by the total (whole) multiplied by 100%.

Example: A drawer contains 6 white socks and 18 black socks. What is the percentage of white socks?

Answer:

\[
6 \text{ white socks} \times \frac{100}{24 \text{ total socks}} = 25\% \text{ white socks}
\]

### Solving Equations (1.4)

An equation in chemistry often contains an unknown. To rearrange an equation to obtain the unknown factor by itself, you keep it balanced by performing matching mathematical operations on both sides of the equation.

- If you eliminate a number or symbol by subtracting, subtract that same number or symbol on the opposite side.
- If you eliminate a number or symbol by adding, add that same number or symbol on the opposite side.
- If you cancel a number or symbol by dividing, divide both sides by that same number or symbol.
- If you cancel a number or symbol by multiplying, multiply both sides by that same number or symbol.

Example: Solve the equation for \(a\):

\[
3a - 8 = 28
\]

Answer:

Add 8 to both sides: \(3a - 8 + 8 = 28 + 8\)

\[
3a = 36
\]

Divide both sides by 3:

\[
\frac{3a}{3} = \frac{36}{3}
\]

\[
a = 12
\]

Check:

\[
3(12) - 8 = 28
\]

\[
36 - 8 = 28
\]

\[
28 = 28
\]

Your answer \(a = 12\) is correct.

### Interpreting Graphs (1.4)

- A graph represents the relationship between two variables.
- The quantities are plotted along two perpendicular axes, which are the \(x\) axis (horizontal) and \(y\) axis (vertical).
- The title indicates the components of the \(x\) and \(y\) axes.
- Numbers on the \(x\) and \(y\) axes show the range of values of the variables.
- The graph shows the relationship between the component on the \(y\) axis and that on the \(x\) axis.

### Writing Numbers in Scientific Notation (1.5)

- A number written in scientific notation consists of a coefficient and a power of 10.

A number is written in scientific notation by:

- Moving the decimal point to obtain a coefficient that is at least 1 but less than 10.
- Expressing the number of places moved as a power of 10. The power of 10 is positive if the decimal point is moved to the left, negative if the decimal point is moved to the right.

Example: Write the number 28 000 in scientific notation.

Answer: Moving the decimal point four places to the left gives a coefficient of 2.8 and a positive power of 10. The number 28 000 written in scientific notation is \(2.8 \times 10^4\).
For each of the following, indicate if the answer has a positive or negative sign: (1.4)

a. Two negative numbers are added.
   -4
   b. A positive and negative number are multiplied.

For each of the following, indicate if the answer has a positive or negative sign: (1.4)

b. A negative number is subtracted from a positive number.
   12 - -48 = 36
   c. Two negative numbers are divided.

Clinical Applications

Classify each of the following statements as an observation or a conclusion: (1.2)

b. A patient breaks out in hives after receiving penicillin.

For each of the following, indicate if the answer has a positive or negative sign: (1.4)

Classify each of the following as an observation, a hypothesis, an experiment, or a conclusion: (1.2)

a. A nurse tells a patient that her baby who gets sick after drinking milk may be lactose intolerant.
   c. Numerous studies have shown that omega-3 fatty acids lower triglyceride levels.

Write each of the following in scientific notation: (1.5)

b. 0.000 000 34
   c. 0.066
   d. 2700

Write each of the following in scientific notation: (1.5)

a. 0.0042
   b. 310
   c. 890 000 000
   d. 0.000 000 056

Clinical Applications

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion: (1.2)

b. Every spring, you have congestion and a runny nose.
   c. Many research studies have linked obesity to heart disease.

Which of the following will help you develop a successful study plan? (1.3)

b. working the Sample Problems as you go through a chapter
   c. self-testing
   d. reading through the chapter, but working the problems later

Which of the following will help you develop a successful study plan? (1.3)

b. working the Sample Problems as you go through a chapter
   c. self-testing
   d. reading through the chapter, but working the problems later

Evaluate each of the following: (1.4)

4 × (-8) = ____
-168
-4

Evaluate each of the following: (1.4)

-95 - (-11) = ____
152
-19

Challenge Problems

The following problems are related to the topics in this chapter. However, they do not all follow the chapter order, and they require you to combine concepts and skills from several Sections. These problems will help you increase your critical thinking skills and prepare for your next exam.

Classify each of the following as an observation, a hypothesis, an experiment, or a conclusion: (1.2)

b. If I chop the log into smaller wood pieces, it will expand to the proper size.
   c. When I added air to the bicycle tire, it was still flat.
   d. The bicycle tire has a leak in it.
1.53 Solve each of the following for x: (1.4)
   a. \(2x + 5 = 41\)
   b. \(\frac{5x}{3} = 40\)

1.54 Solve each of the following for z: (1.4)
   a. \(3z - (-6) = 12\)
   b. \(\frac{4z}{-12} = -8\)

Use the following graph for problems 1.55 and 1.56:

### Solubility of Carbon Dioxide in Water Versus Temperature

![Graph showing solubility of carbon dioxide in water versus temperature](image)

**ANSWERS**

**Answers to Selected Practice Problems**

1.1 a. Chemistry is the study of the composition, structure, properties, and reactions of matter.
   b. A chemical is a substance that has the same composition and properties wherever it is found.

1.3 Many chemicals are listed on a vitamin bottle such as vitamin A, vitamin B₃, vitamin B₁₂, vitamin C, and folic acid.

1.5 Typical items found in a medicine cabinet and some of the chemicals they contain are as follows:
   - Antacid tablets: calcium carbonate, cellulose, starch, stearic acid, silicon dioxide
   - Mouthwash: water, alcohol, thymol, glycerol, sodium benzoate, benzoic acid
   - Cough suppressant: menthol, beta-carotene, sucrose, glucose

1.7 a. observation
   b. hypothesis
   c. experiment
   d. observation
   e. observation
   f. conclusion

1.9 a. observation
   b. hypothesis
   c. experiment
   d. experiment

1.11 There are several things you can do that will help you successfully learn chemistry: forming a study group, retesting, doing Try It First before reading the Solution, checking Review, working Sample Problems and Study Checks, working Practice Problems and checking Answers, reading the assignment ahead of class, and keeping a problem notebook.

1.13 a. c. and e

1.15 a. thousandths
   b. ones
   c. hundreds

1.17 a. 23
   b. −30
   c. −2

1.19 a. 84%
   b. 72%
   c. 30%

1.21 a. 9
   b. 42

1.23 a. The graph shows the relationship between the temperature of a cup of tea and time.
   b. temperature, in °C
   c. 20 °C to 80 °C
   d. decrease

1.55 a. What does the title indicate about the graph? (1.4)
   b. What is measured on the vertical axis?
   c. What is the range of values on the vertical axis?
   d. Does the solubility of carbon dioxide increase or decrease with an increase in temperature?

1.56 a. What is measured on the horizontal axis? (1.4)
   b. What is the range of values on the horizontal axis?
   c. What is the solubility of carbon dioxide in water at 25 °C?
   d. At what temperature does carbon dioxide have a solubility of 0.20 g/100 g water?