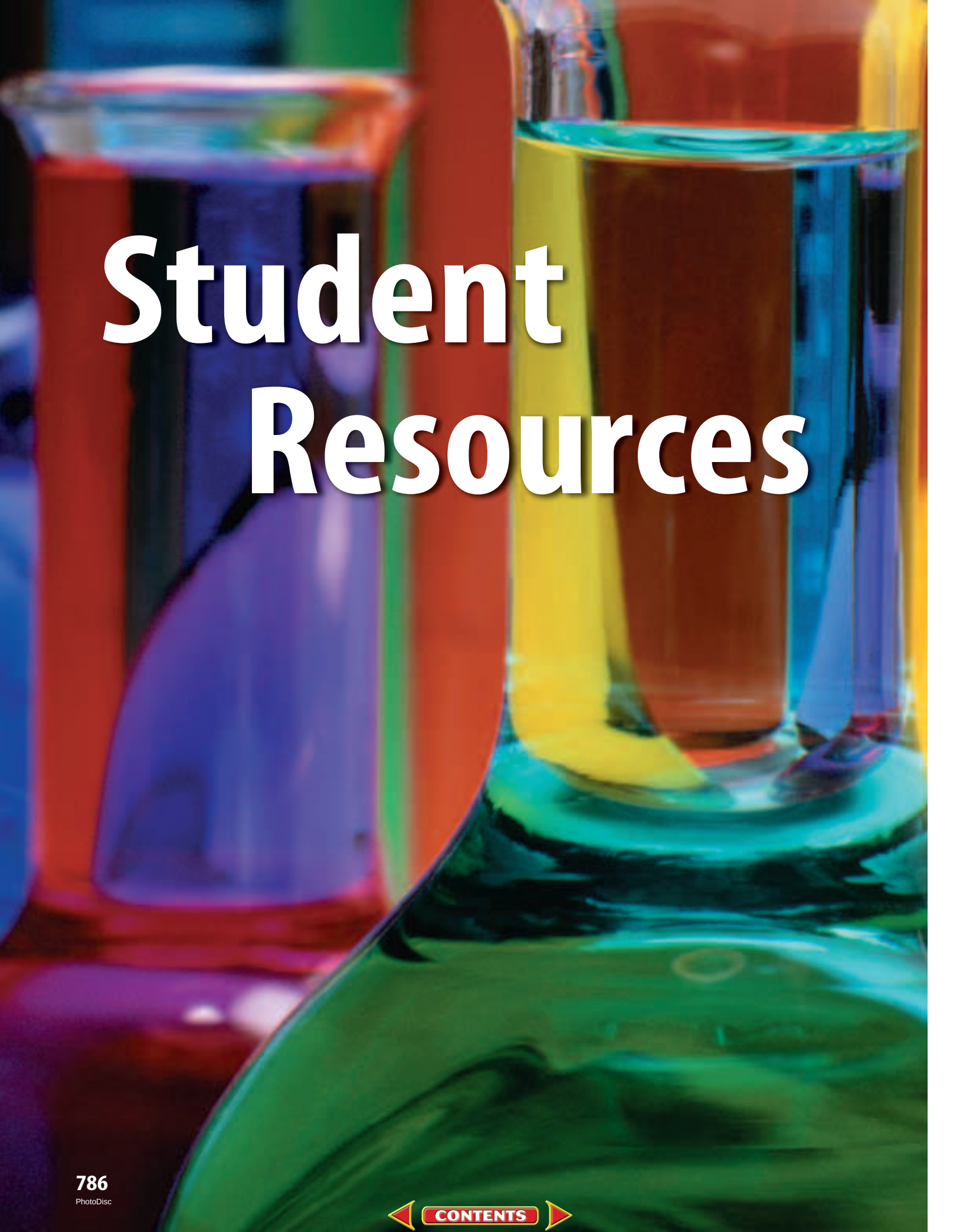


The background of the page is a close-up photograph of laboratory glassware. In the foreground, a large Erlenmeyer flask is partially filled with a bright green liquid. Behind it, a graduated cylinder contains a yellow liquid. To the left, another graduated cylinder holds a red liquid. The glassware is set against a dark, reflective surface, and the lighting creates vibrant, colorful reflections and highlights on the glass and liquids.

Student Resources

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Scientific Methods

Scientists use an orderly approach called the scientific method to solve problems. This includes organizing and recording data so others can understand them. Scientists use many variations in this method when they solve problems.

Identify a Question

The first step in a scientific investigation or experiment is to identify a question to be answered or a problem to be solved. For example, you might ask which gasoline is the most efficient.

Gather and Organize Information

After you have identified your question, begin gathering and organizing information. There are many ways to gather information, such as researching in a library, interviewing those knowledgeable about the subject, testing and working in the laboratory and field. Fieldwork is investigations and observations done outside of a laboratory.

Researching Information Before moving in a new direction, it is important to gather the information that already is known about the subject. Start by asking yourself questions to determine exactly what you need to know. Then you will look for the information in various reference sources, like the student is doing in **Figure 1**. Some sources may include textbooks, encyclopedias, government documents, professional journals, science magazines, and the Internet. Always list the sources of your information.



Figure 1 The Internet can be a valuable research tool.

Evaluate Sources of Information Not all sources of information are reliable. You should evaluate all of your sources of information, and use only those you know to be dependable. For example, if you are researching ways to make homes more energy efficient, a site written by the U.S. Department of Energy would be more reliable than a site written by a company that is trying to sell a new type of weatherproofing material. Also, remember that research always is changing. Consult the most current resources available to you. For example, a 1985 resource about saving energy would not reflect the most recent findings.

Sometimes scientists use data that they did not collect themselves, or conclusions drawn by other researchers. This data must be evaluated carefully. Ask questions about how the data were obtained, if the investigation was carried out properly, and if it has been duplicated exactly with the same results. Would you reach the same conclusion from the data? Only when you have confidence in the data can you believe it is true and feel comfortable using it.

Interpret Scientific Illustrations As you research a topic in science, you will see drawings, diagrams, and photographs to help you understand what you read. Some illustrations are included to help you understand an idea that you can't see easily by yourself, like the tiny particles in an atom in **Figure 2**. A drawing helps many people to remember details more easily and provides examples that clarify difficult concepts or give additional information about the topic you are studying. Most illustrations have labels or a caption to identify or to provide more information.

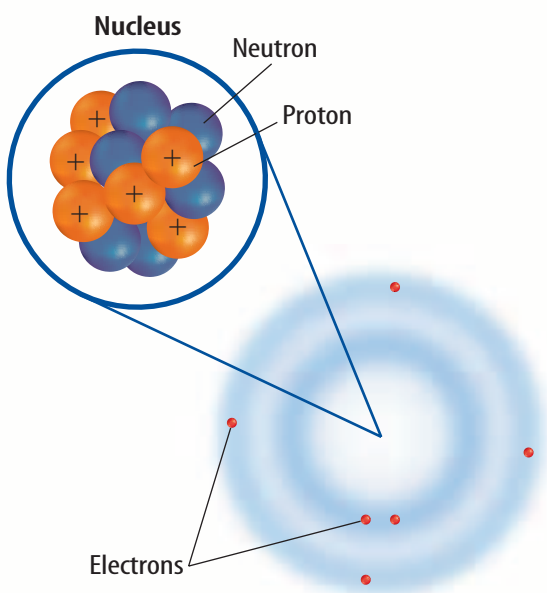


Figure 2 This drawing shows an atom of carbon with its six protons, six neutrons, and six electrons.

Concept Maps One way to organize data is to draw a diagram that shows relationships among ideas (or concepts). A concept map can help make the meanings of ideas and terms more clear, and help you understand and remember what you are studying. Concept maps are useful for breaking large concepts down into smaller parts, making learning easier.

Network Tree A type of concept map that not only shows a relationship, but how the concepts are related is a network tree, shown in **Figure 3**. In a network tree, the words are written in the ovals, while the description of the type of relationship is written across the connecting lines.

When constructing a network tree, write down the topic and all major topics on separate pieces of paper or notecards. Then arrange them in order from general to specific. Branch the related concepts from the major concept and describe the relationship on the connecting line. Continue to more specific concepts until finished.

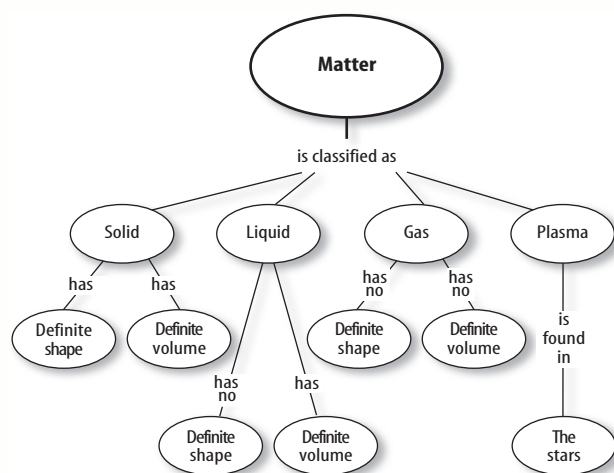


Figure 3 A network tree shows how concepts or objects are related.

Events Chain Another type of concept map is an events chain. Sometimes called a flow chart, it models the order or sequence of items. An events chain can be used to describe a sequence of events, the steps in a procedure, or the stages of a process.

When making an events chain, first find the one event that starts the chain. This event is called the initiating event. Then, find the next event and continue until the outcome is reached, as shown in **Figure 4**.

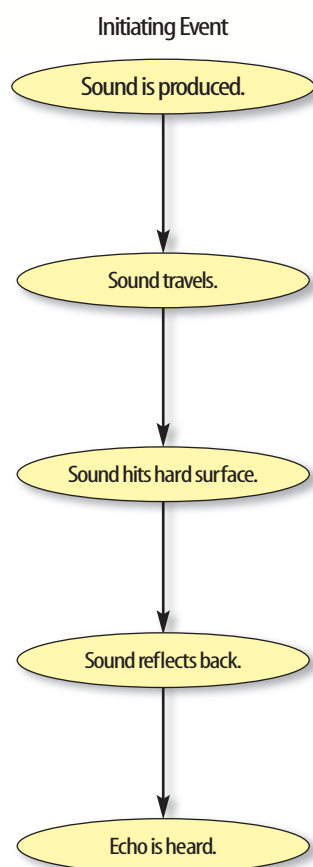


Figure 4 Events-chain concept maps show the order of steps in a process or event. This concept map shows how a sound makes an echo.

Cycle Map A specific type of events chain is a cycle map. It is used when the series of events do not produce a final outcome, but instead relate back to the beginning event, such as in **Figure 5**. Therefore, the cycle repeats itself.

To make a cycle map, first decide what event is the beginning event. This is also called the initiating event. Then list the next events in the order that they occur, with the last event relating back to the initiating event. Words can be written between the events that describe what happens from one event to the next. The number of events in a cycle map can vary, but usually contain three or more events.

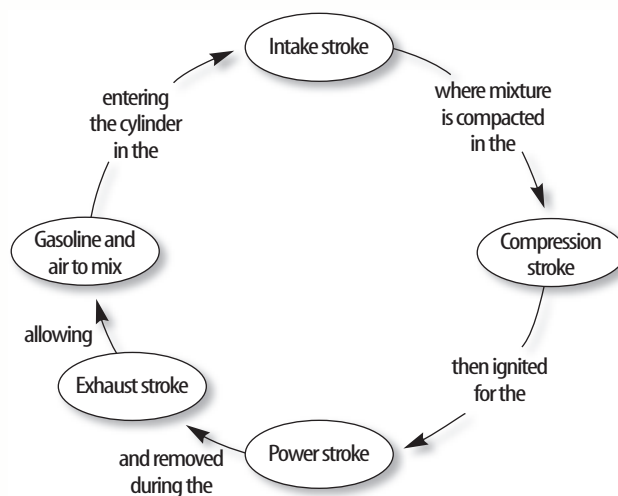


Figure 5 A cycle map shows events that occur in a cycle.

Spider Map A type of concept map that you can use for brainstorming is the spider map. When you have a central idea, you might find that you have a jumble of ideas that relate to it but are not necessarily clearly related to each other. The spider map on sound in **Figure 6** shows that if you write these ideas outside the main concept, then you can begin to separate and group unrelated terms so they become more useful.

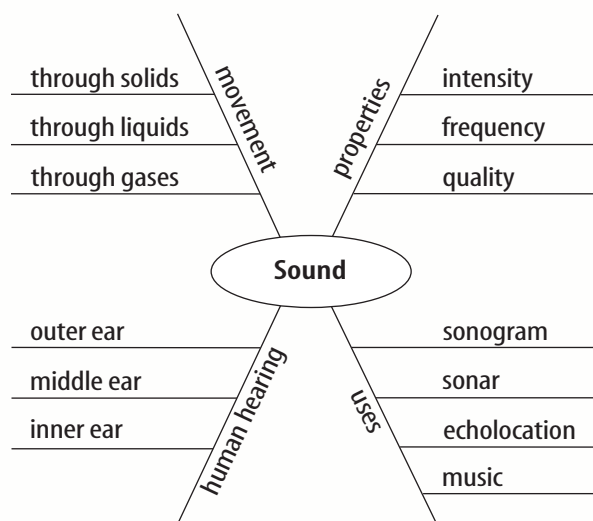


Figure 6 A spider map allows you to list ideas that relate to a central topic but not necessarily to one another.

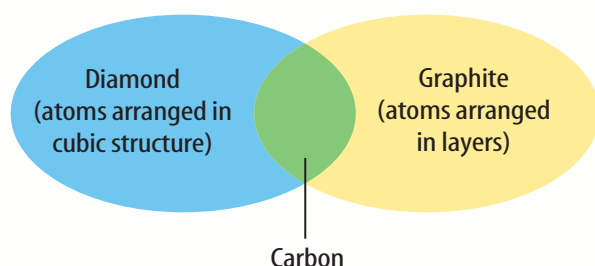


Figure 7 This Venn diagram compares and contrasts two substances made from carbon.

Venn Diagram To illustrate how two subjects compare and contrast you can use a Venn diagram. You can see the characteristics that the subjects have in common and those that they do not, shown in **Figure 7**.

To create a Venn diagram, draw two overlapping ovals that are big enough to write in. List the characteristics unique to one subject in one oval, and the characteristics of the other subject in the other oval. The characteristics in common are listed in the overlapping section.

Make and Use Tables One way to organize information so it is easier to understand is to use a table. Tables can contain numbers, words, or both.

To make a table, list the items to be compared in the first column and the characteristics to be compared in the first row. The title should clearly indicate the content of the table, and the column or row heads should be clear. Notice that in **Table 1** the units are included.

Table 1 Recyclables Collected During Week			
Day of Week	Paper (kg)	Aluminum (kg)	Glass (kg)
Monday	5.0	4.0	12.0
Wednesday	4.0	1.0	10.0
Friday	2.5	2.0	10.0

Make a Model One way to help you better understand the parts of a structure, the way a process works, or to show things too large or small for viewing is to make a model. For example, an atomic model made of a plastic-ball nucleus and pipe-cleaner electron shells can help you visualize how the parts of an atom relate to each other. Other types of models can be devised on a computer or represented by equations.

Form a Hypothesis

A possible explanation based on previous knowledge and observations is called a hypothesis. After researching gasoline types and recalling previous experiences in your family's car you form a hypothesis—our car runs more efficiently because we use premium gasoline. To be valid, a hypothesis has to be something you can test by using an investigation.

Predict When you apply a hypothesis to a specific situation, you predict something about that situation. A prediction makes a statement in advance, based on prior observation, experience, or scientific reasoning. People use predictions to make everyday decisions. Scientists test predictions by performing investigations. Based on previous observations and experiences, you might form a prediction that cars are more efficient with premium gasoline. The prediction can be tested in an investigation.

Design an Experiment A scientist needs to make many decisions before beginning an investigation. Some of these include: how to carry out the investigation, what steps to follow, how to record the data, and how the investigation will answer the question. It also is important to address any safety concerns.

Science Skill Handbook

Test the Hypothesis

Now that you have formed your hypothesis, you need to test it. Using an investigation, you will make observations and collect data, or information. This data might either support or not support your hypothesis. Scientists collect and organize data as numbers and descriptions.

Follow a Procedure In order to know what materials to use, as well as how and in what order to use them, you must follow a procedure. **Figure 8** shows a procedure you might follow to test your hypothesis.

Procedure

1. Use regular gasoline for two weeks.
2. Record the number of kilometers between fill-ups and the amount of gasoline used.
3. Switch to premium gasoline for two weeks.
4. Record the number of kilometers between fill-ups and the amount of gasoline used.

Figure 8 A procedure tells you what to do step by step.

Identify and Manipulate Variables and Controls In any experiment, it is important to keep everything the same except for the item you are testing. The one factor you change is called the independent variable. The change that results is the dependent variable. Make sure you have only one independent variable, to assure yourself of the cause of the changes you observe in the dependent variable. For example, in your gasoline experiment the type of fuel is the independent variable. The dependent variable is the efficiency.

Many experiments also have a control—an individual instance or experimental subject for which the independent variable is not changed. You can then compare the test results to the control results. To design a control you can have two cars of the same type. The control car uses regular gasoline for four weeks. After you are done with the test, you can compare the experimental results to the control results.

Collect Data

Whether you are carrying out an investigation or a short observational experiment, you will collect data, as shown in **Figure 9**. Scientists collect data as numbers and descriptions and organize it in specific ways.

Observe Scientists observe items and events, then record what they see. When they use only words to describe an observation, it is called qualitative data. Scientists' observations also can describe how much there is of something. These observations use numbers, as well as words, in the description and are called quantitative data. For example, if a sample of the element gold is described as being "shiny and very dense" the data are qualitative. Quantitative data on this sample of gold might include "a mass of 30 g and a density of 19.3 g/cm^3 ."



Figure 9 Collecting data is one way to gather information directly.



Figure 10 Record data neatly and clearly so it is easy to understand.

When you make observations you should examine the entire object or situation first, and then look carefully for details. It is important to record observations accurately and completely. Always record your notes immediately as you make them, so you do not miss details or make a mistake when recording results from memory. Never put unidentified observations on scraps of paper. Instead they should be recorded in a notebook, like the one in **Figure 10**. Write your data neatly so you can easily read it later. At each point in the experiment, record your observations and label them. That way, you will not have to determine what the figures mean when you look at your notes later. Set up any tables that you will need to use ahead of time, so you can record any observations right away. Remember to avoid bias when collecting data by not including personal thoughts when you record observations. Record only what you observe.

Estimate Scientific work also involves estimating. To estimate is to make a judgment about the size or the number of something without measuring or counting. This is important when the number or size of an object or population is too large or too difficult to accurately count or measure.

Sample Scientists may use a sample or a portion of the total number as a type of estimation. To sample is to take a small, representative portion of the objects or organisms of a population for research. By making careful observations or manipulating variables within that portion of the group, information is discovered and conclusions are drawn that might apply to the whole population. A poorly chosen sample can be unrepresentative of the whole. If you were trying to determine the rainfall in an area, it would not be best to take a rainfall sample from under a tree.

Measure You use measurements everyday. Scientists also take measurements when collecting data. When taking measurements, it is important to know how to use measuring tools properly. Accuracy also is important.

Length To measure length, the distance between two points, scientists use meters. Smaller measurements might be measured in centimeters or millimeters.

Length is measured using a metric ruler or meter stick. When using a metric ruler, line up the 0-cm mark with the end of the object being measured and read the number of the unit where the object ends. Look at the metric ruler shown in **Figure 11**. The centimeter lines are the long, numbered lines, and the shorter lines are millimeter lines. In this instance, the length would be 4.50 cm.

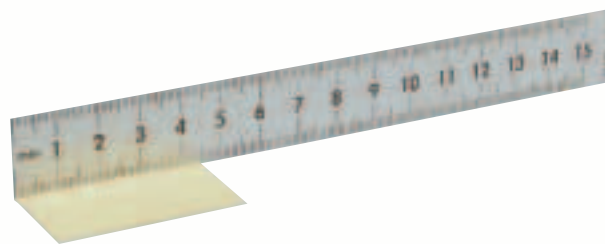


Figure 11 This metric ruler has centimeter and millimeter divisions.

Science Skill Handbook

Mass The SI unit for mass is the kilogram (kg). Scientists can measure mass using units formed by adding metric prefixes to the unit gram (g), such as milligram (mg). To measure mass, you might use a triple-beam balance similar to the one shown in **Figure 12**. The balance has a pan on one side and a set of beams on the other side. Each beam has a rider that slides on the beam.

When using a triple-beam balance, place an object on the pan. Slide the largest rider along its beam until the pointer drops below zero. Then move it back one notch. Repeat the process for each rider proceeding from the larger to smaller until the pointer swings an equal distance above and below the zero point. Sum the masses on each beam to find the mass of the object. Move all riders back to zero when finished.

Instead of putting materials directly on the balance, scientists often take a tare of a container. A tare is the mass of a container into which objects or substances are placed for measuring their masses. To mass objects or substances, find the mass of a clean container. Remove the container from the pan, and place the object or substances in the container. Find the mass of the container with the materials in it. Subtract the mass of the empty container from the mass of the filled container to find the mass of the materials you are using.

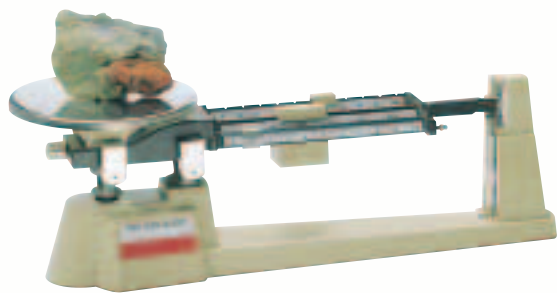


Figure 12 A triple-beam balance is used to determine the mass of an object.

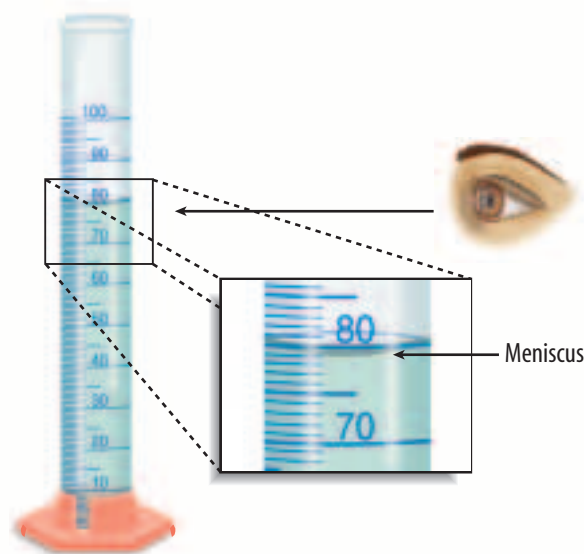


Figure 13 Graduated cylinders measure liquid volume.

Liquid Volume To measure liquids, the unit used is the liter. When a smaller unit is needed, scientists might use a milliliter. Because a milliliter takes up the volume of a cube measuring 1 cm on each side it also can be called a cubic centimeter ($\text{cm}^3 = \text{cm} \times \text{cm} \times \text{cm}$).

You can use beakers and graduated cylinders to measure liquid volume. A graduated cylinder, shown in **Figure 13**, is marked from bottom to top in milliliters. In lab, you might use a 10-mL graduated cylinder or a 100-mL graduated cylinder. When measuring liquids, notice that the liquid has a curved surface. Look at the surface at eye level, and measure the bottom of the curve. This is called the meniscus. The graduated cylinder in **Figure 13** contains 79.0 mL, or 79.0 cm^3 , of a liquid.

Temperature Scientists often measure temperature using the Celsius scale. Pure water has a freezing point of 0°C and boiling point of 100°C . The unit of measurement is degrees Celsius. Two other scales often used are the Fahrenheit and Kelvin scales.



Figure 14 A thermometer measures the temperature of an object.

Scientists use a thermometer to measure temperature. Most thermometers in a laboratory are glass tubes with a bulb at the bottom end containing a liquid such as colored alcohol. The liquid rises or falls with a change in temperature. To read a glass thermometer like the thermometer in **Figure 14**, rotate it slowly until a red line appears. Read the temperature where the red line ends.

Form Operational Definitions An operational definition defines an object by how it functions, works, or behaves. For example, when you are playing hide and seek and a tree is home base, you have created an operational definition for a tree.

Objects can have more than one operational definition. For example, a ruler can be defined as a tool that measures the length of an object (how it is used). It can also be a tool with a series of marks used as a standard when measuring (how it works).

Analyze the Data

To determine the meaning of your observations and investigation results, you will need to look for patterns in the data. Then you must think critically to determine what the data mean. Scientists use several approaches when they analyze the data they have collected and recorded. Each approach is useful for identifying specific patterns.

Interpret Data The word *interpret* means “to explain the meaning of something.” When analyzing data from an experiment, try to find out what the data show. Identify the control group and the test group to see whether or not changes in the independent variable have had an effect. Look for differences in the dependent variable between the control and test groups.

Classify Sorting objects or events into groups based on common features is called classifying. When classifying, first observe the objects or events to be classified. Then select one feature that is shared by some members in the group, but not by all. Place those members that share that feature in a subgroup. You can classify members into smaller and smaller subgroups based on characteristics. Remember that when you classify, you are grouping objects or events for a purpose. Keep your purpose in mind as you select the features to form groups and subgroups.

Compare and Contrast Observations can be analyzed by noting the similarities and differences between two more objects or events that you observe. When you look at objects or events to see how they are similar, you are comparing them. Contrasting is looking for differences in objects or events.

Science Skill Handbook

Recognize Cause and Effect A cause is a reason for an action or condition. The effect is that action or condition. When two events happen together, it is not necessarily true that one event caused the other. Scientists must design a controlled investigation to recognize the exact cause and effect.

Draw Conclusions

When scientists have analyzed the data they collected, they proceed to draw conclusions about the data. These conclusions are sometimes stated in words similar to the hypothesis that you formed earlier. They may confirm a hypothesis, or lead you to a new hypothesis.

Infer Scientists often make inferences based on their observations. An inference is an attempt to explain observations or to indicate a cause. An inference is not a fact, but a logical conclusion that needs further investigation. For example, you may infer that a fire has caused smoke. Until you investigate, however, you do not know for sure.

Apply When you draw a conclusion, you must apply those conclusions to determine whether the data supports the hypothesis. If your data do not support your hypothesis, it does not mean that the hypothesis is wrong. It means only that the result of the investigation did not support the hypothesis. Maybe the experiment needs to be redesigned, or some of the initial observations on which the hypothesis was based were incomplete or biased. Perhaps more observation or research is needed to refine your hypothesis. A successful investigation does not always come out the way you originally predicted.

Avoid Bias Sometimes a scientific investigation involves making judgments. When you make a judgment, you form an opinion. It is important to be honest and not to allow any expectations of results to bias your judgments. This is important throughout the entire investigation, from researching to collecting data to drawing conclusions.

Communicate

The communication of ideas is an important part of the work of scientists. A discovery that is not reported will not advance the scientific community's understanding or knowledge. Communication among scientists also is important as a way of improving their investigations.

Scientists communicate in many ways, from writing articles in journals and magazines that explain their investigations and experiments, to announcing important discoveries on television and radio. Scientists also share ideas with colleagues on the Internet or present them as lectures, like the student is doing in **Figure 15**.



Figure 15 A student communicates to his peers about his investigation.

SAFETY SYMBOLS

SAFETY SYMBOLS		HAZARD	EXAMPLES	PRECAUTION	REMEDY
DISPOSAL		Special disposal procedures need to be followed.	certain chemicals, living organisms	Do not dispose of these materials in the sink or trash can.	Dispose of wastes as directed by your teacher.
BIOLOGICAL		Organisms or other biological materials that might be harmful to humans	bacteria, fungi, blood, unpreserved tissues, plant materials	Avoid skin contact with these materials. Wear mask or gloves.	Notify your teacher if you suspect contact with material. Wash hands thoroughly.
EXTREME TEMPERATURE		Objects that can burn skin by being too cold or too hot	boiling liquids, hot plates, dry ice, liquid nitrogen	Use proper protection when handling.	Go to your teacher for first aid.
SHARP OBJECT		Use of tools or glassware that can easily puncture or slice skin	razor blades, pins, scalpels, pointed tools, dissecting probes, broken glass	Practice common-sense behavior and follow guidelines for use of the tool.	Go to your teacher for first aid.
FUME		Possible danger to respiratory tract from fumes	ammonia, acetone, nail polish remover, heated sulfur, moth balls	Make sure there is good ventilation. Never smell fumes directly. Wear a mask.	Leave foul area and notify your teacher immediately.
ELECTRICAL		Possible danger from electrical shock or burn	improper grounding, liquid spills, short circuits, exposed wires	Double-check setup with teacher. Check condition of wires and apparatus.	Do not attempt to fix electrical problems. Notify your teacher immediately.
IRRITANT		Substances that can irritate the skin or mucous membranes of the respiratory tract	pollen, moth balls, steel wool, fiberglass, potassium permanganate	Wear dust mask and gloves. Practice extra care when handling these materials.	Go to your teacher for first aid.
CHEMICAL		Chemicals can react with and destroy tissue and other materials	bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammonia, sodium hydroxide	Wear goggles, gloves, and an apron.	Immediately flush the affected area with water and notify your teacher.
TOXIC		Substance may be poisonous if touched, inhaled, or swallowed.	mercury, many metal compounds, iodine, poinsettia plant parts	Follow your teacher's instructions.	Always wash hands thoroughly after use. Go to your teacher for first aid.
FLAMMABLE		Flammable chemicals may be ignited by open flame, spark, or exposed heat.	alcohol, kerosene, potassium permanganate	Avoid open flames and heat when using flammable chemicals.	Notify your teacher immediately. Use fire safety equipment if applicable.
OPEN FLAME		Open flame in use, may cause fire.	hair, clothing, paper, synthetic materials	Tie back hair and loose clothing. Follow teacher's instruction on lighting and extinguishing flames.	Notify your teacher immediately. Use fire safety equipment if applicable.
	Eye Safety Proper eye protection should be worn at all times by anyone performing or observing science activities.		Clothing Protection This symbol appears when substances could stain or burn clothing.		Animal Safety This symbol appears when safety of animals and students must be ensured.
					Handwashing After the lab, wash hands with soap and water before removing goggles.

Safety in the Science Laboratory

The science laboratory is a safe place to work if you follow standard safety procedures. Being responsible for your own safety helps to make the entire laboratory a safer place for everyone. When performing any lab, read and apply the caution statements and safety symbol listed at the beginning of the lab.

General Safety Rules

1. Obtain your teacher's permission to begin all investigations and use laboratory equipment.
2. Study the procedure. Ask your teacher any questions. Be sure you understand safety symbols shown on the page.
3. Notify your teacher about allergies or other health conditions which can affect your participation in a lab.
4. Learn and follow use and safety procedures for your equipment. If unsure, ask your teacher.



5. Never eat, drink, chew gum, apply cosmetics, or do any personal grooming in the lab. Never use lab glassware as food or drink containers. Keep your hands away from your face and mouth.
6. Know the location and proper use of the safety shower, eye wash, fire blanket, and fire alarm.

Prevent Accidents

1. Use the safety equipment provided to you. Goggles and a safety apron should be worn during investigations.
2. Do NOT use hair spray, mousse, or other flammable hair products. Tie back long hair and tie down loose clothing.
3. Do NOT wear sandals or other open-toed shoes in the lab.
4. Remove jewelry on hands and wrists. Loose jewelry, such as chains and long necklaces, should be removed to prevent them from getting caught in equipment.
5. Do not taste any substances or draw any material into a tube with your mouth.
6. Proper behavior is expected in the lab. Practical jokes and fooling around can lead to accidents and injury.
7. Keep your work area uncluttered.

Laboratory Work

1. Collect and carry all equipment and materials to your work area before beginning a lab.
2. Remain in your own work area unless given permission by your teacher to leave it.



3. Always slant test tubes away from yourself and others when heating them, adding substances to them, or rinsing them.
4. If instructed to smell a substance in a container, hold the container a short distance away and fan vapors towards your nose.
5. Do NOT substitute other chemicals/substances for those in the materials list unless instructed to do so by your teacher.
6. Do NOT take any materials or chemicals outside of the laboratory.
7. Stay out of storage areas unless instructed to be there and supervised by your teacher.
3. Dispose of chemicals and other materials as directed by your teacher. Place broken glass and solid substances in the proper containers. Never discard materials in the sink.
4. Clean your work area.
5. Wash your hands with soap and water thoroughly BEFORE removing your goggles.

Emergencies

1. Report any fire, electrical shock, glassware breakage, spill, or injury, no matter how small, to your teacher immediately. Follow his or her instructions.
2. If your clothing should catch fire, STOP, DROP, and ROLL. If possible, smother it with the fire blanket or get under a safety shower. NEVER RUN.
3. If a fire should occur, turn off all gas and leave the room according to established procedures.
4. In most instances, your teacher will clean up spills. Do NOT attempt to clean up spills unless you are given permission and instructions to do so.
5. If chemicals come into contact with your eyes or skin, notify your teacher immediately. Use the eyewash or flush your skin or eyes with large quantities of water.
6. The fire extinguisher and first-aid kit should only be used by your teacher unless it is an extreme emergency and you have been given permission.
7. If someone is injured or becomes ill, only a professional medical provider or someone certified in first aid should perform first-aid procedures.

Laboratory Cleanup

1. Turn off all burners, water, and gas, and disconnect all electrical devices.
2. Clean all pieces of equipment and return all materials to their proper places.

EXTRA Labs

From Your Kitchen, Junk Drawer, or Yard

1 Measure for Measure

Real-World Question

What is the difference in the precision of different measuring instruments?

Possible Materials

- kitchen pot
- ruler
- sewing measuring tape
- carpenter's measuring tape

Procedure

1. Before you begin the lab, review this procedure and make an appropriate data table to record your results. For more information, refer to the *Precision and Significant Digits* section in the **Math Skills Handbook**.
2. With the ruler, measure the diameter, the height, and the circumference of the pot.
3. Measure the same three things with both the sewing tape and the carpenter's tape.

4. The precision is one-half of the smallest division on the measuring device. Subtract this amount from each measurement and calculate the volume in each case.
5. Add half the smallest division to each measurement and calculate the volume in each case.

Conclude and Apply

1. What difficulties did you encounter while measuring? How did you overcome them?
2. Use the measurement of the diameter to calculate what the circumference should be. How does that compare with the measurement you had for circumference?
3. Which measuring tool gave the most precise calculation of volume? Why?
4. Which measuring tool do you think was the best for the job? Explain why.

2 Finding Forces

Real-World Question

What forces act on a moving ball?

Possible Materials

- tennis ball
- softball
- plastic baseball
- football
- rubber ball

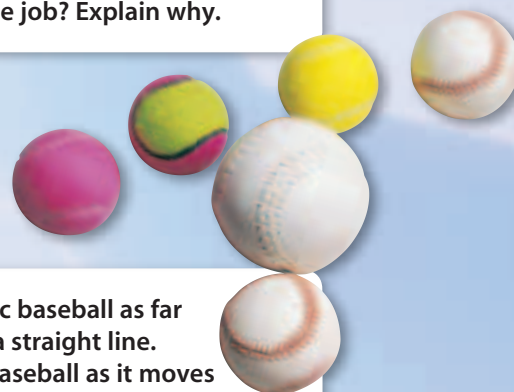
Procedure

1. Go outside and stand in an empty field or lawn where there are no other people, buildings, or cars for 20–30 meters.

2. Throw a plastic baseball as far as you can in a straight line.
3. Observe the baseball as it moves through the air, falls to the ground, and eventually stops.

Conclude and Apply

1. Identify all the forces that acted on the ball from the time you threw it to the time it came to a stop.
2. Infer why baseball batters want the grass of a baseball field cut short.
3. Infer and describe the ball's motion if no outside forces ever acted on it.



3 Look Out Below

Real-World Question

How does an object's mass affect the amount of force it has?

Possible Materials

- aluminum pie pan
- clay
- foam ball
- tennis ball
- baseball
- basketball
- 1-in steel ball-bearing
- metric ruler
- meterstick

Procedure

1. Fill an aluminum pie pan with modeling clay to a depth of 10 cm.
2. Place the pan on a level cement or asphalt surface outside.
3. Measure and record the mass of each ball you will test.
4. Hold the foam ball 2 m above the clay and drop it into the center of the clay.
5. Measure the depth of the crater made by the foam ball in the clay and record it in your Science Journal.
6. Smooth out the clay.
7. Repeat steps 4, 5, and 6 for each ball.

Conclude and Apply

1. Infer what the depth of each crater measures.
2. Compare the crater depth of each ball.
3. Infer the relationship between the mass of each ball and its force.

4 Energy Conversion

Real-World Question

How does energy from solid wax change ice to water?

Possible Materials

- short candle
- matches or lighter
- glass measuring cup
- dry, very cold ice (below 0°C)
- thermometer
- pot
- cooling racks for baked goods

Procedure

1. Set the candle upright in the pot and place the cooling rack on top, resting the rack on the pot. Light the candle. **CAUTION:** Flame will be hot.
2. Transfer the ice straight out of the freezer into the glass measuring cup and set it on the cooling rack directly above the candle. If the ice has started to melt, pat it dry.
3. Note the time and temperature of the water. Record its temperature every minute.

Conclude and Apply

1. List all the energy changes that occur as the candle burns and the ice melts.
2. Graph your temperature data v. time. Mark the changes you listed. How would your graph be different if a Bunsen burner were used instead of a candle? What if a heat lamp were used?
3. The temperature stays at 0°C for a long time before heating up again. Where is the energy from the candle going during this time?

Extra Try at Home Labs

5 Levers that Cut

Real-World Question

What are the ideal mechanical advantages of the scissors in your home?

Possible Materials

- several pairs of scissors
- metric ruler
- sheet of paper
- calculator

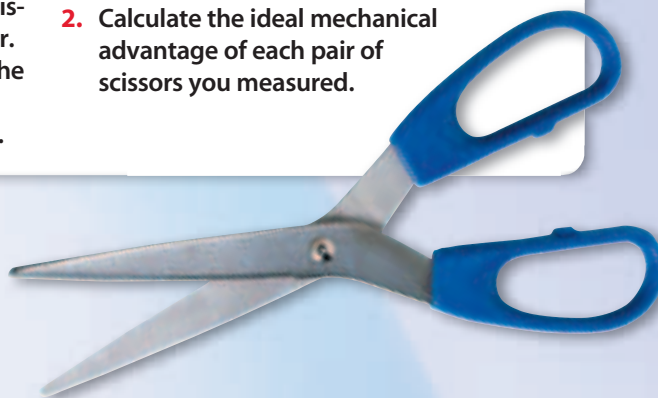
Procedure

1. Open the blades of a pair of scissors wide, insert a sheet of paper, and close the scissors until they just start to cut the paper.
2. Measure the distance from the bolt in the center of the scissors to the spot where the blades are starting to cut the paper.

3. Measure the distance from the bolt in the center of the scissors to the center of the handles.
4. Record your measurements in your Science Journal.
5. Repeat steps 1–3 with several other pairs of scissors.

Conclude and Apply

1. Draw a labeled diagram of a pair of scissors and identify the fulcrum, resistance arm, and effort arm.
2. Calculate the ideal mechanical advantage of each pair of scissors you measured.



6 Ice Melts, Water Cools

Real-World Question

What can a thermometer tell you about water?

Materials

- polystyrene cups (2)
- ice
- thermometer
- lid with a hole for the thermometer
- scale

Procedure

1. Place one cup inside the other and measure their mass.
2. Half fill the inner cup with water and determine the water's mass and temperature.
3. Pat the ice dry if necessary. Measure its mass.
4. Put the ice in the water and place the lid on the cup. When the ice has almost melted, insert the thermometer through the hole in the lid and measure the water's temperature. Record the lowest temperature of the water.

5. The heat gained by the ice is lost by the water. Use the equation $m_{ice} \times 335 \text{ J/g} = m_{water} \times (t_f - t_i) \times c_{water}$ to calculate the specific heat capacity of water.
6. Try the experiment again with heated water.

Conclude and Apply

1. Should you get the same result for c if you start with ice and water at different temperatures than your original trial? Explain. Try to experiment with this if you have time.
2. Why is the lid important?
3. List sources of experimental error. What would you do differently next time?

7 Glowing Bulbs

Real-World Question

How can you make a lightbulb glow without plugging it into an outlet?

Possible Materials

- fluorescent bulb
- soft wool fabric
- silk fabric
- flannel fabric
- flashlight

Procedure

1. Turn the flashlight on and carry your materials into a completely dark room, such as a closet or bedroom with thick curtains.

2. Hold a fluorescent bulb and soft wool in one hand. Turn off the flashlight. Place the wool in your other hand and rub the wool vigorously against the bulb. Observe any change in the bulb. Put down the wool and turn on the flashlight.
3. Repeat step 2 using the silk fabric, and then the flannel fabric.

Conclude and Apply

1. Describe how the fluorescent bulb changed when you rubbed it with each cloth.
2. Identify the type of fabric that caused the greatest change.

8 Magnetic Attraction

Real-World Question

What things in your home are magnetic?

Possible Materials

- refrigerator door magnet
- bar magnet
- horseshoe magnet

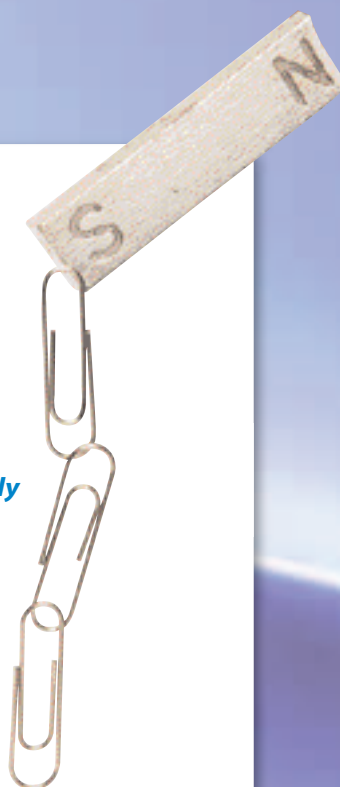
Procedure

1. Obtain a magnet from your refrigerator door, hobby shop, or science store.
2. Test a wide variety of items in your home to find out what materials are magnetic. To test an object, simply hold the magnet against it and observe whether or not the magnet attaches to it.
3. Test materials in your home including tools, kitchen food cans, aluminum foil, bolts, screws, appliances, lamps, bicycles, car parts, and anything else you can think of.

4. Record all the magnetic objects you find in your Science Journal.
5. Research what the magnetic objects found in your home are made of.

Conclude and Apply

1. List the things you tested and found to be magnetic.
2. Infer what types of materials are magnetic.



9 Energy Graphs

Real-World Question

How much energy does the United States use compared to the rest of the world?

Possible Materials

- calculator
- colored pencils
- white paper
- metric ruler
- compass and pencil

Procedure

1. Study the energy consumption chart.
2. Use the data to make a bar graph of the oil consumption of the countries in the chart.

3. Construct a circle graph showing the total energy consumption of the countries in the chart.

Conclude and Apply

1. Calculate the percentage of the world's oil that the USA uses.
2. Calculate the percentage of the world's total energy the USA uses.
3. The population of the United States is 290,300,000, and the world population is 6,300,000,000. Calculate what percentage of the world's population is made up of the U.S. population.

2002 Energy Consumption (Equivalent of Millions of Metric Tons of Oil)

	Oil	Natural Gas	Coal	Hydroelectric	Nuclear	Total Energy Use
USA	894.3	600.7	553.8	58.2	185.8	2,293.0
China	245.7	27.0	663.4	55.8	5.9	997.8
Russia	122.9	349.6	98.5	37.2	32.0	640.2
Japan	242.6	69.7	105.3	20.5	71.3	509.4
Germany	127.2	74.3	84.6	5.9	37.5	329.4
Rest of the world	1,889.9	1,160.7	892.3	414.5	278.3	4,635.2

10 Measuring Refraction

Real-World Question

Do some liquids refract light more than others?

Possible Materials

- glasses (3)
- straws or pencils (3)
- water
- white vinegar
- vegetable oil
- metric ruler or protractor

Procedure

1. Pour 300 mL of water into a glass, 300 mL of vinegar into a second glass, and 300 mL of vegetable oil into a third glass.

2. Place a straw into each glass so that each straw is resting at the same angle.
3. Set the glasses side by side, view them from eye level, and observe the angle of refraction caused by each liquid.
4. Use a metric ruler or protractor to measure the refraction caused by the water, vinegar, and oil.

Conclude and Apply

1. List the amount of refraction created by each liquid.
2. Define *refraction*.

11 It Sounds Different

Real-World Question

How do sounds change when heard through different mediums?

Possible Materials

- wood block
- water
- balloon
- ticking watch

Procedure

1. Hold a wood block next to your ear and have a partner hold a ticking watch next to the block. Note the sound of the watch through the wood.
2. Blow up a balloon and hold the balloon next to your ear. Have a friend hold the ticking watch against the other side of the balloon and note the sound of the watch through the air in the balloon.

3. Fill the balloon with water and securely tie its neck. Hold the water balloon next to your ear and have a partner hold the ticking watch against the other side of the balloon. Note the sound of the watch through the water in the balloon.

Conclude and Apply

1. Compare the sound of the watch when it traveled through the three different mediums.
2. Infer why the watch sounded different in the different mediums.

12 Electromagnetic Waves

Real-World Question

How do polarized sunglasses stop electromagnetic waves and prevent glare?

Possible Materials

- 2 sets of polarized sunglasses (or one set, broken in half)

Procedure

1. On a sunny day, observe the bright glare from a shiny object without sunglasses.
2. Now close one eye and use the other to look through the polarized lens. Hold the lens in front of your eye, then turn it a quarter turn. Record your observations of how the electromagnetic rays of the sunlight changed in each case.

3. Hold one lens in front of another. Look through both lenses at the shiny object and slowly rotate one lens. Record your observations of what happened to the light.

Conclude and Apply

1. Describe what happened to the sunlight glare when you looked through the double lenses of the glasses and rotated them.
2. Why do you think the brightness is different when holding the glasses horizontally and vertically?
3. Infer how polarized sunglasses block electromagnetic energy from the Sun.

Extra Try at Home Labs

13 Light Show

Real-World Question

What does light look like when it passes through different materials?

Possible Materials

- aluminum foil
- wax paper
- clear plastic wrap
- flashlight

Procedure

1. Have a partner hold a 30-cm $\times$ 30-cm square of plastic wrap about 30 cm from a white wall.
2. Darken the room and shine a flashlight through the plastic wrap. Observe the amount of light that passes through the wrap and shines on the wall. Be sure to keep the flashlight location constant.



3. Hold a 30-cm $\times$ 30-cm square of aluminum foil in front of the wall, darken the room, and shine the light on the foil. Observe what happens to the light.
4. Hold a 30-cm $\times$ 30-cm square of wax paper in front of the wall, darken the room, and shine the light on the paper. Observe the amount of light that strikes the wall.
5. Repeat step 4 after folding the wax paper once, then twice, and then several times.

Conclude and Apply

1. Describe your observations of the light when you shined it on the different materials.
2. Identify translucent materials in your home that are used to partially block light.

14 Mirror, Mirror on the Car

Real-World Question

Why are car side-view mirrors convex mirrors?

Possible Materials

- plane mirror
- tennis balls, cans, or other objects (15)
- meterstick

Procedure

1. Measure a distance of 10 m directly behind your family car. Be certain you are not walking into traffic. (If you do not have access to a car, set up chairs and mirrors to simulate where they are positioned in a car.)
2. Line up 15 objects behind the car. The objects should be perpendicular to the car and about 0.5 m apart. Place the first object in line with the back bumper and line up the other objects so that they extend beyond the rear side view of the driver.

3. Sit in the driver's seat, with a parent or guardian present, and look in the side view mirror. Count the number of objects you can see.
4. Sit in the same position and have a partner place a plane mirror over the side-view mirror. Count the number of objects you can see.

Conclude and Apply

1. Compare the number of objects you saw in the convex, side-view mirror with the number of objects you saw in the plane mirror.
2. Infer why convex mirrors are used for side view mirrors on cars.



15 Lemon Clean

Real-World Question

What chemical changes happen to coins?

Possible Materials

- lemon
- paring knife
- tarnished penny
- tarnished nickel
- tarnished dime
- tarnished quarter
- metric ruler

Procedure

1. Cut a slit in a lemon 1 cm wide and 1 cm deep. Insert a tarnished penny halfway into the slit.
2. On the same side of the lemon, repeat step 1 for the nickel and the dime.
3. Cut a 1.5 cm wide and 1.5 cm deep slit on the same side of the lemon and insert the quarter halfway into the slit.
4. Leave the coins in the lemon for two days before removing them. Observe the chemical change that happened to the sides of the coins that were in the lemon.

Conclude and Apply

1. Describe the change that happened to the coins.
2. Infer why this change happened.

16 Overflowing Ice

Real-World Question

What happens to water when it freezes?

Possible Materials

- plastic drink bottle
- plate
- water
- freezer

Procedure

1. Fill a clean, plastic drink bottle with water. The water should come to the top brim of the bottle.
2. Place a plate in a freezer. Be certain the plate is level and not tilted to one side.
3. Carefully place the bottle on the plate without spilling any of the water. If water spills, refill the bottle.
4. Leave the bottle in the freezer overnight and observe the ice that forms the next day.

Conclude and Apply

1. Describe what the ice looks like.
2. Infer why the ice formed this way.
3. Infer how the results of your experiment would be different if you had used rubbing alcohol instead of water. *Hint: Look up the freezing point of rubbing alcohol.*



Extra Try at Home Labs

17 How big is an atom?

 Real-World Question

If an atom's nucleus were as big as the head of a pin, how far away would the nearest electron be?

Possible Materials

- pins
- measuring tapes
- outdoor playing field
- masking or duct tape

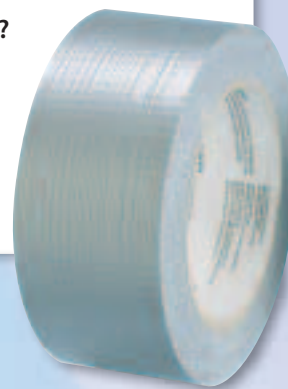
 Procedure

1. The diameter of an atom's nucleus is about 1×10^{-15} m. The orbit of an electron is about 1×10^{-10} m. Calculate how big the orbit would be if the nucleus were the size of the head of a pin (about 0.0001 m).

2. Put your pin through a piece of tape so you can find it later. Measure out the distance to the first electron, and mark the spot with a second pin and tape.

 Conclude and Apply

1. Earth orbits the Sun at about 150 million km. This is 214 times the Sun's radius. How many km away would Earth orbit the Sun, if it were on the same scale as an atom's first electron?
2. How many times the nucleus' radius is the orbit of an electron?



18 Get a Half-life

 Real-World Question

How would you determine the half-life of a radioactive substance?

Possible Materials

- pennies (200)
- shoe box

 Procedure

1. To model the half-life of 200 atoms of a radioactive substance, place 200 pennies in a shoe box, with the "heads" side up.
2. Close the shoe box and shake it for 3 s.
3. Open the shoe box, shift the pennies around until they are all flat, and remove all pennies that are now "tails" side up. Record the number of pennies that you removed from the box and the number of pennies that are left in the box.

4. Repeat steps 2 and 3 until all pennies are removed from the box or you have done this process ten times. Record each shake-and-remove step as increments of 3 s—3 s, 6 s, 9 s, etc. This is the time interval.
5. Graph the data as number of pennies left versus time.

 Conclude and Apply

1. According to the graph, how much decay (shaking) time was required for half of your atoms (pennies) to decay (go "tails" up)?
2. If you increased the number of atoms (pennies), would your results change?
3. How would you define the term *half-life*? How would you measure half-life?

19 Mining for Metals

 Real-World Question

How do miners get metal from ore?

Possible Materials

- potato chips
- rolling pin or heavy book
- plastic bags (2)
- water
- hotplate, kettle, or stove
- tea leaf strainer, flour sifter, or other mesh device

 Procedure

1. Pretend that the potato chips represent ore taken from the ground, and the fat represents a metal compound.

2. Research the mining process and develop a procedure to process the "ore" to refine the "metal."

 Conclude and Apply

1. Were you satisfied with your procedure and results? What could you do better next time?
2. How does your procedure compare to the real mining process?

20 Disappearing Peanuts

 Real-World Question

How can you observe chemical bonds breaking?

Possible Materials 

- polystyrene packing peanuts or polystyrene cups
- acetone fingernail polish remover
- glass jar or shallow dish
- measuring cup

 Procedure

1. Work in a well-ventilated area.
2. Pour 30 mL of acetone into a glass jar or shallow dish.

3. Drop a polystyrene packing peanut into the acetone and observe how the polystyrene and acetone react.
4. Drop several peanuts into the acetone and observe what happens to them.
5. Drop a handful of peanuts into the acetone so that they stack up above the liquid observe the reaction that occurs.

 Conclude and Apply

1. Describe what happened to the polystyrene peanuts.
2. Infer why this happened to the peanuts.

Extra Try at Home Labs

21 Balanced Reactions

Real-World Question

What would a balanced chemical reaction look like, in terms of atoms and molecules?

Possible Materials

- round fruit (grapes, oranges, apples), marshmallows, foam balls, or any other suitable objects to represent atoms
- sharp toothpicks or straightened paper clips to represent bonds

Procedure

1. Look through the chapter to find two examples of chemical reactions. Balance the equations, if necessary.
2. Make a key for your modeling set. For example, grape = carbon, marshmallow = oxygen, apple = magnesium.

3. Model each balanced chemical reaction that you have written down by bonding the "atoms" together with toothpicks or straightened paper clips to make the reactants. Sketch what you have modeled.
4. Using only the atoms from the reactants, break bonds and make new bonds to form the products. Sketch what you have modeled.

Conclude and Apply

1. How do you know that the law of conservation of mass is followed in the reactions you modeled?
2. What would you do to fix a reaction that did not follow the conservation of mass?
3. What is the evidence that a reaction has occurred?

22 Sticky Solution

Real-World Question

How can heat change a solution?

Possible Materials

- cornstarch
- pot
- kitchen stove or hotplate
- glass
- measuring cup
- tablespoon
- wooden spoon
- oven mitt

Procedure

1. Pour 300 mL of water into a clean glass.
2. Add a tablespoon of cornstarch to the water and stir the water until a solution is formed. Observe what the solution looks like.

3. Pour your solution into a pot and boil the solution over a hotplate or stove-top burner.
4. Once the solution is boiling, stir it with a wooden spoon.
5. Boil the solution for 2 min and observe how the solution changes.

Conclude and Apply

1. Describe the water and cornstarch solution before it boiled.
2. Describe how heat changed the water and cornstarch solution.

23 Kitchen Indicator

 Real-World Question

How many pHs can you measure around your home?

Possible Materials

- purple cabbage
- water
- pot
- hotplate or stove
- knife
- several clear glasses
- spoons
- baking soda, juice, soda, vinegar, and milk

 Procedure

1. Chop up the purple cabbage and put it in the pot. Boil it until the water turns purple.
2. Discard the cabbage, but keep the water.

3. Add a spoonful of the cabbage water to a spoonful of each household substance you plan to test. What color is the mixture? (The color change indicates if the substance is acidic or basic. If the color is red or pink, the substance is an acid. If the color is blue, green, or yellow, it is a base.)
4. Record your colors on a chart.
5. Ask an adult to select other substances for you to test. By adding more of the acidic and basic substances, you can get several interesting colors from this indicator.

 Conclude and Apply

How can you prove that vinegar is between drinking soda and baking soda on the pH scale by using the cabbage indicator?

24 Organic Bonding

 Real-World Question

How can you and your family represent organic bonding?

Possible Materials

- family members or friends
- large construction paper rings
- pins or tape

 Procedure

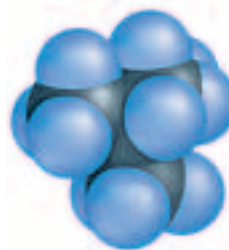
1. You are a carbon atom. Each of your arms and legs is a place for a bond. Link the paper rings to your arms or legs to represent the correct number of hydrogen atoms.
2. Get together with friends to form ethane, propane, butane, and isobutane.
3. With five friends, make a benzene ring. To make a double bond, touch a neighbor's foot with yours while holding his or her hand. Make a single bond with your other neighbor by holding hands.

4. After forming each molecule, try to move from one side of the room to the other. Which molecules twist and bend easily, and which don't? Make a table of your observations.

 Conclude and Apply

1. Use your observations to explain why the boiling point of hydrocarbons increases with the number of carbon atoms.
2. Use your observations to explain why benzene is so stable.
3. How many people would you need to form a protein molecule? Are there enough students in your school?

Isobutane



25 Quick Dry

Real-World Question

Do synthetic fibers dry more quickly than natural fibers?

Possible Materials

- measuring cup
- drinking glasses (4)
- water
- 3-cm × 3-cm squares of:
 - cotton cloth
 - wool cloth
 - polyester cloth
 - nylon cloth

Procedure

1. Pour 400 mL of water into each of the four glasses.

2. Submerge a square of fabric in each beaker and soak the squares for 3 min.
3. Remove the fabric squares, lay them flat on several layers of paper towels, and place them in direct sunlight.
4. Check the dampness of each cloth square every 3 min for 15 min.

Conclude and Apply

1. Describe the results of your activity.
2. Infer why athletes wear polyester or nylon clothing.

Computer Skills

People who study science rely on computers, like the one in **Figure 16**, to record and store data and to analyze results from investigations. Whether you work in a laboratory or just need to write a lab report with tables, good computer skills are a necessity.

Using the computer comes with responsibility. Issues of ownership, security, and privacy can arise. Remember, if you did not author the information you are using, you must provide a source for your information. Also, anything on a computer can be accessed by others. Do not put anything on the computer that you would not want everyone to know. To add more security to your work, use a password.

Use a Word Processing Program

A computer program that allows you to type your information, change it as many times as you need to, and then print it out is called a word processing program. Word processing programs also can be used to make tables.



Figure 16 A computer will make reports neater and more professional looking.

Learn the Skill To start your word processing program, a blank document, sometimes called “Document 1,” appears on the screen. To begin, start typing. To create a new document, click the *New* button on the standard tool bar. These tips will help you format the document.

- The program will automatically move to the next line; press *Enter* if you wish to start a new paragraph.
- Symbols, called non-printing characters, can be hidden by clicking the *Show/Hide* button on your toolbar.
- To insert text, move the cursor to the point where you want the insertion to go, click on the mouse once, and type the text.
- To move several lines of text, select the text and click the *Cut* button on your toolbar. Then position your cursor in the location that you want to move the cut text and click *Paste*. If you move to the wrong place, click *Undo*.
- The spell check feature does not catch words that are misspelled to look like other words, like “cold” instead of “gold.” Always reread your document to catch all spelling mistakes.
- To learn about other word processing methods, read the user’s manual or click on the *Help* button.
- You can integrate databases, graphics, and spreadsheets into documents by copying from another program and pasting it into your document, or by using desktop publishing (DTP). DTP software allows you to put text and graphics together to finish your document with a professional look. This software varies in how it is used and its capabilities.

Use a Database

A collection of facts stored in a computer and sorted into different fields is called a database. A database can be reorganized in any way that suits your needs.

Learn the Skill A computer program that allows you to create your own database is a database management system (DBMS). It allows you to add, delete, or change information. Take time to get to know the features of your database software.

- Determine what facts you would like to include and research to collect your information.
- Determine how you want to organize the information.
- Follow the instructions for your particular DBMS to set up fields. Then enter each item of data in the appropriate field.
- Follow the instructions to sort the information in order of importance.
- Evaluate the information in your database, and add, delete, or change as necessary.

Use the Internet

The Internet is a global network of computers where information is stored and shared. To use the Internet, like the students in **Figure 17**, you need a modem to connect your computer to a phone line and an Internet Service Provider account.

Learn the Skill To access internet sites and information, use a “Web browser,” which lets you view and explore pages on the World Wide Web. Each page is its own site, and each site has its own address, called a URL. Once you have found a Web browser, follow these steps for a search (this also is how you search a database).



Figure 17 The Internet allows you to search a global network for a variety of information.

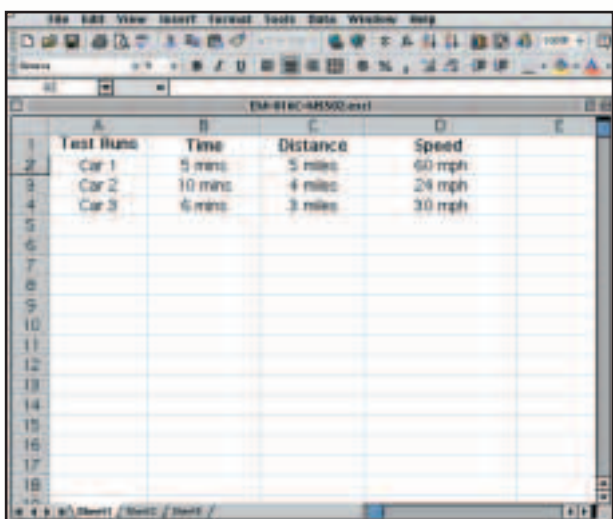
- Be as specific as possible. If you know you want to research “gold,” don’t type in “elements.” Keep narrowing your search until you find what you want.
- Web sites that end in *.com* are commercial Web sites; *.org*, *.edu*, and *.gov* are non-profit, educational, or government Web sites.
- Electronic encyclopedias, almanacs, indexes, and catalogs will help locate and select relevant information.
- Develop a “home page” with relative ease. When developing a Web site, NEVER post pictures or disclose personal information such as location, names, or phone numbers. Your school or community usually can host your Web site. A basic understanding of HTML (hypertext mark-up language), the language of Web sites, is necessary. Software that creates HTML code is called authoring software, and can be downloaded free from many Web sites. This software allows text and pictures to be arranged as the software is writing the HTML code.

Use a Spreadsheet

A spreadsheet, shown in **Figure 18**, can perform mathematical functions with any data arranged in columns and rows. By entering a simple equation into a cell, the program can perform operations in specific cells, rows, or columns.

Learn the Skill Each column (vertical) is assigned a letter, and each row (horizontal) is assigned a number. Each point where a row and column intersect is called a cell, and is labeled according to where it is located—Column A, Row 1 (A1).

- Decide how to organize the data, and enter it in the correct row or column.
- Spreadsheets can use standard formulas or formulas can be customized to calculate cells.
- To make a change, click on a cell to make it activate, and enter the edited data or formula.
- Spreadsheets also can display your results in graphs. Choose the style of graph that best represents the data.



	A	B	C	D
1	Test Runs	Time	Distance	Speed
2	Car 1	5 mins	5 miles	60 mph
3	Car 2	10 mins	4 miles	24 mph
4	Car 3	6 mins	3 miles	30 mph
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

Figure 18 A spreadsheet allows you to perform mathematical operations on your data.

Use Graphics Software

Adding pictures, called graphics, to your documents is one way to make your documents more meaningful and exciting. This software adds, edits, and even constructs graphics. There is a variety of graphics software programs. The tools used for drawing can be a mouse, keyboard, or other specialized devices. Some graphics programs are simple. Others are complicated, called computer-aided design (CAD) software.

Learn the Skill It is important to have an understanding of the graphics software being used before starting. The better the software is understood, the better the results. The graphics can be placed in a word-processing document.

- Clip art can be found on a variety of internet sites, and on CDs. These images can be copied and pasted into your document.
- When beginning, try editing existing drawings, then work up to creating drawings.
- The images are made of tiny rectangles of color called pixels. Each pixel can be altered.
- Digital photography is another way to add images. The photographs in the memory of a digital camera can be downloaded into a computer, then edited and added to the document.
- Graphics software also can allow animation. The software allows drawings to have the appearance of movement by connecting basic drawings automatically. This is called in-betweening, or tweening.
- Remember to save often.

Presentation Skills

Develop Multimedia Presentations

Most presentations are more dynamic if they include diagrams, photographs, videos, or sound recordings, like the one shown in **Figure 19**. A multimedia presentation involves using stereos, overhead projectors, televisions, computers, and more.

Learn the Skill Decide the main points of your presentation, and what types of media would best illustrate those points.

- Make sure you know how to use the equipment you are working with.
- Practice the presentation using the equipment several times.
- Enlist the help of a classmate to push play or turn lights out for you. Be sure to practice your presentation with him or her.
- If possible, set up all of the equipment ahead of time, and make sure everything is working properly.



Figure 19 These students are engaging the audience using a variety of tools.

Computer Presentations

There are many different interactive computer programs that you can use to enhance your presentation. Most computers have a compact disc (CD) drive that can play both CDs and digital video discs (DVDs). Also, there is hardware to connect a regular CD, DVD, or VCR. These tools will enhance your presentation.

Another method of using the computer to aid in your presentation is to develop a slide show using a computer program. This can allow movement of visuals at the presenter's pace, and can allow for visuals to build on one another.

Learn the Skill In order to create multimedia presentations on a computer, you need to have certain tools. These may include traditional graphic tools and drawing programs, animation programs, and authoring systems that tie everything together. Your computer will tell you which tools it supports. The most important step is to learn about the tools that you will be using.

- Often, color and strong images will convey a point better than words alone. Use the best methods available to convey your point.
- As with other presentations, practice many times.
- Practice your presentation with the tools you and any assistants will be using.
- Maintain eye contact with the audience. The purpose of using the computer is not to prompt the presenter, but to help the audience understand the points of the presentation.

Math Review

Use Fractions

A fraction compares a part to a whole. In the fraction $\frac{2}{3}$, the 2 represents the part and is the numerator. The 3 represents the whole and is the denominator.

Reduce Fractions To reduce a fraction, you must find the largest factor that is common to both the numerator and the denominator, the greatest common factor (GCF). Divide both numbers by the GCF. The fraction has then been reduced, or it is in its simplest form.

Example Twelve of the 20 chemicals in the science lab are in powder form. What fraction of the chemicals used in the lab are in powder form?

Step 1 Write the fraction.

$$\frac{\text{part}}{\text{whole}} = \frac{12}{20}$$

Step 2 To find the GCF of the numerator and denominator, list all of the factors of each number.

Factors of 12: 1, 2, 3, 4, 6, 12 (the numbers that divide evenly into 12)

Factors of 20: 1, 2, 4, 5, 10, 20 (the numbers that divide evenly into 20)

Step 3 List the common factors.

1, 2, 4.

Step 4 Choose the greatest factor in the list.

The GCF of 12 and 20 is 4.

Step 5 Divide the numerator and denominator by the GCF.

$$\frac{12 \div 4}{20 \div 4} = \frac{3}{5}$$

In the lab, $\frac{3}{5}$ of the chemicals are in powder form.

Practice Problem At an amusement park, 66 of 90 rides have a height restriction. What fraction of the rides, in its simplest form, has a height restriction?

Add and Subtract Fractions To add or subtract fractions with the same denominator, add or subtract the numerators and write the sum or difference over the denominator. After finding the sum or difference, find the simplest form for your fraction.

Example 1 In the forest outside your house, $\frac{1}{8}$ of the animals are rabbits, $\frac{3}{8}$ are squirrels, and the remainder are birds and insects. How many are mammals?

Step 1 Add the numerators.

$$\frac{1}{8} + \frac{3}{8} = \frac{(1 + 3)}{8} = \frac{4}{8}$$

Step 2 Find the GCF.

$$\frac{4}{8} \text{ (GCF, 4)}$$

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{4}{4} = 1, \frac{8}{4} = 2$$

$\frac{1}{2}$ of the animals are mammals.

Example 2 If $\frac{7}{16}$ of the Earth is covered by freshwater, and $\frac{1}{16}$ of that is in glaciers, how much freshwater is not frozen?

Step 1 Subtract the numerators.

$$\frac{7}{16} - \frac{1}{16} = \frac{(7 - 1)}{16} = \frac{6}{16}$$

Step 2 Find the GCF.

$$\frac{6}{16} \text{ (GCF, 2)}$$

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{6}{2} = 3, \frac{16}{2} = 8$$

$\frac{3}{8}$ of the freshwater is not frozen.

Practice Problem A bicycle rider is going 15 km/h for $\frac{4}{9}$ of his ride, 10 km/h for $\frac{2}{9}$ of his ride, and 8 km/h for the remainder of the ride. How much of his ride is he going over 8 km/h?

Unlike Denominators To add or subtract fractions with unlike denominators, first find the least common denominator (LCD). This is the smallest number that is a common multiple of both denominators. Rename each fraction with the LCD, and then add or subtract. Find the simplest form if necessary.

Example 1 A chemist makes a paste that is $\frac{1}{2}$ table salt (NaCl), $\frac{1}{3}$ sugar ($C_6H_{12}O_6$), and the rest water (H_2O). How much of the paste is a solid?

Step 1 Find the LCD of the fractions.

$$\frac{1}{2} + \frac{1}{3} \quad (\text{LCD}, 6)$$

Step 2 Rename each numerator and each denominator with the LCD.

$$1 \times 3 = 3, \quad 2 \times 3 = 6$$

$$1 \times 2 = 2, \quad 3 \times 2 = 6$$

Step 3 Add the numerators.

$$\frac{3}{6} + \frac{2}{6} = \frac{(3 + 2)}{6} = \frac{5}{6}$$

$\frac{5}{6}$ of the paste is a solid.

Example 2 The average precipitation in Grand Junction, CO, is $\frac{7}{10}$ inch in November, and $\frac{3}{5}$ inch in December. What is the total average precipitation?

Step 1 Find the LCD of the fractions.

$$\frac{7}{10} + \frac{3}{5} \quad (\text{LCD}, 10)$$

Step 2 Rename each numerator and each denominator with the LCD.

$$7 \times 1 = 7, \quad 10 \times 1 = 10$$

$$3 \times 2 = 6, \quad 5 \times 2 = 10$$

Step 3 Add the numerators.

$$\frac{7}{10} + \frac{6}{10} = \frac{(7 + 6)}{10} = \frac{13}{10}$$

$\frac{13}{10}$ inches total precipitation, or $1\frac{3}{10}$ inches.

Practice Problem On an electric bill, about $\frac{1}{8}$ of the energy is from solar energy and about $\frac{1}{10}$ is from wind power. How much of the total bill is from solar energy and wind power combined?

Example 3 In your body, $\frac{7}{10}$ of your muscle contractions are involuntary (cardiac and smooth muscle tissue). Smooth muscle makes $\frac{3}{15}$ of your muscle contractions. How many of your muscle contractions are made by cardiac muscle?

Step 1 Find the LCD of the fractions.

$$\frac{7}{10} - \frac{3}{15} \quad (\text{LCD}, 30)$$

Step 2 Rename each numerator and each denominator with the LCD.

$$7 \times 3 = 21, \quad 10 \times 3 = 30$$

$$3 \times 2 = 6, \quad 15 \times 2 = 30$$

Step 3 Subtract the numerators.

$$\frac{21}{30} - \frac{6}{30} = \frac{(21 - 6)}{30} = \frac{15}{30}$$

Step 4 Find the GCF.

$$\frac{15}{30} \quad (\text{GCF}, 15)$$

$$\frac{1}{2}$$

$\frac{1}{2}$ of all muscle contractions are cardiac muscle.

Example 4 Tony wants to make cookies that call for $\frac{3}{4}$ of a cup of flour, but he only has $\frac{1}{3}$ of a cup. How much more flour does he need?

Step 1 Find the LCD of the fractions.

$$\frac{3}{4} - \frac{1}{3} \quad (\text{LCD}, 12)$$

Step 2 Rename each numerator and each denominator with the LCD.

$$3 \times 3 = 9, \quad 4 \times 3 = 12$$

$$1 \times 4 = 4, \quad 3 \times 4 = 12$$

Step 3 Subtract the numerators.

$$\frac{9}{12} - \frac{4}{12} = \frac{(9 - 4)}{12} = \frac{5}{12}$$

$\frac{5}{12}$ of a cup of flour.

Practice Problem Using the information provided to you in Example 3 above, determine how many muscle contractions are voluntary (skeletal muscle).

Multiply Fractions To multiply with fractions, multiply the numerators and multiply the denominators. Find the simplest form if necessary.

Example Multiply $\frac{3}{5}$ by $\frac{1}{3}$.

Step 1 Multiply the numerators and denominators.

$$\frac{3}{5} \times \frac{1}{3} = \frac{(3 \times 1)}{(5 \times 3)} = \frac{3}{15}$$

Step 2 Find the GCF.

$$\frac{3}{15} \text{ (GCF, 3)}$$

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \quad \frac{15}{3} = 5$$

$$\frac{1}{5}$$

$\frac{3}{5}$ multiplied by $\frac{1}{3}$ is $\frac{1}{5}$.

Practice Problem Multiply $\frac{3}{14}$ by $\frac{5}{16}$.

Find a Reciprocal Two numbers whose product is 1 are called multiplicative inverses, or reciprocals.

Example Find the reciprocal of $\frac{3}{8}$.

Step 1 Inverse the fraction by putting the denominator on top and the numerator on the bottom.

$$\frac{8}{3}$$

The reciprocal of $\frac{3}{8}$ is $\frac{8}{3}$.

Practice Problem Find the reciprocal of $\frac{4}{9}$.

Divide Fractions To divide one fraction by another fraction, multiply the dividend by the reciprocal of the divisor. Find the simplest form if necessary.

Example 1 Divide $\frac{1}{9}$ by $\frac{1}{3}$.

Step 1 Find the reciprocal of the divisor.

The reciprocal of $\frac{1}{3}$ is $\frac{3}{1}$.

Step 2 Multiply the dividend by the reciprocal of the divisor.

$$\frac{\frac{1}{9}}{\frac{1}{3}} = \frac{1}{9} \times \frac{3}{1} = \frac{(1 \times 3)}{(9 \times 1)} = \frac{3}{9}$$

Step 3 Find the GCF.

$$\frac{3}{9} \text{ (GCF, 3)}$$

Step 4 Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \quad \frac{9}{3} = 3$$

$$\frac{1}{3}$$

$\frac{1}{9}$ divided by $\frac{1}{3}$ is $\frac{1}{3}$.

Example 2 Divide $\frac{3}{5}$ by $\frac{1}{4}$.

Step 1 Find the reciprocal of the divisor.

The reciprocal of $\frac{1}{4}$ is $\frac{4}{1}$.

Step 2 Multiply the dividend by the reciprocal of the divisor.

$$\frac{\frac{3}{5}}{\frac{1}{4}} = \frac{3}{5} \times \frac{4}{1} = \frac{(3 \times 4)}{(5 \times 1)} = \frac{12}{5}$$

$\frac{3}{5}$ divided by $\frac{1}{4}$ is $\frac{12}{5}$ or $2\frac{2}{5}$.

Practice Problem Divide $\frac{3}{11}$ by $\frac{7}{10}$.

Use Ratios

When you compare two numbers by division, you are using a ratio. Ratios can be written 3 to 5, 3:5, or $\frac{3}{5}$. Ratios, like fractions, also can be written in simplest form.

Ratios can represent probabilities, also called odds. This is a ratio that compares the number of ways a certain outcome occurs to the number of outcomes. For example, if you flip a coin 100 times, what are the odds that it will come up heads? There are two possible outcomes, heads or tails, so the odds of coming up heads are 50:100. Another way to say this is that 50 out of 100 times the coin will come up heads. In its simplest form, the ratio is 1:2.

Example 1 A chemical solution contains 40 g of salt and 64 g of baking soda. What is the ratio of salt to baking soda as a fraction in simplest form?

Step 1 Write the ratio as a fraction.

$$\frac{\text{salt}}{\text{baking soda}} = \frac{40}{64}$$

Step 2 Express the fraction in simplest form.

The GCF of 40 and 64 is 8.

$$\frac{40}{64} = \frac{40 \div 8}{64 \div 8} = \frac{5}{8}$$

The ratio of salt to baking soda in the sample is 5:8.

Example 2 Sean rolls a 6-sided die 6 times. What are the odds that the side with a 3 will show?

Step 1 Write the ratio as a fraction.

$$\frac{\text{number of sides with a 3}}{\text{number of sides}} = \frac{1}{6}$$

Step 2 Multiply by the number of attempts.

$$\frac{1}{6} \times 6 \text{ attempts} = \frac{6}{6} \text{ attempts} = 1 \text{ attempt}$$

1 attempt out of 6 will show a 3.

Practice Problem Two metal rods measure 100 cm and 144 cm in length. What is the ratio of their lengths in simplest form?

Use Decimals

A fraction with a denominator that is a power of ten can be written as a decimal. For example, 0.27 means $\frac{27}{100}$. The decimal point separates the ones place from the tenths place.

Any fraction can be written as a decimal using division. For example, the fraction $\frac{5}{8}$ can be written as a decimal by dividing 5 by 8. Written as a decimal, it is 0.625.

Add or Subtract Decimals When adding and subtracting decimals, line up the decimal points before carrying out the operation.

Example 1 Find the sum of 47.68 and 7.80.

Step 1 Line up the decimal places when you write the numbers.

$$\begin{array}{r} 47.68 \\ + 7.80 \\ \hline \end{array}$$

Step 2 Add the decimals.

$$\begin{array}{r} 47.68 \\ + 7.80 \\ \hline 55.48 \end{array}$$

The sum of 47.68 and 7.80 is 55.48.

Example 2 Find the difference of 42.17 and 15.85.

Step 1 Line up the decimal places when you write the number.

$$\begin{array}{r} 42.17 \\ - 15.85 \\ \hline \end{array}$$

Step 2 Subtract the decimals.

$$\begin{array}{r} 42.17 \\ - 15.85 \\ \hline 26.32 \end{array}$$

The difference of 42.17 and 15.85 is 26.32.

Practice Problem Find the sum of 1.245 and 3.842.

Multiply Decimals To multiply decimals, multiply the numbers like any other number, ignoring the decimal point. Count the decimal places in each factor. The product will have the same number of decimal places as the sum of the decimal places in the factors.

Example Multiply 2.4 by 5.9.

Step 1 Multiply the factors like two whole numbers.

$$24 \times 59 = 1416$$

Step 2 Find the sum of the number of decimal places in the factors. Each factor has one decimal place, for a sum of two decimal places.

Step 3 The product will have two decimal places.

$$14.16$$

The product of 2.4 and 5.9 is 14.16.

Practice Problem Multiply 4.6 by 2.2.

Divide Decimals When dividing decimals, change the divisor to a whole number. To do this, multiply both the divisor and the dividend by the same power of ten. Then place the decimal point in the quotient directly above the decimal point in the dividend. Then divide as you do with whole numbers.

Example Divide 8.84 by 3.4.

Step 1 Multiply both factors by 10.

$$3.4 \times 10 = 34, 8.84 \times 10 = 88.4$$

Step 2 Divide 88.4 by 34.

$$\begin{array}{r} 2.6 \\ 34 \overline{)88.4} \\ \underline{-68} \\ 204 \\ \underline{-204} \\ 0 \end{array}$$

8.84 divided by 3.4 is 2.6.

Practice Problem Divide 75.6 by 3.6.

Use Proportions

An equation that shows that two ratios are equivalent is a proportion. The ratios $\frac{2}{4}$ and $\frac{5}{10}$ are equivalent, so they can be written as $\frac{2}{4} = \frac{5}{10}$. This equation is a proportion.

When two ratios form a proportion, the cross products are equal. To find the cross products in the proportion $\frac{2}{4} = \frac{5}{10}$, multiply the 2 and the 10, and the 4 and the 5. Therefore $2 \times 10 = 4 \times 5$, or $20 = 20$.

Because you know that both proportions are equal, you can use cross products to find a missing term in a proportion. This is known as solving the proportion.

Example The heights of a tree and a pole are proportional to the lengths of their shadows. The tree casts a shadow of 24 m when a 6-m pole casts a shadow of 4 m. What is the height of the tree?

Step 1 Write a proportion.

$$\frac{\text{height of tree}}{\text{height of pole}} = \frac{\text{length of tree's shadow}}{\text{length of pole's shadow}}$$

Step 2 Substitute the known values into the proportion. Let h represent the unknown value, the height of the tree.

$$\frac{h}{6} = \frac{24}{4}$$

Step 3 Find the cross products.

$$h \times 4 = 6 \times 24$$

Step 4 Simplify the equation.

$$4h = 144$$

Step 5 Divide each side by 4.

$$\begin{array}{l} \frac{4h}{4} = \frac{144}{4} \\ h = 36 \end{array}$$

The height of the tree is 36 m.

Practice Problem The ratios of the weights of two objects on the Moon and on Earth are in proportion. A rock weighing 3 N on the Moon weighs 18 N on Earth. How much would a rock that weighs 5 N on the Moon weigh on Earth?

Use Percentages

The word *percent* means “out of one hundred.” It is a ratio that compares a number to 100. Suppose you read that 77 percent of the Earth’s surface is covered by water. That is the same as reading that the fraction of the Earth’s surface covered by water is $\frac{77}{100}$. To express a fraction as a percent, first find the equivalent decimal for the fraction. Then, multiply the decimal by 100 and add the percent symbol.

Example Express $\frac{13}{20}$ as a percent.

Step 1 Find the equivalent decimal for the fraction.

$$\begin{array}{r} 0.65 \\ 20 \overline{)13.00} \\ \underline{12\ 0} \\ 1\ 00 \\ \underline{1\ 00} \\ 0 \end{array}$$

Step 2 Rewrite the fraction $\frac{13}{20}$ as 0.65.

Step 3 Multiply 0.65 by 100 and add the % sign.

$$0.65 \times 100 = 65 = 65\%$$

$$\text{So, } \frac{13}{20} = 65\%.$$

This also can be solved as a proportion.

Example Express $\frac{13}{20}$ as a percent.

Step 1 Write a proportion.

$$\frac{13}{20} = \frac{x}{100}$$

Step 2 Find the cross products.

$$1300 = 20x$$

Step 3 Divide each side by 20.

$$\begin{array}{l} \frac{1300}{20} = \frac{20x}{20} \\ 65\% = x \end{array}$$

Practice Problem In one year, 73 of 365 days were rainy in one city. What percent of the days in that city were rainy?

Solve One-Step Equations

A statement that two things are equal is an equation. For example, $A = B$ is an equation that states that A is equal to B .

An equation is solved when a variable is replaced with a value that makes both sides of the equation equal. To make both sides equal the inverse operation is used. Addition and subtraction are inverses, and multiplication and division are inverses.

Example 1 Solve the equation $x - 10 = 35$.

Step 1 Find the solution by adding 10 to each side of the equation.

$$\begin{array}{l} x - 10 = 35 \\ x - 10 + 10 = 35 + 10 \\ x = 45 \end{array}$$

Step 2 Check the solution.

$$\begin{array}{l} x - 10 = 35 \\ 45 - 10 = 35 \\ 35 = 35 \end{array}$$

Both sides of the equation are equal, so $x = 45$.

Example 2 In the formula $a = bc$, find the value of c if $a = 20$ and $b = 2$.

Step 1 Rearrange the formula so the unknown value is by itself on one side of the equation by dividing both sides by b .

$$\begin{array}{l} a = bc \\ \frac{a}{b} = \frac{bc}{b} \\ \frac{a}{b} = c \end{array}$$

Step 2 Replace the variables a and b with the values that are given.

$$\begin{array}{l} \frac{a}{b} = c \\ \frac{20}{2} = c \\ 10 = c \end{array}$$

Step 3 Check the solution.

$$\begin{array}{l} a = bc \\ 20 = 2 \times 10 \\ 20 = 20 \end{array}$$

Both sides of the equation are equal, so $c = 10$ is the solution when $a = 20$ and $b = 2$.

Practice Problem In the formula $h = gd$, find the value of d if $g = 12.3$ and $h = 17.4$.

Use Statistics

The branch of mathematics that deals with collecting, analyzing, and presenting data is statistics. In statistics, there are three common ways to summarize data with a single number—the mean, the median, and the mode.

The **mean** of a set of data is the arithmetic average. It is found by adding the numbers in the data set and dividing by the number of items in the set.

The **median** is the middle number in a set of data when the data are arranged in numerical order. If there were an even number of data points, the median would be the mean of the two middle numbers.

The **mode** of a set of data is the number or item that appears most often.

Another number that often is used to describe a set of data is the range. The **range** is the difference between the largest number and the smallest number in a set of data.

A **frequency table** shows how many times each piece of data occurs, usually in a survey. **Table 2** below shows the results of a student survey on favorite color.

Table 2 Student Color Choice		
Color	Tally	Frequency
red		4
blue		5
black		2
green		3
purple		7
yellow		6

Based on the frequency table data, which color is the favorite?

Example The speeds (in m/s) for a race car during five different time trials are 39, 37, 44, 36, and 44.

To find the mean:

Step 1 Find the sum of the numbers.

$$39 + 37 + 44 + 36 + 44 = 200$$

Step 2 Divide the sum by the number of items, which is 5.

$$200 \div 5 = 40$$

The mean is 40 m/s.

To find the median:

Step 1 Arrange the measures from least to greatest.

$$36, 37, 39, 44, 44$$

Step 2 Determine the middle measure.

$$36, 37, \underline{39}, 44, 44$$

The median is 39 m/s.

To find the mode:

Step 1 Group the numbers that are the same together.

$$44, 44, 36, 37, 39$$

Step 2 Determine the number that occurs most in the set.

$$\underline{44}, \underline{44}, 36, 37, 39$$

The mode is 44 m/s.

To find the range:

Step 1 Arrange the measures from largest to smallest.

$$44, 44, 39, 37, 36$$

Step 2 Determine the largest and smallest measures in the set.

$$44, 44, 39, 37, \underline{36}$$

Step 3 Find the difference between the largest and smallest measures.

$$44 - 36 = 8$$

The range is 8 m/s.

Practice Problem Find the mean, median, mode, and range for the data set 8, 4, 12, 8, 11, 14, 16.

Use Geometry

The branch of mathematics that deals with the measurement, properties, and relationships of points, lines, angles, surfaces, and solids is called geometry.

Perimeter The **perimeter** (P) is the distance around a geometric figure. To find the perimeter of a rectangle, add the length and width and multiply that sum by two, or $2(l + w)$. To find perimeters of irregular figures, add the length of the sides.

Example 1 Find the perimeter of a rectangle that is 3 m long and 5 m wide.

Step 1 You know that the perimeter is 2 times the sum of the width and length.

$$P = 2(3 \text{ m} + 5 \text{ m})$$

Step 2 Find the sum of the width and length.

$$P = 2(8 \text{ m})$$

Step 3 Multiply by 2.

$$P = 16 \text{ m}$$

The perimeter is 16 m.

Example 2 Find the perimeter of a shape with sides measuring 2 cm, 5 cm, 6 cm, 3 cm.

Step 1 You know that the perimeter is the sum of all the sides.

$$P = 2 + 5 + 6 + 3$$

Step 2 Find the sum of the sides.

$$P = 2 + 5 + 6 + 3$$

$$P = 16$$

The perimeter is 16 cm.

Practice Problem Find the perimeter of a rectangle with a length of 18 m and a width of 7 m.

Practice Problem Find the perimeter of a triangle measuring 1.6 cm by 2.4 cm by 2.4 cm.

Area of a Rectangle The **area** (A) is the number of square units needed to cover a surface. To find the area of a rectangle, multiply the length times the width, or $l \times w$. When finding area, the units also are multiplied. Area is given in square units.

Example Find the area of a rectangle with a length of 1 cm and a width of 10 cm.

Step 1 You know that the area is the length multiplied by the width.

$$A = (1 \text{ cm} \times 10 \text{ cm})$$

Step 2 Multiply the length by the width. Also multiply the units.

$$A = 10 \text{ cm}^2$$

The area is 10 cm^2 .

Practice Problem Find the area of a square whose sides measure 4 m.

Area of a Triangle To find the area of a triangle, use the formula:

$$A = \frac{1}{2}(\text{base} \times \text{height})$$

The base of a triangle can be any of its sides. The height is the perpendicular distance from a base to the opposite endpoint, or vertex.

Example Find the area of a triangle with a base of 18 m and a height of 7 m.

Step 1 You know that the area is $\frac{1}{2}$ the base times the height.

$$A = \frac{1}{2}(18 \text{ m} \times 7 \text{ m})$$

Step 2 Multiply $\frac{1}{2}$ by the product of 18×7 . Multiply the units.

$$A = \frac{1}{2}(126 \text{ m}^2)$$

$$A = 63 \text{ m}^2$$

The area is 63 m^2 .

Practice Problem Find the area of a triangle with a base of 27 cm and a height of 17 cm.

Circumference of a Circle The **diameter** (d) of a circle is the distance across the circle through its center, and the **radius** (r) is the distance from the center to any point on the circle. The radius is half of the diameter. The distance around the circle is called the **circumference** (C). The formula for finding the circumference is:

$$C = 2\pi r \text{ or } C = \pi d$$

The circumference divided by the diameter is always equal to 3.1415926... This nonterminating and nonrepeating number is represented by the Greek letter π (pi). An approximation often used for π is 3.14.

Example 1 Find the circumference of a circle with a radius of 3 m.

Step 1 You know the formula for the circumference is 2 times the radius times π .

$$C = 2\pi(3)$$

Step 2 Multiply 2 times the radius.

$$C = 6\pi$$

Step 3 Multiply by π .

$$C = 19 \text{ m}$$

The circumference is 19 m.

Example 2 Find the circumference of a circle with a diameter of 24.0 cm.

Step 1 You know the formula for the circumference is the diameter times π .

$$C = \pi(24.0)$$

Step 2 Multiply the diameter by π .

$$C = 75.4 \text{ cm}$$

The circumference is 75.4 cm.

Practice Problem Find the circumference of a circle with a radius of 19 cm.

Area of a Circle The formula for the area of a circle is:

$$A = \pi r^2$$

Example 1 Find the area of a circle with a radius of 4.0 cm.

Step 1 $A = \pi(4.0)^2$

Step 2 Find the square of the radius.

$$A = 16\pi$$

Step 3 Multiply the square of the radius by π .

$$A = 50 \text{ cm}^2$$

The area of the circle is 50 cm^2 .

Example 2 Find the area of a circle with a radius of 225 m.

Step 1 $A = \pi(225)^2$

Step 2 Find the square of the radius.

$$A = 50625\pi$$

Step 3 Multiply the square of the radius by π .

$$A = 158962.5$$

The area of the circle is 158,962 m^2 .

Example 3 Find the area of a circle whose diameter is 20.0 mm.

Step 1 You know the formula for the area of a circle is the square of the radius times π , and that the radius is half of the diameter.

$$A = \pi\left(\frac{20.0}{2}\right)^2$$

Step 2 Find the radius.

$$A = \pi(10.0)^2$$

Step 3 Find the square of the radius.

$$A = 100\pi$$

Step 4 Multiply the square of the radius by π .

$$A = 314 \text{ mm}^2$$

The area is 314 mm^2 .

Practice Problem Find the area of a circle with a radius of 16 m.

Volume The measure of space occupied by a solid is the **volume** (V). To find the volume of a rectangular solid multiply the length times width times height, or $V = l \times w \times h$. It is measured in cubic units, such as cubic centimeters (cm^3).

Example Find the volume of a rectangular solid with a length of 2.0 m, a width of 4.0 m, and a height of 3.0 m.

Step 1 You know the formula for volume is the length times the width times the height.
 $V = 2.0 \text{ m} \times 4.0 \text{ m} \times 3.0 \text{ m}$

Step 2 Multiply the length times the width times the height.
 $V = 24 \text{ m}^3$

The volume is 24 m^3 .

Practice Problem Find the volume of a rectangular solid that is 8 m long, 4 m wide, and 4 m high.

To find the volume of other solids, multiply the area of the base times the height.

Example 1 Find the volume of a solid that has a triangular base with a length of 8.0 m and a height of 7.0 m. The height of the entire solid is 15.0 m.

Step 1 You know that the base is a triangle, and the area of a triangle is $\frac{1}{2}$ the base times the height, and the volume is the area of the base times the height.
 $V = \left[\frac{1}{2} (b \times h) \right] \times 15$

Step 2 Find the area of the base.
 $V = \left[\frac{1}{2} (8 \times 7) \right] \times 15$
 $V = \left(\frac{1}{2} \times 56 \right) \times 15$

Step 3 Multiply the area of the base by the height of the solid.
 $V = 28 \times 15$
 $V = 420 \text{ m}^3$

The volume is 420 m^3 .

Example 2 Find the volume of a cylinder that has a base with a radius of 12.0 cm, and a height of 21.0 cm.

Step 1 You know that the base is a circle, and the area of a circle is the square of the radius times π , and the volume is the area of the base times the height.

$$V = (\pi r^2) \times 21$$

$$V = (\pi 12^2) \times 21$$

Step 2 Find the area of the base.
 $V = 144\pi \times 21$
 $V = 452 \times 21$

Step 3 Multiply the area of the base by the height of the solid.
 $V = 9490 \text{ cm}^3$

The volume is 9490 cm^3 .

Example 3 Find the volume of a cylinder that has a diameter of 15 mm and a height of 4.8 mm.

Step 1 You know that the base is a circle with an area equal to the square of the radius times π . The radius is one-half the diameter. The volume is the area of the base times the height.

$$V = (\pi r^2) \times 4.8$$

$$V = \left[\pi \left(\frac{1}{2} \times 15 \right)^2 \right] \times 4.8$$

$$V = (\pi 7.5^2) \times 4.8$$

Step 2 Find the area of the base.
 $V = 56.25\pi \times 4.8$
 $V = 176.63 \times 4.8$

Step 3 Multiply the area of the base by the height of the solid.
 $V = 847.8$

The volume is 847.8 mm^3 .

Practice Problem Find the volume of a cylinder with a diameter of 7 cm in the base and a height of 16 cm.

Science Applications

Measure in SI

The metric system of measurement was developed in 1795. A modern form of the metric system, called the International System (SI), was adopted in 1960 and provides the standard measurements that all scientists around the world can understand.

The SI system is convenient because unit sizes vary by powers of 10. Prefixes are used to name units. Look at **Table 3** for some common SI prefixes and their meanings.

Table 3 Common SI Prefixes

Prefix	Symbol	Meaning	
kilo-	k	1,000	thousand
hecto-	h	100	hundred
deka-	da	10	ten
deci-	d	0.1	tenth
centi-	c	0.01	hundredth
milli-	m	0.001	thousandth

Example How many grams equal one kilogram?

Step 1 Find the prefix *kilo* in **Table 3**.

Step 2 Using **Table 3**, determine the meaning of *kilo*. According to the table, it means 1,000. When the prefix *kilo* is added to a unit, it means that there are 1,000 of the units in a "kilounit."

Step 3 Apply the prefix to the units in the question. The units in the question are grams. There are 1,000 grams in a kilogram.

Practice Problem Is a milligram larger or smaller than a gram? How many of the smaller units equal one larger unit? What fraction of the larger unit does one smaller unit represent?

Dimensional Analysis

Convert SI Units In science, quantities such as length, mass, and time sometimes are measured using different units. A process called dimensional analysis can be used to change one unit of measure to another. This process involves multiplying your starting quantity and units by one or more conversion factors. A conversion factor is a ratio equal to one and can be made from any two equal quantities with different units. If 1,000 mL equal 1 L then two ratios can be made.

$$\frac{1,000 \text{ mL}}{1 \text{ L}} = \frac{1 \text{ L}}{1,000 \text{ mL}} = 1$$

One can convert between units in the SI system by using the equivalents in **Table 3** to make conversion factors.

Example 1 How many cm are in 4 m?

Step 1 Write conversion factors for the units given. From **Table 3**, you know that $100 \text{ cm} = 1 \text{ m}$. The conversion factors are

$$\frac{100 \text{ cm}}{1 \text{ m}} \text{ and } \frac{1 \text{ m}}{100 \text{ cm}}$$

Step 2 Decide which conversion factor to use. Select the factor that has the units you are converting from (m) in the denominator and the units you are converting to (cm) in the numerator.

$$\frac{100 \text{ cm}}{1 \text{ m}}$$

Step 3 Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. There are 400 cm in 4 m.

$$4 \cancel{\text{ m}} \times \frac{100 \text{ cm}}{1 \cancel{\text{ m}}} = 400 \text{ cm}$$

Practice Problem How many milligrams are in one kilogram? (Hint: You will need to use two conversion factors from **Table 3**.)

Table 4 Unit System Equivalents

Type of Measurement	Equivalent
Length	1 in = 2.54 cm 1 yd = 0.91 m 1 mi = 1.61 km
Mass and Weight*	1 oz = 28.35 g 1 lb = 0.45 kg 1 ton (short) = 0.91 tonnes (metric tons) 1 lb = 4.45 N
Volume	1 in ³ = 16.39 cm ³ 1 qt = 0.95 L 1 gal = 3.78 L
Area	1 in ² = 6.45 cm ² 1 yd ² = 0.83 m ² 1 mi ² = 2.59 km ² 1 acre = 0.40 hectares
Temperature	$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$ $\text{K} = ^{\circ}\text{C} + 273$

*Weight is measured in standard Earth gravity.

Convert Between Unit Systems Table 4 gives a list of equivalents that can be used to convert between English and SI units.

Example If a meterstick has a length of 100 cm, how long is the meterstick in inches?

Step 1 Write the conversion factors for the units given. From **Table 4**, 1 in = 2.54 cm.

$$\frac{1 \text{ in}}{2.54 \text{ cm}} \text{ and } \frac{2.54 \text{ cm}}{1 \text{ in}}$$

Step 2 Determine which conversion factor to use. You are converting from cm to in. Use the conversion factor with cm on the bottom.

$$\frac{1 \text{ in}}{2.54 \text{ cm}}$$

Step 3 Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. Round your answer based on the number of significant figures in the conversion factor.

$$100 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 39.37 \text{ in}$$

The meterstick is 39.4 in long.

Practice Problem A book has a mass of 5 lbs. What is the mass of the book in kg?

Practice Problem Use the equivalent for in and cm (1 in = 2.54 cm) to show how 1 in³ = 16.39 cm³.

Precision and Significant Digits

When you make a measurement, the value you record depends on the precision of the measuring instrument. This precision is represented by the number of significant digits recorded in the measurement. When counting the number of significant digits, all digits are counted except zeros at the end of a number with no decimal point such as 2,050, and zeros at the beginning of a decimal such as 0.03020. When adding or subtracting numbers with different precision, round the answer to the smallest number of decimal places of any number in the sum or difference. When multiplying or dividing, the answer is rounded to the smallest number of significant digits of any number being multiplied or divided.

Example The lengths 5.28 and 5.2 are measured in meters. Find the sum of these lengths and record your answer using the correct number of significant digits.

Step 1 Find the sum.

$$\begin{array}{r} 5.28 \text{ m} \quad 2 \text{ digits after the decimal} \\ + 5.2 \text{ m} \quad 1 \text{ digit after the decimal} \\ \hline 10.48 \text{ m} \end{array}$$

Step 2 Round to one digit after the decimal because the least number of digits after the decimal of the numbers being added is 1.

The sum is 10.5 m.

Practice Problem How many significant digits are in the measurement 7,071,301 m? How many significant digits are in the measurement 0.003010 g?

Practice Problem Multiply 5.28 and 5.2 using the rule for multiplying and dividing. Record the answer using the correct number of significant digits.

Scientific Notation

Many times numbers used in science are very small or very large. Because these numbers are difficult to work with scientists use scientific notation. To write numbers in scientific notation, move the decimal point until only one non-zero digit remains on the left. Then count the number of places you moved the decimal point and use that number as a power of ten. For example, the average distance from the Sun to Mars is 227,800,000,000 m. In scientific notation, this distance is 2.278×10^{11} m. Because you moved the decimal point to the left, the number is a positive power of ten.

The mass of an electron is about 0.000 000 000 000 000 000 000 000 911 kg. Expressed in scientific notation, this mass is 9.11×10^{-31} kg. Because the decimal point was moved to the right, the number is a negative power of ten.

Example Earth is 149,600,000 km from the Sun. Express this in scientific notation.

Step 1 Move the decimal point until one non-zero digit remains on the left.
1.496 000 00

Step 2 Count the number of decimal places you have moved. In this case, eight.

Step 3 Show that number as a power of ten, 10^8 .
The Earth is 1.496×10^8 km from the Sun.

Practice Problem How many significant digits are in 149,600,000 km? How many significant digits are in 1.496×10^8 km?

Practice Problem Parts used in a high performance car must be measured to 7×10^{-6} m. Express this number as a decimal.

Practice Problem A CD is spinning at 539 revolutions per minute. Express this number in scientific notation.

Make and Use Graphs

Data in tables can be displayed in a graph—a visual representation of data. Common graph types include line graphs, bar graphs, and circle graphs.

Line Graph A line graph shows a relationship between two variables that change continuously. The independent variable is changed and is plotted on the x -axis. The dependent variable is observed, and is plotted on the y -axis.

Example Draw a line graph of the data below from a cyclist in a long-distance race.

Table 5 Bicycle Race Data	
Time (h)	Distance (km)
0	0
1	8
2	16
3	24
4	32
5	40

- Step 1** Determine the x -axis and y -axis variables. Time varies independently of distance and is plotted on the x -axis. Distance is dependent on time and is plotted on the y -axis.
- Step 2** Determine the scale of each axis. The x -axis data ranges from 0 to 5. The y -axis data ranges from 0 to 40.
- Step 3** Using graph paper, draw and label the axes. Include units in the labels.
- Step 4** Draw a point at the intersection of the time value on the x -axis and corresponding distance value on the y -axis. Connect the points and label the graph with a title, as shown in **Figure 20**.

Distance v. Time

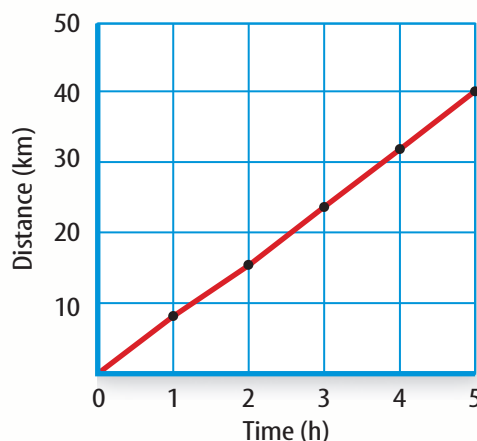


Figure 20 This line graph shows the relationship between distance and time during a bicycle ride.

Practice Problem A puppy's shoulder height is measured during the first year of her life. The following measurements were collected: (3 mo, 52 cm), (6 mo, 72 cm), (9 mo, 83 cm), (12 mo, 86 cm). Graph this data.

Find a Slope The slope of a straight line is the ratio of the vertical change, rise, to the horizontal change, run.

$$\text{Slope} = \frac{\text{vertical change (rise)}}{\text{horizontal change (run)}} = \frac{\text{change in } y}{\text{change in } x}$$

Example Find the slope of the graph in **Figure 20**.

- Step 1** You know that the slope is the change in y divided by the change in x .
- $$\text{Slope} = \frac{\text{change in } y}{\text{change in } x}$$
- Step 2** Determine the data points you will be using. For a straight line, choose the two sets of points that are the farthest apart.
- $$\text{Slope} = \frac{(40-0) \text{ km}}{(5-0) \text{ hr}}$$
- Step 3** Find the change in y and x .
- $$\text{Slope} = \frac{40 \text{ km}}{5 \text{ h}}$$
- Step 4** Divide the change in y by the change in x .
- $$\text{Slope} = \frac{8 \text{ km}}{\text{h}}$$

The slope of the graph is 8 km/h.

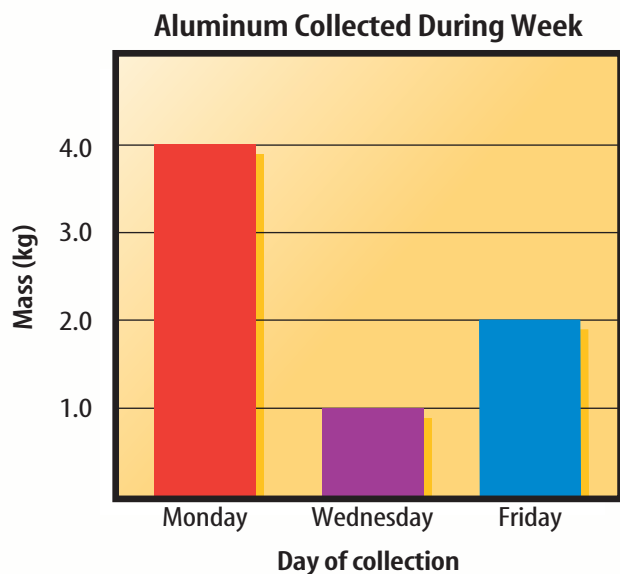
Bar Graph To compare data that does not change continuously you might choose a bar graph. A bar graph uses bars to show the relationships between variables. The x -axis variable is divided into parts. The parts can be numbers such as years, or a category such as a type of animal. The y -axis is a number and increases continuously along the axis.

Example A recycling center collects 4.0 kg of aluminum on Monday, 1.0 kg on Wednesday, and 2.0 kg on Friday. Create a bar graph of this data.

Step 1 Select the x -axis and y -axis variables. The measured numbers (the masses of aluminum) should be placed on the y -axis. The variable divided into parts (collection days) is placed on the x -axis.

Step 2 Create a graph grid like you would for a line graph. Include labels and units.

Step 3 For each measured number, draw a vertical bar above the x -axis value up to the y -axis value. For the first data point, draw a vertical bar above Monday up to 4.0 kg.



Practice Problem Draw a bar graph of the gases in air: 78% nitrogen, 21% oxygen, 1% other gases.

Circle Graph To display data as parts of a whole, you might use a circle graph. A circle graph is a circle divided into sections that represent the relative size of each piece of data. The entire circle represents 100%, half represents 50%, and so on.

Example Air is made up of 78% nitrogen, 21% oxygen, and 1% other gases. Display the composition of air in a circle graph.

Step 1 Multiply each percent by 360° and divide by 100 to find the angle of each section in the circle.

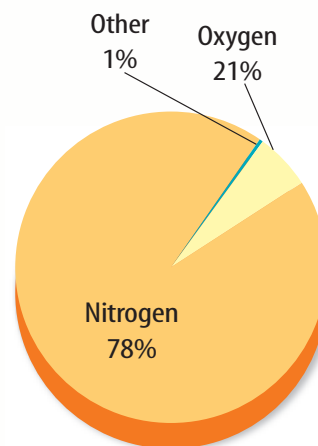
$$78\% \times \frac{360^\circ}{100} = 280.8^\circ$$

$$21\% \times \frac{360^\circ}{100} = 75.6^\circ$$

$$1\% \times \frac{360^\circ}{100} = 3.6^\circ$$

Step 2 Use a compass to draw a circle and to mark the center of the circle. Draw a straight line from the center to the edge of the circle.

Step 3 Use a protractor and the angles you calculated to divide the circle into parts. Place the center of the protractor over the center of the circle and line the base of the protractor over the straight line.



Practice Problem Draw a circle graph to represent the amount of aluminum collected during the week shown in the bar graph to the left.

Formulas

Chapter 1

The Nature of Science

$$\text{Density} = \text{mass/volume}$$

$$\text{Kelvin} = ^\circ\text{Celsius} + 273$$

$$\% \text{ Error} = [(\text{Accepted value} - \text{Experimental value})/\text{Accepted value}] \times 100$$

Chapter 2

Motion

$$\text{Speed} = \text{distance/time}$$

$$\text{Acceleration} = \text{change in velocity/time}$$

$$\text{Change in velocity} = \text{final velocity} - \text{initial velocity}$$

Chapter 3

Forces

$$\text{Acceleration} = \text{net force/mass}$$

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$\text{Gravitational force} = \text{mass} \times (\text{acceleration due to gravity})$$

$$\text{Weight} = \text{mass} \times 9.8 \text{ m/s}^2$$

$$\text{Momentum (p)} = \text{mass} \times \text{velocity}$$

$$\text{Force} = (mv_f - mv_i)/\text{time}$$

$$\text{change in displacement} = \text{initial velocity} (\text{change in time}) + \frac{1}{2} \text{ acceleration}(\text{change in time})^2$$

$$\text{average velocity} = \text{change in displacement/change in time} = (\text{final velocity} + \text{initial velocity})/2$$

$$\text{average acceleration} = \text{change in velocity/change in time}$$

Chapter 4

Energy

$$\text{Kinetic energy} = \frac{1}{2} \text{ mass} \times (\text{velocity})^2$$

$$\text{Gravitational potential energy (GPE)} = \text{mass} \times 9.8 \text{ m/s}^2 \times \text{height}$$

$$\text{Mechanical energy} = \text{gravitational potential energy} + \text{kinetic energy}$$

Chapter 5

Work and Machines

$$\text{Work} = \text{force} \times \text{distance}$$

$$\text{Power} = \text{work/time}$$

$$\text{Efficiency} = (\text{work}_{\text{out}}/\text{work}_{\text{in}}) \times 100\%$$

$$\text{Ideal mechanical advantage (IMA)} = \text{length of effort arm/length of resistance arm} = L_e/L_r$$

$$\text{Ideal mechanical advantage (IMA)} = \text{radius of wheel/radius of axle} = r_w/r_a$$

$$\text{IMA} = \text{effort distance/resistance distance} = \text{length of slope/height of slope} = l/h$$

Chapter 6

Thermal Energy

$$\text{Change in thermal energy} = \text{mass} \times \text{change in temperature} \times \text{specific heat}$$

or

$$Q = m \times (T_{\text{final}} - T_{\text{initial}}) \times C_p$$

$$Q = \text{mass} \times \text{heat of fusion} = mH_f$$

$$Q = \text{mass} \times \text{heat of vaporization} = mH_v$$

Chapter 7 Electricity

Electric current = voltage difference/resistance or $I = V/R$
 Electric power = current $\times$ voltage difference or $P = I \times V$
 Electric energy = power $\times$ time or $E = P \times t$

Series Circuits

$$I_t = I_1 = I_2 = I_3 = \dots$$

$$V_t = V_1 + V_2 + V_3 + \dots$$

$$R_t = R_1 + R_2 + R_3 + \dots$$

Parallel Circuits

$$I_t = I_1 + I_2 + I_3 + \dots$$

$$V_t = V_1 = V_2 = V_3 = \dots$$

$$1/R_t = 1/R_1 + 1/R_2 + 1/R_3 + \dots$$

Chapter 10 Waves

Wave velocity = wavelength $\times$ frequency or $v_w = \lambda \times f$

Chapter 13 Light

Index of refraction =
 speed of light in a vacuum/speed of light in a substance or $n = c/v$

Chapter 16 Solids, Liquids, and Gases

Pressure = force/area or $P = F/A$
 Boyle's law $P_1 \times V_1 = P_2 \times V_2$
 Charles's law $V_1/T_1 = V_2/T_2$

Chapter 22 Solutions

Surface area of a rectangular solid = $2(h \times w) + 2(h \times l) + 2(w \times l)$

EXTRA Math Problems

For help and hints with these problems, visit gpscience.com/extra_problems.

Chapter 1 The Nature of Science

1. How many centimeters are in four meters?
2. How many deciliters are in 500 mL?
3. How many liters are in 2540 cm^3 ?
4. A young child has a mass of 40 kg. What is the mass of the child in grams?
5. Iron has a density of 7.9 g/cm^3 . What is the mass in kg of an iron statue that has a volume of 5.4 L?
6. A 2-L bottle of soda has a volume of 2000 cm^3 . What is the volume of the bottle in cubic meters?
7. A big summer movie has a running time of 96 minutes. What is the movie's running time in seconds?
8. The temperature in space is approximately 3 K. What is this temperature in degrees Celsius?
9. The x-axis of a certain graph is distance traveled in meters and the y-axis is time in seconds. Two points are plotted on this graph with coordinates (2, 43) and (5, 68). What is the elapsed time between the two points?
10. A circle graph has labeled segments of: 57%, 21%, 13%, and 6%. What percentage does the unlabeled segment have?

Chapter 2 Motion

11. John rides his bike 2.3 km to school. After school, he rides an additional 1.4 km to the mall in the opposite direction. What is his total distance traveled?
12. A squirrel runs 4.8 m across a lawn, stops, then runs 2.3 m back in the opposite direction. What is the squirrel's displacement from its starting point?
13. An ant travels 75 cm in 5 s. What was the ant's speed?
14. It took you 6.5 h to drive 550 km. What was your speed?

15. A bus leaves at 9 A.M. with a group of tourists. They travel 350 km before they stop for lunch. Then they travel an additional 250 km until the end of their trip at 3 P.M. What was the average speed of the bus?
16. Halfway through a cross-country meet, a runner's speed is 4 m/s. In the last stretch, she increases her speed to 7 m/s. What is her change in speed?
17. It takes a car one minute to go from rest to 30 m/s. What is the acceleration of this car?
18. You are running at a speed of 10 km/h and hit a patch of mud. Two seconds later your speed is 8 km/h. What is your acceleration in units of m/s^2 ?
19. A weight lifter is trying to lift a 1500-N weight but can apply a force of only 1200 N on the weight. One of his friends helps him lift it all the way. What force was applied to the weight by the weight lifter's friend?
20. During a tug-of-war, Team A is applying a force of 5000 N while Team B is applying a force of 8000 N. What is the net force applied to the rope?
21. You are in a car traveling an average speed of 60 km/h. The total trip is 240 km. How long does the trip take?
22. You are riding in a train that is traveling at a speed of 120 km/h. How long will it take to travel 950 km?
23. A car goes from rest to a speed of 90 km/h in 10 s. What is the car's acceleration in m/s^2 ?
24. A cart rolling at a speed of 10 m/s comes to a stop in 2 s. What is the cart's acceleration?

Chapter 3 Forces

25. A 85-kg mass has an acceleration of 5.5 m/s^2 . What is the net force applied?
26. A 3200-N force is applied to a 160-kg mass. What is the acceleration of the mass?

27. If you are pushing on a box with a force of 20 N and there is a force of 7 N on the box due to sliding friction, what is the net force on the box?
28. A 2-kg object is dropped from a height of 1000 m. What is the force of air resistance on the object when it reaches terminal velocity?
29. How much force is needed to lift a 25-kg mass?
30. A person is on an elevator that moves downward with an acceleration of 1.8 m/s^2 . If the person weighs 686 N, what is the net force on the person?
31. The acceleration due to gravity on the moon is about 1.6 m/s^2 . If you weigh 539 N on Earth, how much would you weigh on the moon?
32. If a 5000-kg mass is moving at a speed of 43 m/s, what is its momentum?
33. How fast must a 50-kg mass travel to have a momentum of 1500 kg m/s?
34. What is the net force on a 4000-kg car that doubles its speed from 15 m/s to 30 m/s over 10 seconds?
35. A book with a mass of 1 kg is sliding on a table. If the frictional force on the book is 5 N, calculate the book's acceleration. Is it speeding up or slowing down?
36. What is the weight of a person with a mass of 80 kg?
37. A car with a mass of 1,200 kg has a speed of 30 m/s. What is the car's momentum?
43. A 2-kg book is moved from a shelf that is 2 m off the ground to a shelf that is 1.5 m off the ground. What is its change in GPE?
44. A car is traveling at 30 m/s with a kinetic energy of 900 kJ. What is its mass?
45. At top of a hill, a rollercoaster has 67,500 J of kinetic energy and 290,000 J of potential energy. Gradually the roller coaster comes to a stop due to friction. If the roller coaster has 30,000 J of potential when it stops, how much heat energy is generated by friction from the top of the hill until it stops?
46. A system has a total mechanical energy of 350 J and kinetic energy of 220 J. What is its potential energy?
47. An object held in the air has a GPE of 470 J. The object then is dropped. Halfway down, what is the object's kinetic energy?
48. A car with a mass of 900 kg is traveling at a speed of 25 m/s. What is the kinetic energy of the car in joules?
49. What is the gravitational potential energy of a diver with a mass of 60 kg who is 10 m above the water?
50. If your weight is 500 N, and you are standing on a floor that is 20 m above the ground, what is your gravitational potential energy?

Chapter 4 Energy

38. What is the kinetic energy of a 5-kg object moving at 7 m/s?
39. An object has kinetic energy of 600 J and a speed of 10 m/s. What is its mass?
40. If you throw a 0.4-kg ball at a speed of 20 m/s, what is the ball's kinetic energy?
41. A rollercoaster car moving around a high turn has 100,000 J of GPE and 23,000 J of KE. What is its mechanical energy?
42. If you have a mass of 80 kg and you are standing on a platform 3 m above the ground, what is your gravitational potential energy?

Chapter 5 Work and Machines

51. When moving a couch, you exert a force of 400 N and push it 4 m. How much work have you done?
52. How much work is needed to lift a 50-kg weight to a shelf 3 m above the floor?
53. By applying a force of 50 N, a pulley system can lift a box with a mass of 20 kg. What is the mechanical advantage of the pulley system?
54. How much energy do you save per hour if you replace a 60-watt lightbulb with a 55-watt lightbulb?
55. Suppose you supply energy to a machine at a rate of 700 W and that the machine converts 560 J into heat every second. At what rate does the machine do work?

Extra Math Problems

56. You exert a force of 200 N on a machine over a distance of 0.3 m. If the machine moves an object a distance of 0.5 m, how much force does the machine exert on the object? Assume friction can be ignored.
57. What is the efficiency of a machine if you do work on the machine at a rate of 1200 W and the machine does work at a rate of 300 W?
58. What is the IMA of a seesaw with a 1.6-m effort arm and a 1.2-m resistance arm?
59. What is the IMA of a wheel with a radius of 0.35 m and an axle radius of 0.04 m?
60. An inclined plane has an IMA of 1.5 and a height of 2.0 m. How long is this inclined plane?
61. What power is used by a machine to perform 800 J of work in 25 s?
62. A person pushes a box up a ramp that is 3 m long, and 1 m high. If the box has a mass of 20 kg, and the person pushes with a force of 80 N, what is the efficiency of the ramp?
63. A first class lever has a mechanical advantage of 5. How large would a force need to be to lift a rock with a mass of 100 kg?
70. A substance with a mass of 10 kg loses 106.5 kJ of heat when its temperature drops 15°C. What is this substance's specific heat?
71. Air is cooled from room temperature (25°C) to 100 K. What is the temperature change in K?
72. To remove 800 J of heat from a refrigerator, the compressor in the refrigerator does 500 J of work. How much heat is released into the surrounding room?
73. A calorimeter contains 1 kg of water [specific heat = 4184 J/(kg K)]. An object with a mass of 4.23 kg is added to the water. If the water temperature increases by 3 K and the temperature of the object decreases by 1 K, what is the specific heat of the object?
74. How much heat is needed to raise the temperature of 100 g of water by 50 K, if the specific heat of water is 4,184 J/kg K?
75. A sample of an unknown metal has a mass of 0.5 kg. Adding 1,985 J of heat to the metal raises its temperature by 10 K. What is the specific heat of the metal?

Chapter 6 Thermal Energy

64. Water has a specific heat of 4184 J/(kg K). How much energy is needed to increase the temperature of a kilogram of water 5°C?
65. The temperature of a block of iron, which has a specific heat of 450 J/(kg K), increases by 3 K when 2700 J of energy are added to it. What is the mass of this block of iron?
66. How much energy is needed to heat 1 kg of sand, which has a specific heat of 664 J/(kg K), from 30°C to 50°C?
67. 1 kg of water (specific heat = 4184 J/(kg K)) is heated from freezing (0°C) to boiling (100°C). What is the change in thermal energy?
68. A concrete statue (specific heat = 600 J/(kg K)) sits in sunlight and warms up to 40°C. Overnight, it cools to 15°C and loses 90,000 J of thermal energy. What is its mass?
69. A glass of water has temperature of 70°C. What is its temperature in K?

Chapter 7 Electricity

76. A circuit has a resistance of 4 Ω . What voltage difference will cause a current of 1.4 A to flow in the circuit?
77. How many amperes of current will flow in a circuit if the voltage difference is 9 V and the resistance in the circuit is 3 Ω ?
78. If a voltage difference of 3 V causes a 1.5 A current to flow in a circuit, what is the resistance in the circuit?
79. The current in an appliance is 3 A and the voltage difference is 120 V. How much power is being supplied to the appliance?
80. What is the current into a microwave oven that requires 700 W of power if the voltage difference is 120 V?
81. What is the voltage difference in a circuit that uses 2420 W of power if 11 A of current flows into the circuit?
82. How much energy is used when a 110 kW appliance is used for 3 hours?

83. A television has a power rating of 210 W. If the television uses 1.68 kWh of energy, for how long has the television been on?
84. How much does it cost to light six 100-W lightbulbs for six hours if the price of electrical energy is \$0.09/kWh?
85. An electric clothes dryer uses 4 kW of electric power. How long did it take to dry a load of clothes if electric power costs \$0.09/kWh, and the cost of using the dryer was \$0.27?
86. What is the resistance of a lightbulb that draws 0.5 amp of current when plugged into a 120-V outlet?
87. How much current flows through a 100-W lightbulb that is plugged into a 120-V outlet?
88. Eight amps of current flow through a hair dryer connected to a 120-V outlet. How much electrical power does the hair dryer use?
89. Compare the electrical energy that is used by a 100-W lightbulb that burns for 10 h, and a 1,200-W hair dryer that is used for 15 min.
95. How many turns are in the primary coil of a step-down transformer that reduces a voltage from 400 V to 100 V and has 80 turns in the secondary coil?
96. How many turns are in the secondary coil of a step-up transformer that increases voltage from 30 V to 150 V and has seven turns in the primary coil?
97. The coil of a 60-Hz generator makes 60 revolutions each second. How many revolutions does the coil make in five minutes?
98. If a generator coil makes 6000 revolutions in two minutes, how many revolutions does it make each second?

Chapter 9 Energy Sources

Chapter 8 Magnetism and Its Uses

90. How many turns are in the secondary coil of a step-down transformer that reduces a voltage from 900 V to 300 V and has 15 turns in the primary coil?
91. A step-down transformer reduces voltage from 2400 V to 120 V. What is the ratio of the number of turns in the primary coil to the number of turns in the secondary coil of the transformer?
92. The current produced by an AC generator switches direction twice for each revolution of the coil. How many times does a 110-Hz alternating current switch direction each second?
93. What is the output voltage from a step-down transformer with 200 turns in the primary coil and 100 turns in the secondary coil if the input voltage was 750 V?
94. What is the output voltage from a step-up transformer with 25 turns in the primary coil and 75 turns in the secondary coil if the input voltage was 120 V?
99. A gallon of gasoline contains about 2800 g of gasoline. If burning one gram of gasoline releases about 48 kJ of energy, how much energy is released when a gallon of gasoline is burned? (1 kJ = 1000 J)
100. An automobile engine converts the energy released by burning gasoline into mechanical energy with an efficiency of about 25%. If burning 1 kg of gasoline releases about 48,000 kJ of energy, how much mechanical energy is produced by the engine when 1 kg of gasoline is burned?
101. You heat a cup of water in a 750-W microwave oven for 40 s, and warm the water by 20°C. If it takes about 20 kJ of energy to raise the temperature of a cup of water by 20°C, what is the efficiency of the microwave oven?
102. On average, solar energy strikes Earth's surface with an intensity of about 200 W/m². If solar cells are 10% efficient, how large an area would have to be covered by solar cells to generate enough electrical power to light a 100-W lightbulb?
103. What is the overall efficiency of a hydroelectric plant if the process of falling water turning a turbine is 80% efficient, the turbine spinning an electric generator is 95% efficient, and the transmission through power lines is 90% efficient?

Extra Math Problems

104. When a certain $^{235}_{92}\text{U}$ nucleus is struck by a neutron, it forms the two nuclei $^{91}_{36}\text{Kr}$ and $^{142}_{56}\text{Ba}$. How many neutrons are emitted when this occurs?
105. A nuclear reactor contains 100,000 kg of enriched uranium. About 4% of the enriched uranium is the isotope uranium-235. What is the mass of uranium-235 in the reactor core?
106. Suppose the number of uranium-235 nuclei that are split doubles at each stage of a chain reaction. If the chain reaction starts with one nucleus split in the first stage, how many nuclei will have been split after six stages?
107. From 1970 to 1995 the carbon dioxide concentration in Earth's atmosphere increased from about 325 parts per million to about 360 parts per million. What was the percentage change in the concentration of carbon dioxide?
108. About 85% of the energy used in the U.S. comes from fossil fuels. How many times greater is the amount of energy used from fossil fuel than the amount used from all other energy sources?

Chapter 10 Waves

109. What is the wavelength of a wave with a frequency of 0.4 kHz traveling at 16 m/s?
110. Two waves are traveling in the same medium with a speed of 340 m/s. What is the difference in frequency of the waves if the one has a wavelength of 5 m and the other has a wavelength of 0.2 m?
111. Transverse wave A has an amplitude of 7 cm. This wave constructively interferes with wave B. While the two waves overlap, the amplitude of the resulting wave is 10 cm. What is the amplitude of wave B?
112. What is the wavelength of a wave with a frequency of 5 Hz traveling at 15 m/s?
113. What is the velocity of a wave that has a wavelength of 6 m and a frequency of 3 Hz?
114. A ray of light hits a mirror at an angle of 35° to the normal. What is the angle of the reflected ray to the normal?
115. A wave has a wavelength of 250 cm and a frequency of 4 Hz. What is its speed?
116. A wave has a frequency of 5.6 MHz. What is the frequency of this wave in Hz?
117. A light ray strikes a mirror and is reflected. The angle between the incident and reflected rays is 86° . What is the angle of the incident ray to the normal?
118. What is the frequency of a wave with a wavelength of 7 m traveling at 21 m/s?

Chapter 11 Sound

119. What is the wavelength of a 440-Hz sound wave traveling with a speed of 347 m/s?
120. A sound wave with a frequency of 440 Hz travels in steel with a speed of 5200 m/s. What is the wavelength of the sound wave?
121. A wave traveling in water has a wavelength of a 750 m and a frequency of 2 Hz. How fast is this wave moving?
122. At 0°C sound travels through air with a speed of about 331 m/s and through aluminum with a speed of 4877 m/s. How many times longer is the wavelength of a sound wave in aluminum compared to the wavelength of a sound wave in air if both waves have the same frequency?
123. The speed of sound in air at 0°C is 331 m/s, and at 20°C is 344 m/s. What is the percentage change in the speed of sound at 20°C compared to 0°C ?
124. In a lab experiment, measurements of the speed of sound in air were 329.7 m/s, 333.6 m/s, 330.8 m/s, 331.7 m/s, and 332.2 m/s. What is the average value of these measurements?
125. What is the frequency of the first overtone of a 440-Hz wave?
126. The wreck of the *Titanic* is at a depth of about 3800 m. A sonar unit on a ship above the *Titanic* emits a sound wave that travels at a speed of 1500 m/s. How long does it take a sound wave reflected from the *Titanic* to return to the ocean surface?

127. A sonar unit on a ship emits a sound wave. The echo from the ocean floor is detected two seconds later. If the speed of sound in water is 1500 m/s, how deep is the ocean beneath the ship?
128. One flute plays a note with a frequency of 443 Hz, and another flute plays a note with a frequency of 440 Hz. What is the frequency of the beats that the flute players hear?
129. A sound wave has a wavelength of 50 m and a frequency of 22 cycles per second. What is the speed of the sound wave?
130. A tsunami travels across the ocean at a speed of 500 km/h. If the distance between the wave crests is 200 km, what is the frequency of the wave?

Chapter 12 Electromagnetic Waves

131. Express the number 20,000 in scientific notation.
132. An electromagnetic wave has a wavelength of 0.054 m. What is the wavelength in scientific notation?
133. Earth is about 4,500,000,000 years old. Express this number in scientific notation.
134. The speed of electromagnetic waves in air is 300,000 km/s. What is the frequency of electromagnetic waves that have a wavelength of 5×10^{-3} km?
135. The speed of radio waves in water is about 2.26×10^5 km/s. What is the frequency of radio waves that have a wavelength of 3.0 km?
136. Radio waves with a frequency of 125,000 Hz have a wavelength of 1.84 km when traveling in ice. What is the speed of the radio waves in ice?
137. Some infrared waves have a frequency of 10,000,000,000,000 Hz. Express this frequency in scientific notation.
138. An infrared wave has a frequency of 1×10^{13} Hz and a wavelength of 3×10^{-5} m. Express this wavelength as a decimal number.
139. An AM radio station broadcasts at a frequency of 620 kHz. Express this frequency in Hz using scientific notation.

140. An FM radio station broadcasts at a frequency of 101 MHz. Express this frequency in Hz using scientific notation.

Chapter 13 Light

141. A ray of light hits a plane mirror at 35° from the normal. What angle does the reflected ray make with the normal?
142. A light ray strikes a plane mirror. The angle between the light ray and the surface of the mirror is 25° . What angle does the reflected ray make with the normal?
143. About 8% of men and 0.5% of women have some form of color blindness. The number of men who experience color blindness is how many times larger than the number of women who experience color blindness?
144. The index of refraction of a material is the speed of light in a vacuum divided by the speed of light in the material. If the index of refraction of the mineral rock salt is 1.52, and the speed of light in a vacuum is 300,000 km/s, what is the speed of light in rock salt?
145. A laser is used to measure the distance from Earth to the Moon. The laser beam is reflected from a mirror on the Moon's surface. If the time needed for the laser to reach the Moon and be reflected back is 2.56 s, and the laser beam travels at 300,000 km/s, what is the distance to the Moon?
146. A light ray is reflected from a plane mirror. If the angle between the incident ray and the reflected ray is 104° , what is the angle of incidence?
147. In the human eye, there are about 7,000,000 cone cells distributed over an area of 5 cm^2 . If cone cells are evenly distributed over this region, how many cone cells are distributed over an area of 2 cm^2 ? Express your answer in scientific notation.
148. What will happen to a ray of light leaving water and entering air if it hits the boundary at an angle of 49° to the normal? (The critical angle for water and air is 49° .)

Extra Math Problems

149. A ray of light hits a plane mirror at 60° from the normal. What is the angle between the reflected ray and the surface of the mirror?
150. When a light beam is reflected from a glass surface, only 4% of the energy carried by the beam is reflected. If a light beam is reflected from one glass surface and then another, what is the ratio of the energy carried by the beam after the second reflection, compared to the energy carried by the beam before the first reflection?

Chapter 14 Mirrors and Lenses

151. A light ray strikes a plane mirror. The angle between the incident light ray and the normal to the mirror is 55° . What is the angle between the reflected ray and the normal?
152. The magnification of a mirror or lens equals the image size divided by the object size. If a plant cell with a diameter of 0.0035 mm is magnified so that the diameter of the image is 0.028 cm, what is the magnification?
153. A convex lens in a magnifying glass has a focal length of 5 cm. How far should the lens be from an object if the image formed is virtual, enlarged, and upright?
154. A concave mirror forms a real image that is $\frac{3}{4}$ the size of the object. How far is the object from the mirror?
155. Magnification equals the image size divided by the object size. Magnification also equals the distance of the image from the lens divided by the distance of the object from the lens. A penny has a diameter of 2.0 cm. A convex lens forms an image with a diameter of 5.2 cm and is 6.0 cm from the lens. What is the distance between the penny and the lens?
156. Light enters the human eye through the pupil. In the dark, the pupil is dilated and has a diameter of about 1 cm. The Keck telescope has a mirror with a diameter of 10 m. If both the pupil and the Keck mirror are circles, what is the ratio of the area of the Keck telescope mirror to the area of a dilated human pupil?
157. A small insect is viewed in a compound microscope. The objective lens of the microscope forms a real image 20 times larger than the insect. The eyepiece lens then magnifies this real image by 10 times. What is the magnification of the microscope?
158. A light source is placed a distance of 1.2 m from a concave mirror on the optical axis. The reflected light rays are parallel and form a light beam. What is the focal length of the mirror?
159. In some types of reflecting telescopes the eyepiece is located behind the concave mirror. A small curved mirror in front of the concave mirror reflects light through a hole in the concave mirror to the eyepiece. Suppose a circular concave mirror with a diameter of 50 cm has a hole with a diameter of 10 cm. What is the ratio of the reflecting area of the mirror with the 10-cm hole to the reflecting area of the same mirror without the hole?
160. Astronomers have proposed building the OWL telescope (**o**ver**w**helmingly **l**arge telescope) with a mirror 100 m in diameter. The diameter of the *Hubble Space Telescope* mirror is 2.4 m. What percentage of the surface area of the OWL mirror would be covered by the surface area of the *Hubble* mirror?

Chapter 15 Classification of Matter

161. Two solutions, one with a mass of 450 g and the other with a mass of 350 g, are mixed. A chemical reaction occurs and 125 g of solid crystals are produced that settle on the bottom of the container. What is the mass of the remaining solution?
162. Carbon reacts with oxygen to form carbon dioxide according to the following equation: $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$. When 120 g of carbon reacts with oxygen, 440 g of carbon dioxide are formed. How much oxygen reacted with the carbon?
163. Salt water is distilled by boiling it and condensing the vapor. After distillation, 1,164 g of water have been collected and 12 g of salt are left behind in the original container. What was the original mass of the salt water?

164. Calcium carbonate, CaCO_3 , decomposes according to the reaction: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. When 250 g of CaCO_3 decompose completely, the mass of CaO is 56% of the mass of the products of this reaction. What is the mass of CO_2 produced?
165. Water breaks down into hydrogen gas and oxygen gas according to the reaction: $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$. In this reaction the mass of oxygen produced is eight times greater than the mass of hydrogen produced. If 36 g of water form hydrogen and oxygen gas, what is the mass of hydrogen gas produced?
166. The size of particles in a solution is about 1 nm (1 nm = 0.000000001 m). Write 0.000000001 m in scientific notation.
167. A chemical reaction produces two new substances, one with a mass of 34 g and the other with a mass of 39 g. What was the total mass of the reactants?
168. The human body is about 65% oxygen. If a person has a mass of 75.0 kg, what is the mass of oxygen in their body?
169. A 112-g serving of ice cream contains 19 g of fat. What percentage of the serving is fat?
170. The mass of the products produced by a chemical reaction is measured. The reaction is repeated five times, with the same mass of reactants used each time. The measured product masses are 50.17 g, 50.12 g, 50.17 g, 50.10 g, and 50.14 g. What is the average of these measurements?
174. The pressure on a balloon that has a volume of 7 L is 100 kPa. If the temperature stays the same and the pressure on the balloon is increased to 250 kPa, what is the new volume of the balloon?
175. Two cylinders contain pistons that are connected by fluid in a hydraulic system. A force of 1,300 N is exerted on one piston with an area of 0.05 m^2 . What is the force exerted on the other piston which has an area of 0.08 m^2 ?
176. A gas-filled weather balloon floating in the atmosphere has an initial volume of 850 L. The weather balloon rises to a region the pressure is 56 kPa, and its volume expands to 1700 L. If the temperature remains the same, what was the initial pressure on the weather balloon?
177. The air in a tire pump has a volume of 1.50 L at a temperature of 5°C. If the temperature is increased to 30°C and the pressure remains constant, what is the new volume?
178. A block of wood with a mass of 1.2 kg is floating in a container of water. If the density of water is 1.0 g/cm^3 , what is the volume of water displaced by the floating wood?
179. In a hydraulic system, a force of 7,500 N is exerted on a piston with an area of 0.05 m^2 . If the force exerted on a second piston in the hydraulic system is 1,500 N, what is the area of this second piston?
180. A gold bar weighs 17.0 N. If the density of gold is 19.3 g/cm^3 , what is the volume of the gold bar?

Chapter 16 Solids, Liquids, and Gases

171. A book is sitting on a desk. The area of contact between the book and the desk is 0.06 m^2 . If the book's weight is 30 N, what is the pressure the book exerts on the desk?
172. A skater has a weight of 500 N. The skate blades are in contact with the ice over an area of 0.001 m^2 . What is the pressure exerted on the ice by the skater?
173. The weight of the water displaced by a person floating in the water is 686 N. What is the person's mass?

181. A book is sitting on a desk. If the surface area of the book's cover is 0.05 m^2 , and atmospheric pressure is 100.0 kPa, what is the downward force of the atmosphere on the book?
182. A piston applies a pressure of 5,000 N/m^2 . If the piston has a surface area of 0.1 m^2 , how much force can the piston apply?

Chapter 17 Properties of Atoms and the Periodic Table

183. Boron has a mass number of 11 and an atomic number of 5. How many neutrons are in a boron atom?

Extra Math Problems

- 184.** A magnesium atom has 12 protons and 12 neutrons. What is its mass number?
- 185.** Iodine-127 has a mass number of 127 and 74 neutrons. What percentage of the particles in an iodine-127 nucleus are protons?
- 186.** How many neutrons are in an atom of phosphorus-31?
- 187.** What is the ratio of neutrons to protons in the isotope radium-234?
- 188.** About 80% of all magnesium atoms are magnesium-24, about 10% are magnesium-25, and about 10% are magnesium-26. What is the average atomic mass of magnesium?
- 189.** The half-life of the radioactive isotope rubidium-87 is 48,800,000,000 years. Express this half-life in scientific notation.
- 190.** The radioactive isotope nickel-63 has a half-life of 100 years. How much of a 10.0-g sample of nickel-63 is left after 300 years?
- 191.** A sample of the radioactive isotope cobalt-62 is prepared. The sample has a mass of 1.00 g. After three minutes, the mass of cobalt-62 remaining is 0.25 g. What is the half-life of cobalt-62?
- 192.** A neutral phosphorus atom has 15 electrons. How many electrons are in the third energy level?

Chapter 18 Radioactivity and Nuclear Reactions

- 193.** How many protons are in the nucleus $^{81}_{36}\text{Kr}$?
- 194.** How many neutrons are in the nucleus $^{56}_{26}\text{Fe}$?
- 195.** What is the ratio of neutrons to protons in the nucleus $^{241}_{95}\text{Am}$?
- 196.** How many alpha particles are emitted when the nucleus $^{222}_{86}\text{Rn}$ decays to $^{218}_{84}\text{Po}$?
- 197.** How many beta particles are emitted when the nucleus $^{40}_{19}\text{K}$ decays to the nucleus $^{40}_{20}\text{Ca}$?
- 198.** An alpha particle is the same as the helium nucleus ^4_2He . What nucleus is produced when the nucleus $^{226}_{88}\text{Ra}$ decays by emitting an alpha particle?

- 199.** How long will it take a sample of $^{194}_{84}\text{Po}$ to decay to 1/8 of its original amount if $^{194}_{84}\text{Po}$ has a half-life of 0.7 s?
- 200.** The half-life of $^{131}_{53}\text{I}$ is 8.04 days. How much time would be needed to reduce 1 g of $^{131}_{53}\text{I}$ to 0.25 g?
- 201.** A sample of radioactive carbon-14 sample has decayed to 12.5% of its original amount. If the half-life of carbon-14 is 5730 years, how old is this sample?
- 202.** A sample of $^{38}_{17}\text{Cl}$ is observed to decay to 25% of the original amount in 74.4 minutes. What is the half-life of $^{38}_{17}\text{Cl}$?

Chapter 19 Elements and Their Properties

- 203.** In seawater the concentration of fluoride ions, F^- , is 1.3×10^{-3} g/L. How many liters of seawater would contain 1.0 g of F^- ?
- 204.** There are three isotopes of hydrogen. The isotope deuterium, with one proton and one neutron in the nucleus, makes up 0.015% of all hydrogen atoms. Of every million hydrogen atoms, how many are deuterium?
- 205.** A vitamin and mineral supplement pill contains 1.0×10^{-5} g of selenium. According to the label on the bottle, this amount is 18% of the recommended daily value. What is the recommended daily value of selenium in g?
- 206.** The density of silver is 10.5 g/cm³ and the density of copper is 8.9 g/cm³. What is the difference in mass between a piece of silver with a volume of 5 cm³ and a piece of copper with a volume of 5 cm³?
- 207.** A person has a mass of 68.3 kg. If 65% of the mass of a human body is oxygen, what is the mass of oxygen in this person's body?
- 208.** The melting point of aluminum is 660.0°C. What is the melting point of aluminum on the Fahrenheit temperature scale?
- 209.** A certain gold ore produces about 5 g of gold for every 1,000 kg of ore that is mined. If one ounce = 28.3 g, how many kg of ore must be mined to produce an ounce of gold?

- 210.** A metal bolt with a mass of 26.6 g is placed in a 50-mL graduated cylinder containing water. The water level in the cylinder rises from 27.0 mL to 30.5 mL. What is the density of the bolt in g/cm^3 ?
- 211.** On a circle graph showing the percentage of elements in the human body, the wedge representing nitrogen takes up 10.8° . What is the percentage of nitrogen in the human body?
- 212.** The synthetic element hassium-261 has a half-life of 9.3 s. The synthetic element fermium-255 has a half-life of 20.1 h. How many times longer is the half-life of fermium-255 than the half-life of hassium-261?

Chapter 20 Chemical Bonds

- 213.** What is the formula of the compound formed when ammonium ions, NH_4^+ , and phosphate ions, PO_4^{3-} , combine?
- 214.** Show that the sum of positive and negative charges in a unit of calcium chloride (CaCl_2) equals zero.
- 215.** What is the formula for iron(III) oxide?
- 216.** How many hydrogen atoms are in three molecules of ammonium phosphate, $(\text{NH}_4)_3\text{PO}_4$?
- 217.** The overall charge on the polyatomic phosphate ion, PO_4^{3-} , is 3-. What is the oxidation number of phosphorus in the phosphate ion?
- 218.** The overall charge on the polyatomic dichromate ion, $\text{Cr}_2\text{O}_7^{2-}$, is 2-. What is the oxidation number of chromium in this polyatomic ion?
- 219.** What is the formula for lead(IV) oxide?
- 220.** What is the formula for potassium chlorate?
- 221.** What is the formula for carbon tetrachloride?
- 222.** What percentage of the mass of a sulfuric acid molecule, H_2SO_4 , is sulfur?

Chapter 21 Chemical Reactions

- 223.** Lithium reacts with oxygen to form lithium oxide according to the equation: $4\text{Li} + \text{O}_2 \rightarrow 2\text{Li}_2\text{O}$. If 27.8 g of Li react completely with 32.0 g of O_2 , how many grams of Li_2O are formed?

- 224.** What coefficients balance the following equation: $_ \text{Zn}(\text{OH})_2 + _ \text{H}_3\text{PO}_4 \rightarrow _ \text{Zn}_3(\text{PO}_4)_2 + _ \text{H}_2\text{O}$?
- 225.** Aluminum hydroxide, $\text{Al}(\text{OH})_3$, decomposes to form aluminum oxide, Al_2O_3 , and water according to the reaction: $2\text{Al}(\text{OH})_3 \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O}$. If 156.0 g of $\text{Al}(\text{OH})_3$ decompose to form 102.0 g of Al_2O_3 , how many grams of H_2O are formed?
- 226.** In the following balanced chemical reaction one of the products is represented by the symbol X: $\text{BaCO}_3 + \text{C} + \text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2\text{O} + 2\text{X}$. What is the formula for the compound represented by X?
- 227.** When propane, C_3H_8 , is burned, carbon dioxide and water vapor are produced according to the following reaction: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. How much propane is burned if 160.0 g of O_2 are used and 132.0 g of CO_2 and 72.0 g of H_2O are produced?
- 228.** Increasing the temperature usually causes the rate of a chemical reaction to increase. If the rate of a chemical reaction doubles when the temperature increases by 10°C , by what factor does the rate of reaction increase if the temperature increases by 30°C ?
- 229.** When acetylene gas, C_2H_2 , is burned, carbon dioxide and water are produced. Find the coefficients that balance the chemical equation for the combustion of acetylene: $_ \text{C}_2\text{H}_2 + _ \text{O}_2 \rightarrow _ \text{CO}_2 + _ \text{H}_2\text{O}$.
- 230.** What coefficients balances the following equation: $_ \text{CS}_2 + _ \text{O}_2 \rightarrow _ \text{CO}_2 + _ \text{SO}_2$?
- 231.** When methane, CH_4 , is burned, 50.1 kJ of energy per gram are released. When propane, C_3H_8 , is burned, 45.8 kJ of energy are released. If a mixture of 1 g of methane and 1 g of propane is burned, how much energy is released per gram of mixture?
- 232.** A chemical reaction produces 0.050 g of a product in 0.18 s. In the presence of a catalyst, the reaction produces 0.050 g of the same product in 0.007 s. How much faster is the rate of reaction in the presence of the enzyme?

Extra Math Problems

Chapter 22 Solutions

- 233.** A cup of orange juice contains 126 mg of vitamin C and 1/2 cup of strawberries contain 42 mg of vitamin C. How many cups of strawberries contain as much vitamin C as one cup of orange juice?
- 234.** A Sacagawea dollar coin is made of manganese brass alloy that is 1/25 nickel. Express this number as a percentage.
- 235.** What is the total surface area of a 2-cm cube?
- 236.** A cube has 2-cm sides. If it is split in half, what is the total surface area of the two pieces?
- 237.** What is the increase in surface area when a cube with 2-cm sides is divided into eight equal parts?
- 238.** How much surface area is lost if two 4-cm cubes are attached at one face?
- 239.** At 20°C, the solubility in water of potassium bromide, KBr, is 65.3 g/100 mL. What is the maximum amount of potassium bromide that will dissolve in 237 mL of water?
- 240.** At 20°C, the solubility of sodium chloride, NaCl, in water is 35.9 g/100 mL. If the maximum amount of sodium chloride is dissolved in 500 mL of water at 20°C, the mass of the dissolved sodium chloride is what percentage of the mass of the solution?
- 241.** At 60°C, the solubility of sucrose (sugar) in water is 287.3 g/100 mL. At this temperature, what is the minimum amount of water needed to dissolve 50.0 g of sucrose?
- 242.** A fruit drink contains 90% water and 10% fruit juice. How much fruit juice does 500 mL of fruit drink contain?
- 245.** If 5.5% of 473.0 mL of vinegar is acetic acid, how many milliliters of acetic acid are there?
- 246.** The difference between the pH of a basic solution and the pH of pure water is 2. What is the pH of the solution?
- 247.** On the pH scale, a decrease of one unit means that the concentration of H^+ ions increases 10 times. If the pH of a solution changes from 6.5 to 4.5, how has the concentration of H^+ ions changed?
- 248.** Write the balanced chemical equation for the neutralization of H_2SO_4 , sulfuric acid, by KOH, potassium hydroxide.
- 249.** Write the balanced chemical equation for the neutralization of HBr, hydrobromic acid, by $Al(OH)_3$, aluminum hydroxide.
- 250.** A molecule of acetylsalicylic acid, or aspirin, has the chemical formula $COOHC_6H_4COOCH_3$. What is the mass of a molecule of acetylsalicylic acid in amu?
- 251.** Write the equation for the reaction when HNO_3 , nitric acid, ionizes in water.
- 252.** When Na_2O , sodium oxide, reacts with water, the base NaOH, sodium hydroxide, is formed. Write the balanced equation for this reaction.

Chapter 24 Organic Compounds

- 253.** The hydrocarbon octane, C_8H_{18} , has a boiling point of 259°F. What is its boiling point on the Celsius temperature scale?
- 254.** A barrel of oil is 42.0 gallons. About 45% of a barrel of oil is turned into gasoline during the fractional distillation process. In 2001, about 19.6 million barrels of crude oil were refined each day. How many gallons of gasoline were produced each day?
- 255.** In 2001, about 56% of the crude oil used by the United States was imported. If the United States used 20.6 million barrels of crude oil a day, how many million barrels of crude oil were imported in 2001?
- 256.** Four molecules of a hydrocarbon contain carbon atoms and 56 hydrogen atoms. What is the formula for a molecule of this hydrocarbon?

Chapter 23 Acids, Bases, and Salts

- 243.** The difference between the pH of an acidic solution and the pH of pure water is 3. What is the pH of the solution?
- 244.** The pH of rain that fell over a region had measured values of 4.6, 5.1, 4.8, 4.5, 4.5, 4.9, 4.7, and 4.8. What was the mean value of the measured pH?

- 257.** For saturated hydrocarbons, the number of hydrogen atoms in a molecule can be calculated by the formula $N_H = 2N_C + 2$, where N_H is the number of hydrogen atoms and N_C is the number of carbon atoms in the molecule. If a molecule of the saturated hydrocarbon decane has 22 hydrogen atoms, how many carbon atoms does a decane molecule contain?
- 258.** Fats supply 9 Calories per gram, carbohydrates and proteins each supply 4 Calories per gram. If 100 g of potato chips contain 7 g of protein, 53 g of carbohydrates, and 35 g of fats, how many Calories are in 100 g of potato chips?
- 259.** The basal metabolism rate (BMR) is the amount of energy required to maintain basic body functions. The BMR is approximately 1.0 Calories/hr per kilogram of body mass. For a person with a mass of 65 kg, how many Calories are needed each day to maintain basic body functions?
- 260.** A food Calorie is an energy unit equal to 4,184 joules. If a person uses 2,070 Calories in one day, what is the power being used? Express your answer in watts.
- 261.** In each 100 g of cheddar cheese there are 33 g of fat. Calculate how many grams of fat are in 250 g of cheddar cheese.
- 262.** A car gets 25 miles per gallon of gas. If the car is driven 12,000 miles in one year and gasoline costs \$1.55 per gallon, what was the cost of the gasoline used in one year?
- 266.** The molecules in a sample of polypropylene have an average length of 60,000 monomers. The monomer of polypropylene has the formula CH_2CHCH_3 . Express in scientific notation the mass, in amu, of a polypropylene molecule made of 60,000 monomers.
- 267.** A certain process for manufacturing integrated circuits packs 47,600,000 transistors into an area of 340 mm^2 . If this process is used to produce an integrated circuit with an area of 1 cm^2 , express in scientific notation the number of transistors in this integrated circuit.
- 268.** The melting points of five different samples of a new aluminum alloy have measured values of 631.5°C , 632.3°C , 636.1°C , 637.4°C , and 630.2°C . What is the mean of these measurements?
- 269.** Rounded to the nearest degree, eight measured values of the melting point of a stainless steel alloy are $1,421^\circ\text{C}$, $1,420^\circ\text{C}$, $1,421^\circ\text{C}$, $1,423^\circ\text{C}$, $1,423^\circ\text{C}$, $1,421^\circ\text{C}$, $1,424^\circ\text{C}$, and $1,419^\circ\text{C}$. What is the mode of these measurements?
- 270.** The measured values of the copper content of seven bronze buttons found at an archaeological site are 83%, 90%, 91%, 72%, 79%, 87%, and 89%. What is the median of these measurements?
- 271.** The number of transistors and other components per mm^2 on an integrated circuit has doubled, on average, every two years. If integrated circuits contained 100,000 transistors in 1982, estimate how many transistors an integrated circuit of the same size contained in 1998.
- 272.** A car contains 200 kg of plastic parts instead of steel parts. The density of steel is twice the density of plastic. If the volume of the plastic parts equals the volume of the same parts made of steel, how much less is the mass (kg) of the car by using plastic parts instead of steel?

Chapter 25 New Materials Through Chemistry

- 263.** A stainless steel spoon contains 30.0 g of iron, 6.8 g of chromium, and 3.2 g of nickel. What percentage of the stainless steel is chromium?
- 264.** A 14-karat gold earring has a mass of 10 g. What is the mass of gold in the earring?
- 265.** In 1997, about 6,400,000,000 kg of polyvinyl chloride were used in the United States. About 6% of the PVC used was for packaging. Express in scientific notation how many kilograms of PVC were used for packaging in 1997.

Physical Science Reference Tables

Standard Units

Symbol	Name	Quantity
m	meter	length
kg	kilogram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of a substance
J	joule	energy, work, quantity of heat
s	second	time
C	coulomb	electric charge
V	volt	electric potential
A	ampere	electric current
Ω	ohm	resistance

Physical Constants and Conversion Factors

Acceleration due to gravity	g	9.8 m/s/s or m/s ²
Avogadro's Number	N_A	6.02×10^{23} particles per mole
Electron charge	e	1.6×10^{-19} C
Electron rest mass	m_e	9.11×10^{-31} kg
Gravitation constant	G	6.67×10^{-11} N $\times$ m ² /kg ²
Mass-energy relationship		1 u (amu) = 9.3×10^2 MeV
Speed of light in a vacuum	c	3.00×10^8 m/s
Speed of sound at STP	331 m/s	
Standard Pressure	1 atmosphere	
	101.3 kPa	
	760 Torr or mmHg	
	14.7 lb/in. ²	

Wavelengths of Light in a Vacuum

Violet	$4.0 - 4.2 \times 10^{-7}$ m
Blue	$4.2 - 4.9 \times 10^{-7}$ m
Green	$4.9 - 5.7 \times 10^{-7}$ m
Yellow	$5.7 - 5.9 \times 10^{-7}$ m
Orange	$5.9 - 6.5 \times 10^{-7}$ m
Red	$6.5 - 7.0 \times 10^{-7}$ m

The Index of Refraction for Common Substances

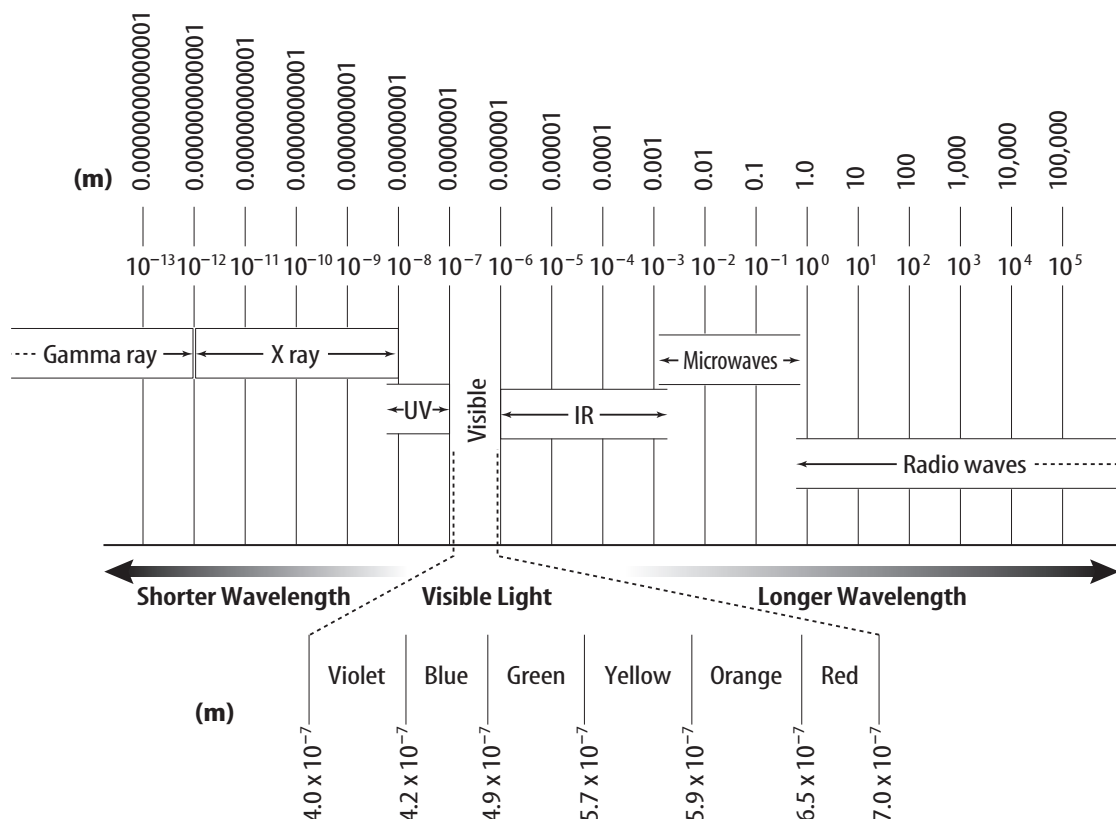
 $(\lambda = 5.9 \times 10^{-7} \text{ m})$

Air	1.00
Alcohol	1.36
Canada Balsam	1.53
Corn Oil	1.47
Diamond	2.42
Glass, Crown	1.52
Glass, Flint	1.61
Glycerol	1.47
Lucite	1.50
Quartz, Fused	1.46
Water	1.33

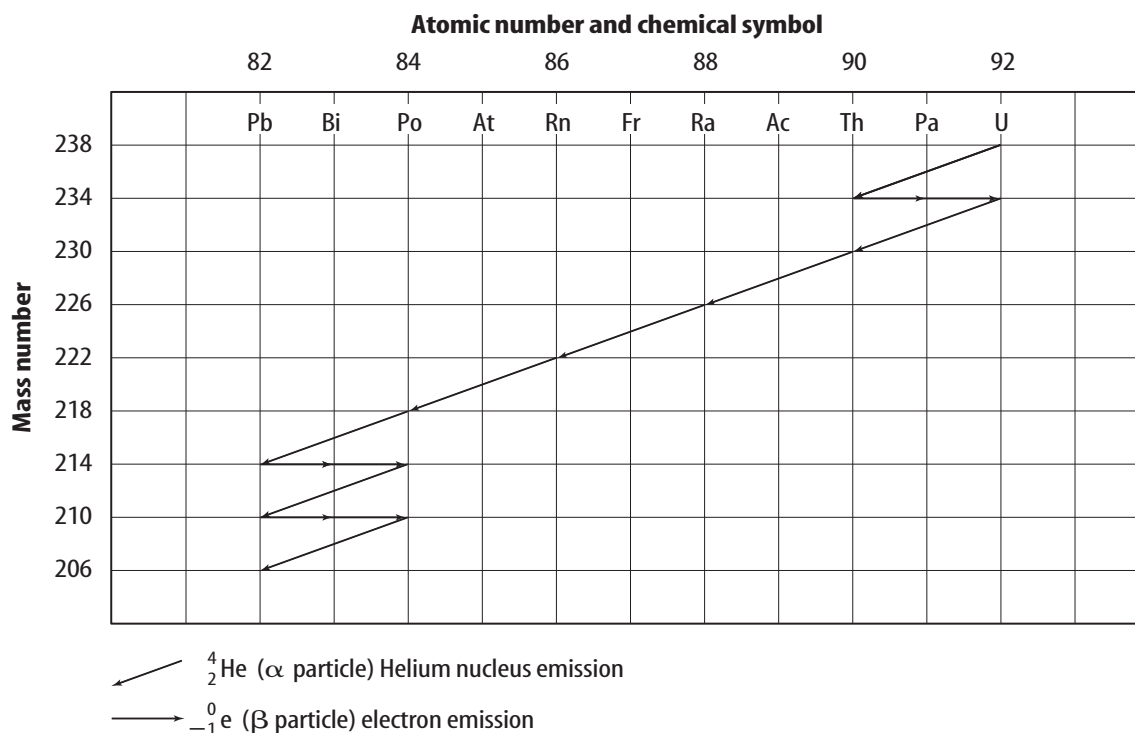
Heat Constants

	Specific Heat (average) (kJ/kg $\times$ $^{\circ}$ C) (J/g $\times$ $^{\circ}$ C)	Melting Point ($^{\circ}$ C)	Boiling Point ($^{\circ}$ C)	Heat of Fusion (kJ/kg) (J/g)	Heat of Vaporization (kJ/kg) (J/g)
Alcohol (ethyl)	2.43 (liq.)	-117	79	109	855
Aluminum	0.90 (sol.)	660	2467	396	10500
Ammonia	4.71 (liq.)	-78	-33	332	1370
Copper	0.39 (sol.)	1083	2567	205	4790
Iron	0.45 (sol.)	1535	2750	267	6290
Lead	0.13 (sol.)	328	1740	25	866
Mercury	0.14 (liq.)	-39	357	11	295
Platinum	0.13 (sol.)	1772	3827	101	229
Silver	0.24 (sol.)	962	2212	105	2370
Tungsten	0.13 (sol.)	3410	5660	192	4350
Water (solid)	2.05 (sol.)	0	-	334	-
Water (liquid)	4.18 (liq.)	-	100	-	-
Water (vapor)	2.01 (gas)	-	-	-	2260
Zinc	0.39 (sol.)	420	907	113	1770

Standard Units

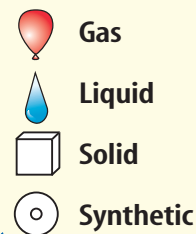


Heat Constants



PERIODIC TABLE OF THE ELEMENTS

Columns of elements are called groups. Elements in the same group have similar chemical properties.



1	2	3	4	5	6	7	8	9
Hydrogen 1 H 1.008								
Lithium 3 Li 6.941	Beryllium 4 Be 9.012							
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305							
Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933
Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc (98)	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906
Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.84	Rhenium 75 Re 186.207	Osmium 76 Os 190.23	Iridium 77 Ir 192.217
Francium 87 Fr (223)	Radium 88 Ra (226)	Actinium 89 Ac (227)	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (266)	Bohrium 107 Bh (264)	Hassium 108 Hs (277)	Meitnerium 109 Mt (268)

State of matter

The first three symbols tell you the state of matter of the element at room temperature. The fourth symbol identifies elements that are not present in significant amounts on Earth. Useful amounts are made synthetically.

The number in parentheses is the mass number of the longest-lived isotope for that element.

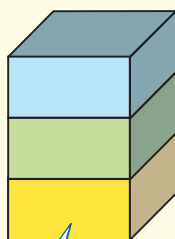
Rows of elements are called periods. Atomic number increases across a period.

Lanthanide series

Actinide series

The arrow shows where these elements would fit into the periodic table. They are moved to the bottom of the table to save space.

Cerium 58 Ce 140.116	Praseodymium 59 Pr 140.908	Neodymium 60 Nd 144.24	Promethium 61 Pm (145)	Samarium 62 Sm 150.36
Thorium 90 Th 232.038	Protactinium 91 Pa 231.036	Uranium 92 U 238.029	Neptunium 93 Np (237)	Plutonium 94 Pu (244)



Metal

Metalloid

Nonmetal

The color of an element's block tells you if the element is a metal, nonmetal, or metalloid.



Visit gpscience.com for updates to the periodic table.

			13	14	15	16	17	18
			Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Helium 2 He 4.003
			Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Neon 10 Ne 20.180
10	11	12	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Argon 18 Ar 39.948
Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.409	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Krypton 36 Kr 83.798
Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Xenon 54 Xe 131.293	Radon 86 Rn (222)
Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Ununquadium * 114 Uuq (289)	** 116			
Darmstadtium 110 Ds (281)	Unununium * 111 Uuu (272)	Ununbium * 112 Uub (285)						

* The names and symbols for elements 111–114 are temporary. Final names will be selected when the elements' discoveries are verified.

** Elements 116 and 118 were thought to have been created. The claim was retracted because the experimental results could not be repeated.

Europium 63 Eu 151.964	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.925	Dysprosium 66 Dy 162.500	Holmium 67 Ho 164.930	Erbium 68 Er 167.259	Thulium 69 Tm 168.934	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.967
Americium 95 Am (243)	Curium 96 Cm (247)	Berkelium 97 Bk (247)	Californium 98 Cf (251)	Einsteinium 99 Es (252)	Fermium 100 Fm (257)	Mendelevium 101 Md (258)	Nobelium 102 No (259)	Lawrencium 103 Lr (262)

Glossary/Glosario

Cómo usar el glosario en español:

1. Busca el término en inglés que desees encontrar.
2. El término en español, junto con la definición, se encuentran en la columna de la derecha.

Pronunciation Key

Use the following key to help you sound out words in the glossary.

a.....back (BAK)
 ay.....day (DAY)
 ah.....father (FAH thur)
 ow.....flower (FLOW ur)
 ar.....car (CAR)
 e.....less (LES)
 ee.....leaf (LEEF)
 ih.....trip (TRIHP)
 i (i + con + e) ..idea (i DEE uh)
 oh.....go (GOH)
 aw.....soft (SAWFT)
 or.....orbit (OR buht)
 oy.....coin (COYN)
 oo.....foot (FOOT)

ew.....food (FEWD)
 yoo.....pure (PYOOR)
 yew.....few (FYEW)
 uh.....comma (CAH muh)
 u (+ con).....rub (RUB)
 sh.....shelf (SHELF)
 ch.....nature (NAY chur)
 g.....gift (GIHFT)
 j.....gem (JEM)
 ing.....sing (SING)
 zh.....vision (VIH zhun)
 k.....cake (KAYK)
 s.....seed, cent (SEED, SENT)
 z.....zone, raise (ZOHN, RAYZ)

English

A

Español

acceleration: rate of change of velocity; can be calculated by dividing the change in the velocity by the time it takes the change to occur. (p. 47)
acid: any substance that produces hydrogen ions, H^+ , in a water solution. (p. 696)
acoustics: the study of sound. (p. 339)
air resistance: force that opposes the motion of objects that move through the air. (p. 73)
alcohol: compound, such as ethanol, that is formed when $-OH$ groups replace one or more hydrogen atoms in a hydrocarbon. (p. 733)
allotropes: different forms of the same element having different molecular structures. (p. 585)
alloy: a mixture of elements that has metallic properties. (p. 758)
alpha particle: particle consisting of two protons and two neutrons that is emitted from a decaying atomic nucleus. (p. 541)
alternating current (AC): electric current that reverses its direction of flow in a regular pattern. (p. 242)
amplitude: a measure of the energy carried by a wave. (p. 300)
aromatic compound: an organic compound that contains the benzene ring structure and may have a pleasant or unpleasant odor and flavor. (p. 731)
atom: the smallest particle of an element that still retains the properties of the element. (p. 507)

aceleración: tasa de cambio de la velocidad; se calcula dividiendo el cambio en la velocidad por el tiempo que toma para que ocurra el cambio. (p. 47)
ácido: sustancia que produce iones de hidrógeno, H^+ , en una solución de agua. (p. 696)
acústica: el estudio del sonido. (p. 339)
resistencia del aire: fuerza que se opone al movimiento de los objetos que se mueven por el aire. (p. 73)
alcohol: compuesto, como el etanol, que se forma cuando grupos $-OH$ reemplazan a uno o más átomos de hidrógeno en un hidrocarburo. (p. 733)
alótropos: formas diferentes del mismo elemento que tienen diferentes estructuras moleculares. (p. 585)
aleación: una mezcla de elementos que tiene propiedades metálicas. (p. 758)
partícula alfa: partícula compuesta por dos protones y dos neutrones y que es emitida por un núcleo atómico en descomposición. (p. 541)
corriente alterna (CA): corriente eléctrica que invierte su dirección de flujo en un patrón regular. (p. 242)
amplitud: medida de la energía transportada por una onda. (p. 300)
compuesto aromático: compuesto orgánico que contiene la estructura del anillo bencénico y que puede tener un olor y un sabor agradables o desagradables. (p. 731)
átomo: la partícula más pequeña de un elemento que mantiene las propiedades del elemento. (p. 507)

atomic number/carbohydrates

- atomic number:** number of protons in an atom's nucleus. (p. 513)
- average atomic mass:** weighted-average mass of the mixture of an element's isotopes. (p. 515)
- average speed:** total distance an object travels divided by the total time it takes to travel that distance. (p. 42)

número atómico/carbohidratos

- número atómico:** número de protones en el núcleo de un átomo. (p. 513)
- masa atómica promedio:** masa de peso promedio resultado de la mezcla de los isótopos de un elemento. (p. 515)
- velocidad promedio:** distancia que recorre un objeto dividida por el tiempo que dura en recorrer dicha distancia. (p. 42)

B

- balanced chemical equation:** chemical equation with the same number of atoms of each element on both sides of the equation. (p. 638)
- balanced forces:** forces on a object that combine to give a zero net force and do not change the motion of the object. (p. 53)
- base:** any substance that forms hydroxide ions, OH^- , in a water solution. (p. 698)
- beta particle:** electron that is emitted from a decaying atomic nucleus. (p. 543)
- bias:** occurs when a scientist's expectations change how the results of an experiment are viewed. (p. 10)
- binary compound:** compound that is composed of two elements. (p. 615)
- biomass:** renewable organic matter from plants and animals, such as wood and animal manure, that can be burned to provide heat. (p. 276)
- boiling point:** the temperature at which the pressure of the vapor in the liquid is equal to the external pressure acting on the surface of the liquid. (p. 479)
- bubble chamber:** radiation detector, consisting of a container of superheated liquid under high pressure, that is used to detect the paths of charged particles. (p. 547)
- buffer:** solution containing ions that react with added acids or bases and minimize their effects on pH. (p. 705)
- buoyancy:** ability of a fluid—a liquid or a gas—to exert an upward force on an object immersed in the fluid. (p. 485)

- ecuación química:** ecuación química con el mismo número de átomos de cada elemento en los dos lados de la ecuación. (p. 638)
- fuerzas equilibradas:** fuerzas en un objeto que se combinan para dar una fuerza neta de cero y no cambiar el movimiento del objeto. (p. 53)
- base:** sustancia que forma iones de hidróxido, OH^- , en una solución de agua. (p. 698)
- partícula beta:** electrón emitido por un núcleo atómico en descomposición. (p. 543)
- predisposición:** ocurre cuando las expectativas de un científico cambian la forma en que son vistos los resultados de un experimento. (p. 10)
- compuesto binario:** compuesto conformado por dos elementos. (p. 615)
- biomasa:** materia orgánica renovable proveniente de plantas y animales, tales como madera y estiércol animal, que puede ser incinerada para producir calor. (p. 276)
- punto de ebullición:** temperatura a la cual la presión del vapor de un líquido es igual a la presión externa que actúa sobre la superficie del líquido. (p. 479)
- cámara de burbujas:** detector de radiación que consiste de un contenedor de un líquido sobrecalentado a alta presión, usado para detectar la trayectoria de las partículas cargadas. (p. 547)
- buffer:** solución que contiene iones que reaccionan con los ácidos o bases agregados y que minimiza los efectos de éstos en el pH. (p. 705)
- fuerza flotante:** capacidad de un fluido, líquido o gas, para ejercer una fuerza ascendente sobre un objeto inmerso en un fluido. (p. 485)

C

- carbohydrates:** group of biological compounds, such as sugars and starches, with twice as many hydrogen atoms as oxygen atoms. (p. 745)

- carbohidratos:** grupo de compuestos biológicos tales como azúcares y almidones que contienen el doble de átomos de hidrógeno que de oxígeno. (p. 745)

Glossary/Glosario

carrier wave/cochlea

carrier wave: specific frequency that a radio station is assigned and uses to broadcast signals. (p. 367)

catalyst: substance that speeds up a chemical reaction without being permanently changed itself. (p. 650)

cathode-ray tube: sealed vacuum tube that produces one or more beams of electrons that produce an image when they strike the coating on the inside of a TV screen. (p. 370)

centripetal acceleration: acceleration of an object toward the center of a curved or circular path. (p. 81)

centripetal force: a net force that is directed toward the center of a curved or circular path. (p. 81)

ceramics: versatile materials made from dried clay or clay-like mixtures with customizable properties; produced by a process in which an object is molded and then heated to high temperatures, increasing its density. (p. 764)

chain reaction: ongoing series of fission reactions. (p. 552)

charging by contact: process of transferring charge between objects by touching or rubbing. (p. 195)

charging by induction: process of rearranging electrons on a neutral object by bringing a charged object close to it. (p. 196)

chemical bond: force that holds atoms together in a compound. (p. 606)

chemical change: change of one substance into a new substance. (p. 462)

chemical equation: shorthand method to describe chemical reactions using chemical formulas and other symbols. (p. 635)

chemical formula: chemical shorthand that uses symbols to tell what elements are in a compound and their ratios. (p. 603)

chemical potential energy: energy stored in chemical bonds. (p. 103)

chemical property: any characteristic of a substance, such as flammability, that indicates whether it can undergo a certain chemical change. (p. 461)

chemical reaction: process in which one or more substances are changed into new substances. (p. 632)

circuit: closed conducting loop through which an electric current can flow. (p. 201)

cloud chamber: radiation detector that uses water or ethanol vapor to detect the paths of charged particles. (p. 546)

cochlea: spiral-shaped, fluid-filled structure in the inner ear that converts sound waves to nerve impulses. (p. 326)

onda transportadora/cóclea

onda transportadora: frecuencia específica que se le asigna a una estación de radio y que la usa para emitir señales. (p. 367)

catalizador: sustancia que acelera una reacción química sin cambiar el mismo permanentemente. (p. 650)

tubo de rayos catódicos: tubo vacío sellado que produce uno o más haces de electrones para producir una imagen al chocar con el revestimiento del interior de una pantalla de televisor. (p. 370)

aceleración centrípeta: aceleración de un objeto dirigida hacia el centro de un trayecto curvo o circular. (p. 81)

fuerza centrípeta: fuerza neta dirigida hacia el centro de un trayecto curvo o circular. (p. 81)

cerámicas: materiales versátiles hechos con arcilla seca o mezclas parecidas a la arcilla con propiedades adaptables, producidos mediante un proceso en el cual un objeto es moldeado y luego sujeto a altas temperaturas, aumentando su densidad. (p. 764)

reacción en cadena: serie continua de reacciones de fisión. (p. 552)

carga por contacto: proceso de transferir carga entre objetos por contacto o frotación. (p. 195)

carga por inducción: proceso de redistribución de los electrones en un objeto neutro acercándoles un objeto con carga. (p. 196)

enlace químico: fuerza que mantiene a los átomos juntos dentro de un compuesto. (p. 606)

cambio químico: transformación de una sustancia en una nueva sustancia. (p. 462)

ecuación química: método simplificado para describir reacciones químicas usando fórmulas químicas y otros símbolos. (p. 635)

fórmula química: nomenclatura química que usa símbolos para expresar qué elementos están en un compuesto y en qué proporción. (p. 603)

energía química potencial: energía almacenada en los enlaces químicos. (p. 103)

propiedad química: cualquier característica de una sustancia, como por ejemplo la combustibilidad, que indique si puede someterse a determinado cambio químico. (p. 461)

reacción química: proceso en el cual una o más sustancias son cambiadas por nuevas sustancias. (p. 632)

circuito: circuito conductor cerrado a través del cual puede fluir una corriente eléctrica. (p. 201)

cámara de vapor: detector de radiaciones que usa vapor de agua o de etanol para detectar la trayectoria de las partículas cargadas. (p. 546)

cóclea: estructura en el oído interno, con forma de espiral y llena de un fluido, la cual convierte las ondas sonoras en impulsos nerviosos. (p. 326)

coefficient/convex lens

coefficient: number in a chemical equation that represents the number of units of each substance taking part in a chemical reaction. (p. 636)

coherent light: light of a single wavelength that travels in a single direction with its crests and troughs aligned. (p. 398)

colloid (KAHL oyd): heterogeneous mixture whose particles never settle. (p. 454)

combustion reaction: a type of chemical reaction that occurs when a substance reacts with oxygen to produce energy in the form of heat and light. (p. 641)

composite: mixture of two materials, one of which is embedded in the other. (p. 775)

compound: substance formed from two or more elements in which the exact combination and proportion of elements is always the same. (p. 452)

compound machine: machine that is a combination of two or more simple machines. (p. 146)

compressional wave: a wave for which the matter in the medium moves back and forth along the direction that the wave travels. (p. 292)

concave lens: a lens that is thicker at the edges than in the middle; causes light rays to diverge and forms reduced, upright, virtual images; and is usually used in combination with other lenses. (p. 426)

concave mirror: a reflective surface that curves inward and can magnify objects or create beams of light. (p. 418)

conduction: transfer of thermal energy by collisions between particles in matter at a higher temperature and particles in matter at a lower temperature. (p. 164)

conductivity (kahn duk TIHV ut ee): property of metals and alloys that allows heat or electrical charges to pass through the material easily. (p. 759)

conductor: material, such as copper wire, in which electrons can move easily. (p. 194)

constant: in an experiment, a variable that does not change when other variables change. (p. 9)

control: standard used for comparison of test results in an experiment. (p. 9)

convection: transfer of thermal energy in a fluid by the movement of warmer and cooler fluid from one place to another. (p. 165)

convex lens: a lens that is thicker in the middle than at the edges and can form real or virtual images. (p. 424)

coeficiente/lente convexo

coeficiente: número en una ecuación química que representa el número de unidades de cada una de las sustancias que participan en una reacción química. (p. 636)

luz coherente: luz de una sola longitud de onda que viaja en una sola dirección con sus crestas y sus depresiones alineadas. (p. 398)

coloide: mezcla heterogénea cuyas partículas nunca se sedimentan. (p. 454)

reacción de combustión: un tipo de reacción química que ocurre cuando una sustancia reacciona con oxígeno para producir energía en forma de calor y luz. (p. 641)

compuesto: mezcla de dos materiales, uno de los cuales está embebido en el otro. (p. 775)

compuesto: sustancia formada por dos o más elementos en la que la combinación y proporción exacta de los elementos es siempre la misma. (p. 452)

máquina compuesta: máquina compuesta por dos o más máquinas simples. (p. 146)

onda de compresión: onda para la cual la materia en el medio se mueve hacia adelante y hacia atrás en la dirección en que viaja la onda. (p. 292)

lente cóncavo: lente que es más delgado en los bordes que en el centro; hace que los rayos de luz se desvíen y forma imágenes reducidas, verticales y virtuales, y generalmente se utiliza en combinación con otros lentes. (p. 426)

espejo cóncavo: superficie reflexiva que se curva hacia el interior y que puede amplificar los objetos o crear rayos de luz. (p. 418)

conducción: transferencia de energía térmica por colisiones entre partículas de materia a una temperatura alta y partículas de materia a una temperatura más baja. (p. 164)

conductividad: propiedad de los metales y aleaciones que permite fácilmente el paso de calor o cargas eléctricas a través del material. (p. 759)

conductor: material, como el alambre de cobre, a través del cual los electrones se pueden mover con facilidad. (p. 194)

constante: en un experimento, una variable que no cambia cuando cambian otras variables. (p. 9)

control: estándar usado para la comparación de resultados de pruebas en un experimento. (p. 9)

convección: transferencia de energía térmica en un fluido por el movimiento de fluidos con mayores y menores temperaturas de un lugar a otro. (p. 165)

lente convexo: lente que es más delgado en el centro que en los bordes y que puede formar imágenes reales o virtuales. (p. 424)

Glossary/Glosario

convex mirror/distillation

convex mirror: a reflective surface that curves outward and forms a reduced, upright, virtual image. (p. 421)

cornea: transparent covering on the eyeball through which light enters the eye. (p. 427)

covalent bond: attraction formed between atoms when they share electrons. (p. 611)

crest: the highest points on a transverse wave. (p. 296)

critical mass: amount of fissionable material required so that each fission reaction produces approximately one more fission reaction. (p. 552)

espejo convexo/destilación

espejo convexo: una superficie reflexiva que se curva hacia el exterior y forma una imagen reducida, vertical y virtual. (p. 421)

córnea: cubierta transparente del globo ocular a través de la cual entra la luz al ojo. (p. 427)

enlace covalente: atracción formada entre átomos que comparten electrones. (p. 611)

cresta: los puntos más altos en una onda transversal. (p. 296)

masa crítica: cantidad de material fisiónable requerido de manera que cada reacción de fisión produzca aproximadamente una reacción de fisión adicional. (p. 552)

D

decibel: unit for sound intensity; abbreviated dB. (p. 329)

decomposition reaction: chemical reaction in which one substance breaks down into two or more substances. (p. 642)

density: mass per unit volume of a material. (p. 19)

deoxyribonucleic (dee AHK sih ri boh noo klay ihk) acid: a type of essential biological compound found in the nuclei of cells that codes and stores genetic information and controls the production of RNA. (p. 744)

dependent variable: factor that changes as a result of changes in the other variables. (p. 9)

depolymerization: process using heat or chemicals to break a polymer chain into its monomers. (p. 741)

diatomic molecule: a molecule that consists of two atoms of the same element. (p. 579)

diffraction: the bending of waves around an obstacle; can also occur when waves pass through a narrow opening. (p. 306)

diffusion: spreading of particles throughout a given volume until they are uniformly distributed. (p. 479)

direct current (DC): electric current that flows in only one direction. (p. 242)

displacement: distance and direction of an object's change in position from the starting point. (p. 39)

dissociation: process in which an ionic compound separates into its positive and negative ions. (p. 677)

distance: how far an object moves. (p. 39)

distillation: process that can separate two substances in a mixture by evaporating a liquid and recondensing its vapor. (p. 461)

decibel: unidad que mide la intensidad del sonido; se abrevia dB. (p. 329)

reacción de descomposición: reacción química en la cual una sustancia se descompone en dos o más sustancias. (p. 642)

densidad: masa por unidad de volumen de un material. (p. 19)

ácido desoxirribonucleico: compuesto biológico esencial encontrado en el núcleo de células que codifican y almacenan información genética y que controla la producción de ARN. (p. 744)

variable dependiente: factor que varía como resultado de los cambios en las otras variables. (p. 9)

despolimerización: proceso en el que se utilizan calor o químicos para descomponer una cadena de polímeros en sus monómeros. (p. 741)

molécula diatómica: molécula formada por dos átomos del mismo elemento. (p. 579)

difracción: curvatura de las ondas alrededor de un obstáculo, la cual también puede ocurrir cuando éstas pasan a través de una abertura angosta. (p. 306)

difusión: propagación de partículas en la totalidad de un volumen determinado hasta que se distribuyen de manera uniforme. (p. 479)

corriente directa (CD): corriente eléctrica que fluye en una sola dirección. (p. 242)

desplazamiento: distancia y dirección del cambio de posición de un objeto desde el punto inicial. (p. 39)

disociación: proceso en el cual un compuesto iónico se separa en sus iones positivos y negativos. (p. 677)

distancia: qué tan lejos se mueve un objeto. (p. 39)

destilación: proceso que puede separar dos sustancias de una mezcla por medio de la evaporación de un líquido y la recondensación de su vapor. (p. 461)

doping/electromagnetic waves

doping: process of adding impurities to a semiconductor to increase its conductivity. (p. 768)

Doppler effect: change in pitch or frequency that occurs when a source of a sound is moving relative to a listener. (p. 331)

double-displacement reaction: chemical reaction that produces a precipitate, water, or a gas when two ionic compounds in solution are combined. (p. 643)

ductile: ability of metals to be drawn into wires. (p. 570)

ductility (duk TIHL uh tee): ability of metals or alloys to be pulled into wires. (p. 759)

dopaje/ondas electromagnéticas

dopaje: proceso que consiste en añadir impurezas a un semiconductor para aumentar su conductividad. (p. 768)

efecto Doppler: cambio en la altura o frecuencia que ocurre cuando una fuente de sonido se mueve en relación con un oyente. (p. 331)

reacción de doble desplazamiento: reacción química que produce un precipitado, agua o gas cuando se combinan dos compuestos iónicos en una solución. (p. 643)

ductibilidad: capacidad de los metales para convertirse en alambres. (p. 570)

ductilidad: capacidad de los metales o aleaciones para ser convertidos en alambres. (p. 759)

E

eardrum: tough membrane in the outer ear that is about 0.1 mm thick and transmits sound vibrations into the middle ear. (p. 325)

echolocation: process in which objects are located by emitting sounds and interpreting sound waves that are reflected. (p. 339)

efficiency: ratio of the output work done by the machine to the input work done on the machine, expressed as a percentage. (p. 136)

elastic potential energy: energy stored when an object is compressed or stretched. (p. 103)

electrical power: rate at which electrical energy is converted to another form of energy; expressed in watts (W). (p. 210)

electric current: the net movement of electric charges in a single direction, measured in amperes (A). (p. 201)

electric motor: device that converts electrical energy to mechanical energy by using the magnetic forces between an electromagnet and a permanent magnet to make a shaft rotate. (p. 235)

electrolyte: compound that breaks apart in water, forming charged particles (ions) that can conduct electricity. (p. 676)

electromagnet: temporary magnet made by wrapping a wire coil, carrying a current, around an iron core. (p. 232)

electromagnetic induction: process in which electric current is produced in a wire loop by a changing magnetic field. (p. 238)

electromagnetic waves: waves created by vibrating electric charges, can travel through a vacuum or through matter, and have a wide variety of frequencies and wavelengths. (p. 354)

tímpano: membrana fuerte del oído externo que tiene más o menos 0.1 mm de grosor y transmite las vibraciones del sonido al oído medio. (p. 325)

ecolocalización: proceso en el cual los objetos son localizados emitiendo sonidos e interpretando ondas de sonido que se reflejan. (p. 339)

eficiencia: relación del trabajo efectuado por una máquina y el trabajo hecho en ésta, expresada en porcentaje. (p. 136)

energía elástica potencial: energía almacenada cuando un objeto es comprimido o estirado. (p. 103)

potencia eléctrica: proporción a la cual la energía eléctrica se convierte en otra forma de energía; se expresa en vatios (V). (p. 210)

corriente eléctrica: movimiento neto de cargas eléctricas en una sola dirección, medido en amperios (A). (p. 201)

motor eléctrico: dispositivo que convierte la energía eléctrica en energía mecánica usando las fuerzas magnéticas entre un electroimán y un imán permanente para que el eje gire. (p. 235)

electrolito: compuesto que se descompone en agua formando partículas cargadas (iones) que pueden conducir electricidad. (p. 676)

electroimán: imán temporal que se hace envolviendo una bobina de cable que conduce una corriente, alrededor de un núcleo de hierro. (p. 232)

inducción electromagnética: proceso en el cual una corriente eléctrica es producida en un circuito cerrado de cable mediante un campo magnético cambiante. (p. 238)

ondas electromagnéticas: ondas creadas por la vibración de cargas eléctricas, que pueden viajar a través del vacío o de la materia y que tienen una amplia variedad de frecuencias y de longitudes de onda. (p. 354)

Glossary/Glosario

electron cloud/friction

- electron cloud:** area around the nucleus of an atom where the atom's electrons are most likely to be found. (p. 511)
- electron dot diagram:** uses the symbol for an element and dots representing the number of electrons in the element's outer energy level. (p. 522)
- electrons:** particles surrounding the center of an atom that have a charge of $1-$. (p. 507)
- element:** substance with atoms that are all alike. (p. 450)
- endergonic reaction:** chemical reaction that requires energy input (heat, light, or electricity) in order to proceed. (p. 649)
- endothermic reaction:** chemical reaction that requires heat energy in order to proceed. (p. 649)
- exergonic reaction:** chemical reaction that releases some form of energy, such as light or heat. (p. 648)
- exothermic reaction:** chemical reaction in which energy is primarily given off in the form of heat. (p. 648)
- experiment:** organized procedure for testing a hypothesis; tests the effect of one thing on another under controlled conditions. (p. 8)

nube de electrones/fricción

- nube de electrones:** área alrededor del núcleo de un átomo en donde hay más probabilidad de encontrar los electrones de los átomos. (p. 511)
- diagrama de punto de electrones:** usa el símbolo de un elemento y puntos que representan el número de electrones en el nivel de energía externo del elemento. (p. 522)
- electrones:** partículas que rodean el centro de un átomo que tienen la carga de $1-$. (p. 507)
- elemento:** sustancia en la cual todos los átomos son iguales. (p. 450)
- reacción endergónica:** reacción química que requiere entrada de energía (calor, luz o electricidad) para poder proceder. (p. 649)
- reacción endotérmica:** reacción química que requiere energía de calor para proceder. (p. 649)
- reacción exergónica:** reacción química que libera una forma de energía, tal como, luz o calor. (p. 648)
- reacción exotérmica:** reacción química en la cual la energía es inicialmente emitida en forma de calor. (p. 648)
- experimento:** procedimiento organizado para probar una hipótesis; prueba el efecto de una cosa sobre otra bajo condiciones controladas. (p. 8)

F

- first law of thermodynamics:** states that the increase in thermal energy of a system equals the work done on the system plus the heat added to the system. (p. 175)
- fluorescent light:** light that results when ultraviolet radiation produced inside a fluorescent bulb causes the phosphor coating inside the bulb to glow. (p. 395)
- focal length:** distance from the center of a lens or mirror to the focal point. (p. 418)
- focal point:** the point on the optical axis of a concave mirror or convex lens where light rays, that are initially parallel to the optical axis, pass through after they strike the mirror or lens. (p. 418)
- force:** a push or pull exerted on an object. (p. 52)
- fossil fuels:** oil, natural gas, and coal; formed from the decayed remains of ancient plants and animals. (p. 257)
- frequency:** the number of wavelengths that pass a fixed point each second; is expressed in hertz (Hz). (p. 297)
- friction:** force that opposes the sliding motion between two touching surfaces. (p. 70)

- primera ley de la termodinámica:** establece que el aumento en la energía térmica de un sistema es igual al trabajo realizado sobre el sistema más el calor agregado a éste. (p. 175)
- luz fluorescente:** luz que resulta cuando una radiación ultravioleta producida dentro de una bombilla fluorescente hace que brille el revestimiento de fósforo dentro de la bombilla. (p. 395)
- longitud focal:** distancia desde el centro de un lente o espejo al punto focal. (p. 418)
- punto focal:** el punto en el eje óptico de un espejo cóncavo o lente convexo en el cual los rayos de luz, que inicialmente son paralelos al eje óptico, cruzan luego de chocar con el espejo o lente. (p. 418)
- fuerza:** impulso o tracción sobre un objeto. (p. 52)
- combustibles fósiles:** petróleo, gas natural y carbón formados por los restos descompuestos de plantas y animales ancestrales. (p. 257)
- frecuencia:** el número de longitudes de onda que pasan por un punto fijo en un segundo; se expresa en hertz (Hz). (p. 297)
- fricción:** fuerza que se opone al movimiento deslizante entre dos superficies en contacto. (p. 70)

G

galvanometer: a device that uses an electromagnet to measure electric current. (p. 234)

gamma ray: electromagnetic wave with no mass and no charge that travels at the speed of light and is usually emitted with alpha or beta particles from a decaying atomic nucleus; has a wavelength less than about ten trillionths. (pp. 365, 543)

Geiger counter: radiation detector that produces a click or a flash of light when a charged particle is detected. (p. 548)

generator: device that uses electromagnetic induction to convert mechanical energy to electrical energy. (p. 238)

geothermal energy: thermal energy in hot magma; can be converted by a power plant into electrical energy. (p. 275)

Global Positioning System (GPS): a system of satellites and ground monitoring stations that enable a receiver to determine its location at or above Earth's surface. (p. 373)

graph: visual display of information or data that can provide a quick way to communicate a lot of information and allow scientists to observe patterns. (p. 22)

gravitational potential energy: energy stored by objects due to their position above Earth's surface; depends on the distance above Earth's surface and the object's mass. (p. 104)

gravity: attractive force between two objects that depends on the masses of the objects and the distance between them. (p. 75)

group: vertical column in the periodic table. (p. 520)

galvanómetro: dispositivo que usa un electroimán para medir la corriente eléctrica. (p. 234)

rayo gama: onda electromagnética sin masa ni carga que viaja a la velocidad de la luz y que usualmente es emitida con partículas alfa o beta a partir de un núcleo atómico en descomposición; tiene una electromagnética con longitudes de onda menores a diez trillonésimas de metro. (pp. 365, 543)

contador Geiger: detector de radiación que produce un sonido seco o un destello de luz al detectar una partícula cargada. (p. 548)

generador: dispositivo que usa inducción electromagnética para convertir energía mecánica en energía eléctrica. (p. 238)

energía geotérmica: energía térmica en el magma caliente, la cual se puede convertir mediante una planta industrial en energía eléctrica. (p. 275)

Sistema de Posicionamiento Global (GPS): sistema de satélites y estaciones de monitoreo en tierra que permiten que un receptor determine su ubicación en o sobre la superficie terrestre. (p. 373)

gráfica: presentación visual de información que puede suministrar una forma rápida de comunicar gran cantidad de información y que permite que los científicos puedan observar los patrones. (p. 22)

energía gravitacional potencial: energía almacenada por objetos debido a su posición sobre la superficie terrestre, la cual depende de la distancia sobre la superficie terrestre y de la masa del objeto. (p. 104)

gravedad: fuerza de atracción entre dos objetos que depende de las masas de los objetos y de la distancia entre ellos. (p. 75)

grupo: columna vertical en la tabla periódica. (p. 520)

H

half-life: amount of time it takes for half the nuclei in a sample of a radioactive isotope to decay. (p. 544)

heat: thermal energy that flows from a warmer material to a cooler material. (p. 160)

heat engine: device that converts thermal energy into work. (p. 176)

heat of fusion: amount of energy required to change a substance from the solid phase to the liquid phase. (p. 478)

vida media: tiempo requerido para que se descomponga la mitad de los núcleos de una muestra de isótopo radiactivo. (p. 544)

calor: energía térmica que fluye de un material caliente a uno frío. (p. 160)

motor de calor: dispositivo que convierte la energía térmica en trabajo. (p. 176)

calor de fusión: cantidad de energía necesaria para cambiar una sustancia del estado sólido al líquido. (p. 478)

Glossary/Glosario

heat of vaporization/infrared waves

heat of vaporization: the amount of energy required for the liquid at its boiling point to become a gas. (p. 479)

heterogeneous (het uh ruh JEE nee us) mixture: mixture, such as mixed nuts or a dry soup mix, in which different materials are unevenly distributed and are easily identified. (p. 453)

holography: technique that produces a complete three-dimensional photographic image of an object. (p. 401)

homogeneous (hoh moh JEE nee us) mixture: solid, liquid, or gas that contains two or more substances blended evenly throughout. (p. 454)

hydrate: compound that has water chemically attached to its ions and written into its chemical formula. (p. 620)

hydrocarbon: saturated or unsaturated compound containing only carbon and hydrogen atoms. (p. 727)

hydroelectricity: electricity produced from the energy of falling water. (p. 273)

hydronium ions (hi DROH nee um • I ahnz): H_3O^+ ions, which form when an acid dissolves in water and H^+ ions interact with water. (p. 696)

hypothesis: educated guess using what you know and what you observe. (p. 8)

calor de vaporización/ondas infrarrojas

calor de vaporización: cantidad de energía necesaria para que un líquido en su punto de ebullición se convierta en gas. (p. 479)

mezcla heterogénea: mezcla, tal como una mezcla de nueces o una mezcla seca para hacer sopa, en la cual diferentes materiales están distribuidos en forma desigual y se pueden identificar fácilmente. (p. 453)

holografía: técnica que produce una imagen fotográfica tridimensional completa de un objeto. (p. 401)

mezcla homogénea: sólido, líquido, o gas que contiene dos o más sustancias mezcladas de manera uniforme en toda la mezcla. (p. 454)

hidrato: compuesto que contiene agua químicamente conectada a sus iones y representada en su fórmula química. (p. 620)

hidrocarburos: compuestos saturados o no saturados que contienen únicamente átomos de carbono e hidrógeno. (p. 727)

hidroelectricidad: electricidad producida a partir de la energía generada por una caída de agua. (p. 273)

iones de hidronio: iones H_3O^+ que se forman cuando un ácido se disuelve en agua y los iones H^+ interactúan con el agua. (p. 696)

hipótesis: suposición fundamentada que se basa en lo que se sabe y lo que se observa. (p. 8)

I

incandescent light: light produced by heating a piece of metal, usually tungsten, until it glows. (p. 394)

inclined plane: simple machine that consists of a sloping surface, such as a ramp, that reduces the amount of force needed to lift something by increasing the distance over which the force is applied. (p. 144)

incoherent light: light that contains more than one wavelength, and travels in many directions with its crests and troughs unaligned. (p. 398)

independent variable: factor that, as it changes, affects the measure of another variable. (p. 9)

index of refraction: property of a material indicating how much light slows down when traveling in the material. (p. 386)

indicator: organic compound that changes color in acids and bases. (p. 696)

inertia: resistance of an object to a change in its motion. (p. 54)

infrared waves: electromagnetic waves that have a wavelength between about 1 mm and 750 billionths of a meter. (p. 362)

luz incandescente: luz que se produce al calentar una pieza de metal, generalmente tungsteno, hasta que brille. (p. 394)

plano inclinado: máquina simple que consiste de una superficie inclinada, tal como una rampa, que reduce la fuerza necesaria para levantar un objeto aumentando la distancia sobre la cual se aplica dicha fuerza. (p. 144)

luz incoherente: luz que contiene más de una longitud de onda y que viaja en varias direcciones con sus crestas y depresiones no alineadas. (p. 398)

variable independiente: factor que, a medida que cambia, afecta la medida de otra variable. (p. 9)

índice de refracción: propiedad de un material para indicar la cantidad de luz que se frena al pasar a través del material. (p. 386)

indicador: compuesto orgánico que cambia de color en presencia de ácidos y bases. (p. 696)

inercia: resistencia de un objeto a cambiar su movimiento. (p. 54)

ondas infrarrojas: ondas electromagnéticas que tienen una longitud de onda entre aproximadamente 1 mm y 750 billonésimas de metro. (p. 362)

inhibitor/kinetic theory

inhibitor: substance that slows down a chemical reaction or prevents it from occurring by combining with a reactant. (p. 650)

instantaneous speed: speed of an object at a given point in time; is constant for an object moving with constant speed, and changes with time for an object that is slowing down or speeding up. (p. 42)

insulator: material in which electrons are not able to move easily. (p. 195)

insulator: material in which heat flows slowly. (p. 169)

integrated circuit: tiny chip of semiconductor material that can contain millions of transistors, diodes, and other components. (p. 768)

intensity: amount of energy that flows through a certain area in a specific amount of time. (p. 328)

interference: occurs when two or more waves overlap and combine to form a new wave. (p. 308)

internal combustion engine: heat engine that burns fuel inside the engine in chambers or cylinders. (p. 176)

ion: charged particle that has either more or fewer electrons than protons. (pp. 608, 676)

ionic bond: attraction formed between oppositely charged ions in an ionic compound. (p. 610)

ionization: process in which electrolytes dissolve in water and separate into charged particles. (p. 676)

isomers: compounds with identical chemical formulas but different molecular structures and shapes. (p. 729)

isotopes: atoms of the same element that have different numbers of neutrons. (p. 514)

inhibidor/teoría cinética

inhibidor: sustancia que reduce una reacción química o previene que ocurra por una combinación con un reactivo. (p. 650)

velocidad instantánea: velocidad de un objeto en un punto dado en el tiempo; es constante para un objeto que se mueve a una velocidad constante y cambia con el tiempo en un objeto que está reduciendo o aumentando su velocidad. (p. 42)

aislador: material a través del cual los electrones no se pueden mover con facilidad. (p. 195)

aislador: material en el cual el calor fluye lentamente. (p. 169)

circuito integrado: pedazo minúsculo de material semiconductor que puede contener millones de transistores, diodos y otros componentes. (p. 768)

intensidad: cantidad de energía que fluye a través de cierta área en un tiempo específico. (p. 328)

interferencia: ocurre cuando dos o más ondas se superponen y combinan para formar una nueva onda. (p. 308)

motor de combustión interna: motor de calor que quema combustible en su interior en cámaras o cilindros. (p. 176)

ion: partícula cargada que tiene ya sea más o menos electrones que protones. (pp. 608, 676)

enlace iónico: atracción formada entre iones con cargas opuestas en un compuesto iónico. (p. 610)

ionización: proceso en el cual los electrolitos se disuelven en agua y se separan en partículas cargadas. (p. 676)

isómeros: compuestos con fórmulas químicas idénticas pero diferentes estructuras y formas moleculares. (p. 729)

isótopos: átomos del mismo elemento que tienen diferente número de neutrones. (p. 514)

J

joule: SI unit of energy. (p. 102)

julio: unidad SI de energía. (p. 102)

K

kinetic energy: energy a moving object has because of its motion; depends on the mass and speed of the object. (p. 102)

kinetic theory: explanation of the behavior of molecules in matter; states that all matter is made of constantly moving particles that collide without losing energy. (p. 476)

energía cinética: energía que tiene un cuerpo debido a su movimiento, la cual depende de la masa y velocidad del objeto. (p. 102)

teoría cinética: explicación del comportamiento de las moléculas en la materia, la cual establece que todas las sustancias están compuestas de partículas en constante movimiento que colindan sin perder energía. (p. 476)

Glossary/Glosario

law of conservation of charge/mass number

ley de la conservación de carga/número de masa

L

law of conservation of charge: states that charge can be transferred from one object to another but cannot be created or destroyed. (p. 193)

law of conservation of energy: states that energy can never be created or destroyed. (p. 111)

law of conservation of mass: states that the mass of all substances present before a chemical change equals the mass of all the substances remaining after the change. (p. 465)

lever: simple machine consisting of a bar free to pivot about a fixed point called the fulcrum. (p. 138)

lipids: group of biological compounds that contains the same elements as carbohydrates but in different arrangements and combinations, and includes saturated and unsaturated fats and oils. (p. 746)

loudness: human perception of sound intensity. (p. 329)

luster: property of metals and alloys that describes having a shiny appearance or reflecting light. (p. 759)

ley de la conservación de carga: establece que la carga puede ser transferida entre un objeto y otro pero no puede ser creada o destruida. (p. 193)

ley de la conservación de energía: establece que la energía nunca puede ser creada ni destruida. (p. 111)

ley de conservación de la masa: establece que la masa de todas las sustancias presente antes de un cambio químico es igual a la masa de todas las sustancias resultantes después del cambio. (p. 465)

palanca: máquina simple que consiste de una barra que puede girar sobre un punto fijo llamado pivote. (p. 138)

lípidos: grupo de compuestos biológicos que contienen los mismos elementos que los carbohidratos pero en diferentes disposiciones y combinaciones, y que incluye grasas y aceites saturados o no saturados. (p. 746)

volumen de sonido: percepción humana de la intensidad del sonido. (p. 329)

lustre: propiedad de los metales y aleaciones que describe que tienen una apariencia brillante o que reflejan la luz. (p. 759)

M

machine: device that makes doing work easier by increasing the force applied to an object, changing the direction of an applied force, or increasing the distance over which a force can be applied. (p. 132)

magnetic domain: group of atoms in a magnetic material with the magnetic poles of the atoms pointing in the same direction. (p. 229)

magnetic field: surrounds a magnet and exerts a force on other magnets and objects made of magnetic materials. (p. 225)

magnetic pole: region on a magnet where the magnetic force exerted by a magnet is strongest; like poles repel and opposite poles attract. (p. 225)

magnetism: the properties and interactions of magnets. (p. 224)

malleability (mal yuh BIHL yt ee): ability of metals and alloys to be rolled or hammered into thin sheets. (pp. 570, 759)

mass: amount of matter in an object. (p. 19)

mass number: sum of the number of protons and neutrons in an atom's nucleus. (p. 513)

máquina: artefacto que facilita la ejecución del trabajo aumentando la fuerza que se aplica a un objeto, cambiando la dirección de una fuerza aplicada o aumentando la distancia sobre la cual se puede aplicar una fuerza. (p. 132)

dominio magnético: grupo de átomos en un material magnético en el cual los polos magnéticos de los átomos apuntan en la misma dirección. (p. 229)

campo magnético: rodea a un imán y ejerce una fuerza sobre otros imanes y objetos hechos de materiales magnéticos. (p. 225)

polo magnético: zona en un imán en donde la fuerza magnética ejercida por un imán es la más fuerte; los polos iguales se repelen y los polos opuestos se atraen. (p. 225)

magnetismo: propiedades e interacciones de los imanes. (p. 224)

maleabilidad: capacidad de los metales y aleaciones de ser rolados o martillados para formar láminas delgadas. (pp. 570, 759)

masa: cantidad de materia en un objeto. (p. 19)

número de masa: suma del número de protones y neutrones en el núcleo de un átomo. (p. 513)

mechanical advantage (MA)/neutron

- mechanical advantage (MA):** ratio of the output force exerted by a machine to the input force applied to the machine. (p. 136)
- mechanical energy:** sum of the potential energy and kinetic energy in a system. (p. 108)
- medium:** matter in which a wave travels. (p. 291)
- melting point:** temperature at which a solid begins to liquefy. (p. 478)
- metal:** element that typically is a hard, shiny solid, is malleable, and is a good conductor of heat and electricity. (p. 570)
- metallic bonding:** occurs because electrons move freely among a metal's positively charged ions and explains properties such as ductility and the ability to conduct electricity. (p. 571)
- metalloid:** element that shares some properties with metals and some with nonmetals. (p. 584)
- microscope:** uses convex lenses to magnify small, close objects. (p. 435)
- microwaves:** radio waves with wavelengths of between about 1 m and 1 mm. (p. 361)
- mirage:** image of a distant object produced by the refraction of light through air layers of different densities. (p. 388)
- model:** can be used to represent an idea, object, or event that is too big, too small, too complex, or too dangerous to observe or test directly. (p. 11)
- molecule:** a neutral particle that forms as a result of electron sharing. (p. 611)
- momentum:** property of a moving object that equals its mass times its velocity. (p. 86)
- monomer:** small molecule that forms a link in a polymer chain and can be made to combine with itself repeatedly. (pp. 739, 771)
- music:** sounds that are deliberately used in a regular pattern. (p. 333)

ventaja mecánica (MA)/neutrón

- ventaja mecánica (MA):** relación de la fuerza ejercida por una máquina y la fuerza aplicada a dicha máquina. (p. 136)
- energía mecánica:** suma de la energía potencial y energía cinética en un sistema. (p. 108)
- medio:** materia a través de la cual viaja una onda. (p. 291)
- punto de fusión:** temperatura a la cual un sólido comienza a licuarse. (p. 478)
- metal:** elemento típicamente duro, sólido brillante, maleable y buen conductor del calor y la electricidad. (p. 570)
- enlace metálico:** ocurre debido a que los electrones se mueven libremente entre los iones de un metal cargados positivamente y explica propiedades tales como la ductibilidad y la capacidad para conducir electricidad. (p. 571)
- metaloides:** elemento que tiene algunas propiedades de los metales y algunas de los no metales. (p. 584)
- microscopio:** instrumento que usa lentes convexas para amplificar objetos pequeños cercanos. (p. 435)
- microondas:** ondas de radio con longitudes de onda entre aproximadamente 1 mm y 1 m. (p. 361)
- espejismo:** imagen de un objeto distante producida por la refracción de la luz a través de capas de aire de diferentes densidades. (p. 388)
- modelo:** puede ser usado para representar una idea, objeto o evento que es demasiado grande, demasiado pequeño, demasiado complejo o demasiado peligroso para ser observado o probado directamente. (p. 11)
- molécula:** partícula neutra que se forma al compartir electrones. (p. 611)
- inercia:** propiedad de un objeto en movimiento que es igual a su masa por su velocidad. (p. 86)
- monómero:** pequeña molécula que forma una conexión en una cadena de polímeros y que se puede combinar consigo misma repetidamente. (pp. 739, 771)
- música:** sonidos que se usan deliberadamente en un patrón regular. (p. 333)

N

- net force:** sum of the forces that are acting on an object. (p. 53)
- neutralization:** chemical reaction that occurs when the H_3O^+ ions from an acid react with the OH^- ions from a base to produce water molecules. (p. 707)
- neutron:** neutral particle, composed of quarks, inside the nucleus of an atom. (p. 507)

- fuerza neta:** suma de fuerzas que actúan sobre un objeto. (p. 53)
- neutralización:** reacción química que ocurre cuando los iones H_3O^+ de un ácido reaccionan con los iones OH^- de una base para producir moléculas de agua. (p. 707)
- neutrón:** partícula neutra, compuesta por quarks, dentro del núcleo de un átomo. (p. 507)

Glossary/Glosario

Newton's second law of motion/Ohm's law

Newton's second law of motion: states that the acceleration of an object is in the same direction as the net force on the object, and that the acceleration equals the net force divided by the mass. (p. 69)

Newton's third law of motion: states that when one object exerts a force on a second object, the second object exerts a force on the first object that is equal in strength and in the opposite direction. (p. 83)

nonelectrolyte: substance that does not ionize in water and cannot conduct electricity. (p. 676)

nonmetal: element that usually is a gas or brittle solid at room temperature, is not malleable or ductile, is a poor conductor of heat and electricity, and typically is not shiny. (p. 578)

nonpolar: not having separated positive and negative areas; nonpolar materials do not attract water molecules and do not dissolve easily in water. (p. 681)

nonpolar molecule: molecule that shares electrons equally and does not have oppositely charged ends. (p. 614)

nonrenewable resources: natural resource, such as fossil fuels, that cannot be replaced by natural processes as quickly as it is used. (p. 263)

nuclear fission: process of splitting an atomic nucleus into two or more nuclei with smaller masses. (p. 551)

nuclear fusion: reaction in which two or more atomic nuclei form a nucleus with a larger mass. (p. 553)

nuclear reactor: uses energy from a controlled nuclear chain reaction to generate electricity. (p. 264)

nuclear waste: radioactive by-product that results when radioactive materials are used. (p. 268)

nucleic acids: essential organic polymers that control the activities and reproduction of cells. (p. 744)

nucleotides: complex, organic molecules that make up RNA and DNA; contain an organic base, a phosphoric acid unit, and a sugar. (p. 744)

nucleus: positively charged center of an atom that contains protons and neutrons and is surrounded by a cloud of electrons. (p. 507)

segunda ley de movimiento de Newton/ley de Ohm

segunda ley de movimiento de Newton: establece que la aceleración de un objeto es en la misma dirección que la fuerza neta del objeto y que la aceleración es igual a la fuerza neta dividida por su masa. (p. 69)

tercera ley de movimiento de Newton: establece que cuando un objeto ejerce una fuerza sobre un segundo objeto, el segundo objeto ejerce una fuerza igual de fuerte sobre el primer objeto y en dirección opuesta. (p. 83)

no electrolito: sustancia que no se ioniza en el agua y no puede conducir electricidad. (p. 676)

no metal: elemento que por lo general es un gas o un sólido frágil a temperatura ambiente, no es maleable o dúctil, es mal conductor del calor y la electricidad, y por lo general no es brillante. (p. 578)

no polar: sustancia que no tiene áreas positivas y negativas separadas; los materiales no polares no atraen las moléculas de agua y no se disuelven fácilmente en ésta. (p. 681)

molécula no polar: molécula que comparte equitativamente los electrones y que no tiene extremos con cargas opuestas. (p. 614)

recursos no renovables: recursos naturales, tales como combustibles fósiles, que no pueden ser reemplazados por procesos naturales tan pronto como son usados. (p. 263)

fisión nuclear: proceso de división de un núcleo atómico en dos o más núcleos con masas más pequeñas. (p. 551)

fusión nuclear: reacción en la cual dos o más núcleos atómicos forman un núcleo con mayor masa. (p. 553)

reactor nuclear: usa energía de una reacción nuclear controlada en cadena para generar electricidad. (p. 264)

desperdicio nuclear: subproducto radioactivo que resulta del uso de materiales radiactivos. (p. 268)

ácidos nucleicos: polímeros orgánicos esenciales que controlan las actividades y la reproducción de las células. (p. 744)

nucleótidos: moléculas orgánicas complejas que componen el ARN y el ADN y que contienen una base orgánica, una unidad de ácido fosfórico y un azúcar. (p. 744)

núcleo: centro de un átomo con carga positiva que contiene protones y neutrones y está rodeado por una nube de electrones. (p. 507)

Ohm's law: states that the current in a circuit equals the voltage difference divided by the resistance. (p. 205)

ley de Ohm: establece que la corriente en un circuito es igual a la diferencia de voltaje dividida por la resistencia. (p. 205)

opaque/physical property

- opaque:** material that absorbs or reflects all light and does not transmit any light. (p. 384)
- optical axis:** imaginary straight line that is perpendicular to the center of a concave mirror or convex lens. (p. 418)
- organic compounds:** large number of compounds containing the element carbon. (p. 726)
- overtone:** vibration whose frequency is a multiple of the fundamental frequency. (p. 334)
- oxidation:** the loss of electrons from the atoms of a substance. (p. 645)
- oxidation number:** positive or negative number that indicates how many electrons an atom has gained, lost, or shared to become stable. (p. 615)

opaco/propiedad física

- opaco:** material que absorbe o refleja toda la luz pero no la transmite. (p. 384)
- eje óptico:** línea recta imaginaria perpendicular al centro de un espejo cóncavo o lente convexo. (p. 418)
- compuestos orgánicos:** un gran número de compuestos que contienen el elemento carbono. (p. 726)
- armónico:** vibración cuya frecuencia es un múltiplo de la frecuencia fundamental. (p. 334)
- oxidación:** la pérdida de electrones de los átomos de una sustancia. (p. 645)
- número de oxidación:** número positivo o negativo que indica cuántos electrones ha ganado, perdido o compartido un átomo para poder ser estable. (p. 615)

P

- parallel circuit:** circuit in which electric current has more than one path to follow. (p. 208)
- pascal:** SI unit of pressure. (p. 490)
- period:** horizontal row in the periodic table. (p. 523); the amount of time it takes one wavelength to pass a fixed point; is expressed in seconds. (p. 297)
- periodic table:** organized list of all known elements that are arranged by increasing atomic number and by changes in chemical and physical properties. (p. 516)
- petroleum:** liquid fossil fuel formed from decayed remains of ancient organisms; can be refined into fuels and used to make plastics. (p. 259)
- pH:** a measure of the concentration of hydronium ions in a solution using a scale ranging from 0 to 14, with 0 being the most acidic and 14 being the most basic. (p. 704)
- photon:** particle that electromagnetic waves sometimes behave like; has energy that increases as the frequency of the electromagnetic wave increases. (p. 358)
- photovoltaic cell:** device that converts solar energy into electricity; also called a solar cell. (p. 271)
- physical change:** any change in size, shape, or state of matter in which the identity of the substance remains the same. (p. 460)
- physical property:** any characteristic of a material, such as size or shape, that you can observe or attempt to observe without changing the identity of the material. (p. 458)

- circuito paralelo:** circuito en el cual la corriente eléctrica tiene más de una trayectoria para seguir. (p. 208)
- pascal:** unidad SI de presión. (p. 490)
- período:** fila horizontal en la tabla periódica. (p. 523); la cantidad de tiempo que requiere una longitud de onda para pasar un punto fijo; se expresa en segundos. (p. 297)
- tabla periódica:** lista organizada de todos los elementos conocidos y que han sido ordenados de manera ascendente por número atómico y por cambios en sus propiedades químicas y físicas. (p. 516)
- petróleo:** combustible fósil líquido que se forma a partir de residuos en descomposición de organismos ancestrales y que puede ser refinado para producir combustibles y usado para hacer plásticos. (p. 259)
- pH:** medida de la concentración de iones de hidronio en una solución, usando una escala de 0 a 14, en la cual 0 es la más ácida y 14 la más básica. (p. 704)
- fotón:** partícula como la cual algunas veces se comportan las ondas electromagnéticas; tiene energía que aumenta a medida que la frecuencia de la onda electromagnética aumenta. (p. 358)
- células fotovoltaicas:** dispositivo que convierte la energía solar en electricidad; también llamada celda solar. (p. 271)
- cambio físico:** cualquier cambio en tamaño, forma o estado de una sustancia en la cual la identidad de la sustancia sigue siendo la misma. (p. 460)
- propiedad física:** cualquier característica de un material, tal como tamaño o forma, que se puede haber observar o tratado de observar sin cambiar la identidad del material. (p. 458)

Glossary/Glosario

pigment/pulley

pigment: colored material that is used to change the color of other substances. (p. 392)

pitch: how high or low a sound seems; related to the frequency of the sound waves. (p. 330)

plane mirror: flat, smooth mirror that reflects light to form upright, virtual images. (p. 473)

plasma: matter consisting of positively and negatively charged particles. (p. 480)

polar: having separated positive and negative areas; polar materials attract water molecules and dissolve easily in water. (p. 667)

polarized light: light whose waves vibrate in only one direction. (p. 400)

polar molecule: molecule with a slightly positive end and a slightly negative end as a result of electrons being shared unequally. (p. 614)

polyatomic ion: positively or negatively charged, covalently bonded group of atoms. (p. 619)

polyethylene: polymer formed from a chain containing many ethylene units; often used in plastic bags and plastic bottles. (p. 739)

polymer: class of natural or synthetic substances made up of many smaller, simpler molecules, called monomers, arranged in large chains. (pp. 739, 771)

potential energy: stored energy an object has due to its position. (p. 103)

power: amount of work done, or the amount of energy transferred, divided by the time required to do the work or transfer the energy; measured in watts (W). (p. 129)

precipitate: insoluble compound that comes out of solution during a double-displacement reaction. (p. 643)

pressure: amount of force exerted per unit area; SI unit is the pascal (Pa). (p. 486)

product: in a chemical reaction, the new substance that is formed. (p. 632)

proteins: large, complex, biological polymers formed from amino acid units; make up many body tissues such as muscles, tendons, hair, and fingernails. (p. 742)

proton: particle, composed of quarks, inside the nucleus of an atom that has a charge of $1+$. (p. 507)

pulley: simple machine that consists of a grooved wheel with a rope, chain, or cable running along the groove; can be either fixed or movable. (p. 141)

pigmento/polea

pigmento: material de color que se usa para cambiar el color de otras sustancias. (p. 392)

altura: qué tan alto o bajo parece un sonido; tiene relación con la frecuencia de las ondas sonoras. (p. 330)

espejo plano: espejo plano y liso que refleja la luz para formar imágenes verticales y virtuales. (p. 473)

plasma: materia consistente de partículas con cargas positivas y negativas. (p. 480)

polar: sustancia que tiene áreas positivas y negativas separadas; los materiales polares atraen las moléculas de agua y se disuelven fácilmente en ésta. (p. 667)

luz polarizada: luz cuyas ondas vibran en una sola dirección. (p. 400)

molécula polar: molécula con un extremo ligeramente positivo y otro ligeramente negativo como resultado de un compartir desigual de los electrones. (p. 614)

ion poliatómico: grupo de átomos enlazados covalentemente, con carga positiva o negativa. (p. 619)

polietileno: polímero formado por una cadena que contiene varias unidades de etileno; es comúnmente usado en la fabricación de bolsas y envases plásticos. (p. 739)

polímero: clase de sustancias naturales o sintéticas compuestas por muchas moléculas más simples y pequeñas, llamadas monómeros, ordenadas en largas cadenas. (pp. 739, 771)

energía potencial: energía almacenada que un objeto tiene debido a su posición. (p. 103)

potencia: cantidad de trabajo realizado o cantidad de energía transferida, dividida por el tiempo requerido para realizar el trabajo o transferir la energía; medida en vatios (V). (p. 129)

precipitado: compuesto insoluble que resulta de una solución durante una reacción de doble desplazamiento. (p. 643)

presión: cantidad de fuerza ejercida por unidad de área; la unidad SI es el pascal (Pa). (p. 486)

producto: es la nueva sustancia que se forma en una reacción química. (p. 632)

proteínas: polímeros biológicos extensos y complejos formados por unidades de aminoácidos; conforman muchos tejidos del cuerpo como los músculos, los tendones, el pelo y las uñas. (p. 742)

protón: partícula, compuesta por quarks, dentro del núcleo de un átomo que tiene una carga de $1+$. (p. 507)

polea: máquina simple que consiste de una rueda acanalada con una cuerda, cadena o cable que se desliza por el canal y que puede ser fija o móvil. (p. 141)

Q

quarks: particles of matter that make up protons and neutrons. (p. 507)

quarks: partículas de materia que constituyen los protones y neutrones. (p. 507)

R

radiant energy: energy carried by an electromagnetic wave. (p. 357)

radiation: transfer of thermal energy by electromagnetic waves. (p. 167)

radioactive element: element, such as radium, whose nucleus breaks down and emits particles and energy. (p. 572)

radioactivity: process that occurs when a nucleus decays and emits alpha, beta, or gamma radiation. (p. 538)

radio waves: electromagnetic waves with wavelengths longer than about 1 mm, used for communications. (p. 361)

rarefaction: the least dense regions of a compressional wave. (p. 296)

reactant: in a chemical reaction, the substance that reacts. (p. 632)

real image: an image formed by light rays that converge to pass through the place where the image is located. (p. 419)

reduction: the gain of electrons by the atoms of a substance. (p. 645)

reflecting telescope: uses a concave mirror, plane mirror, and convex lens to collect and focus light from distant objects. (p. 433)

refracting telescope: uses two convex lenses to gather and focus light from distant objects. (p. 433)

refraction: the bending of a wave as it changes speed in moving from one medium to another. (p. 304)

renewable resource: energy source that is replaced almost as quickly as it is used. (p. 271)

resistance: tendency for a material to oppose electron flow and change electrical energy into thermal energy and light; measured in ohms (Ω). (p. 203)

resonance: the process by which an object is made to vibrate by absorbing energy at its natural frequencies. (p. 311)

resonator: hollow, air-filled chamber that amplifies sound when the air inside it vibrates. (p. 335)

energía radiante: energía transportada por una onda electromagnética. (p. 357)

radiación: transferencia de energía térmica mediante ondas electromagnéticas. (p. 167)

elemento radiactivo: elemento, como el radio, cuyo núcleo se divide y emite partículas y energía. (p. 572)

radiactividad: proceso que ocurre cuando un núcleo se descompone y emite radiación alfa, beta o gama. (p. 538)

ondas de radio: ondas electromagnéticas con longitudes de onda más largas de aproximadamente 1 mm y que se usan en las comunicaciones. (p. 361)

rarefacción: las regiones menos densas de una onda de compresión. (p. 296)

reactante: es la sustancia que reacciona en una reacción química. (p. 632)

imagen real: imagen formada por rayos de luz que convergen para pasar a través del sitio donde está localizada la imagen. (p. 419)

reducción: la obtención de electrones por los átomos de una sustancia. (p. 645)

telescopio reflexivo: usa un espejo cóncavo, un espejo plano y lentes convexas para recolectar y enfocar la luz proveniente de objetos distantes. (p. 433)

telescopio refractivo: usa dos lentes convexas para reunir y enfocar la luz proveniente de objetos distantes. (p. 433)

refracción: curvatura de una onda al cambiar su velocidad al pasar de un medio a otro. (p. 304)

recursos renovables: fuente de energía que es reemplazada casi tan pronto como es usada. (p. 271)

resistencia: tendencia de un material de oponerse al flujo de los electrones y convertir la energía eléctrica en energía térmica y luz; se mide en ohmios (Ω). (p. 203)

resonancia: el proceso por el cual un objeto vibra al absorber energía en sus frecuencias naturales. (p. 311)

resonador: cámara hueca, llena de aire, que amplifica el sonido cuando vibra el aire en su interior. (p. 335)

Glossary/Glosario

retina/sliding friction

retina: inner lining of the eye that has cells which convert light images into electrical signals for interpretation by the brain. (p. 427)

retina/fricción deslizante

retina: capa interna del ojo que posee células que convierten imágenes iluminadas en señales eléctricas para que el cerebro las interprete. (p. 427)

S

salt: compound formed when negative ions from an acid combine with positive ions from a base. (pp. 580, 707)

saturated hydrocarbon: compound, such as propane or methane, that contains only single bonds between carbon atoms. (p. 728)

saturated solution: any solution that contains all the solute it can hold at a given temperature. (p. 673)

scientific law: statement about what happens in nature that seems to be true all the time; does not explain why or how something happens. (p. 12)

scientific method: organized set of investigation procedures that can include stating a problem, forming a hypothesis, researching and gathering information, testing a hypothesis, analyzing data, and drawing conclusions. (p. 7)

screw: simple machine that consists of an inclined plane wrapped in a spiral around a cylindrical post. (p. 145)

second law of thermodynamics: states that it is impossible for heat to flow from a cool object to a warmer object unless work is done. (p. 175)

semiconductor: materials having conductivity properties between that of metals (good conductors) and nonmetals (insulators) and having controllable conductivity parameters. (pp. 585, 767)

series circuit: circuit in which electric current has only one path to follow. (p. 207)

SI: International System of Units—the improved, universally accepted version of the metric system that is based on multiples of ten and includes the meter (m), liter (L), and kilogram (kg). (p. 15)

simple machine: machine that does work with only one movement—lever, pulley, wheel and axle, inclined plane, screw, and wedge. (p. 138)

single-displacement reaction: chemical reaction in which one element replaces another element in a compound. (p. 643)

sliding friction: frictional force that opposes the motion of two surfaces sliding past each other. (p. 72)

sal: compuesto iónico que se forma cuando un halógeno adquiere un electrón de un metal. (pp. 580, 707)

hidrocarburo saturado: compuesto, como el propano y el metano, que contiene únicamente enlaces simples entre los átomos de carbono. (p. 728)

solución saturada: cualquier solución que contiene todo el soluto que puede retener a una temperatura determinada. (p. 673)

ley científica: enunciado acerca de lo que ocurre en la naturaleza, lo cual parece ser cierto en todo momento, sin explicar cómo o por qué algo ocurre. (p. 12)

método científico: conjunto organizado de procedimientos de investigación que puede incluir el planteamiento de un problema, formulación de una hipótesis, investigación y recopilación de información, comprobación de la hipótesis, análisis de datos y elaboración de conclusiones. (p. 7)

tornillo: máquina simple que consiste de un plano inclinado envuelto en espiral alrededor de un poste cilíndrico. (p. 145)

segunda ley de la termodinámica: establece que es imposible que el calor fluya de un objeto frío a uno caliente, a menos que se realice un trabajo. (p. 175)

semiconductor: materiales que tienen propiedades de conductividad entre aquellas de los metales (buenos conductores) y los no metales (aisladores) y que tienen parámetros de conductividad controlables. (pp. 585, 767)

circuito en serie: circuito en el cual la corriente eléctrica tiene una sola trayectoria para seguir. (p. 207)

SI: Sistema Internacional de Unidades: la versión mejorada y aprobada universalmente del sistema métrico que se basa en múltiplos de diez e incluye el metro (m), el litro (L) y el kilogramo (Kg). (p. 15)

máquina simple: máquina que realiza el trabajo con un solo movimiento: palanca, polea, rueda y eje, plano inclinado, tornillo y cuña. (p. 138)

reacción de un solo desplazamiento: reacción química en la cual un elemento reemplaza a otro elemento en un compuesto. (p. 643)

fricción deslizante: fuerza de fricción que se opone al movimiento de dos superficies que se deslizan entre sí. (p. 72)

soaps/sublimation

- soaps:** organic salts with nonpolar, hydrocarbon ends that interact with oils and dirt and polar ends that helps them dissolve in water. (p. 712)
- solar collector:** device used in an active solar heating system that absorbs radiant energy from the Sun. (p. 174)
- solenoid:** a wire wrapped into a cylindrical coil. (p. 232)
- solubility:** maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature. (p. 671)
- solute:** in a solution, the substance being dissolved. (p. 665)
- solution:** homogeneous mixture that remains constantly and uniformly mixed and has particles that are so small they cannot be seen with a microscope. (pp. 454, 664)
- solvent:** in a solution, the substance in which the solute is dissolved. (p. 665)
- sonar:** system that uses the reflection of sound waves to detect objects underwater. (p. 341)
- sound quality:** difference between sounds having the same pitch and loudness. (p. 334)
- specific heat:** amount of thermal energy needed to raise the temperature of 1 kg of a material 1°C. (p. 161)
- speed:** distance an object travels per unit of time. (p. 39)
- standard:** exact, agreed-upon quantity used for comparison. (p. 14)
- standing wave:** a wave pattern that forms when waves of equal wavelength and amplitude, but traveling in opposite directions, continuously interfere with each other; has points called nodes that do not move. (p. 310)
- static electricity:** the accumulation of excess electric charge on an object. (p. 192)
- static friction:** frictional force that prevents two surfaces from sliding past each other. (p. 71)
- strong acid:** any acid that dissociates almost completely in solution. (p. 702)
- strong base:** any base that dissociates completely in solution. (p. 703)
- strong force:** attractive force that acts between protons and neutrons in an atomic nucleus. (p. 537)
- sublimation:** the process of a solid changing directly to a vapor without forming a liquid. (p. 581)

jabones/sublimación

- jabones:** sales orgánicas con extremos de hidrocarburos no polares que interactúan con aceites y suciedad, y con extremos polares que ayudan a disolverlos en agua. (p. 712)
- recolector solar:** dispositivo utilizado en un sistema activo de calefacción solar, el cual absorbe la energía radiante del sol. (p. 174)
- solenoid:** cable envuelto en forma de bobina cilíndrica. (p. 232)
- solubilidad:** máxima cantidad de soluto que puede ser disuelto en una cantidad dada de solvente a una temperatura determinada. (p. 671)
- soluto:** en una solución, la sustancia que está disuelta. (p. 665)
- solución:** mezcla homogénea que permanece constante y uniformemente mezclada y que tiene partículas tan pequeñas que no pueden ser vistas en un microscopio. (pp. 454, 664)
- solvente:** en una solución, la sustancia en la cual se disuelve el soluto. (p. 665)
- sonar:** sistema que usa la reflexión de las ondas sonoras para detectar objetos bajo el agua. (p. 341)
- calidad del sonido:** diferencia entre sonidos que tienen la misma altura e intensidad sonora. (p. 334)
- calor específico:** cantidad de energía térmica necesaria para aumentar un grado centígrado la temperatura de un kilogramo de material. (p. 161)
- velocidad:** distancia que recorre un objeto por unidad de tiempo. (p. 39)
- estándar:** cantidad exacta y acordada, usada para hacer comparaciones. (p. 14)
- onda estacionaria:** patrón de una onda que se forma cuando ondas con la misma longitud de onda y amplitud, pero que viajan en direcciones opuestas, interfieren continuamente entre sí; tiene puntos llamados nodos que no se mueven. (p. 310)
- electricidad estática:** la acumulación del exceso de carga eléctrica en un objeto. (p. 192)
- fricción estática:** fuerza que evita que dos superficies en contacto se deslicen una sobre otra. (p. 71)
- ácido fuerte:** cualquier ácido que se disocie casi por completo en una solución. (p. 702)
- base fuerte:** cualquier base que se disocie completamente en una solución. (p. 703)
- fuerza de atracción:** fuerza de atracción que actúa entre protones y neutrones en un núcleo atómico. (p. 537)
- sublimación:** proceso mediante el cual un sólido se convierte directamente en vapor sin pasar por estado líquido. (p. 581)

Glossary/Glosario

substance/transceiver

substance: element or compound that cannot be broken down into simpler components and maintain the properties of the original substance. (p. 450)

substituted hydrocarbon: hydrocarbon with one or more of its hydrogen atoms replaced by atoms or groups of other elements. (p. 732)

supersaturated solution: any solution that contains more solute than a saturated solution at the same temperature. (p. 674)

suspension: heterogeneous mixture containing a liquid in which visible particles settle. (p. 456)

synthesis reaction: chemical reaction in which two or more substances combine to form a different substance. (p. 642)

synthetic: describes polymers, such as plastics, adhesives, and surface coatings, that are made from hydrocarbons. (p. 771)

sustancia/radio transmisor-receptor

sustancia: elemento o compuesto que no se puede descomponer en componentes más simples y que mantiene las propiedades de la sustancia original. (p. 450)

hidrocarburo sustituido: un hidrocarburo en el cual uno o más de sus átomos de hidrógeno son reemplazados por átomos o grupos de otros elementos. (p. 732)

solución sobresaturada: cualquier solución que contenga más solutos que una solución saturada a la misma temperatura. (p. 674)

suspensión: mezcla heterogénea que contiene un líquido en el cual las partículas visibles se sedimentan. (p. 456)

reacción síntesis: reacción química en la cual se combinan dos o más sustancias para formar una sustancia diferente. (p. 642)

sintético: describe a los polímeros, tales como plásticos, adhesivos y recubrimientos de superficies, hechos de hidrocarburos. (p. 771)

T

technology: application of science to help people. (p. 13)

temperature: measure of the average kinetic energy of all the particles in an object. (p. 159)

theory: explanation of things or events that is based on knowledge gained from many observations and investigations. (p. 12)

thermal energy: sum of the kinetic and potential energy of the particles in an object; is transferred by conduction, convection, and radiation. (p. 159)

thermal expansion: increase in the size of a substance when the temperature is increased. (p. 481)

thermodynamics: study of the relationship between thermal energy, heat, and work. (p. 174)

titration (ti TRAY shun): process in which a solution of known concentration is used to determine the concentration of another solution. (p. 710)

total internal reflection: occurs when light strikes a boundary between two materials and is completely reflected. (p. 402)

tracer: radioactive isotope, such as iodine-131, that can be detected by the radiation it emits after it is absorbed by a living organism. (p. 554)

transceiver: device that transmits one radio signal and receives another radio signal at the same time, allowing a cordless phone user to talk and listen at the same time. (p. 371)

tecnología: aplicación de la ciencia en beneficio de la población. (p. 13)

temperatura: medida de la energía cinética promedio de todas las partículas en un objeto. (p. 159)

teoría: explicación de las cosas o eventos que se basa en el conocimiento obtenido a partir de numerosas observaciones e investigaciones. (p. 12)

energía térmica: suma de la energía cinética y potencial de las partículas en un objeto, la cual se transfiere por conducción, convección y radiación. (p. 159)

expansión térmica: aumento del tamaño de una sustancia al aumentar la temperatura. (p. 481)

termodinámica: estudio de la relación entre la energía térmica, el calor y el trabajo. (p. 174)

titulación: proceso mediante el cual una solución con una concentración conocida es usada para determinar la concentración de otra solución. (p. 710)

reflexión interna total: ocurre cuando la luz choca con el límite entre dos materiales y se refleja completamente. (p. 402)

indicador radiactivo: isótopo radioactivo, tal como el yodo-131, que puede ser detectado por la radiación que emite después de ser absorbido por un organismo vivo. (p. 554)

radio transmisor-receptor: dispositivo que transmite y recibe una señal de radio al mismo tiempo, permitiendo que un usuario de un teléfono inalámbrico pueda hablar y escuchar al mismo tiempo. (p. 371)

transformer/variable

transformer: device that uses electromagnetic induction to increase or decrease the voltage of an alternating current. (p. 243)

transition elements: elements in Groups 3 through 12 of the periodic table; occur in nature as uncombined elements and include the iron triad and coinage metals. (p. 574)

translucent: material that transmits some light but not enough to see objects clearly through it. (p. 384)

transmutation: process of changing one element to another through radioactive decay. (p. 542)

transparent: material that transmits almost all the light striking it so that objects can be clearly seen through it. (p. 384)

transuranium elements: elements having more than 92 protons, all of which are synthetic and unstable. (p. 589)

transverse wave: wave for which the matter in the medium moves back and forth at right angles to the direction the wave travels; has crests and troughs. (p. 292)

trough: the lowest points on a transverse wave. (p. 296)

turbine: large wheel that rotates when pushed by steam, wind, or water and provides mechanical energy to a generator. (p. 240)

Tyndall effect: scattering of a light beam as it passes through a colloid. (p. 455)

transformador/variable

transformador: dispositivo que usa inducción electromagnética para aumentar o disminuir el voltaje de una corriente alterna. (p. 243)

elementos de transición: los elementos de los grupos 3 al 12 de la tabla periódica que se encuentran en la naturaleza como elementos sin combinar e incluyen la tríada de hierro y los metales con los que se fabrican las monedas. (p. 574)

translúcido: material que transmite alguna luz pero no la suficiente para ver claramente los objetos a través del mismo. (p. 384)

transmutación: proceso de cambio de un elemento a otro mediante la descomposición radioactiva. (p. 542)

transparente: material que transmite casi toda la luz, chocándola de tal manera que los objetos pueden ser claramente vistos a través del mismo. (p. 384)

elementos transuránicos: elementos que tienen más de 92 protones, todos los cuales son sintéticos e inestables. (p. 589)

onda transversal: onda para la cual la materia en el medio se mueve hacia adelante y hacia atrás en ángulos rectos respecto a la dirección en que viaja la onda; ésta tiene cresta y depresiones. (p. 292)

depresión: los puntos más bajos en una onda transversal. (p. 296)

turbina: rueda grande que gira al ser impulsada por vapor, viento o agua y que suministra energía mecánica a un generador. (p. 240)

efecto Tyndall: difusión de un rayo de luz al pasar a través de un coloide. (p. 455)

U

ultrasonic: sound waves with frequencies above 20,000 Hz. (p. 330)

ultraviolet waves: electromagnetic waves with wavelengths between about 400 billionths and 10 billionths of a meter. (p. 363)

unsaturated hydrocarbon: compound, such as ethene or ethyne, that contains at least one double or triple bond between carbon atoms. (p. 730)

unsaturated solution: any solution that can dissolve more solute at a given temperature. (p. 673)

ultrasónico: ondas de sonido con frecuencia superiores a 20,000 Hz. (p. 330)

ondas ultravioleta: ondas electromagnéticas con longitudes de onda entre aproximadamente 10 y 400 billonésimas de metro. (p. 363)

hidrocarburo no saturado: compuesto, como el etileno, que contiene al menos un enlace doble o triple entre los átomos de carbono. (p. 730)

solución no saturada: cualquier solución que puede disolver más solutos a una temperatura determinada. (p. 673)

V

variable: factor that can cause a change in the results of an experiment. (p. 9)

variable: factor que puede causar un cambio en los resultados de un experimento. (p. 9)

Glossary/Glosario

velocity/X rays

velocity: the speed and direction of a moving object. (p. 44)

virtual image: an image formed by diverging light rays that is perceived by the brain, even though no actual light rays pass through the place where the image seems to be located. (p. 418)

viscosity: a fluid's resistance to flow. (p. 489)

visible light: electromagnetic waves with wavelengths of 750 to 400 billionths of a meter that can be detected by human eyes. (p. 363)

voltage difference: related to the force that causes electric charges to flow; measured in volts (V). (p. 200)

volume: amount of space occupied by an object. (p. 18)

velocidad direccional/rayos X

velocidad direccional: la rapidez y dirección de un objeto en movimiento. (p. 44)

imagen virtual: la imagen que se forma al divergir los rayos de luz, la cual es percibida por el cerebro, aún cuando ningún rayo de luz real pase por el sitio donde la imagen parezca estar localizada. (p. 418)

viscosidad: resistencia de un fluido al flujo. (p. 489)

luz visible: ondas electromagnéticas con longitudes de onda entre 400 y 750 billonésimas de metro y que pueden ser detectadas por el ojo humano. (p. 363)

diferencia de voltaje: se refiere a la fuerza que causa que las cargas eléctricas fluyan; se mide en voltios (V). (p. 200)

volumen: espacio ocupado por un objeto. (p. 18)

W

wave: a repeating disturbance or movement that transfers energy through matter or space. (p. 290)

wavelength: distance between one point on a wave and the nearest point just like it. (p. 297)

weak acid: any acid that only partly dissociates in solution. (p. 702)

weak base: any base that does not dissociate completely in solution. (p. 703)

wedge: simple machine that is an inclined plane with one or two sloping sides. (p. 145)

weight: gravitational force exerted on an object. (p. 77)

wheel and axle: simple machine that consists of a shaft or axle attached to the center of a larger wheel, so that the shaft and the wheel rotate together. (p. 143)

work: transfer of energy that occurs when a force makes an object move; measured in joules. (p. 126)

onda: alteración o movimiento repetitivo que transfiere energía a través de la materia o el espacio. (p. 290)

longitud de onda: distancia entre un punto en una onda y el punto semejante más cercano. (p. 297)

ácido débil: cualquier ácido que solamente se disocia parcialmente en una solución. (p. 702)

base débil: cualquier base que no se disocia completamente en una solución. (p. 703)

cuña: máquina simple que consiste de un plano inclinado con uno o dos lados en declive. (p. 145)

peso: fuerza gravitacional ejercida sobre un objeto. (p. 77)

rueda y eje: máquina simple que consiste de una barra o eje sujeto al centro de una rueda de mayor tamaño de manera que el eje y la rueda giran juntos. (p. 143)

trabajo: transferencia de energía que se produce cuando una fuerza hace mover un objeto y que se mide en julios. (p. 126)

X

X rays: electromagnetic waves with wavelengths between about 10 billionths of a meter and 10 trillionths of a meter, that are often used for medical imaging. (p. 365)

rayos X: ondas electromagnéticas con longitudes de onda entre 10 billonésimas de metro y 10 trillonésimas de metro, las cuales se utilizan con frecuencia para producir imágenes de uso médico. (p. 365)

Italic numbers = illustration/photo **Bold numbers** = vocabulary term
lab = a page on which the entry is used in a lab
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LM—Light Microscope

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