Table of Contents

Student Resources

Table of Contents

Skill Handbook ................. 1015
  Make Comparisons .............. 1015
  Take Notes and Outline ......... 1016
  Analyze Media Sources ......... 1017
  Debate Skills .................. 1018
Science Skill Handbook ......... 1019
  Scientific Methods
    Identify a Question ........... 1019
    Gather and Organize Information ... 1019
    Form a Hypothesis ........... 1022
    Test the Hypothesis ........ 1022
    Collect Data ................ 1023
    Analyze the Data .......... 1026
    Draw Conclusions .......... 1027
    Communicate ............... 1027
Safety Guidelines in the Laboratory
  General Safety Rules ......... 1028
  Safety Symbols .............. 1029
Math Skill Handbook .......... 1030
  Math Review
    Use Fractions ............ 1030
    Use Ratios ............... 1033
    Use Decimals ........... 1033
    Use Proportions ........ 1034
    Use Percentages ........ 1035
    Solve One-Step Equations .... 1035
    Use Statistics .......... 1036
    Use Geometry ............ 1037
Science Applications
  Measure in SI ............... 1040
  Dimensional Analysis ....... 1040
  Precision and Significant Figures ... 1041
  Scientific Notation .......... 1042
  Make and Use Graphs .......... 1042
Formulas
  Chapter Formulas ........... 1044

Additional Practice Problems . . 1046
Reference Handbook .......... 1064
  Minerals .................. 1064
  Rocks ................... 1066
  Weather Map Symbols ....... 1067
  Physical Science Reference Tables .... 1068
  Periodic Table of the Elements .. 1070
Glossary/Glosario ............ 1072
Index ....................... 1099
Credits ...................... 1120
Make Comparisons

Why learn this skill?
Suppose you want to buy a portable MP3 music player, and you must choose between three models. You would probably compare the characteristics of the three models, such as price, amount of memory, sound quality, and size in order to determine which model is best for you. In the study of chemistry, you often make comparisons between the structures of elements and compounds. You will also compare scientific discoveries or events from one time period with those from another period.

Learn the Skill
When making comparisons, you examine two or more items, groups, situations, events, or theories. You must first decide what will be compared and which characteristics you will use to compare them. Then identify any similarities and differences.

For example, comparisons can be made between the two models in the illustration on this page. The structure of the hydrogen atom can be compared to the structure of the oxygen atom. By reading the labels, you can see that both atoms have protons, neutrons, and electrons.

Practice the Skill
Create a table with the heading Hydrogen and Oxygen Atoms. Make three columns. Label the first column Protons. Label the second column Neutrons. Label the third column Electrons. Make two rows. Label the first row Hydrogen. Label the second row Oxygen. List the number of protons for each atom in the first column. Fill in the number of neutrons and electrons for each atom in the remaining columns. When you have finished the table, answer the following questions.
1. What is being compared? How are they being compared?
2. What do hydrogen and oxygen atoms have in common?
3. Describe how the differences between these two atoms affect the number of energy levels that each atom has.

Apply the Skill
Make Comparisons On page 180 you will find illustrations of a dry cell and an wet cell. Compare these two illustrations carefully. Then, identify the similarities and the differences between the two cells.
Take Notes and Outline

Why learn this skill?

One of the best ways to remember something is to write it down. Taking notes—writing down information in a brief and orderly format—not only helps you remember, but also makes studying easier.

Learn the Skill

There are several styles of note taking, but all put information in a logical order. As you read, identify and summarize the main ideas and details that support them and write them in your notes. Paraphrase—that is, state in your own words—the information rather than copying it directly from the text. Using note cards or developing a personal “shorthand”—using symbols to represent words—can help.

You might also find it helpful to create an outline when taking notes. When outlining material, first read the material to identify the main ideas. In textbooks, section headings provide clues to main topics. Then, identify and fill in the subheadings and subdetails.

Practice the Skill

Read the following excerpt from Chapter 12. Use the steps you just read about to take notes or create an outline. Then answer the questions that follow.

Look around your darkened room at night. After your eyes adjust to the darkness, you can see some familiar objects. Brightly colored objects look gray or black in the dim light. If you turn on the light, however, you might see all of the objects in the room, including their colors. What you see depends on the amount of light in the room and the color of the objects. To see an object, it must reflect some light back to your eyes.

Objects can absorb, reflect, and transmit light. Objects that transmit light allow light to pass through them. An object’s material determines the amount of light it absorbs, reflects, and transmits. The material in the first candleholder in Figure 1 is opaque. Opaque materials only absorb and reflect light; no light passes through them. As a result, you cannot see the candle.

Materials such as the second candleholder in Figure 1 are described as translucent. Translucent materials transmit light but also scatter it. You cannot see clearly through translucent materials, and objects appear blurry. The third candleholder in Figure 1 is transparent. Transparent materials transmit light without scattering it, so you can see objects clearly through them.

1. What is the main topic of the excerpt?
2. What are the first, second, and third ideas?
3. Name one detail for each of the ideas.

Apply the Skill

Take Notes and Outline Go to Section 1 of Chapter 15 and take notes by paraphrasing and using shorthand or by creating an outline. Use the section title and headings to help you create your outline. Summarize the section using only your notes.
Analyze Media Sources

Why learn this skill?
To stay informed, people use a variety of media sources, including print media, broadcast media, and electronic media. The Internet has become an especially valuable research tool. It is convenient to use, and the information contained on the Internet is plentiful. Whichever media source you use to gather information, it is important to analyze the source to determine its accuracy and reliability.

Learn the Skill
There are a number of issues to consider when analyzing a media source. Most important is to check the accuracy of the source and content. The author and publisher or sponsors should be credible and clearly indicated. To analyze print media or broadcast media, ask yourself the following questions:

- Is the information current?
- Are the resources revealed?
- Is more than one resource used?
- Is the information biased?
- Does the information represent both sides of an issue?
- Is the information reported firsthand or secondhand?

Practice the Skill
To analyze print media, choose two articles—one from a newspaper and the other from a news magazine—about an issue on which public opinion is divided. Then answer these questions:

1. What points are the articles trying to make? Were the articles successful? Can the facts be verified?
2. Did either article reflect a bias toward one viewpoint or another? List any unsupported statements.

3. Was the information reported firsthand or secondhand? Do the articles seem to represent both sides fairly?
4. How many resources can you identify in the articles? List them.

To analyze electronic media, visit a Web site as instructed by your teacher. Read the information on that Web site, and then answer these questions.

1. Who is the author or sponsor of the Web site?
2. What links does the Web site contain? How are they appropriate to the topic?
3. What resources were used for the information on the Web site?

Apply the Skill
Analyze Sources of Information  Think of an issue on which public opinion is divided. Use a variety of media resources to read about this issue. Which news source more fairly represents the issue? Which news source has the most reliable information? Can you identify any biases?
Debate Skills

New research leads to new scientific information. There are often opposing points of view on how this research is conducted, how it is interpreted, and how it is communicated. Some of the features in your book offer a chance to debate a current controversial topic. Here is an overview on how to conduct a debate.

Choose a Position and Research

First, choose a scientific issue that has at least two opposing viewpoints. The issue can come from current events, your textbook, or your teacher. These topics could include human cloning or environmental issues. Topics are stated as affirmative declarations, such as “Cloning human beings is beneficial to society.”

One speaker will argue the viewpoint that agrees with the statement, called the positive position, and another speaker will argue the viewpoint that disagrees with the statement, called the negative position. Either individually or with a group, choose the position for which you will argue. The viewpoint that you choose does not have to reflect your personal belief. The purpose of debate is to create a strong argument supported by scientific evidence.

After choosing your position, conduct research to support your viewpoint. Use resources in your media center or library to find articles, or use your textbook to gather evidence to support your argument.

Hold the Debate

You will have a specific amount of time, determined by your teacher, in which to present your argument. Organize your speech to fit within the time limit: explain the viewpoint that you will be arguing, present an analysis of your evidence, and conclude by summing up your most important points. Try to vary the elements of your argument. Your speech should not be a list of facts, a reading of a newspaper article, or a statement of your personal opinion, but an analysis of your evidence in an organized manner. It is also important to remember that you must never make personal attacks against your opponent. Argue the issue. You will be evaluated on your overall presentation, organization and development of ideas, and strength of support for your argument.

Additional Roles

There are other roles that you or your classmates can play in a debate. You can act as the timekeeper. The timekeeper times the length of the debaters’ speeches and gives quiet signals to the speaker when time is almost up (usually a hand signal).

You can also act as a judge. There are important elements to look for when judging a speech: an introduction that tells the audience what position the speaker will be arguing, strong evidence that supports the speaker’s position, and organization. The speaker also must speak clearly and loudly enough for everyone to hear. It is helpful to take notes during the debate to summarize the main points of each side’s argument.
**Scientific Methods**

Scientists use an orderly approach called the scientific method to investigate problems. This includes organizing and recording data so others can understand them. Scientists use many variations in this method when they perform an investigation. Although there is variation, there are six common steps to the scientific methods, as shown in Figure 1.

**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. Some sources may include textbooks, encyclopedias, government documents, professional journals, science magazines, and the Internet. Always list the sources of your information.

**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. 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 it can help you both understand and remember what you are studying. Concept maps are useful for breaking large concepts down into smaller parts, which makes learning easier.

Network Tree  A type of concept map that shows how related ideas branch out from a central concept 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 note cards. 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 flowchart, 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.
Sound is produced.
Sound travels.
Sound hits hard surface.
Sound reflects back.
Echo is heard.

**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 cycle map is a specific type of events chain. 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 spider map is a type of concept map that you can use for brainstorming. 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.
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. 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 define the variables, how to carry out the investigation, what steps to follow, and how to record the data. It also is important to address any safety concerns.

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.

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**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, as 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

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>Paper (kg)</th>
<th>Aluminum (kg)</th>
<th>Glass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>5.0</td>
<td>4.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Wednesday</td>
<td>4.0</td>
<td>1.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Friday</td>
<td>2.5</td>
<td>2.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
**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.

**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.

**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 fuel economy.

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. All other factors in an experiment must remain constant. **Table 2** summarizes the types of variables that are used in an experiment.

### Table 2 Types of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent</td>
<td>Changes according to the changes of the independent variable</td>
</tr>
<tr>
<td>Independent</td>
<td>The variable that is changed to test the effect on the dependent variable</td>
</tr>
<tr>
<td>Constant</td>
<td>A factor that does not change when other variables change</td>
</tr>
<tr>
<td>Control</td>
<td>The standard by which the test results can be compared</td>
</tr>
</tbody>
</table>

**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/cm³.”

**Figure 9** Collecting data is one way to gather information directly.
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, random 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 every day. 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.
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.

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 (cm³ = cm × cm × cm).

You can use 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 cm³, 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 home base.

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.
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 experiment 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.
Safety Guidelines in the Laboratory

The laboratory is a safe place to work if you are aware of important safety rules and if you are careful. You must be responsible for your own safety and for the safety of others. The safety rules given here and the first aid instruction in Table 3 will protect you and others from harm in the lab. While carrying out procedures in any of the Launch Labs, MiniLabs, or Labs, notice the safety symbols and warning statements. The safety symbols are explained in the chart on the next page.

1. Always obtain your teacher’s permission to begin a lab.
2. Study the procedure. If you have questions, ask your teacher. Be sure you understand all safety symbols shown.
3. Use the safety equipment provided for you. Goggles and a safety apron should be worn when any lab calls for using chemicals.
4. When you are heating a test tube, always slant it so the mouth points away from you and others.
5. Never eat or drink in the lab. Never inhale chemicals. Do not taste any substance or draw any material into your mouth.
6. If you spill any chemical, wash it off immediately with water. Report the spill immediately to your teacher.
7. Know the location and proper use of the fire extinguisher, safety shower, fire blanket, first aid kit, and fire alarm.
8. Keep all materials away from open flames. Tie back long hair.
9. If a fire should break out in the classroom, or if your clothing should catch fire, smother it with the fire blanket or a coat, or get under a safety shower. NEVER RUN.
10. Report any accident or injury, no matter how small, to your teacher.

Follow these procedures as you clean up your work area.

1. Turn off the water and gas. Disconnect electrical devices.
2. Return materials to their places.
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 thoroughly after working in the laboratory.

### Table 3

<table>
<thead>
<tr>
<th>Injury</th>
<th>Safe Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>Apply cold water. Notify your teacher immediately.</td>
</tr>
<tr>
<td>Cuts and bruises</td>
<td>Stop any bleeding by applying direct pressure. Cover cuts with a clean dressing. Apply cold compresses to bruises. Notify your teacher immediately.</td>
</tr>
<tr>
<td>Fainting</td>
<td>Leave the person lying down. Loosen any tight clothing and keep crowds away. Notify your teacher immediately.</td>
</tr>
<tr>
<td>Foreign matter in eye</td>
<td>Flush with plenty of water. Use eyewash bottle or fountain. Notify your teacher immediately.</td>
</tr>
<tr>
<td>Poisoning</td>
<td>Note the suspected poisoning agent and call your teacher immediately.</td>
</tr>
<tr>
<td>Any spills on skin</td>
<td>Flush with large amounts of water or use safety shower. Notify your teacher immediately.</td>
</tr>
</tbody>
</table>
These safety symbols are used in laboratory and investigations in this book to indicate possible hazards. Learn the meaning of each symbol and refer to this page often. Remember to wash your hands thoroughly after completing lab procedures.

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

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.

Radioactivity
This symbol appears when radioactive materials are used.

Handwashing
After the lab, wash hands with soap and water before removing goggles.
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.

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

Step 1 Write the fraction.
\[
\text{part} \quad \frac{12}{\text{whole}}
\]

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.
\[
\frac{12}{4} = \frac{3}{2} \quad \frac{20}{4} = \frac{5}{1}
\]

\( \frac{3}{5} \) 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, 18 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.
\[
\frac{4}{8} \quad \text{(GCF, 4)}
\]

Step 3 Divide the numerator and denominator by the GCF.
\[
\frac{4}{4} = 1, \quad \frac{8}{4} = 2
\]

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

Example 2 If \( \frac{7}{16} \) of a region 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.
\[
\frac{6}{16} \quad \text{(GCF, 2)}
\]

Step 3 Divide the numerator and denominator by the GCF.
\[
\frac{6}{2} = 3, \quad \frac{16}{2} = 8
\]

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

Practice Problem A bicycle rider is riding at a rate of 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 riding at a rate greater than 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 \((\text{C}_6\text{H}_{12}\text{O}_6)\), and the remainder is water \((\text{H}_2\text{O})\). How much of the paste is a solid?

Step 1 Find the LCD of the fractions.
\[
\frac{1}{2} + \frac{1}{3} = \frac{3}{6} + \frac{2}{6} = \frac{5}{6}
\]
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.
\[
\frac{3}{6} + \frac{2}{6} = \frac{5}{6}
\]
\(\frac{5}{6}\) 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 sum of these averages?

Step 1 Find the LCD of the fractions.
\[
\frac{7}{10} + \frac{3}{5} = \frac{7}{10} + \frac{6}{10} = \frac{13}{10}
\]
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.
\[
\frac{7}{10} + \frac{6}{10} = \frac{13}{10}
\]
\(\frac{13}{10}\) inches total precipitation, or \(\frac{1}{2}\) inch.

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.
\[
\frac{7}{10} - \frac{3}{15} = \frac{7}{10} - \frac{2}{10} = \frac{5}{10}
\]
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.
\[
\frac{21}{30} - \frac{6}{30} = \frac{15}{30} = \frac{5}{10}
\]
Step 4 Find the GCF.
\[
\frac{15}{30} = \frac{5}{10}
\]
\(\frac{5}{10}\) 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.
\[
\frac{3}{4} - \frac{1}{3} = \frac{3}{4} - \frac{1}{3}
\]
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.
\[
\frac{9}{12} - \frac{4}{12} = \frac{5}{12}
\]
\(\frac{5}{12}\) of a cup of flour

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?

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.
\[
\frac{3 \div 3}{15 \div 3} = \frac{1}{5}
\]

\( \frac{3}{5} \) multiplied by \( \frac{1}{3} \) is \( \frac{1}{5} \).

**Practice Problem**  Multiply \( \frac{3}{14} \) by \( \frac{5}{16} \).

**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.
\[
\text{The reciprocal of } \frac{1}{3} \text{ is } \frac{3}{1}.
\]

**Step 2**  Multiply the dividend by the reciprocal of the divisor.
\[
\frac{1}{9} \times \frac{3}{1} = \frac{(1 \times 3)}{(9 \times 1)} = \frac{3}{9}
\]

**Step 3**  Find the GCF.
\[
\frac{3}{9} \text{ (GCF, 3)}
\]

**Step 4**  Divide the numerator and denominator by the GCF.
\[
\frac{3 \div 3}{9 \div 3} = \frac{1}{3}
\]

\( \frac{1}{9} \) 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.
\[
\text{The reciprocal of } \frac{1}{4} \text{ is } \frac{4}{1}.
\]

**Step 2**  Multiply the dividend by the reciprocal of the divisor.
\[
\frac{3}{5} \times \frac{4}{1} = \frac{(3 \times 4)}{(5 \times 1)} = \frac{12}{5}
\]

\( \frac{3}{5} \) 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

A ratio compares two different numbers. For example, if you have 3 dogs and 5 cats, the ratio of dogs to cats can be written “3 to 5,” 3:5. Notice that you have eight total animals in this example—3 dogs and 5 cats.

Ratios can represent one type of probability, called odds. This is a ratio that compares the number of ways a certain outcome occurs to the number of possible 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 most likely outcome of 100 flips is 50 heads and 50 tails, or 50:50. Like fractions, ratios can be written in simplest form—50:50 becomes 1:1. To write this as a fraction, you would say $\frac{1}{2}$ the flips are heads and $\frac{1}{2}$ are tails.

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.
salt:baking soda = 40:64

Step 2 Express the fraction in simplest form.
The GCF of 40 and 64 is 8.
40 ÷ 8 = 5, and 64 ÷ 8 = 8

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

Example 2 Sean rolls a 6-sided die 6 times. Predict how many times the side with a 3 will show in six rolls.

Step 1 Write the ratio as a fraction.
\[
\frac{\text{number of sides with a 3}}{\text{number of total sides}} = \frac{1}{6}
\]

Step 2 Multiply by the number of attempts.
\[
\frac{1}{6} \times 6 \text{ attempts} = \frac{6}{6} = 1
\]

In six rolls, Sean will likely roll one 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 easily written as a decimal. The decimal point separates the ones place from the tenths place. For example, $\frac{27}{100}$ means 0.27.

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.
47.68
+ 7.80

Step 2 Add the decimals.
47.68
+ 7.80
55.48

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 numbers.
42.17
− 15.85

Step 2 Subtract the decimals.
42.17
− 15.85
26.32

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 you multiply numbers without decimals. 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, so the sum is 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.  
\[ 3.4 \times 10 = 34, \quad 8.84 \times 10 = 88.4 \]

**Step 2** Divide 88.4 by 34.  
\[
\begin{array}{c}
2.6 \\
34)88.4 \\
-68 \\
204 \\
-204 \\
0 \\
\end{array}
\]

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 ratios 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.  
\[
\frac{h}{6 \text{ m}} = \frac{24 \text{ m}}{4 \text{ m}}
\]

**Step 3** Find the cross products.  
\[ h \times 4 \text{ m} = 6 \text{ m} \times 24 \text{ m} \]

**Step 4** Simplify the equation.  
\[ 4h = 144 \text{ m} \]

**Step 5** Divide each side by 4.  
\[ \frac{(4 \text{ m}) h}{4} = \frac{144 \text{ m}}{4} \]

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 proportional. 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.

0.65

\[
\begin{array}{c}
20 \overline{13.00} \\
12.0 \\
1.00 \\
1.00 \\
0
\end{array}
\]

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

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

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

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.

$\frac{1300}{20} = \frac{20x}{20}$

$65\% = x$

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 expressions 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.

$x - 10 = 35$

$x - 10 + 10 = 35 + 10$

$x = 45$

Step 2 Check the solution.

$x - 10 = 35$

$45 - 10 = 35$

$35 = 35$

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 $b$.

$\frac{a}{b} = \frac{bc}{b}$

$a = bc$

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

$\frac{a}{b} = c$

$\frac{20}{2} = c$

$10 = c$

Step 3 Check the solution.

$a = bc$

$20 = 2 \times 10$

$20 = 20$

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 1** below shows the results of a student survey on favorite color.

<table>
<thead>
<tr>
<th>Color</th>
<th>Tally</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>I II I</td>
<td>4</td>
</tr>
<tr>
<td>Blue</td>
<td>I I I</td>
<td>5</td>
</tr>
<tr>
<td>Black</td>
<td>I I</td>
<td>2</td>
</tr>
<tr>
<td>Green</td>
<td>I I I</td>
<td>3</td>
</tr>
<tr>
<td>Purple</td>
<td>I I I I</td>
<td>7</td>
</tr>
<tr>
<td>Yellow</td>
<td>I I I I</td>
<td>6</td>
</tr>
</tbody>
</table>

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.

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.

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, 39, 44, 44

The median is 39 m/s.

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.

44, 44, 36, 37, 39

The mode is 44 m/s.

Find the range:

**Step 1** Arrange the measures from greatest to least.

44, 44, 39, 37, 36

**Step 2** Determine the greatest and least measures in the set.

44, 44, 39, 37, 36

**Step 3** Find the difference between the greatest and least 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 lengths 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.
\[
P = 2 \text{ cm} + 5 \text{ cm} + 6 \text{ cm} + 3 \text{ cm}
\]
Step 2 Find the sum of the sides.
\[
P = 2 \text{ cm} + 5 \text{ cm} + 6 \text{ cm} + 3 \text{ cm}
\]
\[
P = 16 \text{ cm}
\]
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 by 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 cm².

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 m².

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:

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

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

$$C = 2\pi (3 \text{ m})$$

Step 2  Multiply 2 times the radius.

$$C = \pi (6 \text{ m})$$

Step 3  Multiply by $\pi$.

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

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 $\pi$.

$$C = \pi (24.0 \text{ cm})$$

Step 2  Multiply the diameter by $\pi$.

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

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  $A = \pi (4.0 \text{ cm})^2$

Step 2  Find the square of the radius.

$$A = 16\pi \text{ cm}^2$$

Step 3  Multiply the square of the radius by $\pi$.

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

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  $A = \pi (225 \text{ m})^2$

Step 2  Find the square of the radius.

$$A = 50,625\pi \text{ m}^2$$

Step 3  Multiply the square of the radius by $\pi$.

$$A = 158,962.5 \text{ m}^2$$

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 $\pi$ and that the radius is half of the diameter.

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

Step 2  Find the radius.

$$A = \pi (10.0 \text{ mm})^2$$

Step 3  Find the square of the radius.

$$A = 100\pi \text{ mm}^2$$

Step 4  Multiply the square of the radius by $\pi$.

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

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 by the width by the height, or \(V = l \times w \times h\). It is measured in cubic units, such as cubic centimeters \((\text{cm}^3)\).

**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 by the width by 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 by the height.

**Example 1**  Find the volume of a prism that has two triangular bases with lengths of 8.0 m and heights 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.

\[
V = \left[ \frac{1}{2} (b \times h) \right] \times 15 \text{ m}
\]

**Step 2**  Find the area of the base.

\[
V = \left[ \frac{1}{2} (8 \text{ m} \times 7 \text{ m}) \right] \times 15 \text{ m}
\]

\[
V = \left( \frac{1}{2} \times 56 \text{ m}^2 \right) \times 15 \text{ m}
\]

**Step 3**  Multiply the area of the base by the height of the solid.

\[
V = 28 \text{ m}^2 \times 15 \text{ m}
\]

\[
V = 420 \text{ m}^3
\]

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 \(\pi\), and the volume is the area of the base times the height.

\[
V = (\pi r^2) \times 21 \text{ cm}
\]

\[
V = \pi (12 \text{ cm})^2 \times 21 \text{ cm}
\]

**Step 2**  Find the area of the base.

\[
V = 144\pi \text{ cm}^2 \times 21 \text{ cm}
\]

\[
V = 452 \text{ cm}^2 \times 21 \text{ cm}
\]

**Step 3**  Multiply the area of the base by the height of the solid.

\[
V = 9,490 \text{ cm}^3
\]

The volume is 9,500 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 \(\pi\). The radius is one-half the diameter. The volume is the area of the base times the height.

\[
V = (\pi r^2) \times 4.8 \text{ mm}
\]

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

**Step 2**  Find the area of the base.

\[
V = 56.25\pi \text{ mm}^2 \times 4.8 \text{ mm}
\]

\[
V = 176.63 \text{ mm}^2 \times 4.8 \text{ mm}
\]

**Step 3**  Multiply the area of the base by the height of the solid.

\[
V = 847.8 \text{ mm}^3
\]

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 2 for some common SI prefixes and their meanings.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilo-</td>
<td>k</td>
<td>1,000</td>
</tr>
<tr>
<td>hecto-</td>
<td>h</td>
<td>100</td>
</tr>
<tr>
<td>deka-</td>
<td>da</td>
<td>10</td>
</tr>
<tr>
<td>deci-</td>
<td>d</td>
<td>0.1</td>
</tr>
<tr>
<td>centi-</td>
<td>c</td>
<td>0.01</td>
</tr>
<tr>
<td>milli-</td>
<td>m</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Example How many grams equal one kilogram?

Step 1 Find the prefix kilo- in Table 2.

Step 2 Using Table 2, 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 2 to make conversion factors.

Example 1 How many cm are in 4 m?

Step 1 Write conversion factors for the units given. From Table 2, you know that 100 cm = 1 m. The conversion factors are

\[
\frac{100 \text{ cm}}{1 \text{ m}} \quad \text{and} \quad \frac{1 \text{ m}}{100 \text{ cm}}
\]

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.

\[
4 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 400 \text{ cm}
\]

Practice Problem How many milligrams are in one kilogram? (Hint: You will need to use two conversion factors from Table 2.)
### Table 3 Unit System Equivalents

<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
</tr>
<tr>
<td>1 in. = 2.54 cm</td>
<td></td>
</tr>
<tr>
<td>1 yd = 0.91 m</td>
<td></td>
</tr>
<tr>
<td>1 mi = 1.61 km</td>
<td></td>
</tr>
<tr>
<td><strong>Mass and weight</strong></td>
<td></td>
</tr>
<tr>
<td>1 oz = 28.35 g</td>
<td></td>
</tr>
<tr>
<td>1 lb = 0.45 kg</td>
<td>1 ton (short) = 0.91 tonnes (metric tons)</td>
</tr>
<tr>
<td>1 lb = 4.45 N</td>
<td></td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
</tr>
<tr>
<td>1 in.³ = 16.39 cm³</td>
<td></td>
</tr>
<tr>
<td>1 qt = 0.95 L</td>
<td></td>
</tr>
<tr>
<td>1 gal = 3.78 L</td>
<td></td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td></td>
</tr>
<tr>
<td>1 in.² = 6.45 cm²</td>
<td></td>
</tr>
<tr>
<td>1 yd² = 0.83 m²</td>
<td></td>
</tr>
<tr>
<td>1 mi² = 2.59 km²</td>
<td></td>
</tr>
<tr>
<td>1 acre = 0.40 hectares</td>
<td></td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>°C = ((°F - 32) \div 1.8)</td>
<td>°C = °C + 273</td>
</tr>
</tbody>
</table>

**Convert Between Unit Systems** Table 3 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 3, 1 in. = 2.54 cm.  
\[\frac{1 \text{ in.}}{2.54 \text{ cm}} \quad \text{and} \quad \frac{2.54 \text{ cm}}{1 \text{ in.}}\]

**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 to the nearest tenth.  
\[100 \text{ cm} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 39.37 \text{ in.}\]

The meterstick is about 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 relationship 1 in. = 2.54 cm to show how 1 in.³ = 16.39 cm³.

**Precision and Significant Figures**

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 figures recorded in the measurement. When counting the number of significant figures, all figures 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 figures 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 figures.

**Step 1** Find the sum.  
\[
\begin{array}{c}
5.28 \text{ m} \\
+ 5.2 \text{ m}
\end{array}
\]

**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 figures are in the measurement 7,071,301 m? How many significant figures 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 figures.
Scientific Notation

Oftentimes the 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 $2.278 \times 10^{11}$ 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 $0.000\ 000\ 000\ 000\ 000\ 000\ 000\ 000\ 000\ 911$ kg. Expressed in scientific notation, this mass is $9.11 \times 10^{-31}$ 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, $10^8$. Earth is $1.496 \times 10^8$ km from the Sun.

Practice Problem  Express each of the following in scientific notation: $0.005835$ g, $300,000$ m/s, $15,000,000$ K, $0.00020$ cm.

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 in Table 4 from a cyclist in a long-distance race.

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
</tbody>
</table>

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 50.

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 1.

Figure 1  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.

\[
slope = \frac{\text{vertical change (rise)}}{\text{horizontal change (run)}} = \frac{\text{change in } y}{\text{change in } x}
\]

**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 \(x\).

\[
slope = \frac{\text{change in } y}{\text{change in } x}
\]

**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.

\[
slope = \frac{(40 - 0) \text{ km}}{(5 - 0) \text{ h}}
\]

**Step 3** Find the change in \(y\) and \(x\).

\[
slope = \frac{40 \text{ km}}{5 \text{ h}}
\]

**Step 4** Divide the change in \(y\) by the change in \(x\).

The slope of the graph is 8 km/h.

**Bar Graph** To compare data that does not change continuously, you might use 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** 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.

\[
78 \times \frac{360°}{100} = 280.8°
\]

\[
21 \times \frac{360°}{100} = 75.6°
\]

\[
1 \times \frac{360°}{100} = 3.6°
\]

**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.

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

**Chapter 1 The Nature of Science**

Density = \( \frac{\text{mass}}{\text{volume}} \)

Kelvin = °Celsius + 273

\[ \% \text{ Error} = \left| \frac{\text{Accepted value} - \text{Experimental value}}{\text{Accepted value}} \right| \times 100 \]

**Chapter 2 Motion**

Speed = \( \frac{\text{distance}}{\text{time}} \)

Acceleration = \( \frac{\text{change in velocity}}{\text{time}} \)

Change in velocity = final velocity – initial velocity

**Chapter 3 Forces and Newton's Laws**

Acceleration = \( \frac{\text{net force}}{\text{mass}} \)

Force = mass \( \times \) acceleration

Gravitational force = mass \( \times \) (acceleration due to gravity)

Weight = mass \( \times \) gravity

Momentum \((p)\) = mass \( \times \) velocity

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

Change in position = initial velocity (change in time) + \( \frac{1}{2} \) acceleration (change in time)\(^2\)

Average velocity = \( \frac{\text{change in position}}{\text{change in time}} \)

Average acceleration = \( \frac{\text{change in velocity}}{\text{change in time}} \)

**Chapter 4 Work and Energy**

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

Gravitational potential energy \((\text{GPE})\) = mass \( \times \) gravity \( \times \) height

Mechanical energy = gravitational potential energy + kinetic energy

Work = force \( \times \) distance

Power = \( \frac{\text{work}}{\text{time}} \)

Efficiency = \( \left( \frac{\text{work}_{\text{out}}}{\text{work}_{\text{in}}} \right) \times 100\% \)

Ideal mechanical advantage \((\text{IMA})\) = \( \frac{\text{length of effort arm}}{\text{length of resistance arm}} = \frac{L_e}{L_r} \)
Ideal mechanical advantage (IMA) \( \frac{\text{radius of wheel}}{\text{radius of axle}} = \frac{r_w}{r_a} \)

IMA = \( \frac{\text{effort distance}}{\text{resistance distance}} = \frac{\text{length of slope}}{\text{height of slope}} = \frac{l}{h} \)

**Chapter 5 Thermal Energy**

Change in thermal energy = mass \( \times \) change in temperature \( \times \) specific heat or

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

**Chapter 6 Electricity**

Electric current = \( \frac{\text{voltage difference}}{\text{resistance}} \) or \( I = \frac{V}{R} \)

Electric power = current \( \times \) voltage difference or \( P = I \times V \)

Electric energy = power \( \times \) time or \( E = P \times t \)

**Series Circuits**

\[ I_1 = I_2 = I_3 = \ldots \]

\[ V_1 = V_2 + V_3 + \ldots \]

\[ R_1 = R_2 + R_3 + \ldots \]

**Parallel Circuits**

\[ I = I_1 + I_2 + I_3 + \ldots \]

\[ V_1 = V_2 = V_3 = \ldots \]

\[ \frac{1}{R_1} = \frac{1}{R_2} + \frac{1}{R_3} + \ldots \]

**Chapter 9 Introduction to Waves**

Wave velocity = wavelength \( \times \) frequency

or \( v_w = \lambda \times f \)

**Chapter 12 Light**

Index of refraction = \( \frac{\text{speed of light in a vacuum}}{\text{speed of light in a substance}} \) or \( n = \frac{c}{v} \)

**Chapter 14 Solids, Liquids, and Gases**

Pressure = \( \frac{\text{force}}{\text{area}} \) or \( P = \frac{F}{A} \)

Boyle’s law \( P_1 \times V_1 = P_2 \times V_2 \)

Charles’s law \( \frac{V_1}{T_1} = \frac{V_2}{T_2} \)

**Chapter 21 Solutions**

Surface area of a rectangular solid = \( 2(h \times w) + 2(h \times l) + 2(w \times l) \)
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 2,540 cm³?
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/cm³. 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 2,000 cm³. 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?
11. A car can travel 14 km on 1 L of gasoline. What percent of its fuel efficiency does another car have if it travels 10 km on 1 L of gasoline?
12. What is the fuel efficiency of a car if it gets 45 percent of the fuel efficiency of another car that travel 15 km on 1 L of gasoline?
13. Data from a new Web site takes 17 min to download. How many seconds does it take?
14. A circle graph shows the comparative effects of five new technologies. The circle graph has segments labeled 45 percent, 32 percent, 12 percent, and 3 percent. What is the correct label of the fifth segment?
15. If a new Internet connections reduces a download time of 17 min by 85 percent, how much time (in minutes and seconds) will it take now?
16. Because of a new health center in a town, the cases of influenza are 25 percent fewer. How many cases should you expect during the next month if the town usually has 300 cases per month?
17. If a person can sell 10 computers per day and a new technology allows her to triple her sales, how many computers can she expect to sell the next day?
18. A technologically advanced engine runs at twice the efficiency of an older engine. If the older engine allows a car to travel at a fuel efficiency of 8 km/L, what is the fuel efficiency of the advanced engine?

Chapter 2
Motion

1. 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?
2. 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?
3. An ant travels 75 cm in 5 s. What was the ant's speed?
4. It takes a car one minute to go from rest to 30 m/s east. What is the acceleration of this car?
5. It took you 6.5 h to drive 550 km. What was your average speed?

6. 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?

7. 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?

8. 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?

9. 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?

10. A car goes from rest to a velocity of 108 km/h north in 10 s. What is the car’s acceleration in m/s²?

11. A cart rolling south at a speed of 10 m/s comes to a stop in 2 s. What is the cart’s acceleration?

12. A car with a mass of 1,200 kg has a velocity of 30 m/s west. What is the car’s momentum?

13. If a 5,000-kg mass is moving at a velocity of 40 m/s south, what is its momentum?

14. How fast must a 50-kg mass travel to have a momentum of 1,500 kg-m/s east?

Chapter 3
Forces and Newton’s Laws

1. 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?

2. A weight lifter is trying to lift a 1,500-N weight but can apply a force of only 1,200 N on the weight. One of his friends helps him lift it at a constant velocity. What force was applied to the weight by the weight lifter’s friend?

3. During a tug-of-war, Team A pulls with a force of 5,000 N while Team B pulls with a force of 8,000 N. What is the net force applied to the rope?

4. A 80-kg mass has an acceleration of 5.5 m/s² north. What is the net force applied?

5. A force of 3,200 N west is applied to a 160-kg mass. What is the acceleration of the mass?

6. A 2.5-kg object is dropped from a height of 1,000 m. What is the force of air resistance on the object when it reaches terminal velocity?

7. How much force is needed to lift a 25-kg mass at a constant velocity?

8. A person is on an elevator that moves downward with an acceleration of 1.8 m/s². If the person weighs 686 N, what is the net force on the person?

9. What is the net force on a 4,000-kg car that doubles its velocity from 15 m/s west to 30 m/s west over 10 seconds?

10. A book with a mass of 1 kg is sliding to the left 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?

Chapter 4
Work and Energy

1. When moving a couch, you exert a force of 400 N and push it 4.0 m. How much work have you done on the couch?
Additional Practice Problems

2. How much work is needed to lift a 50-kg weight 3.0 m?

3. 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?

4. How much energy do you save per hour if you replace a 60-watt lightbulb with a 55-watt lightbulb?

5. What is the efficiency of a machine if your work on the machine is 1200 J and the machine's output work is 300 J?

6. What power is used by a machine to perform 800 J of work in 25 s?

7. 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?

8. A 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?

9. What is the kinetic energy from the motion of a 5.0-kg object moving at 7.0 m/s?

10. An object has 600 J of kinetic energy from its motion and a speed of 10 m/s. What is its mass?

11. If you throw a 0.4-kg ball at a speed of 20 m/s, what is the kinetic energy from the ball's motion?

12. If you have a mass of 80 kg and you are standing on a platform 3.0 m above the ground, what is the gravitational potential energy between you and Earth relative to the ground?

13. A 2.0-kg book is moved from a shelf that is 2.0 m off the ground to a shelf that is 1.5 m off the ground. What is the change in GPE?

14. A car moving at 30 m/s has 900 kJ of kinetic energy from its motion. What is the car's mass?

15. A car with a mass of 900 kg is traveling at a speed of 25 m/s. What is the kinetic energy from the car's motion?

16. If your weight is 500 N, and you are standing on a floor that is 20 m above the ground, what is the gravitational potential energy between you and Earth, relative to the ground?

Chapter 5
Thermal Energy

1. Water has a specific heat of 4,184 J/(kg·°C). How much energy is needed to increase the temperature of a kilogram of water 5.0°C?

2. The temperature of a block of iron, which has a specific heat of 450 J/(kg·°C), increases by 3°C when 2,700 J of energy are added to it. What is the mass of this block of iron?

3. How much energy is needed to heat 1.0 kg of sand, which has a specific heat of 664 J/(kg·°C), from 30°C to 50°C?

4. 1 kg of liquid water (specific heat = 4,184 J/(kg·°C)) is heated from freezing (0°C) to boiling (100°C). What is the water's change in thermal energy?

5. A concrete statue (specific heat = 600 J/(kg·°C)) sits in sunlight and warms up to 40°C. Overnight, it cools to 15°C and transfers 90,000 J of thermal energy to its surroundings. What is its mass?

6. A substance with a mass of 10.0 kg transfers 106.5 kJ of thermal energy to its surroundings when its temperature drops 15°C. What is this substance's specific heat?

7. How much heat is needed to raise the temperature of 100 g of water by 50°C, if the specific heat of water is 4,184 J/kg·°C?
8. A calorimeter contains 1.0 kg of water (specific heat = 4,184 J/(kg·°C)). An object with a mass of 4.23 kg is added to the water. If the water temperature increases by 3.0°C and the temperature of the object decreases by 1.0°C, what is the specific heat of the object?

9. A sample of an unknown metal has a mass of 0.5 kg. Adding 1,985 J of thermal energy to the metal raises its temperature by 10°C. What is the specific heat of the metal?

Chapter 6
Electricity

1. A circuit has a resistance of 4.0 Ω. What voltage difference will produce a current of 1.4 A in the circuit?

2. How many amperes of current will there be in a circuit if the voltage difference is 9.0 V and the resistance in the circuit is 3.0 Ω?

3. If a voltage difference of 3.0 V causes a 1.5 A current in a circuit, what is the resistance in the circuit?

4. The current in an appliance is 3.0 A and the voltage difference is 120 V. How much power is being supplied to the appliance?

5. What is the current into a microwave oven that requires 700 W of power if the voltage difference is 120 V?

6. What is the voltage difference in a circuit that uses 2,420 W of power when the current through the circuit is 11 A?

7. How much energy is converted when a 110 kW appliance is used for 3.0 hours?

8. How much does it cost to light six 100-W lightbulbs for six hours if the price of electrical energy is $0.09/kWh?

Chapter 7
Magnetism and Its Uses

1. 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?

2. A step-down transformer reduces voltage from 2,400 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?

3. 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?

4. 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 800 V?

5. The coil of a 60-Hz generator makes 60 revolutions each second. How many revolutions does the coil make in five minutes?
6. 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?

7. 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?

8. 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?

9. If a generator coil makes 6,000 revolutions in two minutes, how many revolutions does it make each second?

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**Chapter 8**

**Energy Sources and the Environment**

1. A gallon of gasoline contains about 2,800 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 = 1,000 J)

2. 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?

3. Refer to the pie chart Energy Sources in Figure 2. According to the pie chart, petroleum represents 38 percent of the consumable energy sources in the United States. If 39.7 quadrillion BTUs of petroleum are consumed each year, what amount of energy (in quadrillion BTUs) does coal use account for?

4. Refer to Figure 8, a graph of carbon dioxide concentration (ppm) vs. time (years). If the average carbon dioxide concentration in 1960 was 315 parts per million and the average carbon dioxide concentration in 2010 is 385 parts per million, what is the percentage change in the concentration of carbon dioxide over the past 50 years?

5. 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?

6. 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?

7. From 1970 to 2010, the carbon dioxide concentration in Earth’s atmosphere increased from about 325 parts per million to about 385 parts per million. What is the percentage change in the concentration of carbon dioxide over the past 40 years?

8. 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?

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**Chapter 9**

**Introduction to Waves**

1. What is the wavelength of a wave with a frequency of 0.4 kHz traveling at 16 m/s?

2. What is the wavelength of a wave with a frequency of 5 Hz traveling at 15 m/s?

3. A wave has a wavelength of 250 cm and a frequency of 4 Hz. What is its speed?
4. 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 5.0 m and the other has a wavelength of 0.2 m?

5. What is the speed of a wave that has a wavelength of 6.0 m and a frequency of 3.0 Hz?

6. What is the frequency of a wave with a wavelength of 7 m traveling at 21 m/s?

7. 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?

Chapter 10
Sound

1. What is the wavelength of a 440-Hz sound wave traveling with a speed of 347 m/s?

2. A sound wave with a frequency of 440 Hz travels in steel with a speed of 5,200 m/s. What is the wavelength of the sound wave?

3. A wave traveling in water has a wavelength of 750 m and a frequency of 2 Hz. How fast is this wave moving?

4. At 0°C sound travels through air with a speed of about 331 m/s and through aluminum with a speed of 4,877 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?

5. 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?

6. What is the frequency of the first overtone of a 440-Hz wave?

7. The wreck of the Titanic is at a depth of about 3,800 m. A sonar unit on a ship above the Titanic emits a sound wave that travels at a speed of 1,500 m/s. How long does it take a sound wave reflected from the Titanic to return to the ocean surface?

8. 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 1,500 m/s, how deep is the ocean beneath the ship?

9. 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?

10. A sound wave has a wavelength of 50 m and a frequency of 22 Hz. What is the speed of the sound wave?

Chapter 11
Electromagnetic Waves

1. Express the number 20,000 in scientific notation.

2. An electromagnetic wave has a wavelength of 0.054 m. What is the wavelength in scientific notation?

3. Earth is about 4,500,000,000 years old. Express this number in scientific notation.

4. The speed of electromagnetic waves in air is 300,000 km/s. What is the frequency of electromagnetic waves that have a wavelength of $5 \times 10^{-3}$ km?

5. 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?
6. The speed of radio waves in water is about $2.26 \times 10^5$ km/s. What is the frequency of radio waves that have a wavelength of 3.0 km?

7. Some infrared waves have a frequency of 10,000,000,000,000 Hz. Express this frequency in scientific notation.

8. An infrared wave has a frequency of $1 \times 10^{13}$ Hz and a wavelength of $3 \times 10^{25}$ m. Express the wave's speed as a decimal number.

9. An AM radio station broadcasts at a frequency of 620 kHz. Express this frequency in Hz using scientific notation.

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

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**Chapter 12**

**Light**

1. A ray of light hits a plane mirror at 35° from the normal. What angle does the reflected ray make with the normal?

2. 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?

3. 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?

4. 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°.)

5. 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?

6. About 8% of men and 0.5% of women have some form of color blindness. The percent of men who experience color blindness is how many times larger than the percent of women who experience color blindness?

7. 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?

8. 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?

9. In the human eye, there are about 7,000,000 cone cells distributed over an area of 5 cm². If cone cells are evenly distributed, how many cone cells are distributed over an area of 2 cm²? Express your answer in scientific notation.

10. 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?

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**Chapter 13**

**Mirrors and Lenses**

1. 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?
2. 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?

3. 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?

4. 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?

5. 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?

6. 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?

7. Astronomers have proposed building the Thirty Meter Telescope with a mirror 30.0 m in diameter. The diameter of the Hubble Space Telescope mirror is 2.4 m. What percent of the surface area of the telescope’s mirror would be covered by the surface area of the Hubble mirror?

8. 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?

Chapter 14
Solids, Liquids, and Gases

1. A book is sitting on a desk. The area of contact between the book and the desk is 0.06 m². If the book's weight is 30 N, what is the pressure the book exerts on the desk?

2. A skater has a weight of 500 N. The skate blades are in contact with the ice over an area of 0.001 m². What is the pressure exerted on the ice by the skater?

3. The weight of the water displaced by a person floating in the water is 686 N. What is the person’s mass?

4. 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?

5. 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?

6. 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/cm³, what is the volume of water displaced by the floating wood?
7. 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 that has an area of 0.08 m$^2$?

8. A gas-filled weather balloon floating in the atmosphere has an initial volume of 850 L. The weather balloon rises to a region where the pressure is 56 kPa, and its volume expands to 1,700 L. If the temperature remains the same, what was the initial pressure on the weather balloon?

9. 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?

10. 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?

11. 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?

**Chapter 15**

**Classification of Matter**

1. The size of particles in a solution is about 1 nm (1 nm = 0.000000001 m). Write 0.000000001 m in scientific notation.

2. A chemical reaction produces two new substances, one with a mass of 34 g and the other with a mass of 39 g. What is the total mass of the reactants?

3. The human body is about 65% oxygen by mass. If a person has a mass of 75.0 kg, what is the mass of oxygen in his body?

4. 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?

5. Carbon reacts with oxygen to form carbon dioxide according to the following equation: C + O$_2$ → CO$_2$. When 120 g of carbon reacts with oxygen, 440 g of carbon dioxide are formed. How much oxygen reacted with the carbon?

6. 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?

7. Calcium carbonate, CaCO$_3$, decomposes according to the reaction: CaCO$_3$ → CaO + 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?

8. Water breaks down into hydrogen gas and oxygen gas according to the reaction: 2H$_2$O → 2H$_2$ + 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?

9. A 112-g serving of ice cream contains 19 g of fat. What percentage of the serving is fat?

10. 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?
### Chapter 16
**Properties of Atoms and the Periodic Table**

1. The boron atom has a mass number of 11 and an atomic number of 5. How many neutrons are in the boron atom?

2. A magnesium atom has 12 protons and 12 neutrons. What is its mass number?

3. Iodine-127 has a mass number of 127 and 74 neutrons. What percentage of the particles in an iodine-127 nucleus are protons?

4. How many neutrons are in an atom of phosphorus-31?

5. What is the ratio of neutrons to protons in the isotope radium-234?

6. 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?

7. The half-life of the radioactive isotope rubidium-87 is 48,800,000,000 years. Express this half-life in scientific notation.

8. 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?

9. 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?

10. A neutral phosphorus atom has 15 electrons. How many electrons are in the third energy level?

### Chapter 17
**Elements and Their Properties**

1. In seawater the concentration of fluoride ions, \( F^- \), is \( 1.3 \times 10^{-3} \) g/L. How many liters of seawater would contain 1.0 g of \( F^- \)?

2. 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?

3. A vitamin and mineral supplement pill contains \( 1.0 \times 10^{-5} \) 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?

4. The density of silver is 10.5 g/cm\(^3\) and the density of copper is 8.9 g/cm\(^3\). What is the difference in mass between a piece of silver with a volume of 5 cm\(^3\) and a piece of copper with a volume of 5 cm\(^3\)?

5. A person has a mass of 68.3 kg. If 18% of the mass of a human body is carbon, what is the mass of carbon in this person’s body?

6. A 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?

7. 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\(^3\)?

8. 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?
9. The melting point of aluminum is 660.0°C. What is the melting point of aluminum on the Fahrenheit temperature scale?

10. The synthetic element hassium-269 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 18
Chemical Bonds

1. What is the formula of the compound formed when ammonium ions (NH₄⁺) and phosphate ions (PO₄³⁻) combine?

2. Show that the sum of positive and negative charges in a unit of calcium chloride (CaCl₂) equals zero.

3. What is the formula for iron(III) oxide?

4. How many hydrogen atoms are in three molecules of ammonium phosphate, (NH₄)₃PO₄?

5. The overall charge on the polyatomic phosphate ion (PO₄³⁻) is 3⁻. What is the oxidation number of phosphorus in the phosphate ion?

6. The overall charge on the polyatomic dichromate ion (Cr₂O₇²⁻) is 2⁻. What is the oxidation number of chromium in this polyatomic ion?

7. What is the formula for lead(IV) oxide?

8. What is the formula for potassium chlorate?

9. What is the formula for carbon tetrachloride?

10. What is the name of NaF?

11. What is the name of Al₂O₃?

12. What percentage of the mass of a sulfuric acid molecule (H₂SO₄) is sulfur?

Chapter 19
Chemical Reactions

1. Lithium reacts with oxygen to form lithium oxide according to the equation:
   4Li + O₂ → 2Li₂O.
   If 27.8 g of Li react completely with 32.0 g of O₂, how many grams of Li₂O are formed?

2. What coefficients balance the following equation: _Zn(OH )₂ + H₃PO₄ → _Zn₃(PO₄)₂ + _H₂O?

3. Aluminum hydroxide, Al(OH)₃, decomposes to form aluminum oxide, Al₂O₃, and water according to the reaction:
   2Al(OH)₃ → Al₂O₃ + 3H₂O.
   If 156.0 g of Al(OH)₃ decompose to from 102.0 g of Al₂O₃, how many grams of H₂O are formed?

4. In the following balanced chemical reaction one of the products is represented by the symbol X:
   BaCO₃ + C + H₂O → Ba(OH)₂ + 2X.
   What is the formula for the compound represented by X?

5. When propane (C₃H₈) is burned, carbon dioxide and water vapor are produced according to the following reaction:
   C₃H₈ + 5O₂ → 3CO₂ + 4H₂O.
   How much propane is burned if 160.0 g of O₂ are used and 132.0 g of CO₂ and 72.0 g of H₂O are produced?

6. 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?
7. When acetylene gas (C₂H₂) is burned, carbon dioxide and water are produced. Find the coefficients that balance the chemical equation for the combustion of acetylene:

\[ \text{C}_2\text{H}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}. \]

8. What coefficients balance the following equation:

\[ \text{CS}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{SO}_2 \]

9. When methane, CH₄, is burned, 50.1 kJ of energy per gram are released. When propane, C₃H₈, is burned, 45.8 kJ of energy are released. If a mixture of 1.0 g of methane and 1.0 g of propane is burned, how much energy is released per gram of mixture?

10. 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 0.0070 s. How much faster is the rate of reaction in the presence of the enzyme?

Chapter 20
Radioactivity and Nuclear Reactions

1. How many protons are in the nucleus \(^{81}_{36}\)Kr?

2. How many neutrons are in the nucleus \(^{56}_{26}\)Fe?

3. What is the ratio of neutrons to protons in the nucleus \(^{241}_{95}\)Am?

4. How many alpha particles are emitted when the nucleus \(^{222}_{86}\)Rn decays to \(^{218}_{84}\)Po?

5. An alpha particle is the same as the helium nucleus \(^{1}_{2}\)He. What nucleus is produced when the nucleus \(^{226}_{88}\)Ra decays by emitting an alpha particle?

6. A sample of \(^{38}_{17}\)Cl is observed to decay to 25% of the original amount in 74.4 minutes. What is the half-life of \(^{38}_{17}\)Cl?

7. How many beta particles are emitted when the nucleus \(^{40}_{19}\)K decays to the nucleus \(^{40}_{20}\)Ca?

8. How long will it take a sample of \(^{194}_{84}\)Po to decay to 1/8 of its original amount if \(^{194}_{84}\)Po has a half-life of 0.70 s?

9. The half-life of \(^{131}_{53}\)I is 8.04 days. How much time would be needed to reduce 1.00 g of \(^{131}_{53}\)I to 0.25 g?

10. A sample of radioactive carbon-14 sample has decayed to 12.50% of its original amount. If the half-life of carbon-14 is 5730 years, how old is this sample?

11. Recall that objects in motion have kinetic energy. How fast would a 1,500-kg car need to travel in order to increase its mass by 1.0 kg?

12. The Kashiwazaki-Kariwa nuclear power plant is capable of converting approximately 8 billion J of nuclear energy into electrical energy every second. How much energy does the Kashiwazaki-Kariwa nuclear power plant convert to electrical energy in 1 year? How much mass is this equivalent to?

Chapter 21
Solutions

1. A cup of orange juice contains 126 mg of vitamin C and \(\frac{1}{2}\) 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?

2. A Sacagawea dollar coin is made of manganese brass alloy that is \(\frac{1}{25}\) nickel. Express this number as a percentage.

3. What is the total surface area of a 2-cm cube?
4. A cube has 2-cm sides. If it is split in half, what is the total surface area of the two pieces?

5. What is the increase in surface area when a cube with 2-cm sides is divided into eight equal parts?

6. How much surface area is lost if two 4-cm cubes are attached at one face?

7. 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?

8. 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?

9. 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?

10. A fruit drink contains 90% water and 10% fruit juice. How much fruit juice does 500 mL of fruit drink contain?

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**Chapter 22**

**Acids, Bases, and Salts**

1. The difference between the pH of an acidic solution and the pH of pure water is 3. What is the pH of the solution?

2. 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?

3. A molecule of acetylsalicylic acid, or aspirin, has the chemical formula COOHCH₃H₂COOCH₃. What is the mass of a molecule of acetylsalicylic acid in amu?

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**Chapter 23**

**Organic Compounds**

1. 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?

2. 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?
3. The hydrocarbon octane, $C_{8}H_{18}$, has a boiling point of 259°F. What is its boiling point on the Celsius temperature scale?

4. Four molecules of a saturated hydrocarbon contain carbon atoms and 56 hydrogen atoms. What is the formula for a molecule of this hydrocarbon?

5. 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?

6. 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.

7. 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.

8. A car gets 25 miles per gallon of gas. If the car is driven 12,000 miles in one year and gasoline costs $2.55 per gallon, what was the cost of the gasoline used in one year?

### Chapter 24

**New Materials Through Chemistry**

1. A 14-karat gold earring has a mass of 10 g. What is the mass of gold in the earring?

2. 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.

3. 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?

4. The molecules in a sample of polypropylene have an average length of 60,000 monomers. The monomer of polypropylene has the formula $CH_{2}CHCH_{3}$. Express in scientific notation the mass, in amu, of a polypropylene molecule made of 60,000 monomers.

5. 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.

6. 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?

7. 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?

8. 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 1992, estimate how many transistors an integrated circuit of the same size contained in 2008.

9. 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
Earth’s Internal Processes

1. How long after an earthquake will a seismograph 3,000 km away from the epicenter record S-waves that travel at 3.6 km/s?

2. If it takes 48 min 20 s for P-waves traveling at 6.0 km/s to reach and be recorded by a seismograph, how far away is the epicenter?

3. If S-waves lag behind P-waves by 1 min 52 s for every 1,000 km of distance from the earthquake epicenter, how much difference between the arrival times of P-waves and S-waves would be measured at 3,000 km? At 3,500 km?

4. With a P-wave–S-wave lag time of 1 min 52 s for every 1,000 km of distance from the earthquake epicenter, how much difference in time would be measured at 3,000 km? At 3,500 km?

5. If surface waves travel at 3.2 km/s, when would you expect them to arrive at a seismograph that is 2,500 km away from the earthquake epicenter?

6. If P-waves travel at 3.6 km/s and S-waves travel at 6.0 km/s through Earth’s crust, what percentage of the speed of P-waves would you expect S-waves to travel at other depths inside Earth?

7. The volume of a cone is \( \frac{1}{3} \pi r^2 h \). If Paricutín is 424 m high and has a base 2.8 km across, what is the volume of the cinder cone?

8. If two places diverge at a rate of 1.3 cm/year, how much farther apart, in kilometers, will the tow plates be after 200 million years?

9. How many times faster are plates moving at 7.3 cm/year than are plates moving at 1.3 cm/year?

10. The volume of a sphere is \( \frac{4}{3} \pi r^3 \). The radius of Earth is 6,378 km, and the radius of its core (including both outer and inner cores) is 3,486 km. What percent of the total volume of Earth is its core?

Chapter 26
Earth Materials

1. If oxygen makes up 46.6% of the mass of Earth’s crust and silicon makes up 27.7%, what is the total percent of the crust’s mass for oxygen and silicon?

2. If oxygen and silicon make up 74.3% of the mass of Earth’s crust, what percent of this number is silicon’s percentage?

3. How many total atoms of aluminum and oxygen combined make up one molecule of corundum (Al₂O₃)?

4. What is the ratio of silicon to oxygen in a molecule of olivine ((Mg,Fe)₂SiO₄)?

5. Other than the common eight elements that make up Earth’s crust, all other elements make up only 1.5%. If oxygen makes up 46.6% of Earth’s crust, how many times greater is the amount of oxygen in Earth’s crust than those other elements?

6. The Mohs scale of hardness consists of ten categories, each associated with a mineral standard. How many categories are between hardness 7-quartz and hardness 2-gypsum?

7. The volume of a sphere is \( \frac{4}{3} \pi r^3 \). If a particle of gravel has a radius of 2 mm and a sand grain has a radius of 1 mm, how many times bigger is the volume of the gravel?

8. If a sedimentary rock has a porosity of 15%, how much volume do the mineral grains and cement take up?
9. If you have a halite cube that measures 4 cm on each side, what is the total surface area of the cube?

10. What is the ratio of oxygen atoms to potassium atoms in one molecule of K-feldspar, \((\text{KAlSi}_3\text{O}_8)\)?

**Chapter 27**

**Earth’s Changing Surface**

1. If soil erosion averages 2.5 cm per year and the average soil profile is 3.2 m thick with 40% topsoil, how long will it take for the topsoil to erode away?

2. The average soil profile in your area is 2.1 m thick. Topsoil erodes at 2.0 cm per year. What percent of the soil profile is topsoil if it erodes in 14 years?

3. Soil erosion in your area averages 3.5 cm per year. The average soil profile is 3.7 m thick and 35% of that is topsoil. Soil replacement though weathering is 0.2 cm per year. How long will it take for the topsoil to erode?

4. Observations taken at the mouth of a stream include a flow rate of 120 m³/s and a suspended sediment load of 1.8 kg/m³. How many kilograms of sediment potentially could drop out of this stream each day?

5. Observations taken at the mouth of a stream include a flow rate of 85 m³/s and a suspended sediment load of 1.6 kg/m³. How many kilograms of sediment potentially could drop out of this stream each day?

6. An aquifer is 400 km in length, 185 km in width, and 80 km thick. Sampling of the aquifer material shows it has an average porosity of 15%. What is the volume of porosity?

7. Suppose a community with a human population of 800 has a water consumption rate of 900 L per person per day. This community relies on an aquifer that is thought to contain 1.2 billion L of water. Assuming no change in average water consumption or significant recharge of the aquifer, how many years will this water supply last?

8. An aquifer has dimensions of 350 km in length, 175 km in width, and 65 km thick. Sampling of the aquifer material shows it has an average porosity of 10%. What is the volume of porosity?

9. If three half-lives for an isotope have passed, what fraction of the original isotope would be present in the igneous rock?

10. If the half-life of an isotope is 12,000 years and the amount of the isotope present is only \(\frac{1}{16}\) of the original amount present, how old is the igneous rock containing the isotope?

**Chapter 28**

**Weather and Climate**

1. If a snowy surface reflects 90% of the solar radiation that strikes it and bare soil reflects 30%, how many times more solar radiation is reflected from a snowy surface than from bare soil?

2. The amount of rainfall over five days is 4 cm, 2 cm, 0.4 cm, 0.2 cm, and 1.3 cm. What is the average rainfall per day?

3. Air pressure at Earth’s surface is 101.3 kPa. What is the air pressure at 16 km if it is \(\frac{1}{10}\) the air pressure at Earth’s surface?

4. Air pressure at Earth’s surface is 101.3 kPa. If air pressure in an average car tire is equal to two atmospheres, what is the pressure in an average car tire?
5. Much of northern Florida receives 1,300 mm of rain on average per year, and the southern part of the Everglades receives 1,650 mm of rain on average per year. What percent of the rainfall in the southern part of the Everglades is the rainfall in northern Florida?

6. If the tilt of Earth's axis has varied from 21.5° to 24.5° over time, what is the value of the range of Earth's axial tilt?

7. Most of Earth's atmosphere is within 30 km of Earth's surface. If Earth's atmosphere extends about 10,000 km above Earth's surface, what percent of the atmosphere's depth contains most of Earth's atmosphere?

8. If a tornado travels at 50 km/h and cuts a path of destruction 10 km long, how many minutes did it take to do this?

9. If there have been eight glacial periods during the past 200,000 years, what is the rate at which these have occurred?

10. The three main gases in Earth's atmosphere are nitrogen: 78%, oxygen: 21%, and argon and trace gases: 1%. If a circle graph were drawn to represent these data, how many degrees would represent each section?

Chapter 29
The Earth-Moon-Sun System

1. Earth's diameter is 12,714 km from pole to pole and 12,756 at the equator. How much less is Earth's diameter from pole to pole than at the equator?

2. Earth's circumference is 40,075 km at the equator and 40,008 km through the two poles. How much greater is Earth's circumference around the equator?

3. If a day on Earth lasts 23 h and 56 min, how many minutes are in one day?

4. Earth's average density is 5.52 g/cm³. If the Moon's average density is 3.31 g/cm³, what percent of Earth's density is the Moon's density?

5. Earth is one AU (149,600,000 km) from the Sun. If Jupiter is 5.2 AU from the Sun, how many kilometers is Jupiter from the Sun?

6. If Earth rotates 15° each hour, how many degrees will it rotate in three hours?

7. Earth is tilted 23.5°. If the Sun is 50° above the southern horizon when it is directly over the equator, how high in the sky will the Sun be on the first day of summer?

8. The Sun has a diameter of 1,392,000 km and is about 400 times larger than the Moon. What is the approximate diameter of the Moon?

9. If there are 29.5 days in one synodic month, how many synodic months are there in one year of 365 days?

10. The South Pole-Aitken Basin on the Moon is 12 km deep and 2,500 km wide. How many times wider is the basin than it is deep?

Chapter 30
The Solar System

1. What fraction of a complete orbit (360°) would a planet move through if its H.L. changes from 32° to 302°?

2. What fraction of a complete orbit (360°) would a planet move through if its H.L. changes from 152° to 242°?

3. Earth's atmospheric pressure is 101.3 kPa. What is the atmospheric pressure on the surface of Titan if it is 1.5 times that of Earth?
4. What is the atmospheric pressure on the surface of Mars if it is 0.6 percent of Earth's?

5. If the atmospheric pressure of Triton's atmosphere is 0.002 percent of Earth's, what is the atmospheric pressure on the surface of Triton?

6. If a planet has a H.L. of 73°, what percentage of the total orbit (360°) would this represent?

7. If the diameters of Earth and Uranus are 12,756 km and 51,118 km respectively, approximately how many Earths could fit across Uranus's diameter?

8. The volume of a sphere is \(\frac{4}{3}\pi r^3\). If the radius of Earth is 6,378 km and the radius of Jupiter is 71,492 km, how many Earths would fit inside Jupiter?

9. The volume of a sphere is \(\frac{4}{3}\pi r^3\). If the radius of Mars is 3,394 km and the radius of Earth is 6,378 km, what percentage of Earth's volume is Mars's volume?

10. On average, Earth is 150 million km (1 AU) from the Sun. If Saturn is 9.53 AU from the Sun, what is the distance from the Sun to Saturn in kilometers?

11. If Venus takes 0.62 years to orbit the Sun and Saturn takes 29.42 years to orbit the Sun, how many times will Venus orbit the Sun during each orbit of Saturn?

12. If Earth is tilted 23.5° and Uranus is tilted 97.9°, how many times greater is the axial tilt of Uranus than that of Earth?

Chapter 31
Stars and Galaxies
1. If the focal length of a telescope's objective is 900 mm and the focal length of its eyepiece is 10 mm, what is the magnifying power of this telescope?

2. If the focal length of a telescope's objective is 700 mm and the magnifying power of the telescope is 40 times, what is the focal length of an eyepiece?

3. If it takes 25 days for a sunspot to travel once around the Sun, about how many days would it take to travel across the face of the Sun?

4. If a solar prominence blasts material from the Sun at a speed of 600 km/s, how long in hours and minutes would it take for material to arrive at Earth 150 million km away?

5. How many times larger in area is a 250-mm–diameter objective than a 100-mm–diameter objective?

6. How many times larger in area is an 8-m–diameter objective than a 5-m–diameter objective?

7. How many times wider is an elliptical galaxy that is nine million light-years across than one that is 3,000 light-years across?

8. A telescope's objective has a focal length of 1,200 mm. It is used with two eyepieces that have focal lengths of 12 mm and 18 mm. How many times greater is the magnifying power of the telescope when the 12-mm eyepiece is used?

9. A telescope's objective has a focal length of 1,500 mm. It is used with two eyepieces that have focal lengths of 20 mm and 12.5 mm. What percent of the magnifying power obtained using the 12.5-mm eyepiece is achieved using the 20-mm eyepiece?

10. If the age of the universe was thought to be 20 billion years but is now considered to be 13.7 billion years, how much younger is the universe now previously thought to be?
# Minerals with Metallic Luster

<table>
<thead>
<tr>
<th>Mineral (Formula)</th>
<th>Color</th>
<th>Streak</th>
<th>Hardness</th>
<th>Specific Gravity</th>
<th>Crystal System</th>
<th>Breakage Pattern</th>
<th>Uses and Other Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bornite (Cu$_5$FeS$_4$)</td>
<td>bronze, tarnishes to dark blue purple</td>
<td>gray-black</td>
<td>3</td>
<td>4.9–5.4</td>
<td>tetragonal</td>
<td>uneven fracture</td>
<td>source of copper called “peacock ore” because of the purple shine when it tarnishes</td>
</tr>
<tr>
<td>Chalcopyrite (CuFeS$_2$)</td>
<td>brassy to golden yellow</td>
<td>greenish black</td>
<td>3.5–4</td>
<td>4.2</td>
<td>tetragonal</td>
<td>uneven fracture</td>
<td>main ore of copper</td>
</tr>
<tr>
<td>Chromite (FeCr$_2$O$_4$)</td>
<td>black or brown</td>
<td>brown to black</td>
<td>5.5</td>
<td>4.6</td>
<td>cubic</td>
<td>irregular fracture</td>
<td>ore of chromium, stainless steel, metallurgical bricks</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>copper red</td>
<td>copper red</td>
<td>3</td>
<td>8.5–9</td>
<td>cubic</td>
<td>hackly</td>
<td>coins, pipes, gutters, wire, cooking utensils, jewelry, decorative plaques; malleable and ductile</td>
</tr>
<tr>
<td>Galena (PbS)</td>
<td>gray</td>
<td>gray to black</td>
<td>2.5</td>
<td>7.5</td>
<td>cubic</td>
<td>cubic cleavage perfect</td>
<td>source of lead, used in pipes, shields for X-rays, fishing equipment sinkers</td>
</tr>
<tr>
<td>Gold (Au)</td>
<td>pale to golden yellow</td>
<td>yellow</td>
<td>2.5–3</td>
<td>19.3</td>
<td>cubic</td>
<td>hackly</td>
<td>jewelry, money, gold leaf, fillings for teeth, medicines; does not tarnish</td>
</tr>
<tr>
<td>Graphite (C)</td>
<td>black to gray</td>
<td>black to gray</td>
<td>1–2</td>
<td>2.3</td>
<td>hexagonal</td>
<td>basal cleavage (scales)</td>
<td>pencil lead, lubricants for locks, rods to control some small nuclear reactions, battery poles</td>
</tr>
<tr>
<td>Hematite (specular) (Fe$_2$O$_3$)</td>
<td>black or reddish brown</td>
<td>red or reddish brown</td>
<td>6</td>
<td>5.3</td>
<td>hexagonal</td>
<td>irregular fracture</td>
<td>source of iron; roasted in a blast furnace, converted to “pig” iron, made into steel</td>
</tr>
<tr>
<td>Magnetite (Fe$_3$O$_4$)</td>
<td>black</td>
<td>black</td>
<td>6</td>
<td>5.2</td>
<td>cubic</td>
<td>conchoidal fracture</td>
<td>source of iron, naturally magnetic, called lodestone</td>
</tr>
<tr>
<td>Pyrite (Fe$_5$S$_4$)</td>
<td>light, brassy yellow</td>
<td>greenish black</td>
<td>6.5</td>
<td>5.0</td>
<td>cubic</td>
<td>uneven fracture</td>
<td>source of iron, “fool’s gold,” alters to limonite</td>
</tr>
<tr>
<td>Pyrrhotite (Fe$_{1–X}$S)</td>
<td>*contains one less atom of Fe than S</td>
<td>bronze</td>
<td>4</td>
<td>4.6</td>
<td>hexagonal</td>
<td>uneven fracture</td>
<td>an ore of iron and sulfur; may be magnetic</td>
</tr>
<tr>
<td>Silver (Ag)</td>
<td>silvery white, tarnishes to black</td>
<td>light gray to silver</td>
<td>2.5</td>
<td>10–12</td>
<td>cubic</td>
<td>hackly</td>
<td>coins, fillings for teeth, jewelry, silver plate, wires; malleable and ductile</td>
</tr>
</tbody>
</table>
Table 2  
Minerals with Nonmetallic Luster

<table>
<thead>
<tr>
<th>Mineral (Formula)</th>
<th>Color</th>
<th>Streak</th>
<th>Hardness</th>
<th>Specific Gravity</th>
<th>Crystal System</th>
<th>Breakage Pattern</th>
<th>Uses and Other Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augite ((Ca, Na) (Mg, Fe, Al) (Al, Si$_2$O$_6$))</td>
<td>black</td>
<td>colorless</td>
<td>6</td>
<td>3.3</td>
<td>monoclinic</td>
<td>2-directional cleavage</td>
<td>square or 8-sided cross section</td>
</tr>
<tr>
<td>Corundum (Al$_2$O$_3$)</td>
<td>colorless, blue, brown, green, white, pink, red</td>
<td>colorless</td>
<td>9</td>
<td>4.0</td>
<td>hexagonal</td>
<td>fracture</td>
<td>gemstones: ruby is red, sapphire is blue; industrial abrasive</td>
</tr>
<tr>
<td>Feldspar (orthoclase) (KAISi$_3$O$_8$)</td>
<td>colorless, white to gray, green, yellow</td>
<td>colorless</td>
<td>6</td>
<td>2.5</td>
<td>monoclinic</td>
<td>two cleavage planes meet at 90° angle</td>
<td>insoluble in acids; used in the manufacturing of porcelain</td>
</tr>
<tr>
<td>Feldspar (plagioclase) (NaAlSi$_3$O$_8$) (CaAl$_2$Si$_3$O$_8$)</td>
<td>gray, green, white</td>
<td>colorless</td>
<td>6</td>
<td>2.5</td>
<td>triclinic</td>
<td>two cleavage planes meet at 86° angle</td>
<td>used in ceramics; striations present on some faces</td>
</tr>
<tr>
<td>Fluorite (CaF$_2$)</td>
<td>colorless, white, blue, green, red, yellow, purple</td>
<td>colorless</td>
<td>4</td>
<td>3–3.2</td>
<td>cubic</td>
<td>cleavage</td>
<td>used in the manufacturing of optical equipment; glows under ultraviolet light</td>
</tr>
<tr>
<td>Garnet (Mg, Fe, Ca, Mn)$_3$ (Al, Fe, Cr)$_2$ (SiO$_4$)$_3$</td>
<td>deep yellow-red, green, black</td>
<td>colorless</td>
<td>7.5</td>
<td>3.5</td>
<td>cubic</td>
<td>conchoidal fracture</td>
<td>used in jewelry; also used as an abrasive</td>
</tr>
<tr>
<td>Hornblende Ca$_2$Na$_2$ (Mg, Fe$_2$)$_3$ (Al, Fe, Ti)$_4$ Si$_8$O$_22$ (O, OH)$_2$</td>
<td>green to black</td>
<td>gray to white</td>
<td>5–6</td>
<td>3.4</td>
<td>monoclinic</td>
<td>cleavage in two directions</td>
<td>will transmit light on thin edges; 6-sided cross section</td>
</tr>
<tr>
<td>Limonite (hydrous iron oxides)</td>
<td>yellow, brown, black</td>
<td>yellow, brown</td>
<td>5.5</td>
<td>2.7–4.3</td>
<td>N/A</td>
<td>conchoidal fracture</td>
<td>source of iron; weathers easily, coloring matter of soils</td>
</tr>
<tr>
<td>Olivine (Mg, Fe)$_2$ SiO$_4$</td>
<td>olive green</td>
<td>colorless</td>
<td>6.5</td>
<td>3.5</td>
<td>orthorhombic</td>
<td>conchoidal fracture</td>
<td>gemstones, refractory sand</td>
</tr>
<tr>
<td>Quartz (SiO$_2$)</td>
<td>colorless, various colors</td>
<td>colorless</td>
<td>7</td>
<td>2.6</td>
<td>hexagonal</td>
<td>conchoidal fracture</td>
<td>used in glass manufacture, electronic equipment, radios, computers, watches, gemstones</td>
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<tr>
<td>Topaz (Al$_2$SiO$_4$ (F, OH)$_2$)</td>
<td>colorless, white, pink, yellow, pale blue</td>
<td>colorless</td>
<td>8</td>
<td>3.5</td>
<td>orthorhombic</td>
<td>basal cleavage</td>
<td>valuable gemstone</td>
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## Table 3  Rocks

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<th>Rock Type</th>
<th>Rock Name</th>
<th>Characteristics</th>
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<tr>
<td><strong>Igneous</strong></td>
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<tr>
<td>(intrusive)</td>
<td>granite</td>
<td>large mineral grains of quartz, feldspar, hornblende, and mica; usually light in color</td>
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<tr>
<td></td>
<td>diorite</td>
<td>large mineral grains of feldspar, hornblende, and mica; less quartz than granite; intermediate in color</td>
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<tr>
<td></td>
<td>gabbro</td>
<td>large mineral grains of feldspar, hornblende, augite, olivine, and mica; no quartz; dark in color</td>
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<tr>
<td>(extrusive)</td>
<td>rhyolite</td>
<td>small or no visible grains of quartz, feldspar, hornblende, and mica; light in color</td>
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<tr>
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<td>andesite</td>
<td>small or no visible grains of quartz, feldspar, hornblende, and mica; less quartz than rhyolite; intermediate in color</td>
</tr>
<tr>
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<td>basalt</td>
<td>small or no visible grains of feldspar, hornblende, augite, olivine, and mica; no quartz; dark in color; vesicles may be present</td>
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<td></td>
<td>obsidian</td>
<td>glassy texture; no visible grains; volcanic glass; fracture is conchoidal; color is usually black, but may be red-brown or black with white flecks</td>
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<tr>
<td></td>
<td>pumice</td>
<td>frothy texture; floats; usually light in color</td>
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<tr>
<td><strong>Sedimentary</strong></td>
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<tr>
<td>(clastic)</td>
<td>conglomerate</td>
<td>coarse-grained; gravel- or pebble-sized grains</td>
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<td></td>
<td>sandstone</td>
<td>sand-sized grains 1/16 to 2 mm in size; varies in color</td>
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<tr>
<td></td>
<td>siltstone</td>
<td>grains smaller than sand but larger than clay</td>
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<tr>
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<td>shale</td>
<td>smallest grains; usually dark in color</td>
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<tr>
<td>(chemical or biochemical)</td>
<td>limestone</td>
<td>major mineral is calcite; usually forms in oceans, lakes, rivers, and caves; often contains fossils; effervesces in dilute HCl</td>
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<tr>
<td></td>
<td>coal</td>
<td>occurs in swampy, low-lying areas; compacted layers of organic material, mainly plant remains</td>
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<tr>
<td><strong>Sedimentary</strong></td>
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<tr>
<td>(chemical)</td>
<td>rock salt</td>
<td>commonly forms as seawater evaporates</td>
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<tr>
<td><strong>Metamorphic</strong></td>
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<tr>
<td></td>
<td>gneiss</td>
<td>well-developed banding because of alternating layers of different minerals, usually of different colors; common parent rock is granite</td>
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<tr>
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<td>schist</td>
<td>well-developed parallel arrangement of flat, sheetlike minerals, mainly micas; common parent rocks are shale and phyllite</td>
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<tr>
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<td>phyllite</td>
<td>shiny or silky appearance; may look wrinkled; common parent rocks are shale and slate</td>
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<tr>
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<td>slate</td>
<td>harder, denser, and shinier than shale; common parent rock is shale</td>
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<tr>
<td>(nonfoliated)</td>
<td>marble</td>
<td>interlocking calcite or dolomite crystals; common parent rock is limestone</td>
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<td>soapstone</td>
<td>composed mainly of the mineral talc; soft with a greasy feel</td>
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<td></td>
<td>quartzite</td>
<td>hard and well-cemented with interlocking quartz crystals; common parent rock is sandstone</td>
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Weather Map Symbols

Sample Plotted Report at Each Station

Symbols Used in Plotting Report

Precipitation | Wind Direction and Speed | Sky Coverage | Fronts and Pressure Systems
---|---|---|---
| | Type of high clouds | Type of middle clouds | Type of precipitation | Temperature (°F) | Barometric pressure in tenths of millibars with initial 9 or 10 omitted (1024.7) | Change in barometric pressure in last 3 hours | Total percentage of sky covered by clouds | Dew point temperature (°F)

Precipitation
- **Fog**
- **Snow**
- **Rain**
- **Thunderstorm**
- **Drizzle**
- **Showers**

Wind Direction and Speed
- 0 calm
- 1–2 knots
- 3–7 knots
- 8–12 knots
- 13–17 knots
- 18–22 knots
- 23–27 knots
- 48–52 knots
1 knot = 1.852 km/h

Dew point temperature (°F)

Type of high clouds
- None

Type of middle clouds
- None

Type of precipitation
- None

Temperature (°F)

Type of low clouds
- None

Clouds

Some Types of High Clouds
- Scattered cirrus
- Dense cirrus in patches
- Veil of cirrus covering entire sky
- Cirrus not covering entire sky

Some Types of Middle Clouds
- Thin altostratus layer
- Thick altostratus layer
- Thin altostratus in patches
- Thin altostratus in bands

Some Types of Low Clouds
- Cumulus of fair weather
- Stratocumulus
- Fractocumulus of bad weather
- Stratus of fair weather

(H) or High Center of high- or low-pressure system
(L) or Low low-pressure system
Cold front
Warm front
Occluded front
Stationary front
# Physical Science Reference Tables

## Standard Units

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<th>Symbol</th>
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<td>length</td>
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<td>mass</td>
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<td>Pa</td>
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<td>pressure</td>
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<td>K</td>
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<td>temperature</td>
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<tr>
<td>mol</td>
<td>mole</td>
<td>amount of a substance</td>
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<tr>
<td>J</td>
<td>joule</td>
<td>energy, work, quantity of heat</td>
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<td>s</td>
<td>second</td>
<td>time</td>
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<td>electric charge</td>
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<td>volt</td>
<td>electric potential</td>
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<td>A</td>
<td>ampere</td>
<td>electric current</td>
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<td>Ω</td>
<td>ohm</td>
<td>resistance</td>
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## Wavelengths of Light in a Vacuum

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<td>Blue</td>
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<td>Yellow</td>
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<td>Orange</td>
<td>650–700</td>
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<td>Red</td>
<td>700–1000</td>
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## Physical Constants and Conversion Factors

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<th>Physical Property</th>
<th>Value</th>
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<td>Acceleration due to gravity g</td>
<td>9.8 m/s² or m/s²</td>
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<tr>
<td>Avogadro’s Number Nₐ</td>
<td>6.02 × 10²³ particles per mole</td>
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<tr>
<td>Electron charge e</td>
<td>1.6 × 10⁻¹⁹ C</td>
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<tr>
<td>Electron rest mass mₑ</td>
<td>9.11 × 10⁻³¹ kg</td>
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<tr>
<td>Gravitation constant G</td>
<td>6.67 × 10⁻¹¹ N m²/kg²</td>
</tr>
<tr>
<td>Mass-energy relationship</td>
<td>1 u (amu) = 9.3 × 10⁹ MeV</td>
</tr>
<tr>
<td>Speed of light in a vacuum c</td>
<td>3.00 × 10⁸ m/s</td>
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<tr>
<td>Speed of sound at STP</td>
<td>331 m/s</td>
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<tr>
<td>Standard Pressure</td>
<td>1 atmosphere</td>
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<tr>
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<td>101.3 kPa</td>
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<tr>
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<td>760 Torr or mmHg</td>
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<td>14.7 lb/in.²</td>
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## Heat Constants

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<tr>
<th>Substance</th>
<th>Specific Heat (average) (kJ/kg × °C)</th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
<th>Heat of Fusion (kJ/kg) (J/g)</th>
<th>Heat of Vaporization (kJ/kg) (J/g)</th>
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<tr>
<td>Alcohol (ethyl)</td>
<td>2.43 (liq.)</td>
<td>-117</td>
<td>79</td>
<td>109</td>
<td>855</td>
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<td>Aluminum</td>
<td>0.90 (sol.)</td>
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<td>2467</td>
<td>396</td>
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<td>-33</td>
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<td>1370</td>
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<td>Copper</td>
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<td>2567</td>
<td>205</td>
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<tr>
<td>Iron</td>
<td>0.45 (sol.)</td>
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<td>2750</td>
<td>267</td>
<td>6290</td>
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<td>Lead</td>
<td>0.13 (sol.)</td>
<td>328</td>
<td>1740</td>
<td>25</td>
<td>866</td>
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<td>Mercury</td>
<td>0.14 (liq.)</td>
<td>-39</td>
<td>357</td>
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<td>Platinum</td>
<td>0.13 (sol.)</td>
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<td>3827</td>
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<td>Silver</td>
<td>0.24 (sol.)</td>
<td>962</td>
<td>2212</td>
<td>105</td>
<td>2370</td>
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<td>Tungsten</td>
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<td>Water (solid)</td>
<td>2.05 (sol.)</td>
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<tr>
<td>Water (liquid)</td>
<td>4.13 (liq.)</td>
<td>100</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Water (vapor)</td>
<td>2.01 (gas)</td>
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<td>-</td>
<td>-</td>
<td>2260</td>
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<tr>
<td>Zinc</td>
<td>0.39 (sol.)</td>
<td>420</td>
<td>907</td>
<td>113</td>
<td>1770</td>
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**Uranium Decay Series**

**Atomic number and chemical symbol**

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- **4He** (α particle) Helium nucleus emission
- **0e** (β particle) electron emission
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<th>Element</th>
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<td>Ytterbium</td>
<td>Yb</td>
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<tr>
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<td>Lu</td>
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<tr>
<td>Curium</td>
<td>Cm</td>
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<td>Berkelium</td>
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<td>Californium</td>
<td>Cf</td>
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<td>Einsteinium</td>
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<td>Fermium</td>
<td>Fm</td>
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<td>Mendelevium</td>
<td>Md</td>
<td>101</td>
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<tr>
<td>Nobelium</td>
<td>No</td>
<td>102</td>
<td>(259)</td>
<td></td>
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<tr>
<td>Lawrencium</td>
<td>Lr</td>
<td>103</td>
<td>(262)</td>
<td></td>
</tr>
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</table>

* The names and symbols for elements 113, 114, 115, 116, and 118 are temporary. Final names will be selected when the elements’ discoveries are verified.
A multilingual science glossary at [connectED@mcgraw-hill.com](http://connectED@mcgraw-hill.com) includes Arabic, Bengali, Chinese, English, Haitian Creole, Hmong, Korean, Portuguese, Russian, Tagalog, Urdu, and Vietnamese.

**Glossary**

**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 (TRIES)
- **i (i+con+i)**.... idea, life (i DEE uh, life)
- **oh** ............... go (GOH)
- **aw** ............... soft (SAWFT)
- **or** ............... orbit (OR but)
- **oy** ............... coin (COYN)
- **oo** ............... foot (FOOT)
- **ew** ............... food (FEWD)
- **yoo** ............... pure (PYOOR)
- **yew** ............... few (FYEW)
- **uh** ............... comma (CAHM ur)
- **u (con)** ........ rub (RUB)
- **sh** ............... shelf (SHEL)
- **ch** ............... nature (NAY chur)
- **g** ............... gift (GHIFT)
- **j** ............... gem (JEM)
- **ing** ............... sing (SING)
- **zh** ............... vision (VIHZ un)
- **k** ............... cake (KAYK)
- **s** ............... seed, cent (SEED, SENT)
- **z** ............... zone, raise (ZOHN, RAYZ)

**English**

- **absolute dating**: process of assigning a numerical age to organisms, objects or events. (p. 870)
- **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. 56)
- **acid**: substance that produces hydrogen ions (H\(^+\)) in a water solution. (p. 678)
- **acid precipitation**: water with a pH below 5.6 that falls to Earth as rain or snow and can harm plants and animals and corrode buildings. (p. 260)
- **acoustics**: the study of sound. (p. 324)
- **air mass**: a large volume of air that has the characteristics of the area over which it forms. (p. 892)
- **air resistance**: force that opposes the motion of objects that move through the air. (p. 87)
- **alcohol**: substituted hydrocarbon, such as ethanol, that is formed when –OH groups replace one or more hydrogen atoms in a hydrocarbon. (p. 713)
- **allotropes**: different molecular structures of the same element. (p. 533)
- **alloy**: a mixture of elements that has metallic properties. (p. 647)

**Español**

- **datación absoluta**: asignar edad a organismos, objetos o eventos (p. 870)
- **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. 56)
- **ácido**: sustancia que produce iones de hidrógeno, (H\(^+\)), en una solución de agua. (p. 678)
- **precipitación ácida**: el agua con un pH inferior a 5,6 que cae a la Tierra como lluvia o nieve y puede dañar a las plantas y los animales, y oxida a los edificios. (p. 260)
- **acústica**: el estudio del sonido. (p. 324)
- **masa de aire**: gran volumen de aire con las características de la zona en que se forma. (p. 892)
- **resistencia del aire**: fuerza que se opone al movimiento de los objetos que se mueven por el aire. (p. 87)
- **alcohol**: hidrocarburos sustituidos, como el etanol, que se forma cuando grupos –OH reemplazan a uno o más átomos de hidrógeno en un hidrocarburo. (p. 713)
- **álótopos**: estructuras moleculares diferentes de un mismo elemento. (p. 533)
- **aleación**: una mezcla de elementos que tiene propiedades metálicas. (p. 647)
### English

- **alpha particle**/partícula alfa: particle consisting of two protons and two neutrons that is emitted from a decaying atomic nucleus. (p. 621)
- **alternating current (AC)**: electric current that reverses its direction of flow in a regular pattern. (p. 220)
- **amine**: a substituted hydrocarbon with an amine group (−NH₂). (p. 715)
- **amplitude**: a measure of the size of the disturbance of a wave, related to the energy that it carries. (p. 283)
- **analog signal**: an electric signal whose values change smoothly over time. (p. 354)
- **aquifer**: rock unit that can store water and transfer it through its pore space. (p. 864)
- **aromatic compound**: an organic compound that contains the benzene ring structure, most have a distinctive smell. (p. 716)
- **asteroid**: rocky object formed from material similar to that of the planets, orbiting the Sun. (p. 967)
- **asthenosphere**: the plastic-like layer of Earth made of partially-molten rock material directly beneath the tectonic plates. (p. 790)
- **astronomical unit**: about 150 million km; equal to the average distance from Earth to the Sun, used to measure distances within the solar system. (p. 968)
- **atom**: the smallest particle of an element that still retains the properties of the element. (p. 489)
- **atomic number**: number of protons in an atom’s nucleus. (p. 495)
- **average atomic mass**: weighted-average mass of an element’s isotopes according to their natural abundance. (p. 497)
- **average speed**: total distance an object travels divided by the total time it takes to travel that distance. (p. 48)
- **balanced chemical equation**: chemical equation with the same number of atoms of each element on both sides of the equation. (p. 586)
- **base**: a substance that produces hydroxide ions (OH⁻) in a water solution. (p. 680)
- **benzene**: (C₆H₆) cyclic hydrocarbon whose carbon atoms are joined with alternating single and double bonds. (p. 711)
- **beta particle**: high-energy electron that is emitted when a neutron decays into a proton. (p. 622)
- **bias**: occurs when a scientist’s expectations change how the results of an experiment are viewed. (p. 11)

### Español

- **partícula alfa**: partícula compuesta por dos protones y dos neutrones y que es emitida por un núcleo atómico en descomposición. (p. 621)
- **corriente alterna (CA)**: corriente eléctrica que invierte su dirección de flujo en un patrón regular. (p. 220)
- **amina**: un hidrocarburo sustituido con un grupo amino (−NH₂). (p. 715)
- **amplitud**: medida del tamaño del desplazamiento por una onda, indica la cantidad de la energía que transporta. (p. 283)
- **señal analógica**: una señal eléctrica cuya valor cambia fluidamente a lo largo del tiempo. (p. 354)
- **roca acuífera**: formación rocosa que puede contener agua y transferirla por medio de sus poros. (p. 864)
- **composto aromático**: compuesto orgánico que contiene la estructura del anillo benzeno, la mayoría tiene una fragancia característica. (p. 716)
- **asteroide**: objeto rocoso formado a partir de material similar a la de los planetas, en órbita solar. (p. 967)
- **astenofera**: capa maleable o suave de la tierra hecha de material rocoso parcialmente fundido y que está directamente debajo de las placas tectónicas. (p. 790)
- **unidad astronómica**: alrededor de 150 millones de kilómetros; igual a la distancia media entre la Tierra y el Sol, se usa para medir distancias en el sistema solar. (p. 968)
- **átomo**: la partícula más pequeña de un elemento que mantiene las propiedades del elemento. (p. 489)
- **número atómico**: número de protones en el núcleo de un átomo. (p. 495)
- **masa atómica promedio**: masa media ponderada de los isótopos de un elemento en función de su abundancia natural. (p. 497)
- **velocidad promedio**: distancia que recorre un objeto dividida por el tiempo que dura en recorrer dicha distancia. (p. 48)
### Glossary

#### big bang theory
Theory that about 13.7 billion years ago, the entire universe was contained in a single point that began expanding outward. (p. 1002)

#### binary compound
Compound that is composed of two elements. (p. 566)

#### biomass
Renewable organic matter from plants and animals, such as wood and animal manure, that can be burned to provide thermal energy. (p. 253)

#### black hole
A region in space that is so dense that nothing can escape its inward pull of gravity. (p. 991)

#### boiling point
The temperature at which the pressure of a vapor of a liquid is equal to the external pressure acting on the surface of the liquid. (p. 435)

#### Boyle's law
States that the volume and pressure of a gas are related, such that if the temperature of a gas remains constant, an increase in volume causes a proportional decrease in the pressure. (p. 448)

#### buffer
Solution that resists changes in pH when limited amounts of acid or base are added. (p. 687)

#### buoyancy
Ability of a fluid, which include liquids and gases, to exert an upward force on an object immersed in it. (p. 441)

#### carbohydrate
Group of biological compounds containing carbon, hydrogen, and oxygen with twice as many hydrogen atoms as oxygen atoms. (p. 725)

#### carrier wave
Specific frequency that a radio station is assigned and uses to broadcast signals. (p. 352)

#### carrying capacity
Maximum number of individuals of a given species that the environment can support. (p. 255)

#### catalyst
Substance that speeds up a chemical reaction without being permanently changed itself. (p. 601)

#### cementation
Process of minerals precipitating out of solution into the spaces between clasts. (p. 825)

#### centripetal acceleration
Acceleration of an object toward the center of a curved or circular path. (p. 59)

#### centripetal force
A force that is directed toward the center of a curved or circular path. (p. 90)

#### 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. 746)

#### chain reaction
Series of fission reactions caused by the release of additional neutrons in every step. (p. 624)

#### charging by contact
The transferring of electrical charge between objects by touching or rubbing. (p. 174)

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### English | Español

| big bang theory | teoría del Big Bang |
---|---
| binary compound | compuesto binario |
| biomass | biomasa |
| black hole | agujero negro |
| boiling point | punto de ebullición |
| Boyle’s law | ley de Boyle |
| buffer | buffer |
| buoyancy | fuerza de flotación |
| carbohydrate | carbohidrato |
| carrier wave | onda transportadora |
| carrying capacity | capacidad de carga |
| catalyst | catalizador |
| cementation | cementación |
| centripetal acceleration | aceleración centrípeta |
| centripetal force | fuerza centrípeta |
| ceramics | cerámicas |
| chain reaction | reacción en cadena |
| charging by contact | cargar por contacto |
charging by induction/cargar por inducción

charging by induction: the rearranging of electrons on a neutral object caused by bringing a charged object close to it. (p. 174)

Charles's law: states that the temperature and volume of a gas are related such that, if the pressure is constant, an increase in temperature will produce a proportionate increase in the volume. (p. 450)

chemical bond: force that holds atoms together in a compound. (p. 556)

chemical change: change of one substance into a new substance. (p. 473)

chemical equation: shorthand method used to describe chemical reactions using chemical formulas and other symbols. (p. 584)

chemical formula: chemical shorthand that uses symbols to tell what elements are in a compound and their ratios. (p. 553)

chemical potential energy: energy that is due to chemical bonds. (p. 117)

chemical property: any characteristic of a substance, such as flammability, that can be observed that produces a new substance. (p. 472)

chemical reaction: process in which one or more substances are changed into new substances. (p. 582)

cinder cone volcano: small steep-sloped volcano with a short eruption cycle, composed of cinder, formed at vents in Earth's crusts, often around the central vent of a larger volcano. (p. 795)

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

clasts: small rock and mineral fragments that can become part of another rock. (p. 824)

cleavage: manner in which a mineral breaks along planes of weakness, creating sets of smooth parallel sides; determined by the arrangement of atoms in the mineral's structure. (p. 811)

cochlea: spiral-shaped, fluid-filled structure in the inner ear that contains tiny hair cells and converts sound waves to nerve impulses. (p. 310)

coefficient: number in a chemical equation that represents the number of units of each substance taking part in a chemical reaction. (p. 584)

coherent light: light of one wavelength that travels in one direction with a constant distance between the corresponding crests of the waves. (p. 382)

collision model: explains why certain factors affect reaction rates, states that particles must collide in order to react. (p. 599)

colloid: heterogeneous mixture whose particles never settle. (p. 466)

cargar por inducción: redistribuir los electrones de un objeto neutro debido al acercarlo a un objeto con carga. (p. 174)

ley de Charles: establece que la temperatura y el volumen de un gas son relacionados de tal manera que si un cambio de la presión, un aumento de temperatura producirá un aumento proporcional en el volumen. (p. 450)

enlace químico: fuerza que mantiene a los átomos juntos en un compuesto. (p. 556)

cambio químico: transformación de una sustancia en una nueva sustancia. (p. 473)

ecuación química: método simplificado utilizado para describir reacciones químicas por medio de fórmulas químicas y otros símbolos. (p. 584)

fórmula química: nomenclatura química que usa símbolos para expresar cuales elementos están en un compuesto y en cuales proporciones. (p. 553)

energía química potencial: energía debido a los enlaces químicos. (p. 117)

propiedad química: cualquier característica de una sustancia, como por ejemplo la combustibilidad, que puede ser observada y produce un nuevo sustancia. (p. 472)

reacción química: proceso en el cual una o más sustancias son cambiadas por nuevas sustancias. (p. 582)

volcán de cono de ceniza: volcán pequeño e inclinado con un ciclo de erupciones corto, compuesto de fragmentos volcánicos acumulados en una chimenea volcánica en la superficie de la tierra, se pueden encontrar alrededor de volcanes más grande. (p. 795)

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

clástica: roca o fragmentos minerales que pueden hacerse parte de otra roca. (p. 824)

exfoliación: manera en la que un mineral se quiebra a lo largo de sus planos creando lados paralelos lisos, se produce por la forma los átomos se disponen en la estructura del mineral. (p. 811)

cóclea: estructura en forma de espiral, llena de líquido en el oído interno que contiene células diminutas del pelo y convierte las ondas sonoras en impulsos nerviosos. (p. 310)

coiciente: número en una ecuación química que representa el número de unidades de cada una de las sustancias que participan en una reacción química. (p. 584)

luz coherente: luz de una sola longitud de onda que viaja en una sola dirección con una distancia constante entre las crestas de las olas. (p. 382)

modelo de colisión: explica por qué ciertos factores afectan las velocidades de reacción, afirma que las partículas deben chocar para que reaccionen. (p. 599)

coloide: mezcla heterogénea cuyas partículas nunca se sedimentan. (p. 466)
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. 590)

comet: object in elliptical orbit around the Sun composed of dust and particles, frozen water, methane and ammonia; vaporized due to heat from Sun, producing a coma and tail. (p. 967)

compaction: process by which clasts stick together due to the weight of overlying material. (p. 825)

composite: mixture of two materials, one of which is embedded or layered in the other. (p. 757)

composite volcano: large and steep-sided volcano composed of layers of lava and ash. (p. 796)

compound: substance in which the atoms of two or more elements are combined in a fixed proportion. (p. 464)

compound machine: machine that is a combination of two or more simple machines. (p. 109)

compression: denser region of a longitudinal wave. (p. 279)

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; often used in combination with other lenses. (p. 410)

concave mirror: a reflective surface that curves inward and can magnify objects or create real images. (p. 402)

concentration: the amount of solute actually dissolved in a given amount of solvent. (p. 653)

conduction: transfer of thermal energy by collisions between the particles that make up matter. (p. 144)

conductivity: property of metals and alloys that allows heat or electrical charges to pass through the material easily. (p. 741)

conductor: material, such as copper wire, through which electrons can move easily. (p. 173)

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

constellation: star pattern that appears to form images, is used by astronomers to locate and name stars, and often is named for a mythological figure. (p. 984)

continental climate: climate not affected by an ocean, characterized by extremes in temperatures. (p. 898)

control: standard used for comparison of test results in an experiment. (p. 10)

convection: transfer of thermal energy in a fluid by the movement of warmer and cooler fluid from one place to another. (p. 145)

reacción de combustión: un tipo de reacción química que ocurre cuando una sustancia reacciona con oxígeno y produce energía en forma de calor y luz. (p. 590)

cometa: objeto en órbita elíptica alrededor del Sol, compuesta de polvo y partículas, agua congelada, metano y amoníaco, vaporizado por el calor del sol, produce una coma y una cola. (p. 967)

compactación: proceso por el que las clásticas se unen, debido al peso de materiales sobreimpuestos. (p. 825)

material compuesto: mezcla de dos materiales, uno de los cuales está integrado por capas o fundido en el otro. (p. 757)

volcán compuesto: Volcanes grandes e inclinados formados por capas de lava y ceniza. (p. 796)

compuesto químico: sustancia en la que los átomos de dos o más elementos se combinan en una proporción fija. (p. 464)

máquina compuesta: máquina compuesta por dos o más máquinas simples. (p. 109)

compresión: la región densa de una onda longitudinal. (p. 279)

lente cóncavo: lente que es más grueso en los bordes que en el centro; hace que los rayos de luz se desvien y forma imágenes reducidas, verticales y virtuales, frecuentemente se utiliza en combinación con otros lentes. (p. 410)

espejo cóncavo: superficie reflexiva que se curva hacia el interior puede aumentar imágenes o crear imágenes reales. (p. 402)

concentración: la cantidad de soluto que se disuelve en una cantidad dada de disolvente. (p. 653)

conducción: transferencia de energía térmica por colisiones entre las partículas que componen una materia. (p. 144)

conductividad: propiedad de los metales y aleaciones que permite fácilmente el paso de calor o cargas eléctricas a través del material. (p. 741)

conductor: material, como el alambre de cobre, a través del cual los electrones se pueden pasar con facilidad. (p. 173)

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

constelación: patrón de estrellas que aparece formar imágenes, utilizada por los astrónomos a localizar y nombrar estrellas, a menudo tienen nombre de una figura mitológica. (p. 984)

clima continental: clima no afectado por un océano, se caracteriza por temperaturas extremas. (p. 898)

control: estándar usado para la comparación de resultados de pruebas en un experimento. (p. 10)

convección: transferencia de energía térmica en un fluido por el movimiento de fluidos con mayores y menores temperaturas de un lugar a otro. (p. 145)
### English

- **convergent plate boundary**: boundary where two plated collisions. (p. 777)
- **convex lens**: a lens that is thicker in the middle than at the edges and can form real or virtual images. (p. 408)
- **Coriolis effect**: the effect of rotation on the motion of any object or fluid; on Earth, air traveling north or south from the equator appears to deflect right or left respectively; the combination of the Coriolis effect and Earth’s heat imbalance creates the trade winds, polar easterlies, and prevailing westerlies. (p. 891)
- **decomposition reaction**: chemical reaction in which one substance breaks down into two or more substances. (p. 591)
- **density**: mass per unit volume of a material. (p. 18)
- **deoxyribonucleic acid**: also called DNA, a type of essential biological compound found in the nuclei of cells that codes and stores genetic information. (p. 728)
- **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 monomer fragments. (p. 723)
- **deposition**: dropping of sediment previously in transport as the erosional agent slows down, or in the case of ice, melts. (p. 854)

### Glossary

<table>
<thead>
<tr>
<th>English</th>
<th>Español</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>dark energy</strong>: energy that might be causing the accelerating expansion of the universe. (p. 1005)</td>
<td><strong>energía oscura</strong>: energía que posiblemente es la causa de la expansión acelerada del universo. (p. 1005)</td>
</tr>
<tr>
<td><strong>dark matter</strong>: type of matter that cannot be seen and can only be detected by its gravitational effects. (p. 1004)</td>
<td><strong>materia oscura</strong>: tipo de materia que no puede ser visto y sólo se puede detectar por sus efectos gravitatorios. (p. 1004)</td>
</tr>
<tr>
<td><strong>decibel</strong>: unit for sound intensity; abbreviated dB. (p. 313)</td>
<td><strong>decibel</strong>: unidad que mide la intensidad del sonido; se abrevia dB. (p. 313)</td>
</tr>
<tr>
<td><strong>decomposition reaction</strong>: chemical reaction in which one substance breaks down into two or more substances. (p. 591)</td>
<td><strong>reacción de descomposición</strong>: reacción química en la cual una sustancia se descompone en dos o más sustancias. (p. 591)</td>
</tr>
<tr>
<td><strong>density</strong>: mass per unit volume of a material. (p. 18)</td>
<td><strong>densidad</strong>: masa por unidad de volumen de un material. (p. 18)</td>
</tr>
<tr>
<td><strong>deoxyribonucleic acid</strong>: also called DNA, a type of essential biological compound found in the nuclei of cells that codes and stores genetic information. (p. 728)</td>
<td><strong>ácido desoxirribonucleico</strong>: también conocido como ADN, compuesto biológico esencial encontrado en el núcleo de las células, codifica y almacena información genética. (p. 728)</td>
</tr>
<tr>
<td><strong>dependent variable</strong>: factor that changes as a result of changes in the other variables. (p. 9)</td>
<td><strong>variable dependiente</strong>: factor que varía como resultado de los cambios en las otras variables. (p. 9)</td>
</tr>
<tr>
<td><strong>depolymerization</strong>: process using heat or chemicals to break a polymer chain into its monomer fragments. (p. 723)</td>
<td><strong>despolimerización</strong>: proceso en el que se utilizan calor o químicos para descomponer una cadena de polímeros en sus fragmentos de monómeros. (p. 723)</td>
</tr>
<tr>
<td><strong>deposition</strong>: dropping of sediment previously in transport as the erosional agent slows down, or in the case of ice, melts. (p. 854)</td>
<td><strong>deposición</strong>: el depósito de sedimentos, previamente transportados por la erosión cuando esta se retrase, o en caso de que el hielo se derrita. (p. 854)</td>
</tr>
</tbody>
</table>

1072 1096 894582.indd   1077
diatomic molecule/molécula diatómica

- **diatomic molecule**: a molecule that consists of two atoms of the same element, joined by a covalent bond. (p. 527)
- **diffraction**: the bending of waves around an obstacle; can also occur when waves pass through a narrow opening. (p. 290)
- **diffusion**: spreading of particles throughout a given volume until they are uniformly distributed. (p. 479)
- **digital signal**: an electric signal with only two possible values: ON and OFF. (p. 354)
- **direct current (DC)**: electric current that flows in only one direction. (p. 220)
- **discontinuity**: boundary between two layers of material that have different densities. (p. 788)
- **displacement**: distance and direction of an object's change in position from the starting point. (p. 45)
- **dissociation**: process in which an ionic compound separates into its positive and negative ions in solution. (p. 659)
- **distance**: the length an object travels, measured in SI units of meters. (p. 45)
- **distillation**: process that can separate two substances in a mixture by evaporating a liquid and recondensing its vapor. (p. 472)
- **divergent plate boundary**: the boundary between two plates that are moving apart. (p. 778)
- **doping**: process of adding impurities to a semiconductor to modify its conductivity. (p. 749)
- **Doppler effect**: change in frequency that occurs when a source is moving relative to an observer. (p. 315)
- **double-displacement reaction**: reaction in which two ionic compounds in solution are combined, can produce a precipitate, water, or a gas. (p. 592)
- **drainage basin**: land area that gathers water for a major river or several major river systems. (p. 855)
- **ductile**: property of metals and alloys that allows them to be drawn into wires. (pp. 570, 741)
- **dwarf planet**: nearly-spherical object in orbit around the Sun that is not a satellite, and has not cleared the debris in its orbit. (p. 967)

**Earth/Tierra**

- **molecula diatómica**: molécula que consta de dos átomos del mismo elemento, unidas por un enlace covalente. (p. 527)
- **difracción**: un cambio de dirección de las ondas al rozar el borde de un obstáculo, la cual también puede ocurrir cuando éstas pasan a través de una abertura angosta. (p. 290)
- **difusión**: propagación de partículas en la totalidad de un volumen determinado hasta que se distribuyen de manera uniforme. (p. 479)
- **señal digital**: una señal eléctrica, con sólo dos valores posibles: ON y OFF. (p. 354)
- **corriente directa (CC)**: corriente eléctrica que fluye en una sola dirección. (p. 220)
- **discontinuidad**: límite entre dos capas de material que tienen diferentes densidades. (p. 788)
- **desplazamiento**: distancia y dirección del cambio de posición de un objeto desde el punto inicial. (p. 45)
- **dissociación**: proceso en el cual un compuesto iónico se separa en sus iones positivos y negativos en una solución. (p. 659)
- **distancia**: la longitud de un objeto de viajes, medido en unidades SI de metros. (p. 45)
- **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. 472)
- **límite de placas divergentes**: frontera entre dos placas tectónicas que se están separando. (p. 778)
- **dopaje**: proceso que consiste en añadir impurezas a un semiconductor para modificar su conductividad. (p. 749)
- **efecto Doppler**: cambio en la frecuencia que se produce cuando una fuente se mueve respecto a un observador. (p. 315)
- **reacción de doble desplazamiento**: reacción química en la cual se combinan dos compuestos iónicos en una solución, puede producir un precipitado, agua o gas. (p. 592)
- **cuenca de drenaje**: área que recolecta el agua para un río importante o para varios sistemas de ríos importantes. (p. 855)
- **ductibilidad**: propiedad de los metales y aleaciones que les permiten ser convertidos en alambres. (pp. 570, 741)
- **planeta enano**: objeto casi-esférico en órbita alrededor del Sol que no es un satélite, y no ha limpiado la vecindad de su órbita. (p. 967)

**English**

- **eardrum**: tough membrane in the outer ear that is about 0.1 mm thick and transmits sound vibrations into the middle ear. (p. 309)
- **Earth**: third planet from the Sun; the only planet in the solar system known to have life, and where water exists as a solid, a liquid, and a gas. (p. 957)

**Español**

- **timpano**: membrana fuerte del oído externo que tiene aproximadamente 0.1 mm de grueso y transmite las vibraciones del sonido al oído medio. (p. 309)
- **Tierra**: tercer planeta desde el Sol, el único planeta del sistema solar donde se ha encontrado vida, y donde el agua existe como sólido, líquido y gas. (p. 957)
earthquake: sudden movement or vibration of the ground that occurs when rocks slip and slide along enormous cracks in Earth's crust. (p. 780)
ecliptic: path of Earth's orbit around the Sun; from Earth, seen as the path that the Sun travels across the zodiac. (p. 924)
echolocation: process by which objects are located by emitting sounds and interpreting the sound waves that are reflected from those objects. (p. 324)
efficiency: ratio of the output work done by the machine to the input work done on the machine, expressed as a percentage. (p. 110)
El Niño: periodic warming of the Pacific Ocean off the coast of western South America that changes global weather patterns. (p. 905)
elastic potential energy: energy that is stored by compressing or stretching an object. (p. 117)
elastic rebound: the sudden release of strain energy from rock as it moves along a fault. (p. 782)
electrical power: rate at which electrical energy is converted to another form of energy; expressed in watts (W). (p. 188)
electric circuit: a closed path that electric current follows. (p. 179)
electric current: the net movement of electric charges in a single direction, measured in amperes (A). (p. 178)
electric field: a region surrounding every electric charge in which a force of attraction or repulsion is exerted on other electric charges. (p. 172)
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. 213)
electrolyte: compound that breaks apart in water, producing charged particles (ions) that can conduct electricity. (p. 658)
electromagnet: temporary magnet created when there is a current in a wire coil. (p. 210)
electromagnetic force: the attractive or repulsive force between electric charges and magnets. (p. 210)
electromagnetic induction: process by which electric current is produced in a wire loop by a changing magnetic field. (p. 216)
electromagnetic wave: waves created by vibrating electric charges; consists of vibrating electric and magnetic fields, and can travel through a vacuum or through matter. (p. 338)
electromagnetism: the interaction between electric charges and magnets. (p. 210)
electron: particle with an electric charge of 1−, surrounds the nucleus of an atom. (p. 489)

terremoto: movimiento brusco o vibración de la tierra que ocurre cuando roca se desliza a lo largo de una grieta enorme en la corteza de la tierra. (p. 780)
eclíptica: sendero de la órbita de la Tierra alrededor del Sol; desde la Tierra, vista como el camino que el Sol recorre por todo el zodíaco. (p. 924)
ecolocalización: proceso por el cual los objetos son localizados por emitir sonidos e interpretando las ondas de sonido que se reflejan. (p. 324)
eficiencia: relación del trabajo efectuado por una máquina y el trabajo hecho en ésta, expresada en porcentaje. (p. 110)
El Niño: calentamiento periódico del Océano Pacífico frente a la costa occidental de América del Sur, causa cambios globales en los patrones climáticos. (p. 905)
energía elástica potencial: energía almacenada por compresionar o estrechar un objeto. (p. 117)
reconversión elástica: la liberación repentina de energía de las rocas a lo largo de una falla. (p. 782)
potencia eléctrica: velocidad a la cual la energía eléctrica se convierte en otra forma de energía; se expresa en vatios (W). (p. 188)
circuito eléctrico: un camino cerrado que sigue la corriente eléctrica. (p. 179)
corriente eléctrica: movimiento neto de cargas eléctricas en una sola dirección, medido en amperios (A). (p. 178)
campo eléctrico: una región en torno a toda carga eléctrica en la que una fuerza de atracción o repulsión se ejerce hacia otras cargas eléctricas. (p. 172)
motor eléctrico: dispositivo que convierte la energía eléctrica en energía mecánica por las fuerzas magnéticas entre un electromané y un imán permanente, y hace que un eje gire. (p. 213)
electrolito: compuesto que se descompone en agua y así produce partículas cargadas (iones) que pueden conducir electricidad. (p. 658)
electromán: imán temporal crea cuando hay una corriente en una bobina de alambre. (p. 210)
fuerza electromagnética: fuerza de atracción o repulsión entre cargas eléctricas y imanes. (p. 210)
inducción electromagnética: proceso mediante el cual se produce la corriente eléctrica en un arco de alambre por un campo magnético variable. (p. 216)
ondas electromagnéticas: olas creadas por la vibración de cargas eléctricas; consta de vibrar los campos eléctricos y magnéticos, y puede viajar a través del vacío o de la materia. (p. 338)
electromagnetismo: la interacción entre las cargas eléctricas y los imanes. (p. 210)
electrón: partícula que rodea con carga eléctrica de 1−, rodea el núcleo de un átomo. (p. 489)
electron cloud: area around the nucleus of an atom where the atom's electrons are most likely to be found. (p. 493)

electron dot diagram: uses the symbol for an element and dots representing the number of electrons in the element's outer energy level. (p. 504)

electroscope: a device, sometimes consisting of two leaves of metallic foil, used to detect electric charge. (p. 176)

element: substance with atoms that are all alike. (p. 462)

eclipse: elongated, closed curve with two foci; shape of Earth’s orbit around the Sun. (p. 920)

endothermic reaction: chemical reaction that requires energy input in the form of light, thermal energy or electricity in order to proceed. (p. 596)

energy: the ability to cause change, measured in joules. (p. 114)

epicenter: the point on Earth’s surface directly above the focus of an earthquake. (p. 782)

equilibrium: state in which forward and reverse reactions or processes occur at equal rates. (p. 602)

equinox: occurs twice a year in March and September, when Earth’s rotational axis is perpendicular to a line connecting the center of Earth to the center of the Sun. (p. 927)

erosion: removal of surface material through the process of weathering. (p. 854)

ester: a substituted hydrocarbon with a –COOC– group. (p. 714)

exergonic reaction: chemical reaction that releases some form of energy, such as light or thermal energy. (p. 595)

exothermic reaction: chemical reaction in which energy is primarily given off in the form of thermal energy. (p. 595)

experiment: organized procedure for testing a hypothesis; tests the effect of one thing on another under controlled conditions. (p. 9)

extrasolar planets: planets in orbit around another star. (p. 954)

extraterrestrial life: life beyond Earth, object of the search by exobiologists. (p. 970)

extrusive igneous rock: rock that formed from lava or ash that solidified on Earth's surface. (p. 820)

field: a region of space in which every point has a physical quantity, such as a force. (p. 77)

fault: crack in Earth's crust along which rock has moved. (p. 782)

falla: grieta en la corteza de la Tierra a lo largo de cual la roca se ha movido. (p. 782)

glossary:

Glossary

field/campo

electron cloud/nube de electrones

falta: grieta en la corteza de la Tierra a lo largo de cual la roca se ha movido. (p. 782)

energía: la habilidad para efectuar un cambio, medida en julio (p. 114)

equivalencia: estado en que reacciones o procesos avancen y retrocedan a tasas iguales. (p. 602)

energía de energía térmica para proceder. (p. 596)

energía: la habilidad para efectuar un cambio, medida en julio (p. 114)

equivalencia: estado en que reacciones o procesos avancen y retrocedan a tasas iguales. (p. 602)

energía de energía térmica para proceder. (p. 596)

equivalencia: estado en que reacciones o procesos avancen y retrocedan a tasas iguales. (p. 602)

extraocular: vida más allá de la Tierra, objeto de la búsqueda por exobiólogos. (p. 970)

roca ignea estrusiva: roca que se ha formado de la lava o de ceniza solidificada en la superficie de la tierra. (p. 820)

roca ignea estrusiva: roca que se ha formado de la lava o de ceniza solidificada en la superficie de la tierra. (p. 820)
gamma ray/rayo gama
filuto: un material transparente que transmite la luz de forma selectiva. (p. 375)
primera ley de la termodinámica: establece que si la energía mecánica del sistema es constante, el aumento de la energía térmica del sistema es igual a la suma de la energía térmica transferida al sistema y el trabajo realizado en el sistema. (p. 155)
fisión: proceso de división en el cual un núcleo atómico de divide entre dos o más núcleos con masas más pequeñas, produciendo grandes cantidades de energía. (p. 241)
luz fluorescente: luz generada mediante el uso de fósforo para convertir la radiación ultravioleta a la luz visible. (p. 378)
longitud focal: distancia desde el centro de un espejo o espejo al punto focal. (p. 402)
focal point: el punto en el eje óptico de un espejo o lente curvo en el cual los rayos de luz, que inicialmente son paralelos al eje óptico, convergen después de chocar al espejo o lente. (p. 402)
focal length: distancia desde el centro de un espejo o espejo al punto focal. (p. 378)
focal point: el punto en el eje óptico de un espejo o lente curvo en el cual los rayos de luz, que inicialmente son paralelos al eje óptico, convergen después de chocar al espejo o lente. (p. 402)
foco: punto de origen de un terremoto, punto desde donde se originan las ondas sísmicas. (p. 782)
rocas foliadas: textura en ciertas rocas metamórficas en la que los cristales están alineadas en hojas y bandas como resultado de condiciones de gran presión. (p. 831)
fuerza: impulso o tracción sobre un objeto. (p. 72)
fósil: restos o rastros de organismos encontrados en las rocas. (p. 871)
combustibles fósiles: petróleo, gas natural y carbón; formado a partir de los restos de antiguas plantas y animales que fueron enterrados y alterados durante millones de años. (p. 235)
fractura: forma en que un mineral sin exfoliación se romperá, produciendo superficies desiguales y irregulares. (p. 811)
frecuencia: el número de longitudes de onda que pasan por un punto fijo en un segundo; se expresa en hercios (Hz). (p. 280)
caída libre: describe la caída de un objeto sobre cual la única fuerza que le actúa es la de la gravedad. (p. 89)
fricción: fuerza que se opone al movimiento deslizante entre dos superficies en contacto. (p. 74)
fusión: proceso en la cual dos o más núcleos atómicos forman un núcleo con mayor masa, produciendo grandes cantidades de energía. (p. 241)
Geiger counter/contador Geiger

**Geiger counter**: radiation detector that produces a click or a flash of light when a charged particle is detected. (p. 629)

**generator**: device that uses electromagnetic induction to convert mechanical energy to electrical energy. (p. 217)

**geocentric model**: Earth-centric model of the solar system. (p. 950)

**geothermal energy**: thermal energy contained in and around magma; can be converted by a power plant into electrical energy. (p. 252)

**giant star**: late stage in a star’s life cycle that occurs when its hydrogen fuel is depleted, its core contracts, and its outer layers expand and cool. (p. 991)

**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. 357)

**global warming**: increase in average temperatures of Earth’s near-surface air and oceans. (p. 904)

**graph**: visual display of information or data. (p. 21)

**gravitational potential energy (GPE)**: energy that is due to the gravitational force between objects. (p. 118)

**gravity**: attractive force between two objects that depends on the masses of the objects and the distance between them. (p. 76)

**greenhouse effect**: natural process in which certain gases in the atmosphere absorb and emit infrared radiation, warming the planet. (p. 886)

**group**: vertical column in the periodic table. (p. 502)

**half-life**: amount of time it takes for half the nuclei in a sample of a radioactive isotope to decay. (p. 632)

**hardness**: measure of a mineral’s resistance to scratching, described by Mohs scale of hardness. (p. 811)

**hazardous waste**: wastes that are poisonous, cause cancer, or can catch fire. (p. 257)

**heat**: energy that is transferred between objects due to a temperature difference between those objects. (p. 140)

**heat engine**: device that converts some thermal energy into mechanical energy. (p. 156)

**heat of fusion**: amount of energy required to change a substance from the solid phase to the liquid phase. (p. 435)

**heat of vaporization**: the amount of energy required for a liquid at its boiling point to become a gas. (p. 435)

**contador Geiger**: detector de radiación que produce un sonido seco o un destello de luz al detectar una partícula cargada. (p. 629)

**generator**: dispositivo que usa inducción electromagnética para convertir energía mecánica en energía eléctrica. (p. 217)

**modelo geocéntrico**: modelo del sistema solar con la Tierra en el centro. (p. 950)

**energía geotérmica**: energía térmica en y alrededor del magma, la cual se puede convertir mediante una planta industrial en energía eléctrica. (p. 252)

**estrella gigante**: fase avanzada del ciclo de vida de una estrella que ocurre cuando se agote su hidrógeno, su núcleo se contrae, y sus capas externas se expanden y enfrían. (p. 991)

**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. 357)

**calentamiento global**: aumento de las temperaturas promedias del aire cerca de la superficie de la Tierra y los océanos. (p. 904)

**gráfica**: presentación visual de información que puede suministrar una forma rápida de comunicar gran cantidad de información. (p. 21)

**energía gravitacional potencial**: energía debida a la fuerza gravitatoria entre objetos (p. 118)

**gravedad**: fuerza de atracción entre dos objetos que depende de las masas de los objetos y de la distancia entre ellos. (p. 76)

**efecto invernadero**: proceso natural en donde ciertos gases en la atmósfera absorben y emiten radiaiones infrarrojas, calentando el planeta. (p. 886)

**grupo**: columna vertical en la tabla periódica. (p. 502)

**vida media**: tiempo requerido para que se descomponga la mitad de los núcleos de una muestra de isótopo radioactivo. (p. 632)

**dureza**: medida de la resistencia de un mineral a ser rasgado; descrita por la escala de dureza de Mohs. (p. 811)

**residuo peligroso**: residuo tóxico, provoca cáncer, o puede incendiarse. (p. 257)

**calor**: la energía que se transfiere entre los objetos debido a una diferencia de temperatura entre esos objetos. (p. 140)

**motor de calor**: dispositivo que convierte térmica en energía mecánica. (p. 156)

**calor de fusión**: cantidad de energía necesaria para cambiar una sustancia del estado sólido al líquido. (p. 435)

**calor de vaporización**: cantidad de energía necesaria para que un líquido en su punto de ebullición se convierta en gas. (p. 435)
<table>
<thead>
<tr>
<th><strong>English</strong></th>
<th><strong>Español</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>incandescent light:</strong> light produced by heating a piece of metal, usually tungsten, until it glows. (p. 378)</td>
<td><strong>luz incandescente:</strong> luz que se produce al calentar una pieza de metal, generalmente tungsteno, hasta que brille. (p. 378)</td>
</tr>
<tr>
<td><strong>incoherent light:</strong> light that can contain more than one wavelength, travel in more than one direction, and has varying distances between the corresponding crests of the waves. (p. 382)</td>
<td><strong>luz incoherente:</strong> luz que puede contener más de una longitud de onda, viaja en más de una dirección, y tiene distancias variables entre las crestas correspondientes de las olas. (p. 382)</td>
</tr>
<tr>
<td><strong>independent variable:</strong> factor that, as it changes, affects the measure of another variable. (p. 9)</td>
<td><strong>variable independiente:</strong> factor que, a medida que cambia, afecta la medida de otra variable. (p. 9)</td>
</tr>
<tr>
<td><strong>index of refraction:</strong> property of a material indicating how much the speed of light is reduced in the material compared to the speed of light in a vacuum. (p. 370)</td>
<td><strong>indice de refracción:</strong> propiedad de un material que indica cuanto la velocidad de la luz se reduce en el material en comparación con la velocidad de la luz en el vacío. (p. 370)</td>
</tr>
<tr>
<td><strong>indicator:</strong> organic compound that changes color in acids and bases. (p. 678)</td>
<td><strong>indicador:</strong> compuesto orgánico que cambia de color en presencia de ácidos y bases. (p. 678)</td>
</tr>
<tr>
<td><strong>inertia:</strong> tendency of an object to resist any change in its motion. (p. 80)</td>
<td><strong>inercia:</strong> tendencia de un objeto a resistir cualquier cambio en su movimiento. (p. 80)</td>
</tr>
<tr>
<td><strong>infiltration:</strong> process by which water enters Earth and becomes groundwater, controlled by topography, surface materials, and type and amount of vegetation. (p. 863)</td>
<td><strong>infiltración:</strong> proceso por el cual el agua entra en la tierra y se convierte en agua subterránea, controlado por la topografía, materiales superficiales, y tipo y cantidad de vegetación. (p. 863)</td>
</tr>
<tr>
<td><strong>infrared wave:</strong> electromagnetic wave with a wavelength between about 1 mm and 700 billionths of a meter. (p. 348)</td>
<td><strong>onda infrarroja:</strong> onda electromagnética que tiene una longitud de onda entre aproximadamente 1 mm y 700 bil-lonésimas de metro. (p. 348)</td>
</tr>
<tr>
<td><strong>inhibitor:</strong> substance that slows down a chemical reaction or prevents it from occurring by combining with a reactant. (p. 601)</td>
<td><strong>inhibidor:</strong> sustancia que reduce una reacción química o previene que ocurra por combinar con un reactivo. (p. 601)</td>
</tr>
</tbody>
</table>
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. 49)

insulator: material in which electrons and thermal energy are not able to move easily. (p. 173)

integrated circuit: tiny chip that can contain millions of transistors, diodes, and other components. (p. 750)

intensity: amount of energy that flows through a certain area in a specific amount of time. (p. 312)

interference: the process of two or more waves overlapping and combining to form a new wave. (p. 292)

internal combustion engine: heat engine that burns fuel inside the engine in chambers or cylinders. (p. 157)

intrusive igneous rock: rock that formed from magma that solidified within Earth’s crust, also called plutonic rock. (p. 817)

ion: charged particle that has either more or fewer electrons than protons. (pp. 558, 676)

ionic bond: the force of attraction between the opposite charges of the ions in an ionic compound. (p. 560)

ionization: process in which electrolytes dissolve in water and separate into charged particles. (p. 658)

isomer: compounds with identical chemical formulas but different molecular structures and shapes. (p. 709)

isotope: atom of an element that has a specific number of neutrons. (p. 496)

jet stream: narrow band of powerful, fast-moving, high-altitude air embedded in the global wind belts. (p. 891)

joule: SI unit of work and energy. (p. 107)

Jupiter: fifth planet from the Sun; the largest planet with continuous, swirling, high-pressure gas storms. (p. 963)

kinetic energy: energy a moving object has because of its motion; determined by the mass and speed of the object. (p. 116)

kinetic theory: explanation of the behavior of particles in gases; states that matter is made of constantly moving particles that collide without losing energy. (p. 432)

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. 49)

aislador: material a través del cual los electrones y la energía térmica no se pueden transferir con facilidad. (p. 173)

circuito integrado: pedazo minúsculo que puede contener millones de transistores, diodos y otros componentes. (p. 750)

intensidad: cantidad de energía que fluye a través de cierta área en un tiempo específico. (p. 312)

interferencia: el proceso de dos o más ondas se superponen y se combinan para formar una nueva ona. (p. 292)

motor de combustión interna: motor de calor que quema combustible en su interior en cámaras o cilindros. (p. 157)

roca ígnea intrusiva: roca ígnea que se ha formado en el magma solidificándose dentro de la corteza terrestre; también llamada roca plutónica. (p. 817)

ion: partícula cargada que tiene ya sea más o menos electrones que protones. (pp. 558, 676)

enlace íónico: fuerza de atracción entre las cargas opuestas de los iones en un compuesto iónico. (p. 560)

ionización: proceso en el cual los electrolitos se disuelven en agua y se separan en partículas cargadas. (p. 658)

isómeros: compuestos con fórmulas químicas idénticas pero con estructuras moleculares diferentes. (p. 709)

isótopo: átomo de un elemento que tiene un cierto número de neutrones. (p. 496)

energía cinética: energía que tiene un cuerpo debido a su movimiento, se determina por la masa y velocidad del objeto. (p. 116)

teoría cinética: explicación del comportamiento de las partículas en un gas, la cual establece que las sustancias son compuestas de partículas en constante movimiento que se chocan sin perder energía. (p. 432)
English | Español
---|---
La Niña: periodic cooling of equatorial ocean surface temperature that modify global weather patterns. (p. 905) | La Niña: enfriamiento periódico de temperatura superficial del océano ecuatorial; modifica a los patrones climáticos globales. (p. 905)

law of conservation of charge: states that charge can be transferred from one object to another but it cannot be created or destroyed. (p. 171) | ley de la conservación de carga: Estados de que se puede ser transferida de un objeto a otro, pero no puede ser creada o destruida. (p. 171)

law of conservation of energy: states that energy cannot be created or destroyed. (p. 120) | ley de la conservación de energía: establece que la energía no puede crearse ni destruirse. (p. 120)

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. 475) | ley de conservación de la masa: establece que la masa de todas las sustancias presentes antes de un cambio químico es igual a la masa de todas las sustancias resultantes después del cambio. (p. 475)

law of conservation of momentum: states that if no external forces act on a group of objects, their total momentum does not change. (p. 91) | ley de conservación del momento: establece que si no actúan fuerzas externas sobre un grupo de objetos, su cantidad de movimiento total no cambia. (p. 91)

Le Chatelier’s principle: states that if a stress is applied to a reaction at equilibrium, the reaction shifts in the direction opposite of the stress. (p. 603) | principio de Le Chatelier: establece que si una tensión se aplica a una reacción en el equilibrio, la reacción se acelera en la dirección opuesta de la tensión. (p. 603)

lever: simple machine consisting of a bar free to pivot about a fixed point called the fulcrum. (p. 109) | palanca: máquina simple que consiste de una barra que puede girar sobre un punto fijo llamado pivote. (p. 109)

light-year: distance light travels in one year—about 9.5 trillion km. (p. 988) | año luz: distancia que recorre la luz en el periodo de un año; alrededor de 9,5 mil de billón km. (p. 988)

linearly polarized light: light whose magnetic field vibrates in only one direction. (p. 384) | luz polarizada lineal: luz cuya campo magnético vibra en una sola dirección. (p. 384)

lipid: group of biological compounds that contains the same elements as carbohydrates but in different proportions, includes saturated and unsaturated fats and oils. (p. 726) | lípido: grupo de compuestos biológicos que contiene los mismos elementos que los hidratos de carbono, pero en diferentes proporciones, incluye grasas saturadas e insaturadas y aceites. (p. 726)

lithosphere: the layer of Earth made of rocky material broken up into tectonic plates, consists of Earth’s crust and uppermost mantle. (p. 790) | litosfera: La capa de la tierra hecha de material rocoso dividida en placas tectónicas, consta de la Corteza terrestre y el manto superior. (p. 790)

Local Group: group of about 50 galaxies including the Milky Way. (p. 998) | Grupo Local: grupo de alrededor de 50 galaxias inclusivo a la Vía Láctea. (p. 998)

longitudinal wave: a wave in which the matter in the medium moves back and forth along the direction that the wave travels. (p. 277) | onda longitudinal: onda por la cual la materia en el medio se mueve para adelante y para atrás en la dirección en que viaja la onda. (p. 277)

longshore current: movement of water, and often, sediment, parallel to the shoreline. (p. 861) | corriente costera: movimiento de agua y a menudo sedimento, paralelo a la línea de playa. (p. 861)

loudness: human perception of sound volume, depends primarily on intensity. (p. 312) | volumen de sonido: percepción humana de la fuerza del sonido, depende primariamente en la intensidad. (p. 312)

lunar eclipse: occurs during full moon, when the Moon enters Earth’s umbra and Earth casts a curved shadow on the Moon’s surface. (p. 934) | eclipse lunar: producido durante una luna llena, cuando la Luna entra la penumbra de la Tierra y la Tierra proyecta una sombra curva sobre la superficie de la Luna. (p. 934)

lustre: property of metals and alloys that describes having a shiny appearance. (p. 741) | lustre: propiedad de los metales y aleaciones que describe la manera como brilla. (p. 741)
<table>
<thead>
<tr>
<th>English</th>
<th>M</th>
<th>Español</th>
</tr>
</thead>
<tbody>
<tr>
<td>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. 109)</td>
<td>máquina: artefacto que facilita la ejecución del trabajo por aumentar la fuerza que se aplica a un objeto, cambiar la dirección de una fuerza aplicada o aumentar la distancia sobre la cual se puede aplicar una fuerza. (p. 109)</td>
<td></td>
</tr>
<tr>
<td>magma: molten rock material inside Earth. (p. 813)</td>
<td>magma: material de roca fundida dentro de la tierra. (p. 813)</td>
<td></td>
</tr>
<tr>
<td>magnetic domain: group of atoms in a magnetic material in which the magnetic poles of the atoms are aligned in the same direction. (p. 207)</td>
<td>dominio magnético: grupo de átomos en un material magnético en el cual los polos magnéticos de los átomos están alineados en la misma dirección. (p. 207)</td>
<td></td>
</tr>
<tr>
<td>magnetic field: region surrounding a magnet that exerts a force on other magnets and objects made of magnetic materials. (p. 203)</td>
<td>campo magnético: región que rodea a un imán que ejerce una fuerza sobre otros imanes y objetos hechos de materiales magnéticos. (p. 203)</td>
<td></td>
</tr>
<tr>
<td>magnetic pole: region on a magnet where the magnetic force exerted by a magnet is strongest; like poles repel and opposite poles attract. (p. 204)</td>
<td>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. 204)</td>
<td></td>
</tr>
<tr>
<td>magnetism: the properties and interactions of magnets. (p. 202)</td>
<td>magnetismo: propiedades e interacciones de los imanes. (p. 202)</td>
<td></td>
</tr>
<tr>
<td>main sequence: section of the H-R diagram that is plotted from the upper left to the lower right and contains 90 percent of all known stars. (p. 989)</td>
<td>secuencia principal: sección del diagrama HR que se traza desde la parte superior izquierda a la inferior derecha y contiene el 90 por ciento de todas las estrellas conocidas. (p. 989)</td>
<td></td>
</tr>
<tr>
<td>malleable: property of metals and alloys that allows them to be hammered or rolled into thin sheets. (pp. 518, 741)</td>
<td>maleable: la propiedad de los metales y aleaciones que les permite ser martillados o enrollados en láminas delgadas. (pp. 518, 741)</td>
<td></td>
</tr>
<tr>
<td>maria: relatively flat, dark-colored regions on the Moon’s surface. (p. 936)</td>
<td>mar lunar: uno de varios regiones en la superficie de la luna relativamente plano y de color oscuro. (p. 936)</td>
<td></td>
</tr>
<tr>
<td>maritime climate: climate strongly influenced by presence of an ocean, tends to be mild due to moisture. (p. 898)</td>
<td>clima marítimo: clima fuertemente influenciado por la presencia de un océano, tiende a ser templado debido a la humedad. (p. 898)</td>
<td></td>
</tr>
<tr>
<td>Mars: fourth planet from the Sun; called the red planet because of high concentrations of iron oxide. (p. 957)</td>
<td>Marte: cuarto planeta desde el Sol, se llama el planeta rojo debido a las altas concentraciones de óxido de hierro. (p. 957)</td>
<td></td>
</tr>
<tr>
<td>mass: amount of matter in an object. (p. 18)</td>
<td>masa: cantidad de materia en un objeto. (p. 18)</td>
<td></td>
</tr>
<tr>
<td>mass number: sum of the number of protons and neutrons in an atom’s nucleus. (p. 495)</td>
<td>número de masa: suma del número de protones y neutrones en el núcleo de un átomo. (p. 495)</td>
<td></td>
</tr>
<tr>
<td>matter: anything that takes up space and has mass. (p. 18)</td>
<td>materia: todo lo que ocupa espacio y tiene masa. (p. 18)</td>
<td></td>
</tr>
<tr>
<td>mechanical advantage (MA): ratio of the output force exerted by a machine to the input force applied to the machine. (p. 111)</td>
<td>ventaja mecánica (MA): relación de la fuerza ejercida por una máquina y la fuerza aplicada a dicha máquina. (p. 111)</td>
<td></td>
</tr>
<tr>
<td>mechanical energy: sum of the potential energy and kinetic energy of the objects in a system. (p. 121)</td>
<td>energía mecánica: suma de la energía potencial y energía cinética de los objetos en un sistema. (p. 121)</td>
<td></td>
</tr>
<tr>
<td>mechanical wave: a wave that can only travel through matter. (p. 276)</td>
<td>onda mecánica: una ola que sólo puede viajar a través de la materia. (p. 276)</td>
<td></td>
</tr>
<tr>
<td>medium: matter through which a wave travels. (p. 276)</td>
<td>medio: materia a través de la cual viaja una onda. (p. 276)</td>
<td></td>
</tr>
<tr>
<td>melting point: temperature at which a solid begins to liquefy. (p. 434)</td>
<td>punto de fusión: temperatura a la cual un sólido comienza a licuarse. (p. 434)</td>
<td></td>
</tr>
<tr>
<td>Mercury: smallest and closest planet to the Sun. (p. 955)</td>
<td>Mercurio: el planeta más pequeño y más cercano al sol. (p. 955)</td>
<td></td>
</tr>
<tr>
<td>metal: element that is shiny, malleable, ductile, and a good conductor of heat and electricity. (p. 518)</td>
<td>metal: elemento que por lo general es brillante, maleable, dúctil, y un buen conductor del calor y la electricidad. (p. 518)</td>
<td></td>
</tr>
</tbody>
</table>
metallic bonding: occurs because some electrons move freely among a metal's positively charged ions, explains properties such as ductility and the ability to conduct electricity. (p. 519)

metalloid: element that shares some properties with metals and some with nonmetals. (p. 532)

meteoroid: sand-to-boulder sized rocky object orbiting the Sun. (p. 967)

microscope: instrument that uses two convex lenses to magnify small, close objects. (p. 418)

microwave: electromagnetic wave with wavelength between about 0.1 mm and 30 cm. (p. 347)

mid-ocean ridge (MOR): a system of mountain ranges with a rift valley between them that extends around Earth on the seafloor; formed where oceanic plates spread apart due to magma rising from Earth's mantle. (p. 774)

Milky Way: spiral galaxy that is about 100,000 light-years in diameter and contains from 200 to 400 billion stars, including the Sun. (p. 997)

mineral: naturally occurring, inorganic solid with a crystalline form. (p. 809)

mirage: image of a distant object produced by the refraction of light through air layers of different densities. (p. 372)

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. 12)

modulation: process of adding a signal to a carrier wave by altering the carrier wave's amplitude, frequency, or other properties. (p. 352)

molar mass: the mass in grams of one mole of a substance. (p. 589)

mole: SI unit for quantity equal to 6.022 × 1023 units of that substance. (p. 588)

molecule: a neutral particle that forms as a result of electron sharing among atoms. (p. 561)

momentum: property of a moving object that equals its mass times its velocity. (p. 86)

monomer: small molecule that can combine with itself repeatedly to form a long chain. (pp. 720, 771)

Moon phase: changing appearance of the Moon as viewed from Earth, depending on the relative positions of the Sun, the Moon, and Earth. (p. 931)

motion: a change in an object's position relative to a reference point. (p. 44)

music: collection of sounds deliberately used in a regular pattern. (p. 317)

enlace metálico: ocurre debido a que algunos electrones se mueven libremente entre los iones de cargados positiva de un metal y explica propiedades tales como la ductibilidad y la capacidad para conducir electricidad. (p. 519)

metaloide: elemento que tiene algunas propiedades de los metales y algunas de los no metales. (p. 532)

meteorito: objeto de piedra de tamaño entre arena hasta tamaño de piedra en órbita solar. (p. 967)

microscopio: instrumento que usa dos lentes convexos para amplificar objetos pequeños y cercanos. (p. 418)

microonda: onda electromagnética con longitud de onda entre aproximadamente 0.1 mm y 30 cm. (p. 347)

dorsal océánica-(MOR): un sistema de cadenas de montañas marcado con un valle larga y extendido alrededor de la Tierra en el fondo marino; formado por las placas oceánicas que se separan debido a la emergencia de magma. (p. 774)

Vía Láctea: galaxia espiral que es de unos 100.000 años-luz de diámetro y contiene 200 a 400 mil millones de estrellas, incluyendo el sol. (p. 997)

mineral: sólido inorgánico de forma cristalina que se producen naturalmente. (p. 809)

espejismo: imagen de un objeto distante producida por la refracción de la luz a través de capas de aire de diferentes densidades. (p. 372)

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. 12)

modulación: proceso de agregar una señal a una onda portadora mediante la alteración de la amplitud de la onda portadora, la frecuencia, u otra propiedad. (p. 352)

maza molar: la masa en gramos de un mol de una sustancia. (p. 589)

mol: unidad SI de cantidad igual a 6,022 × 10^23 unidades de dicha sustancia. (p. 588)

molécula: partícula neutra que se forma al compartir electrones entre átomos. (p. 561)

momento: propiedad de un objeto en movimiento que es igual a su masa por su velocidad. (p. 86)

monómero: pequeña molécula que se puede formar una cadena por combinar consigo misma repetidamente. (pp. 720, 771)

fase de la Luna: el cambio de la apariencia de la luna como se ve desde la Tierra, depende de la posición relativa entre el Sol, la Luna y la Tierra. (p. 931)

movimiento: un cambio de puesto en relación con un punto de referencia. (p. 44)

música: colección de sonidos que se usan deliberadamente en un patrón regular. (p. 317)
nucleic acid: essential organic polymer that controls the activities and reproduction of cells. (p. 728)

net force: sum of all of the forces that are acting on an object. (p. 73)

neutralization: chemical reaction that occurs when the \( \text{H}_2\text{O}^+ \) ions from an acid react with the \( \text{OH}^- \) ions from a base to produce water molecules and a salt. (p. 689)

neutron: electrically neutral particle inside the nucleus of an atom. (p. 489)

neutron star: produced by a collapsing star when protons and electrons in the star's core collide to form neutrons. (p. 991)

Newton's first law of motion: states that an object moving at a constant velocity keeps moving at that velocity unless an unbalanced force acts on it. (p. 80)

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 exerted on it divided by its mass. (p. 82)

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. 84)

node: a point in a standing wave at which the interfering waves always cancel. (p. 294)

nonpolar bond: a covalent bond in which electrons are shared equally by both atoms. (p. 562)

nonpolar molecule: molecule that shares electrons equally and does not have oppositely charged ends. (p. 563)

nonrenewable resources: natural resources, such as fossil fuels, that cannot be replaced by natural processes as quickly as they are used. (p. 240)

nuclear reactor: an apparatus in which controlled nuclear chain reactions generate electricity. (p. 242)

nuclear waste: radioactive by-product that results when radioactive materials are used. (p. 246)

nebula: interstellar cloud of gas, ice and dust. (p. 989)

Neptune: eighth planet from the Sun; has storms similar to Jupiter's and is blue due to methane in the atmosphere. (p. 966)

fuerza neta: suma de las fuerzas que actúan sobre un objeto. (p. 73)

neutralización: reacción química que ocurre cuando los iones \( \text{H}_2\text{O}^+ \) de un ácido reaccionan con los iones \( \text{OH}^- \) de una base para producir moléculas de agua. (p. 689)

neutrón: partícula con carga eléctrica neutral del núcleo de un átomo. (p. 489)

Neptuno: octavo planeta desde el Sol, tiene tormentas similares a las de Júpiter y es de color azul debido al metano en la atmósfera. (p. 966)

nebula: nube interestelar de gas, hielo y polvo. (p. 989)

nucleic acid: ácido nucleico: polímero orgánico esencial que controla las actividades y la reproducción de las células. (p. 728)
photochemical smog/smog fotoquímica

nucleotide/nucleótido

nucleotide: complex, organic molecule that makes up DNA; contains an organic base, a phosphoric acid unit, and a sugar. (p. 728)
nucleus: the small, positively charged center of an atom, contains protons and neutrons. (p. 489)

núcleo: el pequeño centro de carga positiva de un átomo, contiene protones y neutrones. (p. 489)

nucleótido: molécula orgánica compleja que compone el ADN, contiene una base orgánica, una unidad de ácido fosfórico y un azúcar. (p. 728)

Glossary

English | O | Español | E
---|---|---|---

**Ohm’s law**: states that the current in a circuit equals the voltage difference divided by the resistance. (p. 182)

**opaque**: material that absorbs or reflects all light and does not transmit any light. (p. 368)

**optical axis**: imaginary straight line that is perpendicular to the surface at the center of a mirror or lens. (p. 402)

**optical scanner**: device that reads intensities of reflected light and converts the information to digital signals. (p. 388)

**organic compound**: one of a large number of compounds that contain the element carbon. (p. 706)

**overtone**: vibration whose frequency is a multiple of the fundamental frequency. (p. 318)

**oxidation**: the loss of electrons from the atoms of a substance in a chemical reaction. (p. 593)

**oxidation number**: positive or negative number that indicates how many electrons an atom has gained, lost, or shared to become stable. (p. 565)

**circuito paralelo**: circuito en el cual la corriente eléctrica tiene más de una trayectoria para seguir. (p. 186)

**pascal**: SI unit of pressure. (p. 443)

**period**: horizontal row in the periodic table. (p. 502); the amount of time it takes one wavelength to pass a fixed point; is expressed in seconds. (p.280)

**periodic table**: organized list of all known elements that are arranged by increasing atomic number and by changes in chemical and physical properties. (p. 498)

**petroleum**: liquid fossil fuel formed from decayed remains of ancient organisms; can be refined into fuels and used to make plastics. (p. 236)

**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. 686)

**photochemical smog**: the ozone-containing pollution that results from the reaction between sunlight and vehicular or industrial exhaust. (p. 260)

**número de oxidación**: número positivo o negativo que indica cuántos electrones ha ganado, perdido o compartido un átomo para alcanzar la estabilidad. (p. 565)

**compuesto orgánico**: una de un gran número de compuestos que contiene el elemento carbono. (p. 706)

**sobretón**: vibración cuya frecuencia es un múltiplo de la frecuencia fundamental. (p. 318)

**oxidación**: la pérdida de electrones de los átomos de una sustancia en una reacción química. (p. 593)

**ley de Ohm**: establece que la corriente en un circuito es igual a la diferencia de voltaje dividida entre la resistencia. (p. 182)

**opaco**: material que absorbe o refleja toda la luz pero no la transmite. (p. 368)

**eje óptico**: línea recta imaginaria que es perpendicular a la superficie en el centro de un espejo o lente. (p. 402)

**escáner óptico**: dispositivo que lee la intensidad de la luz reflejada y convierte la información en señales digitales. (p. 388)

**complejo orgánico**: una de un gran número de compuestos que contiene el elemento carbono. (p. 706)

**núcleo**: el pequeño centro de carga positiva de un átomo, contiene protones y neutrones. (p. 489)

**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. 686)

**smog fotoquímica**: la contaminación que incluye ozono y que resulta de la reacción entre la luz solar y el escape vehicular o industriales. (p. 260)
**Glossary**

**photon/fotón**
- **photon**: massless energy-containing particle that electromagnetic waves sometimes behave like; the frequency of the electromagnetic wave increases with the energy of the particle. (p. 342)
- **photosphere**: layer of the Sun that emits light into space. (p. 994)
- **photovoltaic cell**: device that converts solar energy into electricity; also called a solar cell. (p. 248)
- **physical change**: any change in size, shape, or state of matter in which the identity of the substance remains the same. (p. 471)
- **physical property**: any characteristic of a material, such as size or shape, that can be observed without changing the identity of the material. (p. 469)
- **pigment**: colored material that is used to change the color of other substances. (p. 376)
- **pitch**: perception of how high or low a sound is; related to the frequency of the sound waves. (p. 314)
- **plane mirror**: flat, smooth mirror that reflects light to form upright, virtual images. (p. 401)
- **plasma**: matter with enough energy to overcome the attractive forces within its atoms, composed of positively and negatively charged particles. (p. 436)
- **polar bond**: a covalent bond in which the electrons are not shared equally, resulting in a slightly positive end and a slightly negative end. (p. 563)
- **polar molecule**: a neutral molecule in which unequal electron sharing results a slightly positive end and a slightly negative end. (p. 563)
- **pollutant**: any substance that contaminates the environment. (p. 256)
- **polyatomic ion**: positively or negatively charged, covalently bonded group of atoms. (p. 569)
- **polyethylene**: polymer formed from a chain containing many ethylene units; often used in plastic bags and plastic bottles. (p. 721)
- **polymer**: class of natural or synthetic substances made up of many smaller, simpler molecules, called monomers, arranged in large chains. (pp. 720, 771)
- **population**: the total number of individuals of one species occupying the same area. (p. 255)
- **pore space**: empty space between clasts, can contain water, oil and natural gas. (p. 825)
- **porosity**: percentage of a material's total volume of pore space, calculated by dividing total volume of pore space by the total volume of the material. (p. 866)
- **potential energy**: energy that is stored due to the interactions between objects. (p. 117)
- **power**: the rate at which energy is converted; measured in watts (W). (p. 126)
- **precipitate**: insoluble compound that is formed in a solution during a double-displacement reaction. (p. 592)

**fotón**: partícula que contiene energía como la cual algunas veces se comportan las ondas electromagnéticas; la frecuencia de la onda electromagnética aumenta con la energía del fotón. (p. 342)
**fotosfera**: capa del Sol que emite luz hacia el espacio. (p. 994)
**célula fotovoltaica**: dispositivo que convierte la energía solar en electricidad; también llamada celda solar. (p. 248)
**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. 471)
**propiedad física**: cualquier característica de un material, tal como tamaño o forma, que se puede observar sin cambiar la identidad del material. (p. 469)
**pigmento**: material de color que se usa para cambiar el color de otras sustancias. (p. 376)
**tono**: percepción de qué tan alto o bajo es un sonido; relacionado a la frecuencia de las ondas sonoras. (p. 314)
**espejo plano**: espejo plano y liso que refleja la luz y forma imágenes verticales y virtuales. (p. 401)
**plasma**: materia con la energía suficiente para superar las fuerzas de atracción entre sus átomos, consiste de partículas con cargas positivas y negativas. (p. 436)
**enlace polar**: enlace en el que los electrones no se comparten por igual, resultando en un lado ligeramente positivo y un lado ligeramente negativo. (p. 563)
**molécula polar**: molécula con un extremo ligeramente positivo y otro ligeramente negativo como resultado de un compartir desigual de los electrones. (p. 563)
**contaminante**: cualquier sustancia que ensucia al medioambiente. (p. 256)
**ión poliatómico**: grupo de átomos enlazados covalentemente, con carga positiva o negativa. (p. 569)
**polietileno**: polímero formado por una cadena que contiene varias unidades de etileno; es comúnmente usado en la fabricación de bolsas y envases plásticos. (p. 721)
**polímero**: clase de sustancias naturales o sintéticas compuestas por muchas moléculas más simples y pequeñas, llamadas monómeros, ordenadas en largas cadenas. (pp. 720, 771)
**población**: el número total de individuos de una especie que ocupa la misma zona. (p. 255)
**espacio poroso**: espacio entre las clásticas, que pueden contener agua, aceite o gas natural. (p. 825)
**porosidad**: porcentaje de espacio poroso en el total del volumen de un material; calculado dividiendo el total del espacio poroso por el volumen total del material. (p. 866)
**energía potencial**: energía almacenada que un objeto tiene debido a las interacciones entre objetos. (p. 117)
**potencia**: tasa de cambio en que la energía se convierte; medida en vatios (W). (p. 126)
**precipitado**: compuesto insoluble que resulta en una solución por medio de una reacción de doble desplazamiento. (p. 592)
pressure/presión

**pressure**: amount of force exerted per unit area; SI unit is the pascal (Pa). (p. 443)

**principle of superposition**: states that in an undisturbed sequence of sedimentary rock layers, the youngest rocks will be at the top, and the oldest will be at the bottom. (p. 870)

**product**: in a chemical reaction, the new substance or substances formed. (p. 582)

**protein**: large, complex, biological polymer formed from amino acid units; make up many body tissues such as muscles, tendons, hair, and fingernails. (p. 724)

**proton**: particle in the nucleus with an electric charge of 1+. (p. 489)

**Quark**: particle of matter that makes up protons and neutrons. (p. 489)

**radiant energy**: energy carried by an electromagnetic wave. (p. 357)

**radiation**: transfer of energy by electromagnetic waves. (p. 147)

**radioactive element**: element, such as radium, whose nucleus breaks down and emits particles and energy. (p. 520)

**radioactivity**: process that occurs when a nucleus decays and emits matter and energy. (p. 620)

**radio telescope**: telescope that collects and magnifies radio waves. (p. 987)

**radio wave**: electromagnetic wave with wavelength longer than about 10 cm, used for communications. (p. 345)

**rarefaction**: the less-dense region of a longitudinal wave. (p. 279)

**reactant**: in a chemical reaction, the substance that reacts. (p. 582)

**reaction rate**: the rate at which reactants change into products in a chemical reaction. (p. 598)

**real image**: an image that appears at a certain location as a result of rays of light converging at that location. (p. 403)

**reduction**: the gain of electrons by the atoms of a substance in a chemical reaction. (p. 593)

**reflecting telescope**: uses mirrors and lenses to collect and focus light from distant objects. (pp. 416, 985)

**Presión**: cantidad de fuerza ejercida por unidad de área; la unidad SI es el pascal (Pa). (p. 443)

**principio de superposición**: establece que en las capas de sedimentos de rocas las capas más recientes estarán arriba y las capas más antiguas abajo. (p. 870)

**producto**: en una reacción química, la sustancia formada o las sustancias formados. (p. 582)

**proteína**: polímero biológico extenso y complejo formado por unidades de aminoácidos; conforma muchos tejidos del cuerpo como los músculos, los tendones, el pelo y las uñas. (p. 724)

**proton**: partícula en el núcleo con una carga eléctrica de 1+. (p. 489)

**energía radiante**: energía transportada por una onda electromagnética. (p. 357)

**radiación**: transferencia de energía mediante ondas electromagnéticas. (p. 147)

**elemento radiactivo**: elemento, como el radio, cuyo núcleo se divide y emite partículas y energía. (p. 520)

**radiactividad**: proceso que ocurre cuando un núcleo se descompone y emite materia y energía. (p. 620)

**telescopio reflexivo**: telescopio que recoge y amplifica las ondas de radio. (p. 987)

**onda de radio**: onda electromagnética con longitud de onda más larga de aproximadamente 10 cm y que se usa en las comunicaciones. (p. 345)

**rarefacción**: la región menos densa de una onda longitudinal. (p. 279)

**reactante**: la sustancia que reacciona en una reacción química. (p. 582)

**velocidad de reacción**: velocidad en que se transforman los reactivos en productos en una reacción química. (p. 598)

**imagen real**: imagen que aparece en un cierto lugar como consecuencia de rayos de luz que convergen en ese lugar. (p. 403)

**reducción**: la obtención de electrones por los átomos de una sustancia en una reacción química. (p. 593)

**telescopio reflexivo**: usa espejos y lentes para recolectar y enfocar la luz proveniente de objetos distantes. (pp. 416, 985)
Glossary

refracting telescope: uses lenses to gather and focus light from distant objects. (pp. 416, 985)

refraction: the bending of a wave caused by a change in its speed as it travels from one medium to another. (p. 288)

regolith: layer of debris on the Moon's surface formed by the accumulation of meteoric material. (p. 936)

relative dating: process of placing objects or events in order in time according to which occurred or formed first, second, and so on. (p. 870)

renewable resource: energy source that is replaced by natural processes faster than it is used. (p. 248)

resistance: tendency for a material to oppose electron flow and to convert electrical energy into other forms of energy, such as thermal energy and light; measured in ohms (Ω). (p. 181)

resonance: the process by which an object is made to vibrate by absorbing energy at its natural frequencies. (p. 295)

resonator: hollow, air-filled chamber that amplifies sound when the air inside it vibrates. (p. 319)

retina: inner lining of the eye that has cells which convert light images into electric signals for interpretation by the brain. (p. 411)

reversible reaction: a reaction that can proceed in both the forward and the reverse directions. (p. 601)

revolution: motion of Earth around the Sun, used to measure time in years. (p. 924)

rift valley: long narrow depression formed in between the peaks along the mid-oceanic ridge. (p. 774)

rock: naturally formed mixture of minerals, rock fragments or volcanic glass, bound together, identified based on composition and texture. (p. 817)

rock cycle: the continual changing of rocks into different types through processes such as high temperature and pressure, weathering, erosion and sedimentation. (p. 833)

rotation: spinning of Earth on its axis; used to measure time in days. (p. 924)

salt: compound formed when negative ions from an acid combine with positive ions from a base. (pp. 580, 689)

saturated hydrocarbon: hydrocarbon, such as propane or methane, in which all the carbon atoms are connected by single covalent bonds. (p. 708)

saturated solution: any solution that contains all the solute it can hold at a given temperature. (p. 655)

telescopic refractivo: usa lentes para reunir y enfocar la luz proveniente de objetos distantes. (pp. 416, 985)

refracción: el cambio en dirección de una ola debido a un cambio en su velocidad por viajar de un medio a otro. (p. 288)

regolito: capa de escombros en la superficie de la Luna, formada por la acumulación de material meteórico. (p. 936)

datación relativa: proceso de ordenar cronológicamente objetos o eventos según estos ocurrieron ya sea primero segundo etc. (p. 870)

recursos renovables: fuente de energía que es reemplazada más rápido de que se consume. (p. 248)

resistencia: tendencia de un material de oponerse al fluido de los electrones y convertir la energía eléctrica en energía térmica y luz; se mide en ohmios (Ω). (p. 181)

resonancia: el proceso por el cual un objeto vibra al absorber energía en sus frecuencias naturales. (p. 295)

resonador: cámara hueca, llena de aire, que amplifica el sonido cuando vibra el aire en su interior. (p. 319)

retina: capa interna del ojo que posee células que convierten imágenes iluminadas en señales eléctricas para que el cerebro las interprete. (p. 411)

reacción reversible: una reacción que puede proceder tanto en el avance que en la dirección retroceso. (p. 601)

revolución: movimiento de la Tierra alrededor del Sol, sirve para medir el tiempo en años. (p. 924)

valle del rift: surco central formado entre los picos a lo largo de la cresta de la dorsal océanica. (p. 774)

roca: mezcla naturalmente formada de minerales, fragmentos de roca o vidrio volcánico mezclado, identificable por medio su composición y textura. (p. 817)

ciclo de las rocas: el continuo proceso de cambio de las rocas a través de diferentes procesos como las altas temperaturas, presión, meteorización, erosión y sedimentación. (p. 833)

rotación: giro de la Tierra en su eje, se utiliza para medir el tiempo en días. (p. 924)

<table>
<thead>
<tr>
<th>English</th>
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<th>Español</th>
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</thead>
<tbody>
<tr>
<td>salt: compound formed when negative ions from an acid combine with positive ions from a base. (pp. 580, 689)</td>
<td>sal: compuesto iónico que se forma cuando un halógeno adquiere un electrón de un metal. (pp. 580, 689)</td>
<td>hidrocarburo saturado: hidrocarburo, como el propano y el metano, en la que todos los átomos de carbono están unidos por enlaces covalentes simples. (p. 708)</td>
</tr>
<tr>
<td>saturated hydrocarbon: hydrocarbon, such as propane or methane, in which all the carbon atoms are connected by single covalent bonds. (p. 708)</td>
<td>saturado solución: cualquier solución que contiene todo el soluto que puede retener a una temperatura determinada. (p. 655)</td>
<td></td>
</tr>
</tbody>
</table>
Saturn: sixth planet from the Sun; the second-largest planet with the most complex ring system. (p. 965)

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. 13)

scientific method: pattern 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. 8)

sea breeze: local wind created by temperature and pressure differences between ocean and land; wind blows toward land in the afternoon, and away from land at night. (p. 899)

second law of thermodynamics: states that energy spontaneously spreads from regions of higher concentration to regions of lower concentration. (p. 155)

sediment transport: process of moving eroded materials from one place to another through the movement of water, ice, wind and due to gravity. (p. 854)

Sedna: distant planetoid, smaller than Pluto, larger than comets, with a very elliptical orbit. (p. 968)

semiconductor: material that conducts an electric current under certain conditions. (pp. 534)

series circuit: circuit in which electric current has only one path to follow. (p. 185)

shadow zone: area on Earth’s surface where no seismic waves from a given Earthquake are recorded. (p. 788)

shield volcano: large, broad, flat volcano composed of layer upon layer of basaltic lava flows. (p. 795)

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)

silica: chemical compound, silica dioxide (SiO₂), a common ingredient in most magma and much of Earth’s crust. (p. 793)

simple machine: machine that does work with only one movement; examples include lever, pulley, wheel and axle, inclined plane, screw, and wedge. (p. 109)

single-displacement reaction: chemical reaction in which one element replaces another element in a compound. (p. 591)

sliding friction: frictional force that opposes the motion of two surfaces sliding past each other. (p. 75)

soap: organic salt with a nonpolar, hydrocarbon end that interacts with oils and dirt and a polar end that causes it to dissolve in water. (pp. 694)
society: group of people that share similar values and beliefs. (p. 30)
solution: mixture of weathered rock, organic matter, water, and air that is capable of supporting plant life. (p. 850)
solar collector: device used in an active solar heating system that transforms radiant energy from the Sun into thermal energy. (p. 153)
solar eclipse: occurs during the new moon, when Earth enters the Moon’s umbra and casts a shadow on the Earth’s surface. (p. 934)
solenoid: a cylindrical coil of wire, used to produce a magnetic field when an electrical current passes through the wire. (p. 210)
solstice: occurs twice a year, in June and December, when Earth’s rotational axis is tilted the most toward, or the most away, from the Sun. (p. 926)
solubility: maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature. (p. 654)
solute: in a solution, the substance being dissolved. (p. 647)
solution: homogenous mixture, remains constantly and uniformly mixed and has particles that are so small they cannot be seen with a microscope. (pp. 467)
solvent: in a solution, the substance in which the solute is dissolved. (p. 647)
sonar: system that uses the reflection of sound waves to detect objects underwater. (p. 326)
sound quality: result of the differences between sounds having the same pitch and loudness. (p. 318)
specific heat: amount of heat needed to raise the temperature of 1 kg of a material 1°C. (p. 141)
spectroscope: device that disperses light into its component wavelengths, using a prism or diffraction grating. (p. 988)
speed: distance an object travels per unit of time. (p. 46)
sphere: three-dimensional, round object whose surface is the same distance from the center in every direction. (p. 918)
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; does not appear to be travelling. (p. 294)
static electricity: the accumulation of excess electric charge on an object. (p. 170)
static friction: frictional force that prevents two surfaces from sliding past each other. (p. 75)
**Glossary**

<table>
<thead>
<tr>
<th>English</th>
<th>T</th>
<th>Español</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>terminal velocity/velocidad límite</strong></td>
<td></td>
<td><strong>velocidad límite</strong> la velocidad máxima que un objeto puede alcanzar cuando pasa en caída libre por una sustancia como aire. (p. 88)</td>
</tr>
<tr>
<td><strong>streak/raya</strong></td>
<td>color of a mineral in its powdered form. (p. 810)</td>
<td>el color del polvo de un mineral. (p. 810)</td>
</tr>
<tr>
<td><strong>streak acid</strong></td>
<td>any acid that dissociates almost completely in solution. (p. 684)</td>
<td>cualquier ácido que se disocie casi por completo en una solución. (p. 684)</td>
</tr>
<tr>
<td><strong>strong acid</strong></td>
<td>any base that dissociates completely in solution. (p. 685)</td>
<td>cualquier base que se disocie completamente en una solución. (p. 685)</td>
</tr>
<tr>
<td><strong>strong base</strong></td>
<td>attractive force that acts between protons and neutrons in an atomic nucleus. (p. 618)</td>
<td>fuerza de atracción que mantiene juntos los protones y neutrones en un núcleo atómico. (p. 618)</td>
</tr>
<tr>
<td><strong>strong force</strong></td>
<td>the movement of a dense oceanic plate under a buoyant continental plate. (777)</td>
<td>el movimiento de una placa oceánica bajo una densa placa continental boyante. (777)</td>
</tr>
<tr>
<td><strong>subduction</strong></td>
<td>the process of a solid changing directly to a vapor without forming a liquid. (p. 435)</td>
<td>proceso mediante el cual un sólido se convierte directamente en vapor sin pasar por el estado líquido. (p.435)</td>
</tr>
<tr>
<td><strong>sublimation</strong></td>
<td>element or compound that cannot be broken down into simpler components without losing the properties of the original substance. (p. 462)</td>
<td>elemento o compuesto que no se puede descomponer en componentes más simples sin perder las propiedades de la sustancia original. (p. 462)</td>
</tr>
<tr>
<td><strong>substituted hydrocarbon</strong></td>
<td>hydrocarbon with one or more of its hydrogen atoms replaced by atoms, or groups of atoms, of other elements. (p. 712)</td>
<td>hidrocarburo sustituido: un hidrocarburo en el cual uno o más de sus átomos de hidrógeno son reemplazados por un átomo, o grupo de átomos, de otros elementos. (p. 712)</td>
</tr>
<tr>
<td><strong>sunspots</strong></td>
<td>darker, cooler areas of the Sun’s photosphere. (p. 994)</td>
<td>áreas más oscuro, más frías de la fotosfera del sol. (p. 994)</td>
</tr>
<tr>
<td><strong>supernova</strong></td>
<td>gigantic explosion of a star in which the temperature within the collapsing star reaches 10 billion K, can evolve into a neutron star. (p. 991)</td>
<td>explosión de una estrella gigantesca en la que la temperatura dentro de la estrella que se colapsa alcanza 10 mil millones K, puede convertirse en una estrella de neutrones. (p. 991)</td>
</tr>
<tr>
<td><strong>supersaturated solution</strong></td>
<td>any solution that contains more solute than a saturated solution at the same temperature. (p. 656)</td>
<td>cualquier solución que contenga más soluto que una solución saturada a la misma temperatura. (p. 656)</td>
</tr>
<tr>
<td><strong>suspension</strong></td>
<td>heterogeneous mixture containing a liquid, and in which visible particles slowly settle due to gravity. (p. 466)</td>
<td>mezcla heterogénea que contiene un líquido, y en el cual las partículas visibles lentamente se sedimentan. (p. 466)</td>
</tr>
<tr>
<td><strong>synthesis reaction</strong></td>
<td>chemical reaction in which two or more substances combine to form a different substance. (p. 591)</td>
<td>reacción química en la cual se combinan dos o más sustancias y forman una sustancia diferente. (p. 591)</td>
</tr>
<tr>
<td><strong>synthetic</strong></td>
<td>a material that is made in a laboratory or chemical plant and does not occur naturally. (p. 753)</td>
<td>un material que se realiza en un laboratorio o fábrica de productos químicos y no se produce de forma natural. (p. 753)</td>
</tr>
<tr>
<td><strong>system</strong></td>
<td>a region or set of regions around which a boundary can be defined. (p. 114)</td>
<td>una región o conjunto de regiones alrededor de lo cual se puede distinguir con un límite. (p. 114)</td>
</tr>
</tbody>
</table>

**English**

- **technology**: application of science to benefit people. (p. 22)
- **temperature**: measure of the average kinetic energy of all the particles that make up an object. (p. 139)
- **temperature inversion**: describes the increasing temperature of air with increasing altitude. (p. 885)
- **terminal velocity**: the maximum speed an object will reach when falling through a substance, such as air. (p. 88)
Glossary

theory: explanation of things or events based on knowledge gained from many observations and investigations. (p. 13)
thermal energy: sum of the kinetic and potential energy of the particles that make up an object. (p. 139)
thermal expansion: increase in the volume of a substance when the temperature is increased. (p. 437)
thermal insulator: a material through which thermal energy moves slowly. (p. 149)
thermodynamics: study of the relationship between thermal energy, heat, and work. (p. 154)
tide: the periodic rise and fall of sea level caused by the gravitational attraction among Earth, the Moon, and the Sun. (p. 930)
time zone: any one of 24 longitudinal strips on Earth about 15° wide on Earth’s surface in which local time is the same. (p. 923)
titration: process in which a solution of known concentration is used to determine the concentration of another solution. (p. 692)
total internal reflection: the complete reflection of light at a boundary that occurs when light strikes at an angle greater than the critical angle, and light travels faster in the second medium than in the first medium. (p. 386)
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. 630)
transceiver: device that transmits radio signals at one frequency and receives radio signals at a different frequency, allowing a user to talk and listen at the same time. (p. 355)
transform plate boundary: tectonic plate boundary in which plates slide horizontally past each other in opposite directions. (p. 778)
transformer: device that uses electromagnetic induction to increase or decrease the voltage of an alternating current. (p. 220)
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. 522)
translucent: material that transmits and scatters light so that objects viewed through it appear blurry. (p. 368)
transmutation: process of changing one element to another through radioactive decay. (p. 623)
transparent: material that transmits light without scattering so that objects are clearly visible through it. (p. 368)
transuranium elements: elements having more than 92 protons, all of which are synthetic and unstable. (p. 539)

theory: explicación de las objetos o eventos que se basa en el conocimiento obtenido a partir de numerosas observaciones e investigaciones. (p. 13)
energia térmica: suma de la energía cinética y potencial de las partículas que componen un objeto. (p. 139)
expansión térmica: aumento del volumen de una sustancia al aumentar la temperatura. (p. 437)
aislante térmico: material a través del cual se mueve la energía térmica muy lentamente. (p. 149)
termodinámica: estudio de la relación entre la energía térmica, el calor y el trabajo. (p. 154)
marea: los ascensos y descensos periódicos del nivel del mar causado por la atracción gravitatoria entre la Tierra, la Luna y el Sol. (p. 930)
zona horaria: uno de 24 franjas de la Tierra alrededor de 15° de ancho en la superficie de la Tierra en el que la hora local es la misma. (p. 923)
titulación: proceso mediante el cual una solución con una concentración conocida es usada para determinar la concentración de otra solución. (p. 692)
reflexión interna total: la reflexión completa de la luz en un límite que se produce cuando la luz incide en un ángulo mayor que el ángulo crítico, y la luz viaja más rápido en el segundo medio que en el primer medio. (p. 386)
indicador radiactivo: isótopo radioactivo, tal como el yodo-131, que se detecta por la radiación que emite después de ser absorbido por un organismo vivo. (p. 630)
radio transmisor-receptor: dispositivo que transmite señales de radio a una frecuencia y recibe señales de radio en una frecuencia diferente, lo que permite al usuario hablar y escuchar al mismo tiempo. (p. 355)
límite de transformación de placa: borde tectónico en la que las placas se deslizan horizontalmente entre sí en direcciones opuestas. (p. 778)
transformador: dispositivo que usa inducción electromagnética para aumentar o disminuir el voltaje de una corriente alterna. (p. 220)
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 triada de hierro y los metales con los que se fabrican las monedas. (p. 522)
translúcido: material que transmite y dispersa la luz para que los objetos vistos a través de ella se vean borrosos. (p. 368)
transmutación: proceso de cambio de un elemento a otro mediante la descomposición radioactiva. (p. 623)
transparente: material que transmite luz sin dispersarse de manera que los objetos son claramente visibles a través de ella. (p. 368)
elementos transuránicos: elementos con más de 92 protones, que son sintéticos e inestables. (p. 539)
**Glossary**

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<thead>
<tr>
<th>English</th>
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<th>Español</th>
</tr>
</thead>
<tbody>
<tr>
<td>transverse wave/onda transversal</td>
<td>variable: a quantity that can have more than a single value, can cause a change in the results of an experiment. (p. 9)</td>
<td>viscosidad/viscosidad</td>
</tr>
<tr>
<td>transverse wave: wave in which the matter in the medium moves at right angles to the direction of the wave, has crests and troughs. (p. 276)</td>
<td>variable: una cantidad que puede tener más de un valor, puede causar un cambio en los resultados de un experimento. (p. 9)</td>
<td></td>
</tr>
<tr>
<td>troposphere: lowest layer of the atmosphere, extending 12 km above Earth's surface, layer where weather takes place. (p. 885)</td>
<td>velocity: the speed and direction of a moving object. (p. 51)</td>
<td></td>
</tr>
<tr>
<td>trough: the lowest point on a transverse wave. (p. 279)</td>
<td>Venus: second planet from the Sun; has a dense atmosphere of mostly carbon dioxide and very high surface temperatures. (p. 956)</td>
<td></td>
</tr>
<tr>
<td>trough: large wheel that rotates when pushed by steam, wind, or water and provides mechanical energy to a generator. (p. 218)</td>
<td>virtual image: an image formed by diverging light rays that is perceived by the brain, even though the light rays do not actually originate from the place where the image appears to be located. (p. 402)</td>
<td></td>
</tr>
<tr>
<td>Tyndall effect: tendency for a beam of light to scatter as it passes through a colloid. (p. 467)</td>
<td>viscosity: a fluid's resistance to flowing. (pp. 446, 793)</td>
<td></td>
</tr>
</tbody>
</table>

**English**

- ultrasound: sound waves with frequency above 20,000 Hz; cannot be heard by humans. (p. 326)
- ultraviolet wave: electromagnetic wave with wavelength between about 400 billionths and 10 billionths of a meter. (p. 349)
- unconformity: gap in the rock record representing a time during with exposed rock was eroded before new layers were deposited. (p. 871)
- uniformitarianism: states that the laws of nature operate today as they have in the past. (p. 870)
- unsaturated hydrocarbon: hydrocarbon, such as ethene or ethyne, that contains at least one double or triple bond between carbon atoms. (p. 709)
- unsaturated solution: any solution that can dissolve more solute at a given temperature. (p. 655)
- Uranus: seventh planet from the Sun; appears blue-green due to methane in the atmosphere; its axis of rotation is tilted on its side. (p. 966)

**Español**

- ultrasonido: onda de sonido con frecuencia superior a 20,000 Hz, no percibido por seres humanos. (p. 326)
- onda ultravioleta: ondas electromagnética con longitud de onda entre aproximadamente 10 y 400 billonésimas de metro. (p. 349)
- disconformidad: evidencia que la roca fue expuesta a erosión antes de que nuevas capas fuesen depositadas. (p. 871)
- uniformitarismo: establece que las leyes de la naturaleza operan hoy de la misma forma que operaban en el pasado. (p. 870)
- hidrocarburo no saturado: hidrocarburo, como el etileno, que contiene al menos un enlace doble o triple entre los átomos de carbono. (p. 709)
- solución no saturada: cualquier solución que puede disolver más soluto a una temperatura determinada. (p. 655)
- Urano: séptimo planeta desde el Sol, aparece de color azul-verde debido al metano en la atmósfera, su eje de rotación inclina a su lado. (p. 966)
**visible light**/luz visible

**visible light**: electromagnetic waves with wavelengths of 700 to 400 billionths of a meter that can be detected by human eyes. (p. 348)

**voltage difference**: related to the force that causes electric charges to flow; measured in volts (V). (p. 178)

**volume**: amount of space occupied by an object. (p. 17)

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**water table**: the upper boundary of the saturated zone in an aquifer. (p. 864)

**wave**: a repeating disturbance that transfers energy as it travels through matter or space. (p. 274)

**wavelength**: distance between one point on a wave and the nearest point just like it. (p. 280)

**weak acid**: any acid that only partly dissociates in solution. (p. 684)

**weak base**: any base that does not dissociate completely in solution. (p. 685)

**weather front**: zone along which two or more air masses interact, producing certain weather conditions. (p. 892)

**weathering**: process that involves the physical or chemical breakdown of materials on Earth's surface. (p. 846)

**weight**: gravitational force exerted on an object. (p. 78)

**white dwarf**: giant star that has lost its outer layers, leaving behind a hot, dense core that continues to contract under gravity. (p. 991)

**work**: transfer of energy when a force is applied over a distance; measured in joules. (p. 106)

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**X-ray**/rayo X

**X-ray**: electromagnetic wave with wavelength between about 10 billionths of a meter and 10 trillionths of a meter, often used for medical imaging. (p. 350)

**rayo X**: onda electromagnética con longitud de onda entre 10 billionésimas de metro y 10 trillionésimas de metro, la cual se utiliza con frecuencia para producir imágenes de uso médico. (p. 350)
Index
<table>
<thead>
<tr>
<th>Index</th>
<th>1101</th>
</tr>
</thead>
</table>

### Index

#### Climate

- act., 606–607 act.; volume, effects of, 600, 600 illus., 604; weathering and, 474, 474 illus., 848–849, 848 illus., 849 illus.
- Chemical energy: cars and, 115, 115 illus.; converting to electrical energy, 234, 235, 238–239, 238 illus.; potential, 117, 117 illus., 125, 126 act., 234; reaction exchanges and, 594–597, 594 illus., 595 illus., 596 illus.
- Chemical equations, 583–589; balanced, 585–587, 585 illus., 586 illus., 587 prob.; coefficients, 584–585, 585 illus.; understanding, 588–589, 588 illus., 588 table; writing, 583–585, 584 table
- Chemical formulas, 553, 553 table, 582, writing, 566–571, 566 table, 567 prob., 568 prob., 568 table, 570 act., 570 table
- Chemical properties, 472, 498
- Chemical sedimentary rocks, 828, 828 act., 828 illus.
- Chemical weathering, 474, 474 illus., 848–849, 848 illus., 849 illus.
- Chernobyl Nuclear Power Plant, 245, 245 illus.
- Chlorine, 560 illus.; chemical bonding and, 555–556, 555 illus.; as a disinfectant, 529, 529 act., 529 illus.; as a halogen, 528; ionic bonding and, 560, 560 illus.; properties, 526
- Chlorofluorocarbons (CFCs), 260, 350
- Cholesterol, 728
- Chromium, 522, 522 illus., 525
- Chromosphere, 993 illus.
- Cinder cone volcanoes, 795, 795 illus., 795 table, 796 illus.
- Circle graphs, 25, 25 illus.
- Circuit breakers, 188, 188 illus.
- Circuits, 168 act., 179; household, 187–188, 187 illus.; 188 illus.; series and parallel, 185–186, 185 illus., 186 illus., 192–193 act.; water, 179, 179 illus.
- Circular motion, 59, 59 illus.
- Cirrus clouds, 887, 887 illus.
- Clasts, 824–825; compaction and cementation of, 825, 825 illus.; detrital sedimentary rocks and, 826–827, 826 table, 827 table; size, 826, 826 illus.; transporting and deposition of, 825, 825 illus.; weathering of, 824, 824 illus.
- Cleavage, 811, 811 illus.
- Clementine spacecraft, 937–938
- Climate, 893–900; factors affecting, 896–899, 897 illus., 898 illus., 899 illus.; mountains, 899, 899 illus.; ocean and land, 998; precipitation and, 898, 898 illus.; small-scale, 899,
**Climate change**
906–907 act.; temperature, 896–897, 897 illus., 901, 901 illus.; types of, 900, 900 illus.; water, 899, 899 illus.; weather and, 895–896, 895 illus., 896 illus.

**Climate change**, 901–907.
See also Greenhouse effect; carbon cycle, 903, 903 prob.; causes, 902–904; El Niño and La Niña, 905, 905 illus.; global warming, 33 act., 239, 904; humans, effects of, 902, 902 illus., 904; ice age and, 901, 901 illus.; land use, 904; long-term, 901, 901 illus.; seasonal, 901

**Clothing**
as a heterogeneous mixture, 465, 466 illus.; as insulation, 149, 149 illus.; polymer fibers, use of in, 762; static electricity, 170–171, 170 illus., 171 illus.

**Clouds**, 887, 887 illus.; on Jupiter, 963, 963 illus.; severe weather and, 893, 893 illus.

**Coal**, 239; exothermic reactions and, 595, 595 illus.; formation of, 235, 235 illus., 238, 829, 829 illus.; mining of, 237–238, 237 illus.; U.S. use of, 237

**Coastlines, continental drift theory and**, 773, 773 illus.

**Cobalt**, 522, 522 illus.

**Cochlea**, 310, 310 illus.

**Coefficients**, 584–585, 585 illus.

**Coherent**, 382

**Coherent light**, 382, 382 illus.

**Coins, metals in**, 523, 523 illus., 525, 647, 647 illus., 648 illus.

**Collapse, 991
**

**Collision model**, 599

**Colloids, 466–467, 466 illus., 467 illus.
**

**Color, light and**, 373–377

**Color blindness**, 375, 375 illus.

**Color filters**, 569 table, 570 table; solubility of in water, 655, 655 illus., 655 table

**Compressional wave**, 279, 279 illus.; amplitude and, 283, 283 illus.; frequency and, 280–281, 281 illus., 296–297 act.; wavelength and, 280, 280 illus.

**Computers**
See also Semiconductors; components, 752, 752 illus.; history of, 751; simulations and, 12, 12 illus.

**Concave lenses**, 410, 410 illus., 410 table. See also Optical instruments; Optical telescopes; eyesight and, 411–414, 411 illus., 412 illus., 413 illus., 414 illus.

**Concave mirrors**, 402–404, 402 illus., 403 act., 403 illus., 404 illus., 406 table. See also Optical instruments; Optical telescopes

**Concentration**, 653–654, 653 illus.; of acids and bases, 685, 685 illus., 688 act.; chemical reaction rates and, 599, 599 illus., 604, 606–607 act.; titration and, 692–693, 692 illus., 693 act., 693 illus.

**Conclusions, drawing, 10
**

**Concrete, 815
**

**Condensation**, 435

**Condense**, 718, 719, 719 illus.

**Conduction**, 144–145, 144 illus., 145 illus., 160–161 act.

**Conductivity**, 741

**Conductors**, 173, 173 illus., 184 act. See also Semiconductors; grounding and, 176, 176 illus.; metals and, 531 act., 648 illus.

**Conservation**
of energy, 120–129, 128–129 act., 234, 597; of mass, 475, 475 illus., 478–479 act., 582–583, 582 illus., 585, 585 illus.

**Conserve**, 597

**Constants**, 9, 9 table, 59

**Constellations**, 924, 924 illus., 984, 984 illus., 991 illus., 992 illus.

**Constructive interference**, 293, 293 illus.

**Consumers, technology and**, 30, 30 illus.

**Contact**, 108

**Contact by charging**, 174

**Continental climate**, 898

**Continental collision**, 777, 777 illus.

**Continental drift theory**, 770 act., 772–774

**Continental glaciers**, 858–859

**Contract**, 953

**Controls**, 9 table, 10

**Convection**, 145; in the atmosphere, 886, 886 act.; in gases and liquids, 151 act.; plate tectonics and, 778–779, 779

**D**

**Dalton, John**, 491, 491 illus.

**Dams, hydroelectric**, 250–251, 250 illus., 251 illus.

**Dark energy**, 1005

**Dark energy, illus.; thermal energy and, 145–146, 146 illus.

**Convection zone, of the sun**, 993, 993 illus.

**Convergent plate boundaries**, 777, 777 illus., 791, 791 illus.

**Convex lenses**, 408–409, 408 illus., 409 illus., 410 table. See also Optical instruments; Optical telescopes; eyesight and, 411–414, 411 illus., 412 illus., 413 illus., 414 illus.

**Convex mirrors**, 405–406, 405 illus., 406 table. See also Optical instruments; Optical telescopes

**Copper**, 923

**Coppernics, Nicholas**, 951

**Copper, 523, 523 illus., 525, 525 illus., 552 illus., 742, 742 illus.

**Coriolis effect**, 891, 891 act.

**Cornea**, 411, 411 illus.

**Corona**, 993 illus.

**Coronal mass ejections (CMEs)**, 995, 995 illus.

**Cosmic**, 1003

**Cosmic background radiation**, 1002 illus., 1003

**Cosmic rays**, 630

**Cosmology**, 1002–1003; big bang theory, 625, 1002–1004, 1002 illus., 1003 illus., 1004 illus.; composition of the universe, 1004–1005, 1005 illus.; cosmic background radiation, 1002 illus., 1003; Doppler effect, 1003–1004, 1005 illus., 1004 illus., 1006–1007 act.

**Covariant fields**, 561, 561 illus., 562, 706

**Covariant compounds**, 527, 570, 570 illus.

**Crab Nebula**, 506 illus.

**Craters**, 936, 936 illus.; on Mars, 960, 960 illus.; on Mercury, 956; on the Moon, 940–941 act.

**Crests**, 279, 279 illus., 284, 284 illus.

**Cronstedt, Axel Fredrik**, 537 illus.

**Cross-cutting relationships**, 870, 870 illus.

**Cryosphere**, 895, 895 illus.

**Crystal systems**, 812, 812 act., 812 illus.

**Cumulus clouds**, 887, 887 illus.

**Curie, Marie**, 488, 537 illus.

**Curie, Pierre**, 488, 537 illus.

**Currents, electrical**, 209, 629.
Dark matter

Dark matter, 454, 1004–1005
DARPA, 64
Data, analyzing, 10, 21
Davy, Sir Humphry, 537 illus.
Daylight, 926, 926 illus.
Daylight Savings Time (DST), 923
Decay. See Nuclear decay
Decibel, 313, 313 illus.
Decomposition reactions, 591, 591 illus.
Definite, 434
Deforestation, 257, 258, 904
Deformation, 781–782, 782 illus.
Deimos (Mars' moon), 958
Deltas, 857, 857 illus.
Democritus, 491, 492 illus.
Density, 144, 441; buoyancy and, 430 act., 442, 442 act., 442 illus.; measuring, 18, 18 act., 18 table; sound speed and, 308, 308 illus.
Dependent variables, 9, 9 table
Depolymerization, 723, 723 illus.
Deposition, 854; by mass wasting, 862; waves and, 861, 861 illus.
Derived units, 18
Destructive interference, 293, 293 illus.
Detergents. See Soaps and detergents
Detrital sedimentary rocks, 826–827; classification, 827; clast size, 826, 826 illus.; composition, 827, 827 illus.; textures, 826 table, 827 table
Developing countries, technology and, 28, 28 illus.
Development, urban, 257, 257 illus.
Device, 188
Diamonds, 533, 533 illus., 540–541 act.
Diatomic molecules, 527
Diet. See Food and diet
Diffraction, 290–291, 290 illus., 291 illus.
Digital signals, 354, 354 illus.
Direct current (DC), 183, 194, 220
Discontinuity, 789
Displacements, 45–46, 45 illus., 46 illus., 46 table
Dissociation, 659, 659 illus.; of bases, 682, 682 illus., 685, 685 illus.
Distance, 45; motion and, 45, 49–50, 49 illus., 50 illus., 61 act.; sound waves and, 312
Distillation, 460 act., 472, 472 illus.; fractional, 718–719, 719 illus.
Distinct, 199
Distort, 417
Distributaries, 857, 857 illus.
Divergent plate boundaries, 778, 778 illus., 791, 791 illus.
Diverse, 319
DNA (deoxyribonucleic acid), 728–729, 729 illus., 732
Doping, 749–750, 749 illus.
Doppler effect, 315; sound and, 315–316, 315 illus., 316 illus.; speed and direction of galaxies, 1003–1004, 1003 illus., 1004 illus., 1006–1007 act.
Doppler on Wheels (DOWs), 908
Dot diagrams. See Electron dot diagrams
Double displacement reactions, 592, 592 illus.
Downrafts, severe weather and, 893, 893 illus.
Drainage basins, 855, 855 illus.
Drinking water, 868, 868 illus., 876
Dry-cell batteries, 180, 180 illus.
Ductile, 518, 518 illus.
Dwarf elliptical galaxies, 998
Dwarf irregular galaxies, 998
Dwarf planets, 967, 967 illus.

Eardrum, 309
Ear(s), sound waves and, 309–310, 309 illus., 310 illus.
Earth, 917–929. See also Atmosphere; Moon(s); crust of, metals in, 525, 525 illus., 536; crust of, minerals in, 808, 808 illus., 809 table, 814, 814 table; crust of, motion of, 52, 52 illus.; geothermal energy, 252, 252 illus.; gravitational field of, 77–79, 77 illus., 78 prob., 78 table, 79 illus., 89; interior of, 788–790, 788 illus., 789 illus., 790 illus.; life on, 957, 957 illus., 969–970, 969 illus., 970 illus.; measuring time on, 922–924, 922 illus., 923 illus., 924 illus.; meteoroids and, 976; orbit of, 920, 924; radiant energy and, 147, 147 illus., 249, 249 illus.; radiation and, 630, 630 illus.; relative size of, 916 act.; revolution of, 924, 924 illus.; rotation of, 924; seasons on, 925–927, 926 act., 928 act.; seismic waves, 278, 278 illus., 298; size and shape of, 918–919, 919 illus.; temperature of, 33 act., 146, 146 illus., 160–161 act., 162, 239, 957, 957 illus.; ultraviolet waves (UV), 349–350, 349 illus., 350 illus.
Earthquakes, 780–787; causes of, 781–782, 781 illus., 782 act.; damages from, 781 illus., 785 illus., 787 illus.; distribution of, 780–781; epicenters, 782, 782 illus., 786 illus., 798–799 act.; measurement of, 784–786, 784 table, 785 illus., 785 table; seismic waves, 782–784, 783 illus., 783 illus., 784 illus.; visualizing the location of an epicenter, 786 illus.
Earth system, 895–896, 895 illus., 896 illus.
Echo, 287, 324
Echolocation, 324, 325 illus.
Eclipse(s), 933–935, 933 act., 934 illus., 935 illus.
Ecliptic, 924
Ecosystems: hydroelectric dams and, 250, 250 illus.; windmills and, 251, 251 illus.
Eddington, Arthur Stanley, 1008
Edison, Thomas Alva, 194
Efficiency, energy, 110, 110 prob., 262–263 act., 348, 348 illus.
Efficient, 250
Einstein, Albert, 342, 626 illus., 1008
Elastic deformation, 782
Elasticity, sound speed and, 308
Elastic potential energy, 117
Elastic rebound, 782
Electrical energy, 115, 115 illus.; converting fossil fuels, 238–239, 238 illus.; converting geothermal energy, 252, 252 illus.; converting solar energy, 248–249, 248 illus., 249 act., 249 illus., 254 act.; converting water energy, 250–251, 250 illus., 251 illus.; cost of, 190, 191; endergonic reactions and, 596, 596 illus.; generators and, 217–220, 217 illus., 218 illus., 219 illus.; mechanical energy and, 234, 238–239, 238 illus., 250, 250 illus.;
Index

Electric field
- power and, 188–191, 188 illus., 189 prob., 190 prob., 191 table; transformation, 125, 125 illus., 234; transmitting, 222, 222 illus.

Electric field, 172, 172 illus., 202, 339, 339 illus.


Electrolytes, 658–659, 678

Electromagnetic force, 210, 618–619, 618 illus.

Electromagnetic induction, 216, 216 illus.

Electromagnetic spectrum, 984


Electromagnets, 210–213; construction of, 224–225 act.; properties, 211, 211 act.; rotation of, 211, 211 illus.; uses of, 212–213, 212 illus., 213 illus., 218–219, 219 illus., 226

Electron cloud, 493, 493 illus., 502, 502 illus.

Electron dot diagrams, 504, 554–556

Electrons, 489, 489 illus.; mass of, 494, 494 illus., 494 table; valence, 503, 554

Electroscopes, 176–177, 176 illus., 177 illus.

Elements, 462, 488. See also Periodic table; specific element; applications of, 462–464, 462 illus., 463 illus., 464 illus.; discovery and making of, 537–539, 537 illus., 538 illus., 542; electron dot diagrams, 504, 554–556; properties, 508–509 act., 516 act.; supernovas and, 991; transition, 522–523, 522 act., 522 illus., 523 illus.; visualizing the discovery of, 537 illus.

Ellipse, 920, 950, 997

Elliptical galaxies, 998, 998 illus.

El Niño, 905, 905 illus.

Energetic reactions, 596, 596 illus., 597

Endothermic reactions, 596, 596 illus.

Energy, 114–130, 115, 138. See also Chemical energy; Electrical energy; Kinetic energy; Mechanical energy; Nuclear energy; Potential energy; Radiant energy; Solar energy; Thermal energy; Waves; conservation of, 120–129, 128–129 act., 234, 597; dark, 1005; electrical power and, 188–191, 188 illus., 189 prob., 190 prob., 191 table; food and diet, 115, 125, 126, 127; machines and, 109–111, 109 illus., 110 prob., 111 illus.; nuclear reactions and, 626–627, 626 illus., 627 prob.; solutions and, 656; work and, 106–108, 106 illus., 107 prob., 108 illus., 113 act.


Energy transformations, 121–127, 234–235, 235 illus.; chemical, 125; electrical, 125, 125 illus.; falling objects, 121, 121 illus.; friction, 124, 124 illus.; gravitational potential energy, 121–123, 121 illus., 122 illus., 123 illus.; human, 127, 127 table; projectile motion, 59, 59 illus., 122, 122 illus.; speed of, 126, 126 act.; swinging motion, 122, 122 illus., 128–129 act.; visualizing, 123 illus.

Engines: heat, 156, 156 illus.; internal combustion, 157, 157 illus.

Environment. See also Animals; Ecosystems; Energy sources; Pollutants/pollution: disasters, 245, 245 illus., 259, 259 illus.; human impact on, 232 act., 255–261, 902, 902 illus., 904

Example Problems
- Acceleration, 58 prob.; balanced chemical equations, 587 prob.; binary ionic compound, naming a, 568 prob.; Boyle’s law, 449 prob.; carbon dioxide, concentration of, 903 prob.; Charle’s law, 451 prob.; chemical formulas, determining, 567 prob.; efficiency, 110 prob.; electrical currents, 182 prob.; electrical energy, 190 prob.; electrical power, 189 prob.; energy to mass, converting, 627 prob.; force, 444 prob.; gravitational potential energy, 119 prob.; high tides, determining, 930 prob.; kinetic energy, 116 prob.; magma, cooling, 822 prob.; mass of product, total, 476 prob.; measurement, 16 prob.; mechanical advantage, 112 prob.; mid-ocean ridges, spreading along, 775 prob.; momentum, 54 prob.;
Exergonic reactions
power, 126 prob.; pressure, 443 prob.; speed, 47 prob.; surface area, 651 prob.; transformers, magnifying power of, 986 prob.; thermal energy changes, 142 prob.; transformer voltage, 221 prob.; water storage volume, 866 prob.; wave speed, 282 prob.; weight, 78; work, 107 prob.
Exergonic reactions, 595, 595 illus., 597
Exosphere, 885, 885 illus.
Exothermic reactions, 595, 595 illus.
Experiments, 9, 11, 11 illus.
Extrasolar planets, 954
Extraterrestrial life, 970, 972 illus.
Extrusive igneous rocks, 820–823; composition, 821, 821 table, 822 prob.; gases, 823, 823 illus.; textures, 820, 820 illus.
Eye(s): lasers and, 382; lenses and eye-sight, 410–414, 410 illus., 411 illus., 412 illus., 413 illus., 414 illus.; light waves and, 374, 374 illus., 400; optics and, 36

F
Fahrenheit, 20
Fall (season), 925–927, 925 illus., 927 illus.
Faraday, Michael, 216
Farming, organic, 257, 257 illus.
Farsightedness, 413, 413 illus.
Fats and oils, 726–728, 727 illus.
Fault(s), 278 illus., 778 illus., 782
Fermi National Accelerator Laboratory, 490
Fiberglass, 757, 757 illus.
Fibers, optical, 386–387, 386 illus., 387 illus.
Fibers, synthetic, 755–758, 756 illus., 757 illus., 758 illus.
Field, 77, 207
Filters: color and, 375, 375 illus.; light and, 384, 384 illus.
Fission, nuclear, 241–243, 624, 624 illus., 626, 636
Flares, 994
Floodplains, 857, 857 illus.
Fluids. See Liquids
Fluorine, 528, 528 illus., 530
FM radio, 352–354, 352 illus., 353 illus., 354 illus.
Focal length, 402, 418 act., 986, 986 prob.
Focal point, 402, 986, 986 prob.
Focus, 782, 782 illus., 789
Foliation, 831–833, 831 illus., 832 illus., 832 table
Food and diet, 507 act. See also
Biological polymers; acid indigestion/relief, 680, 680 act., 689, 689 illus., 693; acids and bases in, 679, 680; baking, chemistry of, 596, 596 illus.; energy from, 115, 125, 126, 127; flavoring, esters and, 714, 714 illus., 730–731 act.; global technological needs and, 28–29, 28 illus., 29 illus.; iodine, importance of, 529, 558, 558 illus.; nonstick surfaces, 574, 715, 715 illus.; nutritional values, 727; radiation and, 630, 630 illus.; salt, importance of, 689, 690, 690 illus.; selenium in, 536; vitamins, polarity of, 666–667, 666 illus., 667 table
Forced-air heating systems, 152, 152 illus.
Force(s), 70 act., 72–96, 94–95 act., 106. See also Gravity; Pressure; balanced, 73, 73 illus.; calculating, 83, 444; centripetal, 90, 90 illus.; electric charge and, 171–172, 171 illus., 172 illus.; electromagnetic, 210, 618–619, 618 illus.; friction and, 74–75, 74 act., 75, 75 illus.; 120; ions and molecules, between, 572–573 act.; machines and, 111, 111 illus.; motion and, 72, 72 illus.; net, 73, 73 illus.; repulsive, 619, 619 illus.; strong, 572–573 act., 618–619, 618 illus., 619 act., 619 illus., 621–623, 621 table, 622 table; unbalanced, 73, 73 illus.; velocity and, 72, 72 illus.; weak, 572–573 act., 618, 622–623, 622 illus.; work and, 106–108, 108 illus.
Forensics, 729, 732
Forests, environmental impacts on, 257, 258, 904
Formulas. See Chemical formulas
Fossil fuels, 234–240, 235. See also
Petroleum; alternatives to, 253, 253 illus.; carbon cycle and, 903; coal, 235, 235 illus., 237–238, 237 illus., 239; converting to electricity, 238–239, 238 illus.; costs of using, 239–240, 239 illus., 240 illus.; exothermic reactions and, 595, 595 illus.; formation of, 235, 235 illus.; impact of, 33 act., 256, 256 illus.; natural gas, 235, 235 illus., 237, 237 act.; pollutants from, 256, 258–261, 258 illus., 259 illus., 260 illus., 261 illus., 698
Fossils, 871, 969; continental drift theory and, 773, 773 illus.; correlation of, 871, 871 illus.; geologic time and, 871–872, 871 illus., 872 illus.
Fracation distillation, 718–719, 719 illus.
Fracture, 811
Francium, 520, 538
Franck, James, 670
Free fall, 89, 89 illus.
Freezing point, 20, 20 illus., 434, 660, 660 illus.
Frequency, 280, 311. See also Radios/radio waves; compressional waves and, 280–281, 281 illus., 296–297 act.; electromagnetic waves and, 341, 345, 345 illus.; natural, 317; pitch and, 314, 314 illus.
Freshwater: use of in the United States, 867, 867 illus.; water cycle and, 863, 863 illus.
Friction, 74–75, 74 act., 75, 120, 781; centripetal forces, 90, 90 illus.; energy transformations and, 124, 124 illus., 159; plate tectonics and, 778–779, 778 illus.; rolling, 75, 75 illus.; sliding, 75, 75 illus.; static, 74–75, 75 illus.
Frost wedging, 847
Fulcher, R. Buckminster, 534
Fundamental, 622
Fundamental forces, 76. See also
Electromagnetic force; Gravity; Strong force; Weak force
Funding, for technology, 31–32, 31 illus.
Fuses, 188, 188 illus.
Fusion, heat of, 434
Fusion, nuclear, 241, 625–626, 625 illus., 627 prob., 989; evolution of stars and, 990–991, 990 illus., 991 illus., 993, 993 illus.

G
Gadolinium, 524
Galaxies, 997–1001; barred spiral, 1001; dark matter in, 454, 1004–1005; distances between, 997, 997 illus.; elements in, 506, 506 illus.; elliptical, 998, 998 illus.; formation of, 999, 999 illus.; irregular, 998, 998 illus.; spiral, 997, 997 illus.
Galileo, 951, 964
Galileo space probe, 964, 971, 972 illus.
Gallium, 532
Galvanometers, 213, 213 illus.
Gamma rays, 351, 621; nuclear decay, 621–623, 622 table, 623 illus.; radiation therapy and, 351, 351 illus.; tracers and, 630–631, 631 illus.
Ganymede (Jupiter’s moon), 964, 964 illus., 971
Gases: atmospheric, 884–885; behavior
Geiger Counter

of, 447–452; coronal mass ejections (CMEs), 995, 995 illus.; dissolving, 649, 649 illus.; greenhouse effect and, 886, 886 illus., 904, 904 illus., 921, 921 illus., 956; in magma, 823, 823 illus.; radon, 630; solubility of, 654 table, 656–657, 657 illus.; as solutions, 647, 647 illus.; temperature and, 657; thermal energy and, 432–436, 433 illus., 435 illus.; volcanic eruptions and, 793, 794

Geiger counter, 629, 629 illus.

Generators, 217–220, 241; motors vs., 218–219, 219 illus.; simple, 217, 217 illus.; thermal energy and, 159, 159 illus.; uses of, 217–218, 217 illus., 218 illus.; visualizing, 219 illus.

Genesis Rock (Moon), 633, 633 illus.

Geocentric model of the solar system, 950–951, 950 illus.

Geologic time, 869–873; absolute dating, 869–870, 872–872, 873 illus.; fossils, 871–872, 871 illus., 872 illus.; relative dating, 869, 870–871, 870 illus., 871 illus.; time zones, 923 illus.; units of, 869, 869 illus., 870 act.

Geologic time scale, 872, 872 illus.

Geothermal energy, 252, 252 illus.

Germanium, 534

Giant impact theory, 939, 939 illus.

Giant Magellan Telescope (GMT), 422

Giant stars, 991, 991 illus.

Glaciers, 854, 854 illus., 858–859, 858 illus., 859 illus.

Gliise 581d (planetary body), 954 illus.

Gliise 581e (planetary body), 954, 954 illus.

Global positioning system (GPS), 357, 357 illus.

Global warming, 33 act., 239, 904

Global winds, 890–891, 890 illus.

Globular star clusters, 992 illus., 1000, 1000 illus., 1001

Goddard, Robert, 96

Gold, 522, 523, 523 illus., 670, 742, 742 illus.

Goodyear, Charles, 754

Gradient, 890

Grams (g), 588

Granite, 846, 846 illus.

Gran Telescopio Canaria, 422

Granules, 994, 994 illus.

Graphite, 533, 533 illus., 540–541 act.

Graphs, 21–25; bar, 24, 24 illus., 24 table; circle, 25, 25 illus.; line, 22–23, 22 illus., 22 table, 23 illus.; motion, graphing, 49–50, 49 illus., 50 illus., 61 act.; speed-time, 57, 57 illus.

Gravitational potential energy, 118, 118 illus., 119 prob., 126 act.; calculating, 118; conservation of energy and, 120, 120 illus.; energy transformations and, 121–123, 121 illus., 122 illus., 123 illus.; water energy and, 250–251, 250 illus., 251 illus.

Gravity, 76, 87, 170; acceleration and, 87–89, 87 illus., 88 illus., 89 illus.; Earth’s shape and, 919, 919 illus.; electrical force and, 172, 618; magnetic field, 920, 920 illus.; projectile motion and, 59, 59 illus., 122, 122 illus.; Saturn’s rings and, 965, 965 illus.; universal gravitation, law of, 76–79, 76 illus., 77 illus., 78 prob., 78 table, 79 illus.

Great Lakes, 859, 899, 899 illus.

Great Red Spot (Jupiter), 963, 963 illus.

Greenhouse effect, 886, 886 illus., 904, 904 illus.; Venus and, 921, 921 illus., 956

Greenland, 858

Gregor, William, 537 illus.

Grounding, 176, 176 illus.


Group, 518

Group 14. See Carbon group

Group 16. See Oxygen group

Group 17. See Halogen group

Gusev Crater (Mars), 960, 960 illus.

Gypsum, 571 illus.

H

Hailey’s comet, 967 illus.

Half-life, 632–633, 632 act., 632 illus., 633 illus., 639, 872

Halocarbons, 715, 715 illus.

Halogen group, 528–529, 528 illus., 529 act., 529 illus.

Hardness, 811, 811 table

Hawaii, volcanic activity, 792, 792 illus., 794, 794 illus., 795, 796 illus.

Hazardous waste, 257

Health and medicine. See also Food and diet; alloys, 745, 745 illus.; bases, 680; ceramics, 748; chemical change of drugs, 472, 472 illus.; fluoride, 528, 528 illus.; global technological needs and, 28–29, 28 illus., 29 illus.; holography, 385; lasers, 382; magnetic resonance imaging (MRI), 346, 346 illus.; polytetrafluoroethylene (PTFE), 574; radiation, effects of on humans, 623, 630, 630 illus.; radiation therapy, 351, 351 illus., 630–631, 631 illus.; safe water, 876; thyroid gland, 529, 558, 558 illus., 631, 631 illus.; ultrasound, 327, 327 illus.; X-rays and gamma rays, 350, 350 illus., 351, 351 illus., 360, 521, 630 illus.

Hearing loss, 310

Heat, 140–143, 141 table; animals and, 148, 148 illus., 660; controlling of, 148–150, 148 illus., 149 act., 149 illus., 150 illus.; melting point, 434, 572–573 act.; thermodynamics and, 154–155, 154 illus., 155 illus.

Heat engines, 156, 156 illus.

Heating, in the atmosphere, 886, 886 illus.

Heating curves, 436, 436 illus.

Heating systems, 152–153, 152 illus., 153 illus.

Heat of fusion, 434

Heat of vaporization, 435

Heat pumps, 159

Heavy-Ion Research Laboratory, 505, 542

Height, gravitational potential energy and, 118

Heliocentric longitude, 952

Heliocentric model of the solar system, 951–952, 951 act., 951 illus.

Helium; atomic number, 617, 617 illus.; balloons and, 530; chemical bonding, 555

Hemisphere, 925

Henry, Joseph, 216

Hermitage, on Mars, 960

Hertz, Heinrich, 342

Hertz (Hz), 280

Hertzsprung, Einjar, 989

Hess, Harry, 774–776, 774 illus., 775 illus., 776 illus.

Heterogeneous mixtures, 465–466, 465 illus., 466 illus.

Heyser, George de, 670

High pressure, 891, 891 illus.

High tides, 930 illus., 931, 931 illus.

Hiroshima, Japan, 624, 636

HIV (human immune deficiency virus), 732

Holography, 385, 385 illus.

Homogeneous mixtures, 467, 467 illus., 646
Horizontal motion

Horizontal motion, 59–60, 59 illus., 60 illus.

Horn, Lyle, 900

Hot-air balloons, 437, 437 illus.

Hot spots, volcanic, 791 illus., 792, 792 illus., 797 act.

Household circuits, 187–188, 187 illus., 188 illus.

How Science Works: dark matter, detecting, 454; element creation, 542; invisibility, reflection and, 298; life beyond Earth, 510; molecular clocks, 732; scientific methods, founding of, 36; X-rays, 360

H–R diagram, 989, 989 illus., 992 illus., 996 act.

Hubble, Edwin, 1002, 1003

Hubble Space Telescope (HST): Doppler effect and, 1004, 1004 illus.; images obtained from, 987, 987 illus., 998 illus.; PTFE protective coating on, 574; reflecting properties of, 417, 417 illus.

Humans. See also Food and diet; Health and medicine: composition of, 526, 526 illus.; environmental effects of, 232 act., 255–261, 902, 902 illus., 904

Human waste, 259

Hurricanes, 894, 894 illus.

Hutton, James, 870

Hydra (Pluto’s moon), 967 illus.

Hydrides, 570–571, 570 act., 571, 571 illus.

Hydraulic lifts, 444, 444 illus.

Hydrocarbon polymers, 721, 721 table

Hydrocarbons, 707–711. See also Substituted hydrocarbons; bonding, 708–710, 708 illus., 708 table, 709 illus., 710 act., 710 illus.; carbon rings, 710–711, 711 illus.; isomers, 709–710, 709 illus., 710 act., 710 illus.; sizes, 708, 708 illus., 708 table; on Titan (Saturn’s moon), 965, 973 illus.

Hydroelectricity, 250–251, 250 illus., 251 illus.

Hydrofluoric acid, 528, 528 illus.

Hydrogen, 526, 526 illus., 527; chemical bonding and, 555; covalent bonding and, 561, 561 illus.; helium vs., 530

Hydrogen chloride, 562, 562 illus., 563; ionization, 658, 658 illus.

Hydrogen fuel cells, 253

Hydrogen peroxide, 536, 536 illus.

Hydronium ions, 678

Hydrosphere, 895, 895 illus.

Hydroxide ions, 680

Hypothesis, 9, 772

Ibn al-Haytham, 36

Ice, sublimation and, 435, 435 illus., 436, 436 illus.

Ice age, climate changes and, 901, 901 illus.

Igneous rocks, 817–823; extrusive, 820–823, 820 illus., 821 table, 822 prop.; identification of, 836–837 act.; intrusive, 817–819, 817 illus., 818 illus.; from the moon, 936; rock cycle and, 833–835, 833 illus., 834 illus.

Impact, 937

Incandescent light, 378, 378 illus., 379 act.

Inclined planes, 109 illus., 113 act.

Incoherent light, 382, 382 illus.

Independent variables, 9, 9 table

Index of refraction, 370

Indictor, 678

Indium, 532

Induction, charging by, 174, 174 illus.

Industrialized, 26

Industrialized countries, technology and, 29

Industry, environmental impact of, 258, 258 illus.

Inertia, 80–81, 80 illus., 81 act.

Infer, 10, 826

Infiltration, water cycle and, 863, 864, 866, 866 illus.

Infrared waves, 348, 348 illus.

Inhibitors, chemical, 601

Inner planets, 953, 953 illus., 955–962. See also specific planet; diameters of, 964 act.; Earth, 957, 957 illus.; Mars, 957–962, 957 illus., 962 act., 971, 971 illus.; Mercury, 955–956, 955 illus.; Venus, 956, 956 illus.

Inner transition metals, 524, 524 illus.

Instruments, musical, 319–321, 319 illus., 320 illus., 321 illus.

Insulators, 173; architectural, 149, 162; ceramic, 747; electrical, 173, 173 illus.; identifying, 184 act.; thermal, 149, 149 illus., 150, 150 illus.

Integrated circuits, 750, 750 illus.

Intensity, 311–312, 312 illus.

Interference, 292–294, 292 illus., 293 illus., 294 illus., 384

Internal, 386

Internal combustion engines, 157, 157 illus.

International Astronomical Union (IAU), 967

International Date Line (IDL), 923

Kepler, Johannes

International System of Units (SI), 15, 15 table, 19 table, 178

Internet, 28

In the Field: acid precipitation, 698; automated cars, 64; capturing a tornado, 908; optical scanning of old texts, 392; polymer fibers, 762; Yellowstone supervolcano, 800

Intrusive igneous rocks, 817–819; magma composition, 818–819, 818 illus.; textures, 819, 819 illus.

Investigation, science and, 6, 7, 8

Invisibility, refraction and, 298

Iodine: as a halogen, 528; potassium iodide, 553, 553 illus., 559, 559 illus.; thyroid gland and, 529, 558, 558 illus.; tracers and, 631, 631 illus.

Io (Jupiter’s moon), 964, 964 illus.

Ionic bonds, 519, 519 illus., 560, 560 illus., 808

Ionization, 658, 684; of acids, 682, 682 illus., 685; of bases, 683, 683 illus., 685

Ions, 558–560, 565, 568; formation of in solution, 658–659, 658 illus., 659 illus.; ionic bonds, 519, 519 illus., 560, 560 illus.; molecules vs., 572–573 act.; transfer of electrons, 559, 559 illus.

Iron, 522

Irregular galaxies, 998, 998 illus.

Isohyets, 898 illus.

Isomers, 709–710, 709 illus., 710 act., 710 illus.

Isotopes, 496–497, 497 illus., 617, 617 illus.; absolute dating and, 872–873, 873 illus.; radioactive, 496, 620, 620 illus.

James Webb Space Telescope, 417, 987

Japan, 624, 636

Jet streams, 891

Joule (unit of work), 107, 110, 114

Jovian planets, 953, 953 illus.

Jupiter, 963–964; atmosphere of, 963, 964; clouds on, 963, 963 illus.; exploration of, 964, 971, 971 illus., 972 illus.; life on, 964, 970, 971; moons of, 964, 964 illus., 971, 971 illus., 972 illus.; motion of, 951, 951 act.; temperature on, 963

Kelvin, Lord, 12

Kelvin (K), 20, 139

Kepler, Johannes, 952
Index

Kevlar, 762

Kilowatt hours (kWh), 190

Kinetic, 122

Kinetic energy, 116, 116 prob., 117 act., 128–129 act., 440; calculating, 116; conservation of energy and, 120, 120 illus.; energy transformations and, 121–123, 121 illus., 122 illus., 123 illus.; temperature and, 136 act., 138–139, 138 illus.; thermal energy and, 139, 139 illus.

Kinetic theory, 432–434; Charles’s law, 450–451, 450 illus., 451 prob.; gas state, 432–433, 432 illus.; liquid state, 433, 433 illus.; solid state, 433, 433 illus.; temperature and, 434; thermal energy and, 434

Krypton, 530

Kuiper Belt, 967, 968

Kwolek, Stephanie, 762

Liquid crystal display (LCD)
energy and, 272 act.; work with simple machines, 104 act.

Lava, 929. See also Magna; viscosity of, 793, 793 act.; volcano formation and, 790

Lavoisier, Antoine-Laurent, 582–583, 585, 585 illus., 590, 608

Lawrence Berkeley National Laboratory, 542

Law(s): of conservation of charge, 171; of conservation of energy, 120, 234, 597; of conservation of mass, 475, 475 illus., 478–479 act., 582–583, 582 illus., 585, 585 illus.; Newton’s first law of motion, 80–81, 80 illus., 81 act.; Newton’s second law of motion, 81–83, 83 prob., 87–90; Newton’s third law of motion, 84–85, 84 illus., 85 illus., 92, 92 illus.; of thermodynamics, 155; universal gravitation, 76–79, 76 illus., 77 illus., 78 prob., 78 table, 79 illus.; use of in science, 13

Lead, 464, 534, 838

Lead-acid batteries, 181

Lead sulfide, 527, 527 illus.

Le Chatelier’s principle, 603–604, 603 illus.

Length, measuring, 16–17, 16 illus., 17 illus.

Lenses, 398 act., 408–414, 410 table. See also Eye(s); Optical instruments; Optical telescopes

Levers, 109 illus.

Lewis, G.N., 504

Light, optics and, 36

Light bulbs, 125 illus., 126, 379 act.

Light filters, 384, 384 illus.

Lightning: cloud formation and, 887; electricity and, 174–176, 175 illus., 176 illus.; thunderstorms and, 893, 893 illus.


Light-years, 988

Linearly polarized light, 384, 384 illus.

Line graphs, 22–23, 22 illus., 22 table, 23 illus.

Lipids, 726–728, 727 illus.

Liquid crystal display (LCD), 439, 439 illus.

Liquids. See also Dissolving; boiling
Index

Metals
Magnetic field, 957–962; atmosphere, 958; color of, 957; comparison to Earth, 921; exploration of, 958–960, 958 illus.; life on, 957, 959, 961, 961 illus.; moons of, 958; orbit of, 957; seasons on, 957; surface of, 958–960, 958 illus.; temperature on, 958; water on, 958, 959, 959 illus.; winds on, 957
Mars Exploration Rovers, 958, 960, 960 illus., 971
Mars Global Surveyor spacecraft, 960
Mars Odyssey orbiter spacecraft, 960
Mars Pathfinder spacecraft, 960
Mars Reconnaissance Orbiter spacecraft, 958, 958 illus., 960, 971, 971 illus.
Mass, 70 act., 72, 494; atoms and, 494–497, 494 illus., 494 table; calculating, 476 prob.; conservation law of, 475, 475 illus., 478–479 act.; 582–583, 582 illus.; 585, 585 illus.; inertia and, 81, 81 act.; Newton’s second law and, 81–83, 83 prob., 87–90; nuclear reactions and, 626–627, 626 illus., 627 prob.; thermal energy and, 140; weight vs., 78
Mass-energy equivalent, 626–627, 627 prob.
Mass number, 495–497, 495 table, 497 illus.
Mass wasting, 862, 862 illus.
Meander, 856
Measurement, 14–20. See also specific measurement; chemical, 588–589, 588 table; density, 18, 18 act., 18 table; of earthquakes, 784–786, 784 table, 785 table, 786 illus.; of geologic time, 869–873, 870 act.; length, 16–17, 16 illus., 17 illus.; matter, 18, 18 act., 18 table; systems of, 14–15, 14 illus., 15 table, 16 prob., 19 table; time and temperature, 19–20, 19 table, 20 illus.; units and standards, 14; volume, 17
Mechanical advantage, 111, 112 prob., 113 act., 124, 124 illus.
Mechanical energy, 115, 121, 121 illus., 130, 152; electrical energy and, 234, 238–239, 238 illus., 250, 250 illus.; friction and, 124, 124 illus., 159; generators and, 159, 159 illus., 217–220, 221 illus., 218, 219 illus.; thermal energy and, 124, 156–159, 156 act., 156 illus., 157 illus., 158 illus., 159 illus.
Mechanical waves, 276–278
Mechanical weathering, 847, 847 illus.
Medicine. See Health and medicine
Medium, 276, 277
Melting point, 434, 572–573 act., 790
Mendelev, Dmitri, 498, 499, 499 table
Mercalli Scale, 785, 785 table
Mercaptans, 715, 715 illus.
Mercury, 518, 523, 955–956, 955 illus., 970
Mercury oxide reaction, 582–583, 585, 585 illus.
Meridians (Mars), 960, 960 illus.
Mesosphere, 885, 885 illus.
Mesozoic Era, 976
Messenger spacecraft, 956
Metal detectors, 226
Metallurgic bonding, 519, 519 illus.
Metalloids, 505, 505 illus., 508–509 act., 532
Metals, 518–525. See also Nonmetals; specific metal; alkali, 520, 520 illus.; alkaline Earth materials, 521, 521 illus.; bonding in, 519, 519 illus.; conductors and, 531 act., 648 illus.; in the Earth’s crust, 525, 525 illus., 790, 790 illus.; halogens, 528–529, 528 illus., 529 illus.; inner transition, 525, 525 illus.; mixed groups, 532–536, 532 illus., 533 illus., 534 illus., 535 illus., 536 illus.; nobel gases, 530, 530 illus.; periodic table and, 505, 505 illus.,
Index

Metamaterials
508–509 act.; properties, 518–519, 518 illus., 519 illus., 531 act.; uses of, 838

Metamaterials, 298

Metamorphic rocks, 830–837; classification, 833; composition, 831; identification of, 836–837 act.; regional and contact metamorphism, 830; rock cycle and, 833–835, 833 illus., 834 illus.; textures, 831–833, 831 illus., 832 illus., 832 table

Metamorphism, 830–835, 832 table

Meteorites, 790, 961, 961 illus., 976; vs. meteoroids, 967

Meteoroids, 967

Meter (M), 44

“Methane cycle,” 510

Methods. See Scientific methods, steps in

M-5 globular star cluster, 992 illus.

Microbes, water pollution and, 876

Microclimates, 889, 906–907 act.

Microorganisms: in extreme environments, 957, 957 illus., 970, 970 illus.; on Mars, 961, 961 illus.; production of gases and, 885

Microscopes, 418, 418 illus.

Microwave ovens, 344 act., 347, 347 act., 347 illus.

Microwaves, 347, 347 act., 347 illus., 356, 1003

Mid-ocean ridge system (MOR), 774–777, 774 illus., 775 illus., 775 prob., 776 illus.; divergent plate boundaries and, 778, 778 illus.

Milky Way galaxy, 997, 998, 1000–1001, 1000 illus., 1001 illus.

Minerals, 525, 808–816, 809. See also specific mineral; atomic arrangement, 810; in the Earth’s crust, 808, 808 illus., 809 table; formation of, 812–813; groups, 813–814, 813 illus., 814 table; identifying, 810–812, 810 illus., 811 illus., 811 table, 812 illus.; physical properties of, 809, 816 act.; uses of, 815

Mines and mining: land, 226; mineral, 525, 525 illus.; salt, 691 illus.


Mirages, 372, 372 illus.

Mirrors, 400–407, 403 act., 406 table, 407 act. See also Optical instruments; Optical telescopes

Mississippi River, 855, 855 illus., 857, 857 illus.

Mixtures, 465–468, 477 act.; colloids, 466–467, 466 illus., 467 illus.; heterogeneous, 465–466, 466 illus., 466 illus.; homogeneous, 467, 467 illus., 646; separating, 465 act., 470, 470 illus.; substances vs., 468, 468 illus.


Modulation, 352–353, 353 illus.

Mohorovičić, 789

Mohs Scale of Hardness, 811, 811 table

Molar mass, 589

Molecular clocks, 732

Molecules, 561–564. See also Nonpolar molecules; Polar molecules; chemical bonding, 561–562, 561 illus., 562 act.; equal and unequal sharing, 562, 562 illus., 563, 563 illus.; ions vs., 572–573 act.

Moles, 588–589, 588 table

Momentum, 54, 86; calculating, 54; colliding objects, 91, 91 illus.; conservation of, 91, 91 illus.; motion and speed, 54–55, 54 prob., 54 table, 55 illus., 62–63 act.; rocket propulsion, 92, 92 illus.

Mono Lake (CA), 970, 970 illus.

Monomers, 720; nucleotides, 728, 728 illus.; polymers, 720, 720 illus., 723; protein, 724–725, 724 illus.

Moonlight, 931

Moon phases, 931, 933 act. See also Lunar phase cycle

Moon(s), 929–941; age of, 936; Apollo space missions, 96, 633, 633 illus., 936–942, 940–941 act.; eclipses, 933–935, 933 act., 934 illus., 935 illus.; giant impact theory, 939, 939 illus.; gravitational fields and, 79 illus.; igneous rocks from, 936; interior of, 937, 937 illus.; of Jupiter, 964, 964 illus., 971, 971 illus., 972 illus.; lunar phase cycle, 929, 931–933, 932 illus., 933 act.; of Mars, 958; of Neptune, 966; origin of, 936, 938–939, 938 illus., 939 illus.; of Pluto, 967, 967 illus.; relative size of, 916 act.; revolution and rotation of, 929, 929 illus.; of Saturn, 310, 965, 965 illus., 973, 973 illus.; surface features, 935–936, 936 illus., 940–941 act.; tidal effects of, 930–931, 930 prob., 931 illus.

MOR. See Mid-ocean ridge system (MOR)

Moraines, glacial deposition and, 859, 859 illus.
Moral issues
Moral issues, 32, 32 illus.
Moseley, Henry G. J., 499
Motion, 44–64. See also Kinetic energy; Speed; Velocity; acceleration and,
56–60, 57 act., 58 prob.; circular, 59,
59 illus.; distance, 45, 49–50, 49 illus.,
50 illus., 61 act.; Earth's crust and,
52, 52 illus.; force and, 72, 72 illus.;
graphing, 49–50, 49 illus., 50 illus.,
61 act.; horizontal, 59–60, 59 illus.,
60 illus.; matter and, 138, 138 illus.;
momentum, 54–55, 54 prob., 54 table,
55 illus., 62–63 act.; Newton's first law
of, 80–81, 80 illus., 81 act.; Newton's
second law of, 81–83, 83 prob., 87–90;
Newton's third law of, 84–85, 84 illus.,
85 illus., 92, 92 illus.; position and,
44–46, 44 illus., 45 illus., 46 illus., 46
table; projectile, 59, 59 illus., 122, 122 illus.; reference points and, 44–45, 44 illus., 45 illus.; relative, 53, 53 illus.;
speed and, 46–50, 47 prob., 47 table,
48 act., 53, 53 illus.; swinging, 122,
123 illus., 128–129 act.; velocity and,
51–53, 51 illus., 52 illus., 53 illus.,
62–63 act.; work and, 106
Motors: electric, 213–215, 213 illus., 214 illus., 215 illus.; generators vs.,
218–219, 219 illus.; visualizing, 219 illus.
Mountains: climate and, 899, 899 illus.;
continental drift theory and, 774, 774 illus.;
on the moon, 936
Mount Etna (Sicily), volcanic activity,
795, 795 illus.
Mount Rainier (WA), volcanic activity,
796 illus.
Mount St. Helens (WA), eruption of,
800
MP3 players, 212, 212 illus., 328–329 act.
MRI (magnetic resonance imaging), 346 illus.
Mudslides, 862, 862 illus.
Music, 317–323; instruments, 319–321,
319 illus., 320 illus., 321 illus.;
mechanical, 330; pitch, 314, 314 illus.,
323 act.; standing waves in, 294, 294 illus.; vibration and, 319–321, 319 illus., 320 illus., 321 illus.

Nagasaki, Japan, 636
Nanotubes, 534, 534 illus.
NASA. See also Space exploration;
Telescopes: Apollo space missions,
96, 633, 633 illus., 936–942, 940–941 act.; choosing materials, 8, 9, 574;
Safeguard Survey, 976; use of comput-
ers, 12
Natural gas, 235, 235 illus., 237, 237 act.
Navigation, satellites and, 357, 357 illus.
Neap tides, 931, 931 illus.
Near-Earth-asteroids (NEAs), 976
Nearsightedness, 414, 414 illus.
Nebraska, 953, 989
Neon light, 379, 379 illus., 530, 530 illus.
Neptune, 79, 966, 966 illus.
Neutonism, 538
Net force, 73, 73 table
Neutrons, 489, 489 illus.; mass of, 494,
494 illus., 494 table; 495, 495 table;
nuclear force and, 618–619, 618 illus.,
619 illus.
Neutron stars, 991
Newton, Sir Issac: motion, first law of,
80–81, 80 illus., 81 act.; motion, sec-
ond law of, 81–83, 83 prob., 87–90;
motion, third law of, 84–85, 84 illus.,
85 illus., 92, 92 illus.; universal gravitation,
law of, 76–79, 76 illus., 77 illus., 78 prob., 78 table, 79 illus.
NGC 4449 (galaxy), 998 illus.
Nickel, 522
Nitrogen, 526, 526 illus., 535, 535 illus.
Nitrogen group, 535, 535 illus.
Nix (Pluto's moon), 967 illus.
Nobel prize, 670
Noble gases: chemical bonding, 554–
555, 554 illus.; periodic table and, 504,
526, 530, 530 illus.
Nodes, 294
Noise, 317
Non-electrolytes, 658
Nonfoliated rocks, 833
Nonmetals, 526–530; bonding in, 519,
519 illus., 527, 527 illus.; periodic
Table and, 505, 505 illus., 526, 526 illus.;
properties, 508–509 act., 526–
527, 526 illus., 527 illus., 531 act.
Nonpolar bonds, 562
Nonpolar molecules, 689; bonding and,
563–564, 564 act., 564 illus.; dissolv-
ing and, 663–665, 663 illus., 664 illus.,
665 act., 665 illus.; vitamins and,
666–667, 666 illus., 667 table
Nonrenewable resources, 240, 240 illus.
Nonsilicates, 814, 814 table
Nonstick surfaces, 574, 715, 715 illus.
Nuclear bombs, 624, 636
Nuclear bulge, 1001–1002, 1001 illus.
Nuclear chain reactions, 243, 243 illus.,
624, 624 illus., 627, 628 act.
Nuclear decay: alpha particles, 621–623,
621 table, 623 illus., 634–635 act.;
beta particles, 621–623, 622 table,
623 illus., 634–635 act.; damage from,
623, 623 illus.; gamma rays, 621–623,
622 table, 623 illus.; half-life, 632–633,
632 act., 632 illus., 633 illus., 639;
transmutation, 623, 623 illus.
Nuclear energy, 241–247; benefits and
risks, 244–245, 245 illus.; disposal of
nuclear waste, 246–247, 247 illus.;
geothermal heat and, 252, 252 illus.
Nuclear fission, 241–243, 624 illus.,
626, 636
Nuclear fusion, 241, 625–626, 625 illus.,
989; evolution of stars and, 990–991,
990 illus., 991 illus., 993, 993 illus.
Nuclear power plants, 244–245, 244 illus.,
245 illus., 624, 624 illus.
Nuclear reactors, 242–243, 242 illus.,
243 illus.
Nuclear waste, 246–247, 247 illus.
Nucleic acids, 728–729, 728 illus., 729 illus.
Nucleotides, 728
Nucleus, 616–620, 884; forces in,
618–619, 619 illus., 619 act.; isotopes,
617, 617 illus.; radioactivity and,
620, 620 illus.; size of, 614 act.,
616, 616 illus.
Nutrition. See Food and diet
Nylons, 755, 756, 756 illus.

Optical instruments
Optical instruments, 415–422; cameras,
419, 419 illus.; microscopes, 418, 418 illus.; telescopes, 415–417, 415 illus.,
Index

Optical scanners
416 illus., 417 illus., 420–421 act., 422, 574
Optical scanners, 388, 388 illus.
Optics, adaptive, 987
Optics, founding of, 36
Orbit, 918, 920, 924
Ores, 525
Organic, 707
Organic acids, 713, 713 illus., 717 act.
Organic farming, 257, 257 illus.
Original horizontality, 870
Orion constellation, 984, 984 illus., 991 illus.
Outer planets, 953, 953 illus., 963–968. See also specific planet; diameters of, 964 act.; dwarf planets, 967, 967 illus.; Jupiter, 951, 951 act., 963–964, 963 illus., 964 illus., 970, 971, 971 illus., 972 illus.; Saturn, 965, 965 illus., 973, 973 illus.; Uranus, 966, 966 illus.
Overtones, 318, 318 illus.
Oxidation, 848, 848 illus.
Oxidation numbers, 565–567, 566 illus., 566 table, 571, 577
Oxidation-reduction reactions, 593, 593 illus.
Oxygen: in the atmosphere, 884, 884 illus.; chemical weathering and, 848, 848 illus.
Oxygen group, 536; covalent bonding and, 561, 561 illus.; substituted hydrocarbons and, 712–714, 713 illus., 714 illus., 717 act., 730–731 act.
Ozone layer, ultraviolet waves (UV), 349–350, 349 illus., 350 illus.

Pagers, 355
Pangaea, 52 illus., 770 act., 772, 772 illus.; evidence of, 773, 773 illus.
Parabolic troughs, 249
Parallel, 777
Parallel circuits, 185–186, 185 illus., 186 illus., 192–193 act.

Parkes, Alexander, 754
Parks, environmental impacts on, 258, 258 illus.
Pascal, Blaise, 442
Pascal’s principle, 442–444, 443 prob., 444, 444 prob.
Pascal (unit of measure), 443
Passive solar heating, 153
Peer review, process of, 11
Penumbra, 934
Perey, Marguerite, 537 illus.
Periodic table of elements, 498–506, 507 act. See also specific element or group; atoms and, 502–504, 502 illus., 503 act., 503 illus., 504 illus.; elements, organizing of, 498–501, 498 act., 498 illus., 498 table, 500–501 illus.; parts of, 502, 505, 505 illus.
Periods (of time), 83
Periods (of waves), 280–281
Perpendicular, 286
Petroleum, 236, 718–723. See also Oil; formation of, 235, 235 illus.; processing, 718–719, 718 illus., 719 illus.; uses for, 236, 236 illus., 720–723, 720 illus., 721 table, 722 illus., 723 illus.
PH, 686–687, 686 illus., 687 illus.
Phobos (Mars’ moon), 958
Phosphors, 524
Phosphorus, 526, 535, 535 illus.
Photochemical smog, 260, 260 illus.
Photons, 342
Photosphere, 993 illus., 994
Photosynthesis, 885, 903
Photovoltaic cell, 248, 248 illus.
Physical change, 471–472, 471 illus., 472 illus., 854; weathering as, 474, 474 illus.
Physical properties, 469–472, 469 illus., 470 illus., 471 illus., 472 illus., 809
Pigments, paint, 376–377, 377 illus.
Pitch, 314, 314, 314 illus., 323 act.
Plane mirror, 401–402, 401 illus., 406 table
Planets, 79, 510. See also Solar system; specific planet; extrasolar, 954, 954 illus.; heliocentric longitude of, 952; inner, 953, 953 illus., 955–962, 962 act., 964 act.; life on, 957, 957 illus., 959, 961 illus., 964, 969–973, 974–975 act.; outer, 963–968, 964 act.
Plasma, 436, 687, 687 illus.
Plastic deformation, 782
Plastics, 755. See also Polymers
Plate boundaries, 776–778, 776 illus., 777 illus., 778 illus.
Potential energy, 777 illus., 778 illus.
Plate tectonics, 772–779; asthenosphere and, 790, 790 illus.; continental drift theory and, 772 act., 772–774; motion and, 52, 52 illus.; rate of movement, 797 act.; seafloor spreading theory, 774–776, 774 illus., 775 illus., 775 prob., 776 illus.; thermal energy and, 778–779, 778 illus., 779 illus.
Platinum, 522, 525
Pleiades star cluster, 992 illus.
Pluto, 967, 967 illus.
Plutonic rocks. See Intrusive igneous rocks
Plutonium, 538
Polar, 667
Polar bonds, 563, 563 illus.
Polarized light, 384, 384 illus., 390–391 act.
Polar molecules, 563, 646; bonding and, 563–564, 563 illus., 564 act.; dissolving and, 663–665, 663 illus., 664 illus., 665 act., 665 illus.; vitamins and, 666–667, 666 illus., 667 table
Political process, technology funding and, 31, 31 illus.
Pollutants/pollution, 256; acid precipitation, 260, 676 act., 698; air, 259–261, 259 illus., 260, 261 illus.; detergents and, 695, 695 illus.; reducing, 261, 261 illus.; water, 258–259, 259 illus., 695, 695 illus., 876
Polynuclear, 569, 569 illus.
Polyesters, 722, 722 illus., 722 table, 755
Polyethylene, 754
Polymer, 720–723, 721, 753. See also Biological polymers; composites, 757–758, 757 illus., 758 illus., 760–761 act.; depolymerization, 723, 723 illus.; fibers of, 762; history of, 753, 754, 754 illus.; hydrocarbon, 721–722, 721 table, 722 illus., 722 table; making, 720, 720 illus., 753, 753 illus.; properties, 721, 754; using, 755–758, 755 illus., 756 illus., 757 illus., 758 illus.
Polytetrafluoroethylene (PTFE), 574
Polyurethane, 755, 757
Pore space, 825, 863
Porosity, 866, 866 illus.
Position, motion and, 44–46, 44 illus., 45, 45 illus., 46 illus., 46 table
Potassium, 520, 553, 553 illus., 559, 559 illus.
Potassium iodide, 553, 553 illus., 559, 559 illus.
Potential energy, 117–123, 119 prob.
Power
128–129 act.; conservation of energy and, 120, 120 illus., 234; energy transformations and, 121–123, 121 illus., 122 illus.

Power, 126, 126 act., 126 prob., 185; calculating, 126; electrical, 188–191, 188 illus., 189 prob., 190 prob., 191 table

Power plants, 218, 218 illus., 239; nuclear, 244–245, 244 illus., 245 illus., 624, 624 illus.

Practice Problems: acceleration, 58 prob.; balanced chemical equations, 587 prob.; binary ionic compound, naming a, 568 prob.; Boyle’s law, 449 prob.; carbon dioxide, 903 prob.; Charles’s law, 451 prob.; chemical formulas, determining, 567 prob.; efficiency, 110 prob.; electrical currents, 182 prob.; electrical energy, 190 prob.; electrical power, 189 prob.; energy to mass, converting, 627 prob.; force, 444 prob.; gravitational potential energy, 119 prob.; kinetic energy, 116 prob.; magma, cooling, 822 prob.; mass of product, total, 476 prob.; measurement, 16 prob.; mechanical advantage, 112 prob.; mid-ocean ridges, spreading along, 775 prob.; momentum, 54 prob.; power, 126 prob.; pressure, 443 prob.; speed, 47 prob.; surface area, 651 prob.; telescopes, magnifying power of, 986 prob.; thermal energy, 142 prob.; tides, 930 prob.; transformer voltage, 221 prob.; water storage volume, 866 prob.; wave speed, 282 prob.; weight, 78 prob.; work, 107 prob.

Praseodymium, 524

Precipitate, 592, 670, 824

Precipitation. See also Rain: climate and, 898, 898 illus.; cloud formation and, 887, 887 illus.; water cycle and, 863, 863 illus.

Pressure, 443–444, 443 prob., 444 illus.; 598. See also Air pressure; Boyle’s Law, 447–450, 447 illus., 448 illus., 449 prob., 450 act.; calculating, 443, 444; chemical reaction rates and, 600, 600 illus.; equilibrium and, 604; solubility and, 657, 657 illus.

Primary, 220

Primary waves, 783, 783 illus., 789

Prime meridian, 923

Principle of superposition, 870

Prisms, 371, 371 illus.

Process, 692

Products, 582

Projectile motion, 59, 59 illus., 122, 122 illus.

Promethium, 538

Prominences, 993 illus., 994, 994 illus.


Proteins, 724–725, 724 illus., 725 illus., 729

Protons, 489, 489 illus.; atomic number and, 495, 495 table; mass of, 494, 494 illus., 494 table; nuclear force and, 618–619, 618 illus., 619 act., 619 illus., 621–623, 621 illus.; quarks and, 490

Ptolemy, 36, 951

Pulleys, 109 illus.

PVC (polyvinyl chloride), 754

Pyroclastic material, 793, 794, 794 illus.

Quarks, 489–490, 489 illus., 490 illus.

Quartz: color, 810, 810 illus.; composition, 827, 827 illus.; in Earth’s crust, 814, 814 table; formation, 818, 819 illus.; fracturing of, 811; hardness, 811, 811 table; uses of, 811 table, 815, 838

Radar, 346

Radiant energy, 115, 115 illus., 248; Earth and, 147, 147 illus., 249, 249 illus.; sun and, 147, 147 illus., 249, 249 illus., 625–626, 625 illus., 627 prob.; transformation of, 125, 125 illus.

Radiation, 345, 629–633; background, 630, 630 illus.; detecting, 629, 629 illus.; humans, effects on, 623, 630, 630 illus.; medicine, use of in, 351, 351 illus., 630–631, 631 illus.; thermal energy and, 147, 147 illus.

Radiation therapy, 351, 351 illus., 630–631, 631 illus.

Radiation zone of the sun, 993, 993 illus.

Radiator heating systems, 153

Radioactive elements, 520

Radioactive isotopes, 496, 620, 620 illus.

Radioactive radium, 521

Radioactive waste, 246–247, 247 illus.

Radioactivity, 620, 869. See also Nuclear decay; half-life, 632–633, 632 act., 632 illus., 633 illus.; power plants and, 245, 245 illus.; technology and, 629–631, 629 illus., 630 illus., 631 illus.

Radiometric dating, 633, 633 illus.


Radio telescopes, 987, 987 illus., 1001, 1001 illus.

Radon gas, 630

Rain: acid precipitation, 260, 676 act., 698; climate and, 898, 898 illus.; cloud formation and, 887, 887 illus.; severe weather and, 893, 893 illus.; water cycle and, 863, 863 illus.

Rainbows, 366 act., 371

Rarefaction, 279, 279 illus., 283, 283 illus.

Ratio, 567

Reactants, 582

Reaction rates, 598–601, 598 illus., 599 illus., 600 illus., 605 act., 606–607 act.

Real image, 403, 403 act.

Recycling, 261, 261 illus., 723, 723 illus.

Reference points, motion and, 44–45, 44 illus., 45 illus.

Reflecting telescopes, 416, 416 illus., 420–421 act., 985, 985 illus.

Reflection, 286–287, 286 illus., 287 illus., 400, 401. See also Mirrors; of light, 369–370, 369 illus., 370 illus., 389 act.

Refracting telescopes, 416, 416 illus., 420–421 act., 985, 985 illus.

Refraction, 288–289, 288 illus., 289 illus., 415, 788; invisibility and, 298; lenses and, 408–414; of light, 370–372, 370 act., 371 illus., 372 illus., 389 act.; seismic waves and, 788–789, 788 illus.; wave action and, 861

Refrigerators, 158, 158 illus.

Region, 898

Regolith, 936

Relative dating, 869, 870–871, 870 illus., 871 illus.
Index

Relative motion
Relative motion, 53, 53 illus.
Renewable energy sources, 248–254
Repulsive force, 619, 619 illus.
Research and development, funding for, 31–32, 31 illus.
Resistance, 181–182, 181 illus.
Resonance, 295, 295 illus., 317
Resonator, 319–321, 319 illus., 320 illus., 321 illus.
Retina, 374, 374 illus., 382, 411, 411 illus.
Reversible reactions, 601–602, 601 illus.
Revolution, 924, 929, 929 illus.
Rhyolitic lavas, 793, 794, 795 table
Rhyolitic rocks, 819, 822 prob.: Richter scale, 784–785, 784 table
Ridge push, 779
Rift valley, 774
Ring of Fire, 791 illus., 792
Rings, 966; of Neptune, 966, 966 illus.; of Saturn, 965, 965 illus.; of Uranus, 966, 966 illus.
Robot lander, 955
Rock cycle, 833–835, 833 illus., 834 illus.
Rockets, 92, 92 illus., 96
Rockslides, 862
Roentgen, William, 360
Roller coasters, acceleration and, 60 illus.
Rolling friction, 75, 75 illus.
Rotation, 924, 929, 929 illus.
Rubber, synthetic, 757
Rubidium, 520
Rubin, Vera, 454
Runoff, 857 act.
Russell, Henry, 989
Rusting, 580 act.
Rutherford, Ernest, 492 illus.
Rutherford model, 492 illus.

Smell, organic compounds and
Sediment transport, 854
Sedna (distant planetoid), 968, 968 illus.
Seismic waves, 278, 278 illus., 298–784, 782 illus., 783 illus., 784 illus.; refraction and, 788–789, 788 illus.
Seismographs, 785–786, 786 illus., 937
Selenium, 536
Semiconductors, 534, 746, 749–752; components in, 534, 534 illus.; doping, 749–750, 749 illus.; integrated circuits, 750, 750 illus.
Series circuits, 185–186, 185 illus., 186 illus.; 192–193 act.
Severe weather, 893–894; cloud formation and, 887, 887 illus.; downbursts, 893; hurricanes, 894, 894 illus.; lightning, 174–176, 175 illus., 176 illus., 887, 893, 893 illus.; thunderstorms, 893, 893 illus.; tornados, 894, 908
Sgr A* (saj ay star), 1001
Shadow zones, 789, 789 illus.
Shepherd moons (Saturn), 965
Shield volcanoes, 795, 795 table, 796 illus.
Shooting stars, 967
Sidereal, 924
SI (International System of Units), 15, 15 table, 19 table, 178
Silica, 793
Silicates, 813–814, 813 illus., 814 table; Earth’s layers and, 790, 790 illus.
Silicon, 463 illus., 534, 534 illus.
Silicone, 756
Silk, 756, 756 illus.
Silver, 523, 523 illus., 743 illus.
Simple machines, 104 act., 109, 109 illus., 111 illus., 113 act.
Simulations, computer, 12, 12 illus.
Single displacement reactions, 591–592, 591 illus., 592 illus.
Slab pull, 779
Sliding friction, 75, 75 illus.
Small Magellanic Cloud (SMC), 998
Small-scale climates, 899, 906–907 act.
Smell, organic compounds and, 715, 716

Safeguard Survey (NASA), 976
Safety belts, car crashes and, 86, 86 illus.
Salt(s), 689–691. See also Sodium chloride; boiling point, effects on, 662 act.; bonding and, 519, 519 illus.; crystal system of, 812 act.; evaporation and, 828, 828 illus.; halogens and, 528; humans, importance of to, 689, 690, 690 illus.; neutralization, 689–690, 689 illus.; soaps and detergents, 694–695, 694 illus., 695 illus.; types of, 690, 690 illus., 690 table; visualizing production of, 691 illus.
Samarium, 524
Sandbars, 861
Satellites, 356; communication, 356, 356 illus.; construction materials in, 758, 758 illus.; global positioning systems (GPS), 357, 357 illus.
Saturated solutions, 655, 655 illus.; sedimentary rock formation, 828, 828 illus.
Saturn, 510, 965, 965 illus., 973, 973 illus.
Scanners, optical, 388, 388 illus.
Science, 6–13. See also Graphs; Measurement; Technology; Tools, scientific; categories of; data, analyzing in, 10, 21; definition of, 6–9; drawing conclusions, 10; forensics and, 729, 732; limitations of, 13, 13 illus.; methods, 8–11, 36; models, use of, 7, 7 illus., 12, 12 illus., 34–35 act.; moral and ethical issues, 32, 32 illus.; Nobel prize in, 670; objectivity, 11; peer review, 11; society and, 30–32; technology vs., 26; theories and laws, 13; trials, 11, 11 illus.
Science and History: air conditioning, 162; altitude, Robert Goddard and, 96; an astronomical debate, 1008; currents, electrical, 194; father of chemistry, 606; music, mechanical, 330; nuclear fission bomb, 636; precipitates, 670; protecting the environment, 264
Science and Technology: asteroids, 976; bicycles, mechanical energy and, 130; car parts, 838; land mines, locating, 226; nonstick surfaces, 574; safe water, 876; superconductors, room temperature and, 480
Scientific methods, steps in, 8–11, 36
Screws, 109 illus.
Sea breeze(s), 899
Seafloor spreading hypothesis, 774–776, 774 illus., 775 illus., 775 prob., 776 illus.
Seasons, 925–927; equinoxes, 927, 927 illus.; hours of daylight, 926, 926 illus.; solstices, 926, 926 act.; sun angle and, 925, 925 illus., 928 act.
Secondary waves, 783, 783 illus., 789, 789 illus.
Section, 309
Sediment, 846
Solutions, 647; nonpolar, 663, 663 illus.; particles, effects of on, 660–661, 660 illus., 661 illus.

Solutions, 467, 644 act., 646–670, 647, 653. See also Dissolving; boiling point, 660–661, 661 illus., 662 act.; concentration and solubility, 653–657, 654 table, 655 table; energy of, 656; freezing point, 660, 660 illus.; particles in, 660–662, 660 illus., 661 illus., 662 act.; pH of, 686–687, 686 illus., 687 illus.; solids as, 647, 647 illus.; types of, 655–656, 655 illus., 655 table, 665 illus.

Solvents, 647, 647 illus., 663; nonpolar, 664, 664 illus.; particles, effects of on, 660–662, 660 illus., 661 illus., 662 act.

Sound, 326, 326 illus.

Sound quality, 318, 318 illus.

Sound speed, 307, 308, 308 illus.


Soviet Union, 956

Spacecraft: Cassini-Huygens, 510, 965, 965 illus., 973 illus.; Clementine, 937–978; Lunar Prospector, 937, 938; Mars Global Surveyor, 960; Mars Odyssey, 960; Mars Pathfinder, 960; Mars Reconnaissance Orbiter, 958, 958 illus., 960, 971, 971 illus.; Messenger, 956; Surveyor, 936

Space exploration. See also NASA; Satellites; Telescopes: Earth’s moon, 96, 633, 633 illus., 936–942, 940–941 act.; Jupiter, 964, 971, 971 illus., 972 illus.; Mars, 958–960, 958 illus., 959 illus., 960 illus., 971, 971 illus.; materials used in, 574; Mercury, 955, 956; Neptune, 966; rockets, 92, 92 illus.; Saturn, 510, 965, 965 illus., 973, 973 illus.; space shuttle, 8, 9; Uranus, 966; Venus, 956

Space probes, 963; Galileo, 964, 971, 972 illus.; Magellan, 956, 956 illus.; Mariner 9, 959, 960; Mariner 10, 955; Viking, 959, 959 illus., 960, 971; Voyager, 964, 966

Space rovers: Opportunity, 958, 960, 960 illus., 971; Sojourner, 960; Spirit, 958, 960, 960 illus., 971

Space telescopes, 417, 417 illus., 420–421 act., 422, 574, 987–988, 987 illus., 1004, 1004 illus.

Speakers, audio, 212, 212 illus.; sound waves and, 306, 306 illus., 311, 311 illus.

Specific heat, 141–143, 141 illus., 141 table, 143 illus.

Spectroscopes, 988, 988 illus.


Speed of light in a vacuum: electromagnetic waves, 341, 341 table, 344 act.; mass-energy, 626, 626 prob.

Sphere, 918

Spiral galaxies, 997, 997 illus.

Spirit space rover, 958, 960, 960 illus., 971

Spitzer Space Telescope, 417, 987

Spotlights, 404, 404 illus.

Spring (season), 925–927, 925 illus., 927 illus.

Springs (grounding), 968, 968 illus.

Spring tides, 931, 931 illus.

Standardized Test Practice: acids, bases, salts, 702–703; atoms, 514–515; chemical bonds, 578–579; chemical reactions, 612–613; Earth materials, 842–843; Earth-Moon-Sun system, 946–947; Earth’s changing surface, 880–881; Earth’s internal processes, 804–805; elements and their properties, 546–547; energy sources and the environment, 268–269; forces and Newton’s laws, 100–101; light, 396–397; magnetism, 230–231; matter, classification of, 484–485; mirrors and lenses, 426–427; motion, 68–69; new materials through chemistry, 766–767; organic compounds, 736–737; periodic table, 514–515; radioactivity and nuclear reactions, 640–641; science, nature of, 40–41; solar system, 980–981; solids, liquids, and gases, 458–459; solutions,
Standing waves
674–675; sound, 334–335; stars and galaxies, 1012–1013; thermal energy, 166–167; waves, electromagnetic, 364–365; waves, introduction to, 302–303; weather and climate, 912–913; work and energy, 134–135

Star clusters, 992 illus., 996 act.
Stars, 984–996. See also Sun; black holes, 991; brightness of, 989, 989 illus., 992 illus.; constellations, 924, 924 illus., 984, 984 illus., 991 illus., 992 illus.; counting, 990 act.; distance from Earth, 924; equilibrium and, 990–991, 990 illus., 991 illus.; evolution of, 990–991, 990 act., 990 illus., 991 illus.; formation of, 989, 989 illus.; giants, 991, 991 illus.; H-R diagram, 989, 989 illus., 992 illus., 996 act.; neutron, 991; nuclear fusion and, 990–991, 990 illus., 991 illus., 993, 993 illus.; observing, 985–988, 985 act., 986 prob.; supergiants, 991, 991 illus.; supernova explosions, 991; surface of, 994–995, 994 illus., 995 illus.; temperature of, 987, 988, 988 illus., 989, 989 illus., 991, 993, 994; twinkling of, 987; visibility of at night, 982 act.; white dwarfs, 991, 1008

States of matter, 590
Static electricity, 170–171, 170 illus., 171 illus.
Static friction, 74–75, 75 illus.
Steel, 525, 743 illus., 744, 838
Steno, Nicolaus, 870
Storm chasing, 908
Stratosphere, 885, 885 illus.
Stratus clouds, 887, 887 illus.
Streak, 810
Stream channels, 874–875 act.
Stream deposits, 856, 856 illus.
Stress, deformation and, 782 act.
Strong acid, 684–685, 685 illus.
Strong base, 685, 685 illus.
Strong force, 618–619, 618 illus., 619 illus., 621–623, 621 table, 622 table; ions vs. molecules, 572–573 act.
Structure, 744
Subatomic particles, 489–490, 489 illus., 490 illus.; detecting, 629, 629 illus.
Subduction zones, 777, 777 illus.
Sublimation, 435, 435 illus., 526
Substance, 462, 468, 477 act., 532
Sugar, 726 illus.
Sulfur, 526, 527, 527 illus., 536
Sum, 293
Summer (season), 925–927, 925 illus., 926 act.
Sun, 366 act., 993–995. See also Solar energy; angle of, 925, 925 illus., 928 act.; convection zone, 993, 993 illus.; core of, 993, 993 illus.; coronal mass ejections (CMEs), 995, 995 illus.; Earth’s orbit around, 920, 924; gravitational field of, 77, 79, 89; interior of, 993, 993 illus.; Milky Way galaxy and, 1000–1001, 1000 illus., 1001 illus.; nuclear fusion and, 241, 625–626, 625 illus., 627 prob.; as a protostar, 990, 990 illus.; radiant energy of, 147, 147 illus., 249, 249 illus., 625–626, 625 illus., 627 prob.; radiation zone, 993, 993 illus.; relative size of, 916 act.; seasons and, 925–927, 926 act., 928 act.; tidal effects of, 930–931, 930 illus., 930 prob.; ultraviolet waves (UV), 349–350, 349 illus., 350 illus.
Sunspots, 993 illus., 994, 994 illus.; coronal mass ejections (CMEs), 995, 995 illus.
Superconductors, 480
Supergiants, 991, 991 illus.
Supernova explosions, 506, 506 illus., 991
Superposition, 870
Supersaturated solutions, 656, 656 illus.
Surface area: chemical reaction rates and, 600, 600 illus.; dissolving and, 650, 650 act., 650 illus., 651 prob, 652
Surface waves, 784, 784 illus.
Surveyor spacecraft, 936
Suspend, 466, 466 illus.
Swinging motion, 122, 123 illus., 128–129 act.
Symbols and elements, 488 table, 553, 553 illus. See also Electron dot diagrams
Synthesis reactions, 591
Synthetic elements, 538–539, 538 illus.
Synthetic fibers, 755–756, 756 illus.
Synchronics, 753
System, 114, 245

Tension, wave speed and
Table salt. See Sodium chloride
Taurus constellation, 992 illus.
Technetium, 538
Technology, 26–32, 31, 64. See also Science and technology; Tools, scientific; economic forces shaping, 31–32, 31 illus., 32 illus.; global needs of, 28–29, 28 illus., 29 illus.; importance of, 4 act., 27 act.; knowledge and skills, 27; methods and techniques, 27; moral and ethical issues, 32, 32 illus.; science vs., 26; social forces shaping, 30–31, 30 illus.; systems of, 28; value of over time, 27, 27 act., 27 illus.
Telephones, 355, 355 illus., 356, 356 illus.
Televisions, 342 act., 354, 354 illus.
Tellurium, 536
Temperature, 138–143, 139, 255, 447. See also Climate change; Global warming; atmosphere and, 146, 146 illus., 160–161 act., 162; Charles’s law, 450–451, 450 illus., 451 prob.; chemical reaction rates and, 599, 599 illus., 604, 605 act., 606–607 act.; climate and, 896–897, 897 illus., 901, 901 illus.; dissolving and, 652, 652 illus., 655–656, 655 illus., 656 table, 656 illus., 657, 668–669 act.; Earth and, 33 act., 146, 146 illus., 160–161 act., 162, 239, 957, 957 illus.; equilibrium and, 604; gases and, 657; on Jupiter, 963; kinetic energy, 136 act., 138–139, 138 illus.; magma and, 818 illus.; on Mars, 958; measuring, 19–20, 19 table, 20 illus., 437, 437 illus.; nuclear fusion and, 625, 625 illus.; solar system and, 953, 970; sound speed and, 307; of stars, 987, 988, 988 illus., 989, 989 illus., 991, 993, 994; superconductors and, 488; thermal energy and, 138–143, 140 illus., 141 illus., 434–436, 435 illus., 436 illus.
Temperature inversion, 885, 889 act.
Tension, wave speed and, 285 act.
Index

Venus

and, 56–60, 57 act., 58 prob.; Earth's crust and, 52, 52 illus.; force and, 72, 72 illus.; momentum and, 54–55, 54 prob., 54 table, 55 illus.; motion and, 51–53, 51 illus., 52 illus., 53 illus., 62–63 act.; speed and, 51–52, 51 illus., 52 illus., 62–63 act., 88, 88 illus.; terminal, 88, 88 illus.

Venus, 956, 956 illus.; comparison of Earth to, 921, 921 illus.; Galileo's observations of, 951; life on, 970

Vertical motion, 59–60, 59 illus., 60 illus.

Very Large Array (VLA), 987, 987 illus.


Victoria Crater (Mars), 960, 960 illus.

Video disks, light and, 383, 383 illus.

Viking space probes, 959, 959 illus., 960, 971

Virtual image, 402, 403 act.

Viscosity, 446, 446 illus., 452–453 act., 793; of lava and magma, 793, 793 act.

Visible light, 348, 348 illus., 368 illus.

Visualizing: alloys, 648 illus., 743 illus.; bat echolocation, 325 illus.; elements, discovery of, 537 illus.; energy transformations, 123 illus.; H–R diagram, 992 illus.; life on Europa, 972 illus.; lightening, 175 illus.; locating an earthquake epicenter, 786 illus.; motors vs. generators, 219 illus.; Ogallala Aquifer, 865 illus.; rock cycle, 834 illus.; salt production, 691 illus.

Vitamins, polarity of, 666–667, 666 illus., 667 illus.

Vocabulary: affect, 660; collapse, 991; constant, 59; contact, 108; contract, 953; definite, 434; device, 188; distinct, 919; distort, 417; diverse, 319; efficient, 250; establish, 583; fundamental, 622; infer, 10, 826; internal, 386; occur, 505; parallel, 777; period, 83; primary, 220; process, 692; ratio, 567; region, 898; section, 309; structure, 744; sum, 293; transfer, 145; transition, 524; transmit, 346; transmute, 850

Vocabulary: review: acceleration, 80; acid, 712; alloys, 740; amplify, 306; amplitude, 352; atom, 538; bases, 724; chemical bonds, 594; chemical formula, 582; chemical potential energy, 234; chemical property, 498; chemical reaction, 830; compound, 552; condense, 718; covalent bonds, 706; data, 21; density, 144, 441; echo, 324; electric currents, 209; electric field, 202; electrolytes, 678; electromagnetic spectrum, 984; elements, 488; ellipse, 950, 997; energy, 138; force, 106; fossil, 969; frequency, 311; friction, 120, 781; gamma rays, 621; gradient, 890; gravity, 170; group, 518; hypothesis, 772; industrialized, 26; interference, 384; investigation, 6; ion, 565, 658; ionic bonds, 808; ionization, 684; kinetic energy, 440; latitude, 922; lava, 929; lithosphere, 895; magnetic field, 338; mass, 72, 494; matter, 274; measurement, 14; mechanical energy, 152; meter, 44; mixture, 817; momentum, 86; nonpolar molecules, 689; nuclear fusion, 989; nucleus, 884; orbit, 918; perpendicular, 286; physical change, 854; polar molecules, 646; polymer, 753; pore space, 863; power, 126; precipitate, 824; pressure, 598; property, 462; radiant energy, 248; radiation, 345; radioactivity, 869; reflection, 400; refraction, 415, 788; resonance, 317; robot lander, 955; sediment, 846; semiconductor, 746; SI (International System of Units), 178; solution, 653; solvents, 663; space probe, 963; speed, 51; states of matter, 590; sublimation, 526; substance, 532; temperature, 255, 447; thermal energy, 378; trace, 901; transparent, 408; universe, 1002; velocity, 56; vibration, 279; visible light, 368; voltage difference, 216; wavelength, 373; work, 114

Vocabulary: scientific vs. common: buffer, 687; coherent, 382; concrete, 815; conductors, 173; conserve, 597; energy, 115; interpret, 75; fiber, 75; field, 207; focus, 789; gravity, 87; heat, 140; hydrate, 571; impact, 937; latitude, 896; meander, 856; medium, 277; organic, 707; pitch, 314; position, 401; pressure, 435; promise, 994; reflection, 373; ring, 966; solution, 647; suspend, 466; system, 245; vacuum, 339; volume, 17

Vocabulary: word origin: acid, 682; amorphous solids, 438; amplitude, 283; aquifer, 864; atom, 489; ceramic, 749; circuit, 179; cosmic, 1003; equilibrium, 602; foliation, 831; friction, 75; libration, 925; isotopes, 617; kinetic, 122; molecule, 561; petroleum, 236; pigment, 376; polar, 667; polymers, 721; satellite, 356; seismograph, 785; solenoid, 210; sonar, 326; technology, 31; thermodynamics, 155; troposphere, 885; velocity, 52; volcano, 959

W

Waning moon, 932 illus., 933


Water, 863, 863 illus.; atmosphere and, 863, 863 illus., 884, 887–888, 887 illus., 888 illus.; boiling point, 20, 20 illus., 435, 435 illus., 436, 436 illus., 660–661, 661 illus., 662 act.; buoyancy, 430 act., 441–442, 441 illus., 442 act., 442 illus.; chemical weathering and, 849; chlorine compounds in, 529 act.; circuits of, 178, 178 illus., 179, 179 illus.; climate and, 899, 899 illus.; compounds with, 570–571, 571 illus.; converting to electricity, 250–251, 250 illus.; 251 illus.; diffusion of light in, 290, 290 illus.; dissolving without, 663–664, 663 illus., 664 illus.; distillation of, 460 act.; drinking, 868, 868 illus., 876; energy waves, 274–275, 274 illus., 276, 276 illus.; erosion and, 855–857, 857 act.; freezing point, 20, 20 illus., 660, 660 illus.; freshwater, 863, 863 illus., 867, 867 illus.; groundwater, 844 act., 863–868, 866 prob.; hydrogen and, 527; ion formation and, 658–659, 658 illus., 659 illus.; on Jupiter's moons, 964; lenses
Water cycle
of, 398 act.; on Mars, 958, 958 illus., 959, 959 illus., 960; mineral formation and, 812, 813; on Neptune, 966; oxygen and, 536; polarity of, 563, 563 illus.; pollution and, 258–259, 259 illus., 695, 695 illus., 876; refraction of light in, 288–289, 288 illus., 289 illus., 370 act., 371 illus.; rock cycle and, 833–835, 833 illus., 834 illus.; on Saturn's moons, 510; shortages, 876; solubility of substances in, 654 table; specific heat of, 141, 141 table; speed of electromagnetic waves in, 340, 340 table, 343, 343 illus.; speed of sound in, 307, 307 table; storage volume of, 866 prob.; thermal expansion and, 438, 438 illus.; weather and, 895–896, 895 illus., 896 illus.

Water cycle, 510; freshwater and, 863, 863 illus.; global, 888, 888 illus.; groundwater and, 864; porosity and, 866, 866 illus.

Water resources, 867–868, 867 illus., 868 illus.

Water table, 864

Water vapor, 884; cloud formation and, 887, 887 illus.

Watt (unit of measure), 126


Waxing moon, 932, 932 illus.

Weak acid, 684, 685, 685 illus.

Weak base, 685, 685 illus.


Weather, 890–894; air masses and weather fronts, 892, 892 illus.; air pressure, 890–891, 890 illus., 891 illus.; climate and, 895–896, 895 illus., 896 illus.; severe, 174–176, 887, 887 illus., 893–894, 893 illus., 894 illus., 908; storm chasing, 908

Weather front(s), 892, 892 illus.

Weathering, 846–849; chemical, 474, 474 illus., 848–849, 848 illus., 849 illus.; everyday, 846; mechanical, 847, 847 illus.; physical, 474, 474 illus.; rate of, 849

Wedges, 109 illus., 111 illus.

Wegener, Alfred, 770 act., 772–774

Weight, 78, 78 prob., 78 table; gravitational acceleration and, 89, 89 illus.

Wells, 868–869, 868 illus., 869 illus.

Westerlies, 890–891, 890 illus.

Wet-cell batteries, 180–181, 180 illus.

Wheels, 109 illus., 111 illus.

White dwarfs, 991, 1008

Wilkinson Microwave Anisotropy Probe (WMAP), 1003, 1003 illus.

Wind: air pressure and, 890–891, 890 illus., 891 illus.; coronal mass ejections (CMEs), 995, 995 illus.; droughts, 893; El Niño and La Niña, 905, 905 illus.; erosion and, 860, 860 illus.; on Neptune, 966

Wind energy, 251, 251 illus.

Winter (season), 925–927, 925 illus., 926 act.

Wood, as fuel, 235, 235 illus.

Work, 104 act., 106–113, 107 prob., 113 act., 114

World Health Organization (WHO), 876

World War II, 624, 636, 670

X

Xenon, 530

X-rays, 350, 350 illus., 360, 630, 630 illus.; barium sulfate and, 521; radiation therapy and, 351, 351 illus., 630–631, 631 illus.; telescopes and, 417

Yellowstone National Park: microorganisms, 970, 970 illus.; rhyolitic lava, 794; supervolcano, 800; volcano hot spot, 792

Z

Zinc, 523

Zodiac, 924, 924 illus.

Zwicky, Fritz, 454
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