Physical Science

Course No. 2003310

Bureau of Instructional Support and Community Services
Division of Public Schools and Community Education
Florida Department of Education

1999

This product was developed by Leon County Schools, Exceptional Student Education Department, through the Curriculum Improvement Project, a special project, funded by the State of Florida, Department of Education, Division of Public Schools and Community Education, Bureau of Instructional Support and Community Services, through federal assistance under the Individuals with Disabilities Education Act (IDEA), Part B.

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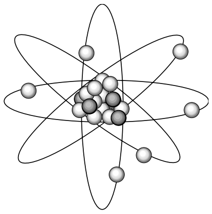

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Table of Contents

Unit 21: Science, Society, and the World

Acknowledgments

The staff of the Curriculum Improvement Project wishes to express appreciation to the content revisor and reviewers for their assistance in the revision of *Physical Science* from original material by content, instructional, and graphic design specialists from Dade, Leon, and Sarasota county school districts.

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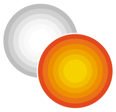
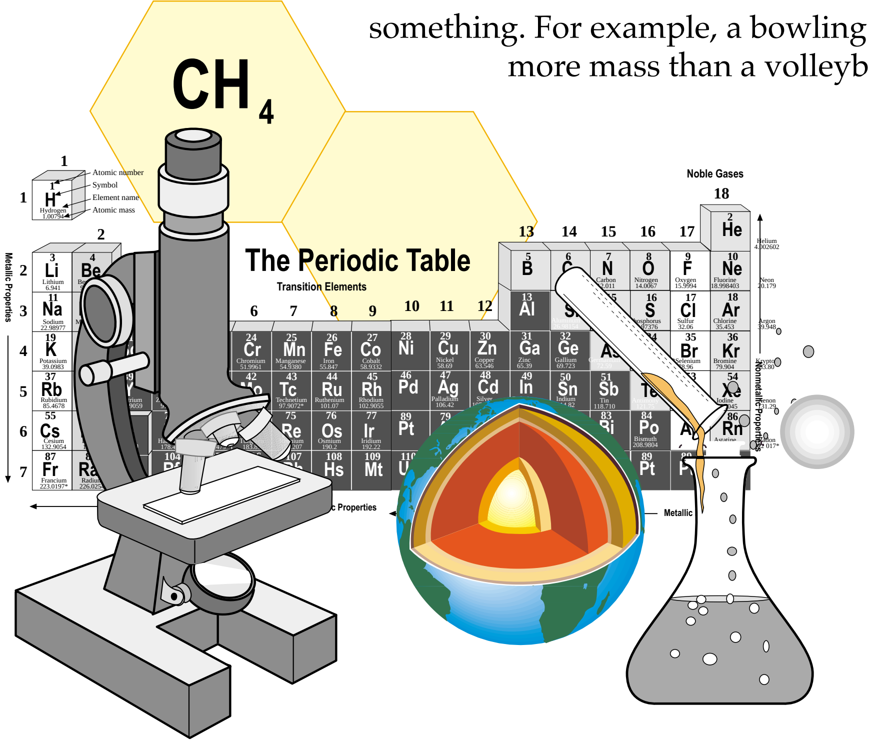
Introduction

Physical science is the study of matter and energy. The total amount of matter and energy in the universe does not change. Some scientists study matter—what it is made of and how it can change. This study is called *chemistry*. Other scientists focus on energy. They investigate what energy is and how it interacts with matter. This area of study is called *physics*. The study of matter and energy are closely related.

These concepts may seem unrelated to our everyday lives. However, the applications of the concepts of physical science are very common and familiar to each of us. Everything on Earth that takes up space is made of matter—both living and nonliving things. It takes energy to power all that matter. Nothing would happen without energy. Energy causes muscles to move, rivers to flow, and the Earth to rotate.



We distinguish between different kinds of matter by observing their physical properties. Odor, shape, size, and color are examples of physical properties—ones that can be observed using the senses. Another property of matter is mass—the amount of matter in something. For example, a bowling ball has more mass than a volleyball.



All matter is made of elements. There are about 120 known elements on Earth. Some elements are oxygen, hydrogen, gold, helium, and nitrogen. Elements can be divided into metals and nonmetals. The names and symbols that stand for the elements (such as O for oxygen) are organized into a chart called the periodic table. The periodic table shows information about the elements.

Elements are made up of tiny units called atoms. Even the atom is made of smaller particles—protons, neutrons, and electrons. Different elements have different numbers of these particles. Atoms join together to form the substances we know. Soap, sugar, and salt are compounds because they are made of two or more different atoms. When the atoms of a compound are bonded together, this is a molecule. Scientists use chemical formulas as a shorthand way of writing the names of compounds.

Matter has three common states—solid, liquid, and gas. The fourth state of matter is plasma. Much of the matter in stars is plasma. On Earth, we rarely deal with plasma. Ice, water, and steam are the three states of matter that we call water. Matter changes from one state to another, making a phase change. In a phase change, molecules remain the same—they are only arranged differently. For example, ice molecules line up and move very little, water molecules move around, and steam molecules vibrate and move around quickly.

Matter only makes chemical changes by way of chemical reactions. A chemical reaction occurs when atoms of different elements combine to form new compounds. The changes that occur in a reaction are often described by chemical equations. These equations, which include the symbols for elements and chemical formulas for compounds, are a way for scientists to describe the reactions more easily.

Compounds or elements mixed together but not bonded chemically are called mixtures. A mixture is made up of more than one kind of substance and can be separated by physical means. There are two types of mixtures—heterogeneous and homogeneous. A solution is a homogeneous mixture in which at least one substance is dissolved into another. In solutions, it is not possible to readily distinguish one substance from another. The salt water you gargle with is a homogenous mixture, as is vinegar, which is made up of acetic acid and water. Both solutions appear clear and you cannot see the particles in the solutions. In heterogeneous mixtures, it is easy to distinguish one material from another. Gravel, concrete, and dry soup mixes are examples of heterogeneous mixtures.

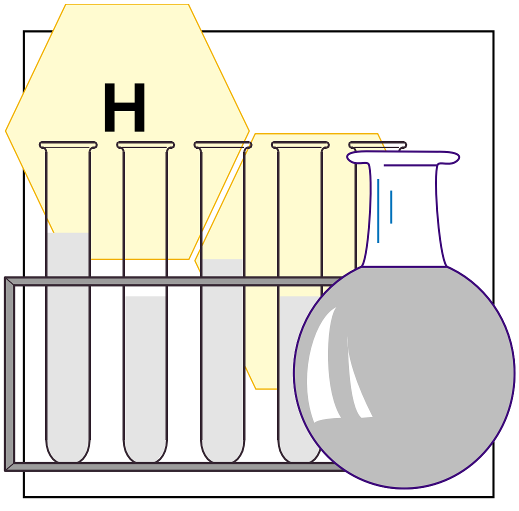
Physical science includes the study of how matter and energy are related. We use matter—all living and nonliving things—to work for us. In science, work means that a force (push or pull) causes something to move. Sir Isaac Newton investigated forces and motion. He asked questions about how gravity, mass, and friction affect motion. Sir Isaac Newton explained these concepts with his three laws of motion.

Work is the product of energy, while energy is the ability to do work. There are many kinds of energy that help us to run our cars, heat our homes, send television pictures, and more. Mechanical energy, electrical energy, heat energy, light energy, sound energy, and atomic energy are just some of the many forms of energy. Energy may change from one form to another, but it cannot be created or destroyed. Energy in motion is called kinetic energy; stored energy is called potential energy. A rock on the edge of a cliff, for example, has potential energy. When the rock begins to fall off the cliff, it has kinetic energy.

Technology uses scientific knowledge to improve the quality of human life. In the search to make work easier, people developed simple and complex machines to improve the power or the rate at which work is done. While a machine cannot create energy, it can transfer energy to make a force stronger. There are six kinds of simple machines that strengthen a force—levers, pulleys, inclined planes, wedges, screws, and wheels and axles. All of these and other complex machines can increase work efficiency or improve the ratio of work input. This increases the power of the people doing the work.

People have combined energy and machines to create technologies as simple as hammer and nail and as highly advanced as some technologies we use today. Some technologies are being used without regard for using up our nonrenewable resources such as water. However, some technologies conserve resources. Scientific discoveries lead to technological inventions and inventions may lead to further discoveries. Scientists use technology to identify problems and provide solutions. Society determines how to use the technology science provides. The study of physical science—understanding matter and energy—makes all of this possible.

Unit 1: Scientific Method

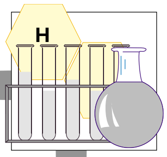


Vocabulary

Study the **scientific method** *vocabulary words and definitions below.*

analog	that which has similar characteristics to another thing (like the similarity between the heart and a pump)
apparatus	the equipment or tools used in a scientific laboratory
computer simulation	a computer program designed to represent the behavior of something in the physical world
conclusion	a judgment or decision based on observation and analysis
data	recorded facts or information
equipment	what is used to carry out a particular purpose or function (as in measuring *equipment*)
experiment	an activity designed to test a hypothesis
Galileo Galilei	an Italian astronomer and physicist who discovered that objects fall at the same rate regardless of mass

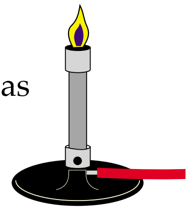
hypothesis	a statement that may explain a group of related observations
laboratory	a place equipped and used for experimental study, research, analysis, testing, or preparation in any branch of science
observation	information we gather by using our senses
safety	the condition of being free from risk or danger
scale model	a man-made version of a physical object that is identical in proportion to the original but which may be smaller in total size
scientific law	a scientific theory that has been tested many times and has produced the same results over a period of many years
scientific method	the set of skills used to solve problems and answer questions in an orderly way
scientific theory	a general statement based on hypotheses that have been tested many times

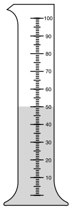


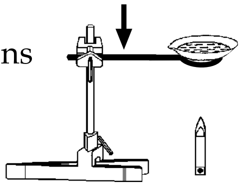
Vocabulary

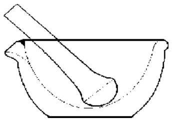
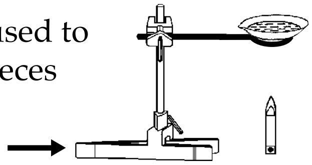
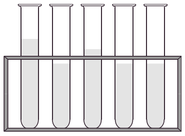
Study the **apparatus** *vocabulary words and definitions below.*

beaker	a deep, wide-mouthed, thin-walled, cylindrical vessel with a pouring lip
Bunsen burner	an instrument that uses a mixture of air and natural gas to make a very hot, blue flame
evaporating dish	a small ceramic dish used as a container to allow small amounts of liquid to evaporate
flask	a narrow-necked, clear vessel used in laboratories
funnel	a utensil with a wide cone at one end and a thin tube at the other; used to pour liquids into a container with a small opening without spilling
graduated cylinder	clear tube with unit markings on the side and a flat base; used for measuring liquids
iron ring	a ring-shaped clamp made of iron that fastens to the ring stand to support glass apparatus







mortar and pestle	a thick heavy bowl (mortar) and a tool shaped like a club (pestle) used for grinding, pounding, or mixing 
pipet	a glass tube used to transfer small amounts of liquid; usually marked to show units of volume
ring stand	a holder or stand used to support various pieces of equipment 
stirring rod	a glass rod used to stir chemical materials
test tube	a glass tube, closed at one end; used in making chemical tests; can be heated
test tube holder	a rack that holds one or more test tubes in an upright position 
thermometer	instrument used to measure temperature
tongs	a tool with two connected curved arms; used to grasp and lift hot apparatus or chemicals
wide-mouthed bottle	a multipurpose container or bottle often used for collecting gas; sometimes called a *gas-collecting bottle*; cannot be heated

Introduction

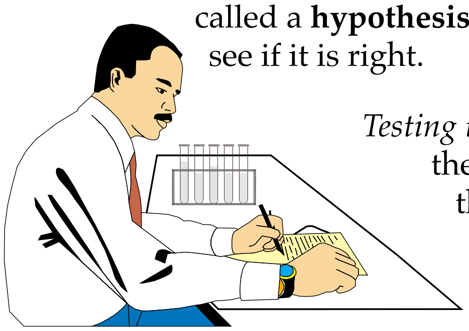
Do you ever wonder about things in nature? Do you wonder why or how? Science provides us with answers about how and why things happen the way they do. Scientists are people who conduct investigations in search of answers. Occasionally, something happens that appears to be totally new. Scientists try to find out how and why it happened. At other times, scientists are unsure if old ideas are really true. They investigate these theories. When a theory appears to be true, scientists may do another investigation. They will see if the theory can predict other answers to the questions of how and why. Sometimes different scientists come to different results. They find different reasons for how or why something has happened. In this case, scientific investigation does two things. First, it compares the possible reasons. Then, it tries to come to a decision about which theory seems the best explanation. The following section describes how scientists find these answers.

Scientific Method

Scientists do certain things in a certain order to find answers. This method is called the **scientific method**. It is a logical way of solving problems or answering questions. The first step is to *identify the problem or ask a question*. The study or research of a problem always begins with a question.

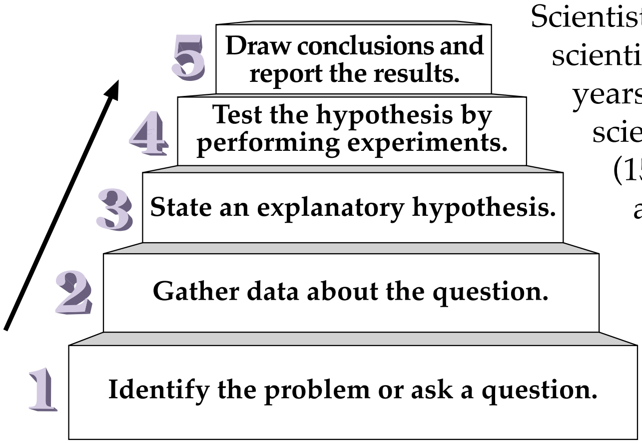
The second step of the scientific method is to *gather data about the question*. Information is collected about the question. **Observations** are made and recorded. This recorded information is called **data**. Another way to gather data is to read books, journals, or other publications that deal with the same or similar problem or question.

The third step is to *state an explanatory hypothesis*. Looking at the data gathered, scientists make an educated guess and suggest what may be the answer to the problem. This guess, based on observations, is called a **hypothesis**. Then the hypothesis must be tested to see if it is right.



Testing the hypothesis by performing experiments is the fourth step. Activities are planned to test the hypothesis. These activities are called **experiments**. The experiments must be done very carefully. Scientists repeat the experiments many times before they accept the results. The same conditions have to be repeated over and over. When the data gathered from each experiment agree with the data from other experiments, then the results may be accepted.

Drawing conclusions and reporting the results is the fifth step. After the experiments are completed, a **conclusion** is made. The conclusion is based on analysis of the data that was gathered in the experiment. The conclusion may agree with the hypothesis or it may disagree.

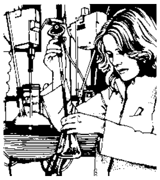


Scientists have been using the scientific method for about 400 years. It began with an Italian scientist named **Galileo Galilei** (1564–1642) who tested ideas about nature to explain the way things happen. Before Galileo, most people believed that heavier objects fell faster than lighter objects. No one bothered to test this idea. Instead, they accepted it as fact. Then Galileo decided to use the scientific method to investigate this hypothesis. Galileo found that objects fall at the same rate of acceleration regardless of their weight because gravity makes all objects accelerate at the same rate. However, gravity is not the only force at work. Objects are also affected by air resistance, the force air exerts on an object. This was a gigantic change in the way the world was seen and understood. Since that time, many other scientists have conducted investigations about gravity. They too have found that Galileo was right about the way things fall.

Even now, such major changes occasionally take place. It is more common, however, for the changes to be small. Whether big or small, changes take place because scientists all over the world share information. Often many scientists are working on the same problem. If the results among the different scientists are not the same, the hypothesis, approach, or methods may have to be changed. If a hypothesis has been tested many times and seems correct, it is called a **scientific theory**. After a theory has been tested and supported many times, it becomes a **scientific law**. In science, no theory or law is ever considered proven. Galileo showed us the reason for this, and, in fact, what Galileo said about gravity is still considered theory.

Scientific Testing

Suppose you wanted to find out if storing popcorn in the refrigerator would make a difference in the number of kernels that did not pop. You would need to also test popcorn stored at room temperature as a *control*, or the standard for comparison. All other conditions for both batches of popcorn would need to be the same: the same brand, same freshness, same storage time, and same method of preparation. Only one condition, the place of storage, should differ. All other factors are *constants* and cannot change.



Scientists often test their hypotheses by conducting experiments under controlled conditions in the scientific **laboratory**. In some cases, conditions cannot be controlled. It would be hard to control conditions when investigating the way people behave or the way the trees in a large forest interact. In these cases, it may not be possible or ethical to conduct an experiment in a laboratory. Instead, scientists observe the widest range of natural behavior possible. Scientists may survey large numbers of people. They may record conditions in the forest for years and years. By doing this, scientists gather information that can be compared to laboratory results.

Another way to test theories about parts of the world is to use a **scale model**. Imagine you wanted to know how a building would behave during an earthquake. You couldn't create an actual earthquake in a laboratory. Instead, you might construct a small scale model of the building. Then you could shake it, simulating an earthquake. More and more, models using **computer simulations** are being made. One advantage of computer simulations is they permit scientists to test theories many times.

Sometimes theories are tested using **analogs**. Analogs are things that are similar but not exactly alike. Scientists use the similarities between analogs to learn. For example, you might want to know how a now extinct dinosaur flew. You might study how bats actually do fly. Bats are analogs to dinosaurs because both bats and dinosaurs flew without having feathers. There are some differences between the two, but the scientists study their similarities. With the right preparation, the results of this investigation would be a fairly accurate prediction and would show what it would take to make a long-dead dinosaur fly. Try to think of an analog to a human. Could you study the analog to learn things about humans? Whether using analogs, computer simulations, or scale models, scientists work to be sure that their results are generally accurate.

Laboratory Testing and Safety

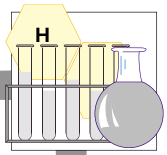
In the laboratory, scientists must be careful to follow all **safety** rules. Careful procedures and safe handling of the **apparatus** (**equipment**) are important for both the scientist and the experiment. Using caution and following safety rules protect scientists from accidents. Avoiding accidents and following laboratory rules also protect the results of the experiments.

Equipment must be kept clean and dry. This care will prevent other substances from interfering with the results of the experiment. Substances used in experiments must be measured accurately. The amount of the substances used will affect the *reaction* or *outcome*. Even the temperature of the room may affect an experiment. All conditions in the scientific laboratory must be controlled and monitored carefully.

Whatever methods of testing are used in the laboratory, safety is the greatest concern. The safety rules which follow have been developed to help you have a safe laboratory experience.

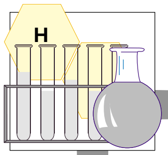
Safety Rules

1. Read and follow directions while working in the science laboratory. When possible, read instructions before entering the laboratory.
2. Always wear protective devices, such as aprons. Wear goggles when working with dangerous or hot chemicals, with objects that may hit you in the eye, or whenever the teacher instructs you to do so.
3. NEVER taste or directly inhale chemicals. The smell of chemicals is sensed by *wafting*. Your teacher can demonstrate this technique.
4. DO NOT bring food or drink into the lab.
5. Wash hands thoroughly after each lab.
6. DO NOT rub eyes or put hands in mouth.
7. Wear clothing suitable for the lab. Cotton clothing is better than polyester or nylon. Always keep your shoes on while in the lab. Roll up long or loose sleeves.
8. DO NOT look directly into the mouth of a filled test tube. DO NOT point the mouth of a filled test tube at another student. The liquid can splash into eyes.
9. DO NOT perform any experiments unless the instructor is in the room.
10. Report ALL minor and major accidents to your instructor.
11. Know the location of the safety shower, fire blanket, and eye wash. Know how to use these important pieces of safety equipment.
12. Turn off burners and the gas outlet when not in use. Never leave a lit burner unattended.
13. Keep lab tables clean and neat to prevent accidents. Wipe all areas at the end of the lab.
14. MAKE SAFETY A HABIT!



Summary

To explain things that occur in nature, scientists ask questions and solve problems. The reasons for doing this include investigating new situations, testing old hypotheses, determining the ability of a theory to predict, and comparing apparently conflicting theories. Scientists use five steps in problem solving. They 1) identify the problem, 2) collect information, 3) state a hypothesis, 4) test the hypothesis, and 5) draw a conclusion. They use experiments to test their ideas or hypotheses. Scientists use controls to maintain the reliability of their results, but sometimes it is not possible to use a control. In these cases, large amounts of data are gathered. At other times, scale models, computer simulations, or analogous systems may be used to test theories and produce reliable results. Ideas that have been tested and appear valid are called theories. Theories that have not been disproven over a long period of time are called laws. To maintain safety in the laboratory and assure the effectiveness of their experiments, scientists must follow all laboratory and safety rules.



Practice

Use the list below to complete the following statements.

analogs
behavior
computer simulations
conclusions
controlled
Galileo
ideas
investigate
models
predict
scientists
small

1. __________________________ are people that conduct investigations in search of answers to the questions of how and why.

2. When something new has happened, scientists __________________________ to find out how and why it happened.

3. Theories are really __________________________ that scientists investigate to see if they are true.

4. Being able to __________________________ possible outcomes is one thing scientists check when investigating theories.

5. Different scientists do not always come to the same __________________________ . In this case, further investigations may be tried to see which theory may be more accurate.

6. __________________________ used the scientific method to show that objects fall at the same rate regardless of their weight.

7. Although major changes in thought take place, more often __________________________ changes take place.

8. Scientists often test their hypotheses by conducting experiments under ____________________ conditions in the scientific laboratory.

9. In cases in which controls cannot be used, scientists observe the widest range of natural ____________________ possible.

10. ____________________ , ____________________ , and ____________________ are other ways to test theories when normal lab techniques cannot be used.

Practice

Arrange the steps of the **scientific method** *in the correct order on the lines provided.*

A. State a hypothesis.

B. Identify the problem or ask a question.

C. Gather data about the question.

D. Draw conclusions.

E. Test the hypothesis by performing experiments.

The correct order is as follows:

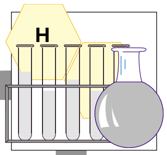
1. ____

2. ____

3. ____

4. ____

5. ____



Practice

Write **True** *if the statement is correct. Write* **False** *is the statement is* not *correct.*

__________ 1. You should taste chemicals to determine if they are acids or bases.

__________ 2. You should wash your hands before the lab but not afterwards since most chemicals are harmless.

__________ 3. You should *NOT* point a test tube at another student.

__________ 4. Food is permitted in the lab but not soft drinks.

__________ 5. Only major accidents should be reported to the instructor.

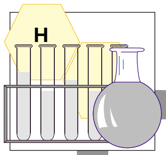
__________ 6. You should turn off burners when *NOT* in use.

__________ 7. You should not perform any experiments unless the instructor is in the room.

__________ 8. Goggles should only be worn when working near a flame.

__________ 9. Nylon and polyester clothes make the best lab clothes since they are flame-resistant.

_________ 10. You should wash your hands thoroughly after each lab.

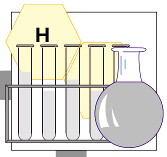


Practice

Use the list below to complete the following statements.

accidents
conclusion
cotton
data
goggles
hypothesis
laboratory
safety
scientific method
taste

1. The method used by scientists to find answers is called the ____ .
2. Recorded information is called ____________________ .
3. A guess based on observation is a ____________________ .
4. A ________________ may agree or may not agree with the hypothesis.
5. Scientific experiments are often conducted in a ________________ .
6. Scientists must be careful to follow all laboratory and ____________________ rules.
7. When working with dangerous or hot chemicals or objects that may hit you in the eye, you should always wear ________________ .
8. Never ____________________ or directly inhale chemicals.
9. ____________________ clothing is better than polyester or nylon while working in the lab.
10. Report all ____________________ to your instructor.



Practice

Circle the letter of the correct answer.

1. To find the answers to questions, scientists perform ____________ .
   a. hypotheses
   b. investigations
   c. conclusions
   d. models

2. One reason scientists experiment and investigate is because ____________ .
   a. something new has been observed
   b. there are no problems
   c. there are no questions
   d. there are no ideas

3. Scientists sometimes investigate older theories to see if they appear to be ____________ .
   a. accurate
   b. recent
   c. data
   d. conclusions

4. Describing how things might be in the future is called ____________ .
   a. hypotheses
   b. prediction
   c. theory
   d. law

5. Scientists sometimes do another investigation when they ____________ .
   a. all agree on their conclusions
   b. all agree on their hypothesis
   c. do not agree on their conclusions
   d. all agree on a law

6. One of the first scientists to use the scientific method was __________ .

   a. Ptolemy
   b. Plato
   c. Aristotle
   d. Galileo

7. When changes in scientific thought take place, it is most common for __________ .

   a. large changes to take place
   b. the changes to be based on old information
   c. small changes to take place
   d. the changes to be reversed and scientific thought to stop

8. Scientists use __________ in experiments to show that the results are related to the condition tested and not some other condition.

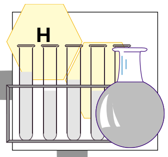
   a. controls
   b. hypothesis
   c. laws
   d. temperature

9. Scientists observe the widest range of natural behaviors possible when __________ .

   a. controls would produce better results
   b. it is not possible or ethical to use controls
   c. a model would produce better results
   d. an analogous system would produce better results

10. An advantage of using computer simulations is that they __________ .

    a. do not use controls
    b. are slower than laboratory experiments
    c. provide inaccurate answers
    d. permit the scientists to test theories many times



11. The first step of the scientific method is to ____________ .

    a. gather data
    b. state hypothesis
    c. identify the problem
    d. draw conclusions

12. A hypothesis is ____________ .

    a. an educated guess
    b. a scientific experiment
    c. a scientific laboratory
    d. a scientific law

13. The second step of the scientific method is to ____________ .

    a. gather data
    b. state hypothesis
    c. make observations
    d. draw conclusions

14. An experiment is ____________ .

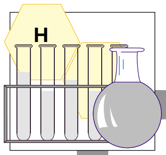
    a. gathered information
    b. a statement based on a hypothesis
    c. recorded observations
    d. an activity performed to test a hypothesis

15. The last step of the scientific method is to ____________ .

    a. gather data
    b. state hypothesis
    c. make observations
    d. draw conclusions

16. Scientific theory is ____________ .

    a. a hypothesis that has appeared true on many occasions
    b. the same conclusion reached over and over again
    c. a theory that has been tested over and over again
    d. many scientists working on the same problem



17. Scientific law is __________ .

    a. a hypothesis proven correct over and over again
    b. the same conclusion reached over and over again
    c. a scientific theory that has been tested and supported over and over again
    d. many scientists working on the same problem

18. Scientific apparatus are __________ .

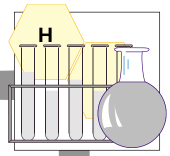
    a. a place equipped and used for experimental study
    b. an activity designed to test a hypothesis
    c. a narrow-necked vessel, normally of blown glass
    d. the equipment or tools in a scientific laboratory

19. A graduated cylinder is __________ .

    a. a glass dropper used to dispense small amounts of liquid
    b. a flat-bottomed tube with unit markings on the side
    c. a narrow-necked vessel, normally of blown glass
    d. a glass tube, closed at one end, used in making chemical tests

20. An instrument that uses a mixture of air and natural gas to make a very hot, blue flame is a(n) __________ .

    a. iron ring
    b. mortar and pestle
    c. Bunsen burner
    d. ring stand



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. equipment used in a scientific laboratory

______ 2. a holder used to support various pieces of equipment

______ 3. a narrow-necked, clear vessel used in laboratories

______ 4. an instrument that makes a hot, blue flame

______ 5. clear tube marked to measure liquid volume and has a flat base

______ 6. used to pour liquids without spilling into containers with small openings

______ 7. bowl and tool for grinding or mixing

______ 8. small glass tube used in making chemical tests

______ 9. tool with two arms used to grasp apparatus

______ 10. instrument used to measure temperature

A. apparatus

B. Bunsen burner

C. flask

D. funnel

E. graduated cylinder

F. mortar and pestle

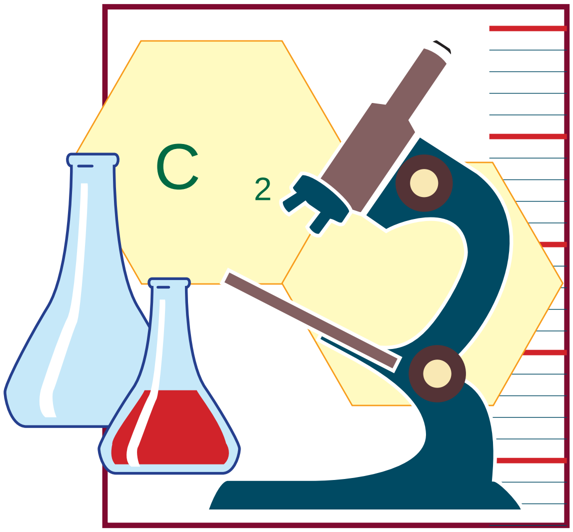
G. ring stand

H. test tube

I. thermometer

J. tongs

Unit 2: Scientific Measurement



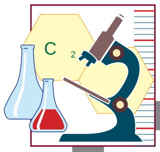
Vocabulary

Study the vocabulary words and definitions below.

Celsius (C)	a temperature scale that sets the boiling point of water at 100° (C), the freezing point of water at 0° (C), and normal body temperature at 37° (C); also known as the Centigrade scale
centigram (cg)	a unit of mass in the metric system equal to $\frac{1}{100}$ of a gram
centiliter (cl or cL)	a unit of volume in the metric system equal to $\frac{1}{100}$ of a liter
centimeter (cm)	a unit of measurement in the metric system equal to $\frac{1}{100}$ of a meter; 100 centimeters equals one meter
cubic centimeter (cm^3)	a unit of the metric system for measuring solid volume; it is also equal to one milliliter
decigram (dg)	a unit of mass in the metric system equal to $\frac{1}{10}$ of a gram
deciliter (dl or dL)	a unit of volume in the metric system equal to $\frac{1}{10}$ of a liter
decimeter (dm)	a unit of distance in the metric system equal to $\frac{1}{10}$ of a meter

degree (°)	unit for measuring temperature
Fahrenheit (F)	a temperature scale that sets the boiling point of water at 212° (F), the freezing point of water at 32° (F), and normal body temperature at 98.6° (F)
gram (g)	a unit of mass and weight in the metric system; used to describe the quantity of matter
kilogram (kg)	a unit of mass and weight in the metric system; 1,000 grams equals one kilogram
kiloliter (kl or kL)	a unit of volume in the metric system; 1,000 liters equals one kiloliter
kilometer (km)	a unit of distance in the metric system; 1,000 meters makes one kilometer
length	the distance from one end of an object to the other end
liter (l or L)	the basic unit for measuring liquid volume in the metric system; equals a bit more than one quart
mass	the amount of material in an object; this measurement is not affected by gravity
meter (m)	basic unit of distance in the metric system; equals approximately 40 inches

metric system	a system of measurement based on the decimal system
milligram (mg)	a unit of mass in the metric system equal to $^{1}/_{1000}$ of a gram
milliliter (ml or mL)	a unit of volume in the metric system equal to $^{1}/_{1000}$ of a liter
millimeter (mm)	a unit of distance in the metric system equal to $^{1}/_{1000}$ of a meter
Systeme Internationale (SI)	the international system of measurement that includes metrics for units of distance, mass, and volume, and the Celsius scale for units of temperature
temperature	the measure of the amount of heat in a substance; a measure of how fast molecules are moving in their random motion
thermometer	instrument used to measure temperature
volume	the amount of space that matter takes up
weight	the measure of the force of gravity pulling on an object



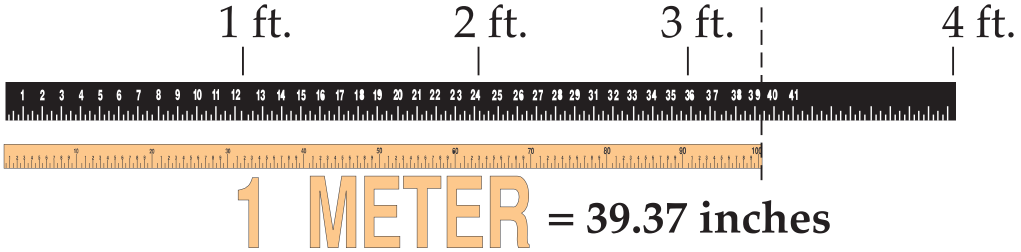
Introduction

Measurement is a very important tool in science. We use measurement to solve problems, compare objects, and record our answers. We will use the **Systeme Internationale** (**SI**) of measurement to measure **length**, **mass and weight**, **volume**, and **temperature**. The most well-known part of SI is the **metric system**. The metric system is a system for measuring mass and weight, distances, and volume. The metric system is easier to use than the system of inches, feet, ounces, and pounds because the metric system is based on the decimal system. This makes it easy to convert from one unit to another by multiplying or dividing it by the appropriate multiple of 10.

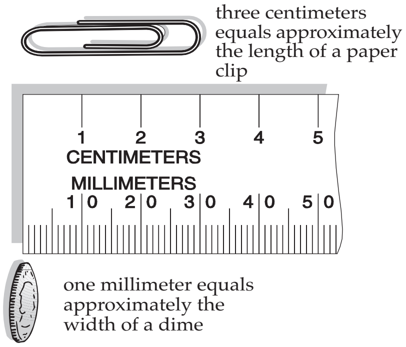
Length

A **meter** (**m**) is the basic unit of *length*. It is a little longer than one yard, which measures 36 inches.

One meter is the same as 39.37 inches. We can use meters to measure the length and width of rooms. Many races are measured in meters.



How do we measure small objects? Each meter is divided into 100 **centimeters** (**cm**). One centimeter is equal to $\frac{1}{100}$ of a meter. Think of a dollar. Each penny is equal to $\frac{1}{100}$ of a dollar. Each centimeter can be divided into 10 parts. These smaller parts are called **millimeters** (**mm**). A millimeter is the same as $\frac{1}{1000}$ of a meter. It takes 1,000 millimeters to make a meter.



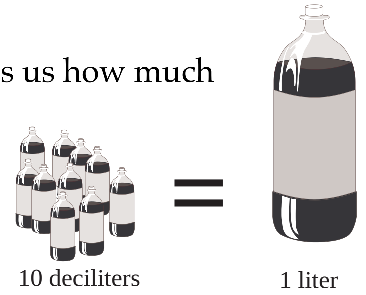
three centimeters equals approximately the length of a paper clip

one millimeter equals approximately the width of a dime

A **decimeter** (**dm**) is equal to $\frac{1}{10}$ a meter. In other words, 10 decimeters are equal to one meter.

Kilometers (**km**) are used to measure long distances. A *kilometer* is 1,000 meters. You use kilometers to measure the distances between cities.

Volume



The **liter** (**l or L**) measures volume. Volume tells us how much space something takes up. One liter is a little more than a quart. A liter can be divided into smaller parts. There are 1,000 liters in one **kiloliter** (**kl or kL**). A **deciliter** (**dl or dL**) is $\frac{1}{10}$ of a liter. In other words, it takes 10 deciliters to equal one liter. A **centiliter** (**cl or cL**) is $\frac{1}{100}$ of a liter. It takes 100 centiliters to make a liter. A **milliliter** (**ml or mL**) is $\frac{1}{1000}$ of a liter. It takes 1,000 milliliters to make a liter.

Solid volume is often measured in **cubic centimeters** (**cm^3**). A small die has the volume of about 1 cm^3. To measure the volume of a solid object, such as a brick, you would measure its length, width, and height, and multiply the three figures together. The measurements of the brick would be in centimeters and the volume would be in cubic centimeters.

Mass and Weight

However, we need to know the difference between mass and weight. Weight is the pull of gravity on an object. Mass is the amount of material in the object. On Earth, the mass and weight of an object are the same, but astronauts weigh less in space than they do on Earth because the pull of gravity is less. Their mass is the same on Earth as in space, but their weight is different. In the metric system, we measure mass and weight by using grams, milligrams, and kilograms.

Because the units of mass and weight were both developed on Earth, the units are the same. We can talk about the mass of a ball or the weight of the ball. We will use the units of grams, milligrams, and kilograms. The measurements would be the same, too. Most times, though, we will discuss mass.

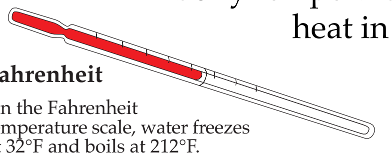
The **gram** (**g**) is used to measure mass and weight. One regular size paper clip has a mass of about one gram. A paper clip that has a mass of one gram also has a weight of one gram. A gram can be divided into smaller parts. These small parts are called **decigrams** (**dg**), **centigrams** (**cg**), and **milligrams** (**mg**). A decigram is $\frac{1}{10}$ of a gram, a centigram is $\frac{1}{100}$ of a gram, and a milligram is $\frac{1}{1000}$ of a gram. It takes 1,000 milligrams to equal a gram.

The mass of a gram of salt is about one milligram. Items which are sold in small amounts, such as medicine, are measured in milligrams.

How do we weigh heavier objects? We use kilograms. A **kilogram** (**kg**) is 1,000 grams. The mass of a baseball bat is about one kilogram. Heavier objects measured in kilograms are people, large animals, vehicles, and metals.

Temperature

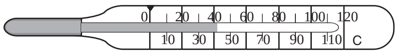
At times we must measure *temperature*. Temperature tells us how hot or cold something is at the moment. A **thermometer** measures temperature in **degrees**. The symbol for degrees is °. There are two common ways to measure temperature. On the **Fahrenheit** (F) temperature scale, water freezes at 32°F and boils at 212°F. This is the temperature scale most often used in the United States. Your normal body temperature is 98.6° F. On the **Celsius** (C) temperature scale, water freezes at 0°C and boils at 100°C. Your body has a temperature of 37°C. Whether you measure your body temperature in *Fahrenheit* or *Celsius*, the amount of heat in your body is the same and only the terms used to describe measurement are different. For most scientific work, temperature is measured on the Celsius scale.



Fahrenheit

On the Fahrenheit temperature scale, water freezes at 32°F and boils at 212°F.

Celsius



On the Celsius temperature scale, water freezes at 0°C and boils at 100°C.

When something feels cold, it is because it lacks enough heat energy to bring it up to 37°C. Cold is not the presence of something but rather an absence of heat. If you are hungry, it is because you lack food. If you are cold, it is because you lack heat. Try to think of things that become cold as things that are losing heat. This is what happens as anything cools: it loses heat.

Whether we use cool objects or heat them, we will use the Celsius temperature scale. Since the Celsius scale is based on the decimal system, it is easy to use.

Summary

Measurement is highly important in science. The SI units of measurement are used in science. These include the metric units of grams and kilograms for mass and weight, meter and kilometer for distance, and liter and kiloliter for volume. The Celsius scale is used to measure temperature.

Practice

Use your **metric ruler** *to* **measure** *the length of the following lines. The abbreviation will tell you which unit of measure to use. Write the correct answer on the line provided. Two examples have been given.*

Lines to Measure

1. ___4.5___ cm _________________________

2. ___45___ mm _________________________

3. _______ cm ___________________________________

4. _______ mm ___________________________________

5. _______ cm ___________

6. _______ mm ___________

7. _______ cm ____

8. _______ mm ____

9. _______ cm ____

10. _______ mm ____

11. _______ mm ______________________

12. _______ mm ________________________________

13. _______ mm ______________

14. _______ mm ____

15. _______ mm ____

Lab Activity 1

Facts:

- All scientific work requires careful and accurate measurements.
- Matter can be measured in terms of length, volume, and mass and/or weight.

Investigate:

- You will use metric units to measure the length of given objects.

Materials:

- metric rulers
- paper clips
- pennies
- pieces of string

Use your **metric ruler** *to determine the length of items in your classroom. Write the correct measurement in* **centimeters** *on the line provided. For the last five items, choose other objects in the classroom to measure.*

__________ 1. your pencil

__________ 2. your desktop

__________ 3. your shoe

__________ 4. a paper clip

__________ 5. the fingernail of your index finger

__________ 6. your neighbor’s arm

__________ 7. your neighbor’s height

__________ 8. this sheet of paper

__________ 9. your science textbook

__________ 10. a piece of string

__________ 11. ____________________

__________ 12. ____________________

__________ 13. ____________________

__________ 14. ____________________

__________ 15. ____________________

Practice

Circle the letter of the correct answer.

1. The space something occupies is its ______________ .

    a. liquid
    b. volume
    c. metric
    d. ounces

2. The basic unit of volume is the ______________ .

    a. liter
    b. meter
    c. gram
    d. pound

3. One ______________________ equals 1,000 milliliters.

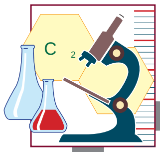
    a. kiloliter
    b. centiliter
    c. liter
    d. meter

4. One _____________________ liters equal 1 kiloliter.

    a. hundred
    b. million
    c. thousand
    d. billion

5. Soft drinks often come in 1 or 2 ____________________ containers.

    a. meter
    b. gram
    c. pound
    d. liter



Practice

Answer each question below on the line provided.

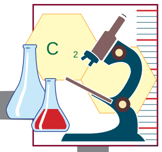
1. Which is *more*, 1 liter or 1 deciliter of gas for your car? __________
2. Which is *less*, 1 liter or 1 milliliter of milk? ____________________
3. Which is *larger*, a 2 kiloliter bottle of cola or a 2 liter bottle of cola?

   ____

4. Which is *larger*, 10 milliliters of water or 10 liters of water?

   ____

5. Which is *larger*, 10 milliliters or 10 deciliters? __________________
6. Which is *larger*, 1 kiloliter or 1 liter? __________________________
7. Which is *larger*, 100 centiliters or 100 kiloliters? _______________



Lab Activity 2

Facts:

- The volume of some solid objects can be measured using a metric ruler.

Investigate:

- You will use metric units to measure the volume of given objects.

Materials:

- class set of centimeter metric rulers
- textbook

1. With a metric ruler, find the length of the textbook to the nearest centimeter. Record your answer on the chart below.
2. Now, find the width of the textbook in the same manner. Record your answer on the chart below.
3. Measure the height of the textbook and record on the chart below.
4. We will now use the measurements that you have recorded below to find the volume of the book.

Volume = Length X Width X Height

Multiply the length of the book by its width. Then multiply that number by its height. Record your answer as the volume of the textbook.

objects	length (cm)	width (cm)	height (cm)	volume (cm)
textbook				

Lab Activity 3

Facts:

- The volume of liquid can be measured using a graduated cylinder.

Investigate:

- You will use metric units to measure the volume of liquid.

Materials:

- graduated cylinders marked in millimeters and centiliters
- water
- liter beaker

1. Look at a graduated cylinder. Note the smallest marks.

   Are these marks centiliters or milliliters? ____________________

2. Fill your cylinder to the 10 milliliter mark. Remember to observe the measurement of the liquid at eye level.

   Ten milliliters equal ________________ centiliter(s).

3. Fill the cylinder to the 10 centiliter mark.

   How many milliliters equal 10 centiliters? ___________________

4. Pour the liquid from the 10 centiliter cylinder into a liter beaker. Repeat the process until the liquid reaches the liter mark on the beaker.

   How many centiliters equal 1 liter? _________________________

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. $\frac{1}{100}$ of a gram

______ 2. how much gravity pulls on an object

______ 3. $\frac{1}{10}$ of a gram

______ 4. the basic unit of mass in the metric system

______ 5. $\frac{1}{1000}$ of a gram

A. centigram

B. decigram

C. gram

D. milligram

E. weight

Match each term with the correct abbreviation. Write the letter on the line provided.

______ 6. centiliter

______ 7. deciliter

______ 8. kiloliter

______ 9. liter

______ 10. milliliter

F. L

G. kL

H. mL

I. dL

J. cL

Practice

Answer each question below.

1. Which is the *smaller* amount, 4 decigrams or 4 kilograms? ________
2. Which is the *smaller* amount, 2 grams or 2 milligrams? __________
3. Which is the *smaller* amount, 1000 kilograms or 1000 grams? ____
4. How many decigrams does it take to make 1 gram? _____________
5. How many centigrams does it take to make 1 gram? ____________
6. How many milligrams does it take to make 1 gram? ____________
7. How many grams does it take to make 1 kilogram? _____________
8. What is the abbreviation for milligram? ________________________
9. What is the abbreviation for kilogram? _________________________
10. What is the abbreviation for decigram? _________________________
11. What is the abbreviation for centigram? ________________________
12. What is the abbreviation for gram? ____________________________

Lab Activity 4

Definition: A **balance** is an instrument used to determine the mass of an object.

Facts:

- All scientific work requires careful and accurate measurements.
- Matter can be measured in terms of length, volume, and mass and/or weight.

Investigate:

- You will measure the mass of various objects.

Materials:

- balance
- pencil
- sheet of notebook paper
- paper clips
- pennies
- textbook

Remember: A milligram is the *smallest* unit of mass that you will be using.

1. Review the definition of a gram, milligram, and kilogram.

   __________ milligrams = 1 gram

   __________ grams = 1 kilogram

2. Set up the balance on your table to find the mass of the items listed below.

A. sheet of notebook paper _______ milligram(s)
B. paper clip _______ gram(s)
C. pencil _______ gram(s)
D. 1 penny _______ gram(s)
E. 1 nickel _______ gram(s)
F. science textbook ______ kilogram(s) _______ gram(s)

Practice

Circle the letter of the correct answer.

1. How hot or cold something is is called its __________ .

   a. meter
   b. temperature
   c. thermometer

2. __________ is a temperature scale with the boiling point at 212°, the freezing point at 32°, and normal body temperature at 98.6°.

   a. Celsius
   b. Fahrenheit
   c. Centigrade

3. The unit for measuring temperature is the __________ .

   a. degree
   b. unit
   c. gram

4. A temperature scale with the boiling point at 100°, the freezing point at 0°, and normal body temperature at 37° is called __________ .

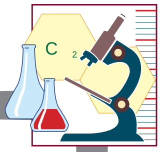
   a. Fahrenheit
   b. CS
   c. Celsius

5. A __________ is an instrument used to measure temperature.

   a. ruler
   b. degree
   c. thermometer

6. The abbreviation of Celsius is __________ .

   a. Cel.
   b. C
   c. CS



7. The abbreviation of degree is ______________ .

   a. dg
   b. D.
   c. °

8. The abbreviation of Fahrenheit is ______________ .

   a. F
   b. FA
   c. Fh.

Lab Activity 5

Facts:

- Temperature is the measure of how hot or cold a material is at the moment.
- We measure the temperature with a thermometer.

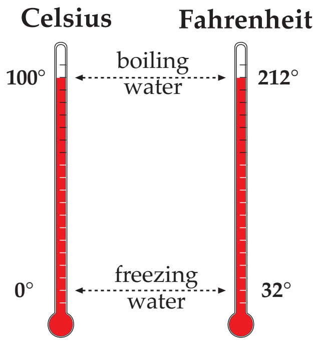
Investigate:

- You will read Fahrenheit and Celsius thermometers and compare a Fahrenheit temperature to a Celsius temperature.

Materials:

- Fahrenheit thermometer
- Celsius thermometer
- a beaker of water

Use the diagram below to answer the following.



1. At what temperature does water freeze on the Celsius scale?

____

2. At what temperature does water freeze on the Fahrenheit scale?

____

3. At what temperature does water boil on the Celsius scale?

   ____

4. At what temperature does water boil on the Fahrenheit scale?

   ____

5. On the Celsius scale, how many degrees are between the freezing and boiling points of water?

   ____

6. On the Fahrenheit scale, how many degrees are between the freezing and boiling points of water?

   ____

7. Which scale shows the larger change in temperature per degree?

   ____

8. Place the Celsius thermometer in the beaker of water. Record the temperature.

   ____________ degrees C

   Place the Fahrenheit thermometer in the beaker of water. Record the temperature.

   ____________ degrees F

9. Use the Celsius thermometer to record the room temperature.

   ____________ degrees C

   Use the Fahrenheit thermometer to record the room temperature.

   ____________ degrees F

10. Which would be warmer, air at 0°C or air at 0°F? ____________

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

0
32
100
212
1,000
centimeter
centimeters
cubic
kilometers
meter
millimeters
temperature

1. The ________________________ is the basic unit of distance in the metric system.

2. If we wanted to measure long distances using a unit in the metric system, we would use ________________________ .

3. One hundred ________________________ equals 1 meter.

4. One thousand ________________________ equals 1 meter.

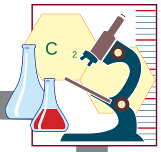
5. Ten millimeters equals 1 ________________________ .

6. One kilometer equals ________________________ meters.

7. One liter equals ________________________ milliliters.

8. A unit in the metric system that measures solid volume is a ________________________ centimeter.

9. ________________________ is the measure of the warmth of an object.



10. Water boils at ______________________ degrees Fahrenheit which is the same as ______________________ degrees Celsius.

11. Water freezes at ______________________ degrees Fahrenheit which is the same as ______________________ degrees Celsius.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. the amount of space matter takes up

______ 2. how long an object is from end to end

______ 3. the measure of the force of gravity pulling on an object

______ 4. the system of measurement based on the decimal system

______ 5. the amount of material in an object

A. length

B. mass

C. metric system

D. volume

E. weight

Match each definition with the correct term. Write the letter on the line provided.

______ 6. metric measurement for volume that is a little larger than one quart

______ 7. prefix meaning $\frac{1}{10}$

______ 8. refix meaning $\frac{1}{100}$

______ 9. prefix meaning $\frac{1}{1000}$

______ 10. metric measurement of weight and mass

______ 11. prefix meaning 1,000

______ 12. basic metric measurement that is a little longer than one yard

F. centi-

G. deci-

H. gram

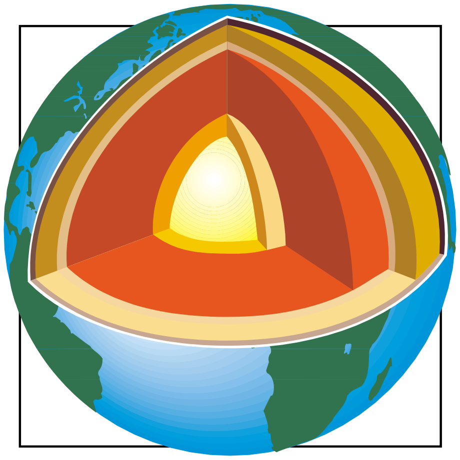
I. kilo-

J. liter

K. meter

L. milli-

Unit 3: Matter



Vocabulary

Study the vocabulary words and definitions below.

boiling point	the temperature at which a liquid turns to a gas
chemical properties	the qualities of matter that indicate whether it can change from one substance to another
chemist	a person who studies chemical operations
chemistry	the science that investigates how matter is made and how it changes
density	the mass per certain volume of a material
forms	kinds or types
freezing point	the temperature at which a liquid turns to a solid
gas	the form of matter that has no definite shape or volume
gravity	the force of attraction between all objects in the universe
liquid	the form of matter that has a definite volume but does not have a definite shape

mass	the amount of matter in a substance
matter	anything that has both mass and volume
melting point	the temperature at which a solid turns to liquid
phase	one of the states of matter of a substance (H_2O occurs in three phases: ice, liquid water, and water vapor.)
physical properties	the qualities of matter that can be observed without changing the matter (color, shape, size, density)
plasma	the form of matter in stars; this is usually gaseous matter under extreme heat and pressure
reacts	changes in response to something
solid	the form of matter that has a definite shape and volume
state	the condition of matter
volume	the amount of space that matter takes up
weight	the force of gravity on an object

Introduction

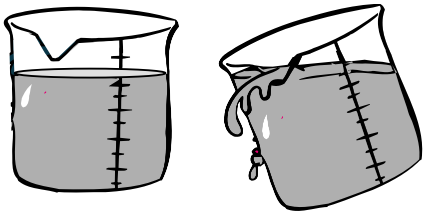
Look around you. Everything you see is **matter**. What is matter? Matter is anything that has **mass** and **volume** (takes up space). Mass is the amount of matter in an object. Remember that **weight** is the force of **gravity** pulling on the object. An object's weight depends on its mass and whether gravity is pulling on it. Earth does not pull on stars that are far away. Because of this, we cannot really talk about their weight. They do have mass, though, and they are matter. All matter takes up space. That means it has volume. So we have learned that all matter has mass and volume.

Even air is matter. It has mass and it takes up space. An empty balloon has less mass than a balloon that has been filled with air. The difference between the two is the mass of the air. The full balloon takes up more space than the empty balloon. You can see that air takes up space.

Not all matter is the same. Look at the different kinds of matter in the room. Books, tables, the air you are breathing, and the water in the sink are all different **forms** or **states** of matter. Scientists call the form of matter its **phase**. There are four phases of matter. **Gases**, **liquids**, and **solids** are all phases of matter commonly found on Earth. The fourth phase of matter is **plasma**. It is a form of matter found in stars. Although plasma is common in the universe, we have little chance to observe plasma. On Earth, plasmas usually do not occur naturally except in parts of flames and in lightning bolts.

A *solid* must have a definite shape and take up a definite amount of space. Look at a rock. It has a definite shape, and it takes up a definite amount of space. Therefore, it is a solid. Rocks are hard, but cotton is soft. Is cotton a solid? Think. Cotton has a definite shape. It takes up a definite amount of space, so cotton is also a solid. Can you change the shape of a rock or of cotton? Because the shape can change does not make the shape indefinite. If something or someone did not change them, then their shapes would remain the same. This is what is meant by a definite shape.

Matter can be a liquid. Pour one liter of water into a liter beaker. It takes up space. Tilt the beaker. The water changes shape. Pour the water into a bowl. It still is a liter of water, but it has a different shape. Liquids have a definite volume but not a definite shape.



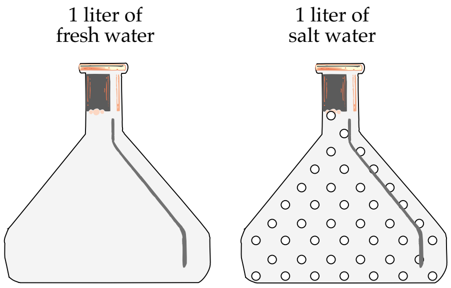
A cup of water takes up space in a beaker. Tilt the beaker. The water changes shape but it is still the same amount of water.

Some matter is in the form of gas. Blow up a balloon. The air takes up space or volume. The air inside the balloon has mass. It does not have its own shape. Gases take on the shape of whatever they are in at the moment. They also fill whatever they are in. It is possible for a beaker of water to be half empty. However, this could not occur in a balloon which had been filled with air. Even when a balloon gets smaller, the new shape is always completely full of gas.

Physical Properties

Now we know that matter commonly exists as a solid, a liquid, or a gas and that it has mass and volume. In what other ways can you describe matter? Suppose you have a few solids in front of you. How could you describe them? You probably will begin by describing their color, shape, size, or degree of hardness. The characteristics that you observe without changing the matter are called **physical properties**. It is easy to see color, shape, and size, and to feel hardness. Another physical property is **density**. Density is the amount of mass of a certain material in a certain volume.

For example, two liter containers are filled with liquids. One container is filled with fresh water. The other container is filled with salt water. The container filled with salt water has more mass than the one with fresh water. That's because salt water has more density than fresh water. The containers have the same volume, but different masses. The difference is in the density of the liquids.



These containers have the same volume (1 liter), but have different masses. Saltwater has a much greater density.

Density is a physical property of matter. Density helps determine the use of many different materials. For example, the comparison of the density of wood and the density of Styrofoam can determine *how* each material is used, and for *what purpose*.

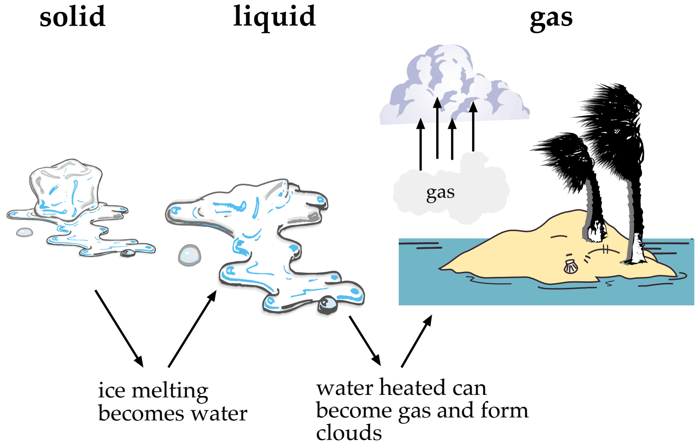
Chemical Properties

We learned that **chemistry** investigates how matter changes. **Chemical properties** of matter depend on how one substance **reacts** with other substances. Paper burns. That is because it reacts with oxygen in the air.

Iron rusts when it reacts with oxygen. Rusting is a result of a chemical property change in which a different substance is produced and the matter changes. Some materials produce gases or metals when they react with other materials. **Chemists** study these changes. Sometimes they can improve products by using the chemical properties of matter.

Changes in the Phases of Matter

We know that matter on Earth normally exists as a solid, a liquid, or a gas. Matter can be changed from one phase to another. For example, water can be a liquid. If it is frozen, it will become a solid. Remember that as substances cool they lose heat. This means they lose energy. Ice has less heat energy than liquid water. When water is heated, it can become a gas and form clouds. As substances like water warm up, they gain heat. Boiling water produces water, gas, or steam. Steam has more heat energy than ice or liquid water. Other materials can be changed from one form to another. When a material melts, it changes from a solid to a liquid. The temperature at which this happens is called the **melting point**. When a substance reaches its **freezing point** or **boiling point**, it also undergoes a physical change from one phase to another, changing some of its physical properties.



Summary

In this unit, we learned how to recognize matter in its different phases. We found out that matter has mass and volume. We are beginning to recognize some of the physical and chemical differences of matter.

Practice

Complete the following statements with the correct answer.

1. Mass is the amount of ____________________ in an object.

2. The pull of gravity on an object is its ____________________ .

3. Matter must have ____________________ and

   ____________________ .

4. a. Air is matter. True or False ____________________ .

   b. All matter is the same. True or False ____________________ .

5. The four phases of matter are ____________________ ,

   ____________________ , ____________________, and

   ____________________ .

6. A solid must have a definite ____________________ and take up

   a definite amount of ____________________ .

7. Three examples of solids are ____________________ ,

   ____________________ , and ____________________ .

8. Liquids have a definite ____________________ but no definite

   ____________________ .

9. Two examples of liquids are ____________________ and

   ____________________ .

10. Gases take on the ____________________ of whatever they are in.

11. Gases will completely ____________________ whatever they are in at the moment.

12. When a material melts, it changes from a ____________________ to a ____________________ .

13. One material that can be a liquid, solid, or gas is ____________________ .

14. Water boils at ____________________ Celsius.

15. Boiling points and freezing points are examples of ____________________ properties.

16. Which has more energy, ice or boiling water? ________________

17. If water loses enough heat energy, what phase of matter will it enter? ____________________

18. Melting a metal means you ____________________ heat.

19. When iron undergoes a reaction to become rust, it is still the same as iron. True or False ____________________

20. Paper that burns no longer has the same physical properties as it did before it was burned. True or False ____________________

Lab Activity: Part 1

Facts:

- Matter has mass and takes up space.

Investigate:

- You will demonstrate, through the use of scientific instruments, that matter has volume and mass.

Materials:

- small gram scale or balance
- graduated cylinder
- balloon
- fishing weights (assorted and lettered)
- water

1. Find the mass of an empty balloon. Record the mass to the nearest milligram on the chart below.

2. Now blow the balloon up and get its mass again. Record the mass to the nearest milligram on the chart.

3. Subtract the mass of the empty balloon from the mass of the inflated balloon. Record the difference on the chart.

mass of the empty balloon	________ milligrams
mass of the inflated balloon	________ milligrams
difference in mass	________ milligrams

a. When did the balloon have greater mass? ____________________

____

b. Why? ____

c. Does the matter inside the balloon have mass? _______________

Lab Activity: Part 2

Continuing with the Lab Activity, answer the following.

1. Fill a graduated cylinder with a quantity of water. Record the amount on the chart below.

2. Tie a string to a fishing weight and place the weight into the water. Record the new volume of water on the chart.

3. Record the difference on the chart.

volume of water in cylinder	_______ milliliters
volume of water plus object	_______ milliliters
difference in volume	_______ milliliters

4. Is the new amount of water greater than or less than the first amount of water?

   ____

5. Did we add more water? ______________________________

6. Why is there a difference between the first amount of water and the second amount of water?

   ____

   ____

7. Did the fishing weight take up the space where the water used to be?

   ____

8. Did the fishing weight take up its own space? ______________

9. From these activities, we have learned that matter has

   __________________ and takes up __________________ .

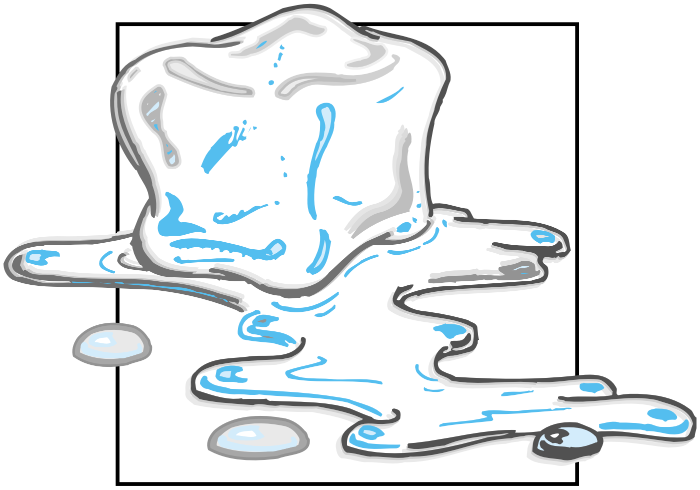
Practice

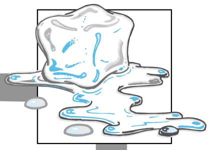
Use the word **liquid**, **gas**, *or* **solid** *to determine the outcome of each of the following actions. Write the correct answer on the line provided.*

Figure out what you would get when...

1. ice melts. ____
2. water freezes. ____________________________________
3. water boils. ______________________________________
4. a liquid gains enough energy to boil. ____________________
5. a solid is heated to its melting point. ___________________
6. steam from a boiling pot collects on the lid of the pot. ________
7. a liquid loses enough energy to reach its freezing point. ______
8. wax is left in the hot sun. ____________________________
9. juice is left in the freezer overnight. ___________________
10. ice cream is left at room temperature. __________________

Unit 4: Changes in Matter





Vocabulary

Study the vocabulary words and definitions below.

carbon dioxide (CO_2)	a gas given off when burning takes place
chemical change	change in which a new substance is produced
combustion	the process of burning a substance
composition	the makeup of a substance
physical change	any change in the form or phase of matter; no new substances are formed
pressure	the force placed on an object
substance	any material or matter

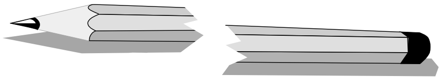
Introduction

Every day you cause changes in matter. There are many ways to change matter. This unit will discuss what these changes are and how they are different.

Physical Changes in Matter

Matter does not always stay the same. We have learned that matter can change back and forth from a liquid, solid, or a gas. The form of matter can be changed by temperature or **pressure**. Squeeze a ball of clay, break a pencil, or drop a glass. What happens? The clay is still clay, the pencil is still a pencil, and the glass is still glass. The size and shape of each piece has changed. These kinds of changes are called **physical changes**. Any change in the form or phase of matter is only a physical change. There is no change in the **composition** of the matter. No new **substances** are formed. The substances remain the same.

Physical Change

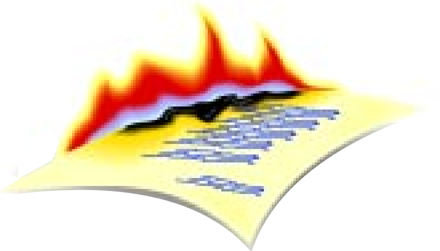


A broken pencil is still a pencil.

Chemical Changes in Matter

What happens when a piece of paper is burned? Heat, light, and smoke are given off. When the burning is complete, we can say that **combustion** is complete. After combustion there is only a pile of ashes left. Where has the paper gone? The appearance has changed, but much more has happened. The composition of the matter has changed. New substances have been formed. **Carbon dioxide**, water vapor, and ashes are produced. In **chemical changes**, energy moves and/or changes form, and a new substance is produced. Sometimes we see this energy as light. At other times, the energy is heat. Combustion is an example of a chemical change that produces heat. Burning wood can warm us. Can you think of a chemical change that takes heat away?

Chemical Change



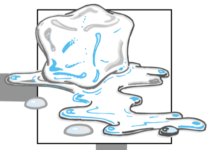
Combustion changes paper to ashes.

When food is cooked, chemical changes take place. A piece of broiled meat is chemically different from a raw piece of meat. Did the meat produce heat? No, you had to provide the heat to change it. Cooking food is an example of a chemical change that absorbs heat, or takes heat away.

Remember, during a chemical change, new substances are formed.

Summary

There are two ways to change matter. In physical changes, the phase or shape of the substance is altered. No new substance is produced. In chemical changes, new substances are created. A common way to cause chemical changes is through combustion.



Practice

Use the list below to complete the following statements.

carbon dioxide
changes
chemical
phase
physical

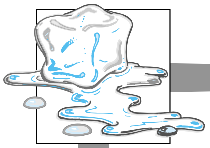
1. Breaking a piece of wood is an example of a ____________________ change.

2. During a ____________________ change, new substances are formed.

3. In chemical ____________________, energy moves and/or changes form.

4. If paper combusts, ____________________, water vapor and ashes are made.

5. A change in the state of matter is a ____________________ change.



Lab Activity

Facts:

- Chemical changes produce new substances.
- Changes in phase are physical changes.
- Heat can be a product of a chemical change.

Investigate:

- You will differentiate between physical and chemical changes through laboratory experiences.

Materials:

- ice
- vinegar
- baking soda
- beakers
- chalk
- dishes
- spoon

1. Break a piece of chalk in half.

   a. Did the ice change form? ________________________________

   b. What is the new form? __________________________________

   c. Did you produce a new substance? ____________________

   d. Is this a physical or a chemical change? ________________

   e. Record your observation on the chart below question 3.

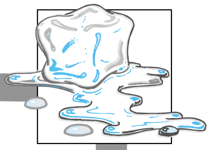
2. Break a piece of chalk in half.

   a. Are the two pieces still chalk? __________________________

   b. Did you produce a *new* substance? ____________________

   c. Is this a physical or a chemical change? ________________

   d. Record your observation on the chart below question 3.



3. Put a small amount of baking soda into a dish. Pour a few drops of vinegar into the dish. Stir the two substances together. Feel the dish.

   a. Does it feel warm? ______________________________

   b. Do you still have vinegar and baking soda? _____________

   c. Could you separate the two substances? _______________

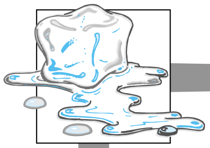
   d. Is this a physical or a chemical change? ________________

   e. Record the physical and chemical changes under the correct heading on the chart below. An example has been provided for each type of change.

Physical and Chemical Changes

Physical  Example: boiling water	**Chemical**  Example: burning paper
1. 2.	1. 2.

   f. You have just learned that by mixing vinegar and baking soda, you produced a ____________________ change. Heat is often a product of a chemical change. One of the new substances you formed is carbon dioxide. Carbon dioxide is a gas. It is the same carbon dioxide as the substance formed when paper is burned.



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a gas given off when burning takes place

______ 2. the makeup of a substance

______ 3. the force placed on an object

______ 4. the process of burning a substance

______ 5. material or matter

______ 6. any change in the form or state of matter

______ 7. any change in which a new substance or substances are produced

A. carbon dioxide

B. chemical change

C. combustion

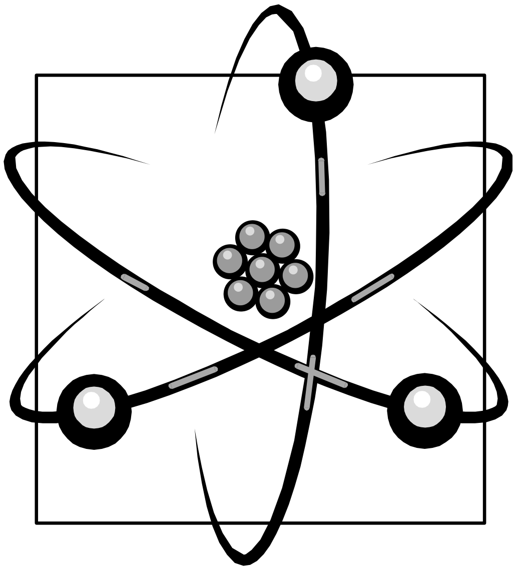
D. composition

E. physical change

F. pressure

G. substance

Unit 5:
Introduction to the Atom



Vocabulary

Study the vocabulary words and definitions below.

atom	the smallest unit of an element that is still that element; the basic building block of matter
attract	move toward each other
bond	the attraction that holds two or more atoms together
charge	a property of an object that causes it to be affected by a magnetic field
compound	a substance formed when two or more elements combine chemically
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
element	a substance that cannot be broken down into a simpler form by ordinary chemical means
molecule	two or more atoms that have a bond of shared electrons
negative charge	the charge of an electron

neutral	being neither positively nor negatively charged
neutron	the neutral particle found in the nucleus of an atom; a neutron has no charge
nucleus	the middle part of an atom around which the electron(s) move
orbit	the path(s) that the electron follows around the center of an atom
positive charge	the charge of a proton; considered opposite of negative
proton	the positively charged particle in the nucleus of an atom
repel	push away from
shell	the space that electron(s) occupy while in a certain orbit

Introduction

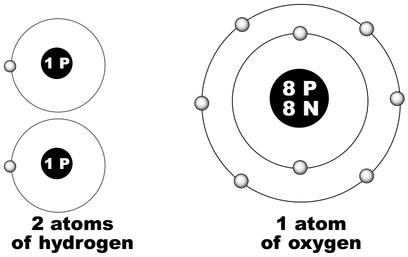
Did you ever wonder what is in air? Have you ever thought about how there are an incredible number of different things in the world? All that you see, touch, and feel is made from tiny units of matter. This unit will introduce you to these unseen building blocks of the universe.

Elements

There are thousands and thousands of different substances in the world. Water is a substance. Sugar is a substance. Oxygen is a substance. All of the substances that we know are made of **elements**. The elements are the substances that have unique chemical and physical properties. Elements cannot be broken down into other substances that are unique. Of water, sugar, oxygen, which is the element? One way to find out is through chemistry. If we break down the water, we will get hydrogen and oxygen gas. If we break down the sugar, we get hydrogen, oxygen, and carbon. We cannot use chemistry to break down the oxygen. This means that oxygen is the element. Oxygen is a part of such substances as water, sugar, carbon dioxide, rust, and wood.

Atoms

All substances are made of **atoms**. Atoms are very tiny pieces of matter. An atom is the smallest unit of an element that is still that element. This may sound strange, but what it means is that an atom of gold is still gold. You cannot see that atom of gold. You cannot feel it. Despite this, it still has the physical and chemical properties of gold. Atoms still have all the properties of the element. An atom is the smallest unit of an element that can go through a chemical change. An atom can gain or lose **electrons**, a process which can then change its **charge**. Electrons are negatively charged particles that **orbit** the **nucleus** of an atom. If an atom gains extra electrons, it will become **negatively charged** (–). A loss of electrons will create a **positive charge** (+). There are about 120 different elements. So, there are about 120 different kinds of atoms. These atoms can combine with each other and form many different kinds of substances. One substance made from the combining of atoms is water. Water is made of two atoms of hydrogen and one atom of oxygen. One model for the hydrogen atoms is shown here. Hydrogen has one **shell** of electrons. There is only one electron in the shell. The other, larger atom, is a similar model of oxygen. Oxygen has two shells of electrons. The outer shell has six electrons. In the next section we will talk about how these atoms combine. When two or more atoms combine, a chemical change takes place.

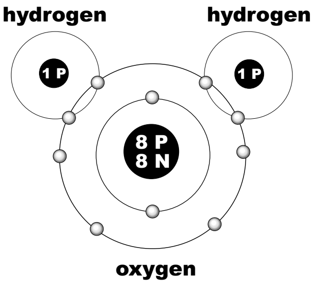


Water Molecule Broken Down into Its Elements

Molecules

A **molecule** is formed when atoms share electrons. In chemical reactions, only electrons are involved. This is because only electrons are on the outside of the atoms. Because its electrons are shared, a molecule is always made of two or more atoms.

Look at the diagram of a water molecule on the left. It has two hydrogen atoms and one oxygen atom. Notice where the electrons are in the diagram of the water molecule. Each hydrogen atom has its own electron, but each now shares an electron with oxygen. Oxygen has six electrons in its outer shell. Oxygen now shares electrons with the hydrogen atoms. Because these three atoms are sharing electrons, they form a molecule. Water is the substance made of molecules that have two hydrogen atoms and one oxygen atom.



Water Molecule

Some molecules are not made of different types of atoms. For instance, the element chlorine is often seen as a molecule. In this case, two atoms of chlorine share electrons. Even though chlorine is often a molecule, it is still an element. Why is this? If you broke the **bonds** between the water, you would have two gases (hydrogen and oxygen) which are very different from water. If you broke the bonds between chlorine atoms, you would still have chlorine. Chlorine is just one of the elements that commonly form molecules. In fact, both oxygen and hydrogen atoms will form molecules when not bonded to other atoms. Now that you know what a molecule is, the next section will discuss **compounds**.

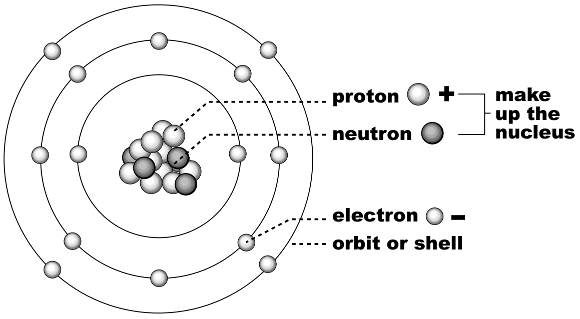
Compounds

A compound has two or more atoms of different kinds. Oxygen, remember, is an element. Its molecules are made of two atoms of oxygen. Water, however, is a compound. Its molecules are made of two atoms of hydrogen and one atom of oxygen. The behavior of molecules is determined by the forces holding the molecules together. The molecules in matter help explain the differences between solids, liquids, and gases. In a solid, the molecules are very close together. They cannot move around very easily. The molecules in a liquid are further apart and can move easily. In a gas, the molecules are very far apart. They can move freely. That’s why the molecules of a gas always can fill a container.

When matter changes phase, the distance between the molecules changes. Gaining heat usually causes the molecules to move apart. This may cause melting. Freezing, which is a loss of heat energy, causes the molecules to slow down and move closer together.

Inside the Atom

It is hard to imagine anything as small as an atom, but atoms are made of even smaller parts. Except for hydrogen, atoms have **protons**, **neutrons**, and electrons. (Hydrogen is made only of a proton and an electron.) The middle part of an atom is called the nucleus. It is made of protons and neutrons. Around the nucleus are electrons. Electrons move around the center of the atom. The paths they follow are called orbits. Orbits group together at certain distances from the nucleus. Then the orbits are grouped together, and this is known as a shell.

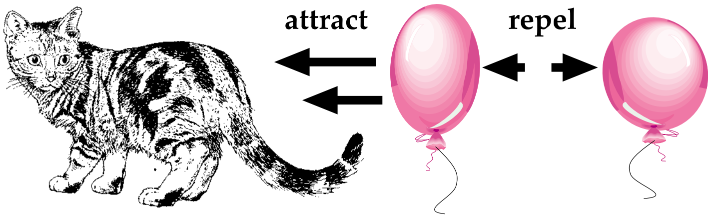


Parts of the Atom

Each part of the atom is important. The proton has a positive charge. In math or science, a positive is shown with a plus (+) sign. A neutron has no charge. (Neutron sounds almost like **neutral**.) The electron that orbits around the center of the atom has a negative charge. Negative is shown by a minus (–) sign. The electrons are the part of the atom that react chemically with other atoms.

We said that a proton has a positive charge, a neutron has no charge, and an electron has a negative charge. What do we mean by the word "charge"? It stands for an electrical charge. Things that have the same charge push each other away or **repel**, but things that have different charges will move toward each other or **attract**. The forces that push and pull objects based on their charges are known as electrical forces. These electrical forces are often described by the phrase, "Opposites attract, likes repel."

Usually matter is neutral. It has no charge. In an atom, the number of electrons (–) equals the number of protons (+). It is possible for an electron (–) to be added to an atom. Rub two balloons filled with air on a piece of fur or wood. The atoms in the balloons pick up an extra electron atom from the fur. They now have a negative (–) charge. Place the balloons next to each other. They will move away from each other. Remember, two negatives (–) will push away from or repel each other. What about the fur? It has lost electrons. Now it has a positive (+) charge. Rub a balloon on the fur. The balloon is negative (–) and the fur is positive (+). The balloon should move toward the fur.



Opposites attract, likes repel.

Summary

We have learned some important facts about atoms. We know that they are the smallest unit of an element that is still the element. Elements are made of only one kind of atom. We know they form molecules when they share electrons. We also know they combine with other atoms to make compounds. Atoms have smaller parts called neutrons, protons, and electrons. We learned that same or like charges move away from each other. Different or unlike charges move toward each other.

Lab Activity

Facts:

- Atoms are a fundamental unit of structure.
- Atoms combine to form molecules.

Investigate:

- You will create, through laboratory experiences, simple models of molecules.

Materials:

- toothpicks
- poster board
- two sizes of Styrofoam balls
- glue
- colored markers

Oxygen Molecule

1. We are going to build a model of an oxygen molecule. An oxygen molecule has two oxygen atoms.
2. Pick up two large Styrofoam balls. Each one stands for an atom of oxygen.
3. Label each ball with an O for oxygen. Remember that the O is the symbol for oxygen.
4. Place a toothpick in one of the O atoms. Connect the other O atom to the end of the toothpick.

   a. How many atoms are connected? ____________________________

   b. Are the atoms the same? _____________________________________

   c. You have just made a model of a molecule of _________________ .

5. Glue the molecule to a piece of poster board.

6. Label your model "Molecule of Oxygen."

Water Molecule

1. Now we are going to create a model of a molecule of water.

   Is water an element or a compound? ____________________

2. Since compounds are made from two or more different elements,we will need to use different kinds of balls in our model.

3. Choose one larger ball and label it with an O for oxygen.

4. Choose two smaller balls. Label each with an H for hydrogen.

5. Use toothpicks to connect an H atom to each side of the O atom.

   How many atoms are in the molecule of water? ______________

6. Glue the model to a piece of poster board.

7. Label your model "Molecule of Water."

Illustrations

1. Draw a picture of your oxygen model in the space below. Label the atoms with the correct symbols.

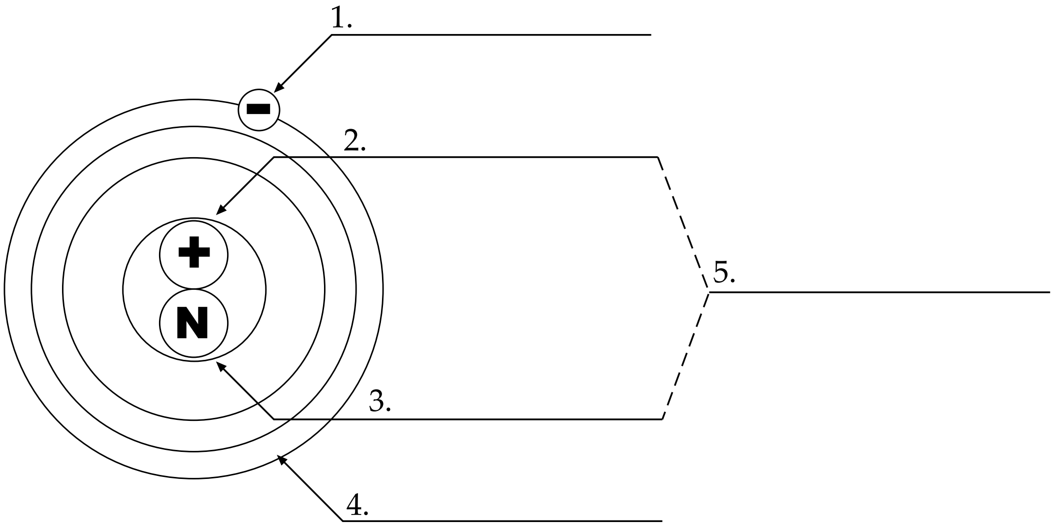
2. Draw a picture of your water molecule in the space below. Label the atoms with the correct symbols.

3. Which of the items represented the bond between the atoms?

____

Practice

Label the parts of the **atom** *in the diagram below.*



Practice

The symbol ⊕ *represents* **protons**. *The symbol* ⊖ *represents* **electrons**. *Write what would happen if the two charges were placed near each other. Use the terms:* **repel** (push away) or **attract** (move toward each other).

________________ 1. ⊕ ⊕

________________ 2. ⊖ ⊖

________________ 3. ⊖ ⊕

________________ 4. ⊕ ⊖

Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

apart
atom
distance
electrons
forces
molecule
nucleus
orbit
phase
together

1. An ____________________ is the smallest unit of an element that is still that element.

2. A ____________________ is two or more atoms that share electrons in a bond.

3. When matter changes phase, the ____________________ between the molecules changes.

4. The behavior of these molecules is determined by the ____________________ that hold them together.

5. Heat usually causes molecules to move ____________________ .

6. Freezing usually causes the molecules to slow down and move ____________________ .

7. Changes in ____________________ , like melting, are caused by gaining or losing energy.

8. Except for hydrogen, atoms are made of protons, neutrons, and ____________________ .

9. The middle part of the atom is the ____________________ .

10. ____________________ move around the center of the atom.

11. The path that the electrons follow is called an

____________________ .

attract
away
negative
neutral
no
one
positive
repel
shell
toward

12. The space that electron(s) occupy while in a certain orbit is called a

____________________ .

13. The proton has a ____________________ charge.

14. The electron has a ____________________ charge.

15. The neutron has ____________________ charge.

16. ____________________ means no charge.

17. If two positive charges were placed near each other, they would

____________________ . (repel or attract)

18. If two negative charges were placed near each other, they would

____________________ . (repel or attract)

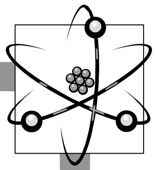
19. If a negative charge was placed near a positive charge, they would

____________________ . (repel or attract)

20. Like charges move ________________________ from each other.

21. Opposite charges move ________________________ each other.

22. Elements are made of only ________________________ kind of atom.



Practice

Use the list below to write the correct term for each definition on the line provided.

atom
bond
charge
compound
electron
element
molecule
negative charge
neutron
nucleus
orbit
positive charge
proton
shell

______________________________ 1. the charge of an electron

______________________________ 2. the charge of a proton

______________________________ 3. the smallest unit of an element that is still that element

______________________________ 4. two or more atoms that have a bond of shared electrons

______________________________ 5. a property of an object that causes it to be affected by a magnetic field

______________________________ 6. the positively charged particle in the nucleus of an atom

______________________________ 7. the space that electron(s) occupy while in a certain orbit

______________________________ 8. the path that the electron follows around the center of an atom

______________________________ 9. the middle part of an atom

______________________________ 10. the neutral particle found in the nucleus of an atom; has no charge

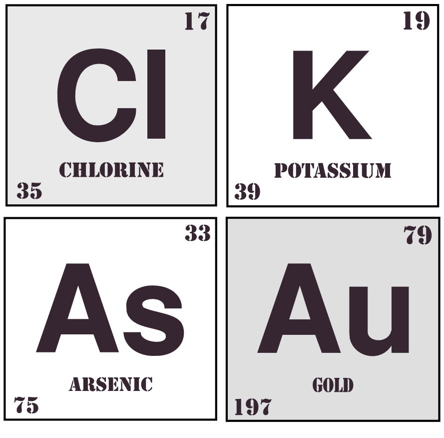
______________________________ 11. the negatively charged particle of an atom

____________________ 12. the attraction that holds two or more atoms together

____________________ 13. when two or more elements combine chemically

____________________ 14. a substance that cannot be broken down into a simpler form by ordinary chemical means

Unit 6: Atomic Theory



Vocabulary

Study the vocabulary words and definitions below.

alchemists	a group of people who searched for a way to turn ordinary metals into gold
atomic mass unit (amu)	a unit of mass equal to the mass of a proton or a neutron; $\frac{1}{12}$ of the mass of a carbon atom
atomic number	a number used to identify an element and represent its placement in the periodic table; identifies the number of protons in the nucleus of an atom
atomic mass	the mass of protons and neutrons found in the nucleus of an atom
group	elements arranged in a vertical column on the periodic table representing similarities in properties
metal	a substance that has a specific luster, is usually a good conductor of heat and electricity, and can be pounded or drawn into various shapes
nonmetal	an element that does not have the properties of a metal

period	arrangement of elements into horizontal rows on the periodic table
periodic table	a table showing the arrangement of the chemical elements according to their atomic numbers and chemical properties
rare	not common or usual; hard to find
theory	an idea or explanation based on scientific experiment

Introduction

You have learned what atoms are, and in this unit, you will add to that knowledge. You will be introduced to theories about how atoms behave. You will also begin to see how scientists can predict behavior.

Reviewing the Atom

Think about what you have learned about the atom. The atom is the smallest unit of an element. An atom of silver still has all the properties of silver. You should also remember that atoms can combine with other atoms to form molecules and compounds.

History of the Atom

How did man learn about the atom? Atoms are too small to be seen. But as long as 2,000 years ago, the Greeks were curious about matter. They wondered how it was made. Many guesses were made about the atom. At first they guessed that atoms could not be split apart. Today we know that is not true, but these early ideas helped scientists study atoms.

About 150 years ago, an English chemist named John Dalton studied atoms. His **theory** about atoms stated the following:

- Elements are made of atoms.
- All atoms in an element have the same mass.
- Atoms cannot be split apart.
- Atoms combine with atoms of other elements to make new substances.

Some of Dalton's theory has been disproved, but it was the beginning of the modern study of atoms.

There have been many modern inventions that helped scientists study atoms. Scientists can study the atom by breaking it up into electrons, protons, and neutrons. These small parts still cannot be seen. However, the path they leave can be photographed. It's a little like knowing a jet is in the sky by watching the path it leaves.

Atomic Number

The total number of elements is not known. It is often stated that there are about 120 elements. This means that there are essentially 120 different kinds of atoms. How are these atoms different from each other? The atoms of different elements have different numbers of protons. The protons are found in the center of the atom. The **atomic number** of any element tells how many protons are in the atom. All atoms of a particular element have the same number of protons. This is why the atomic number identifies the element. Remember also that atoms without a charge have the same number of electrons as protons. This is why the atomic number also tells the number of electrons in an atom. If an atom has 15 protons, it also has 15 electrons, and its atomic number is 15.

Periodic Table of Elements

Suppose someone gave you a box filled with different kinds of balls. They asked you to arrange them in order so that you could always find the one you wanted. How would you begin? Would you arrange them by color, size, weight, or some other property?

People who studied matter had the same problem. They had a set of elements they wanted to arrange in some kind of order, so they tried a few ways. Among the earliest groups of people during the Middle Ages to try to arrange matter in an ordered way were the **alchemists**. The alchemists wanted to change ordinary **metals** into the element gold. As you have learned, chemical changes don't alter elements. The alchemists did not succeed in creating gold. However, they did learn a great deal about elements. This set the stage for modern chemistry.

At one time, it was believed that substances burned because of some inner property. This theory was widely accepted. Although some scientists could use this theory to predict combustion, it didn't work well. Then scientists theorized that the element oxygen might exist. The theory stated that when oxygen combined with substances, changes took place. Eventually the old theory was discarded. Because the new theory better described the world, it was eventually accepted.

In this way, many elements were discovered. Each time a new finding was made, it was subjected to many tests. If other scientists could not show it was wrong, then the new theory might be accepted. After a while, scientists began to see a better picture of the world.

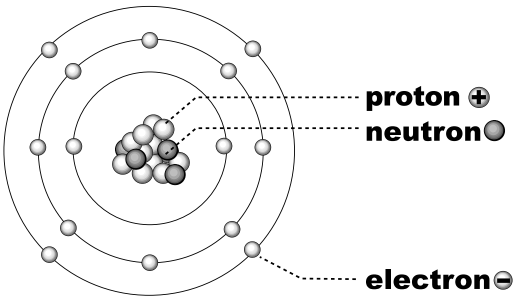
Now, scientists had quite a group of elements. They decided to make a chart or table based on the atomic number of each atom. Since hydrogen has an atomic number of one (1), it became the first element on the table. However, there were some problems with the table, because it had some missing spaces. Scientists theorized that there were unknown elements, so they experimented to find the missing elements. A few were discovered in the natural world, and a few were created in the laboratory. Some of the new elements are very **rare**. Today we generally count about 120 elements. Their atomic numbers range from one to 120. Scientists who discovered the new elements were allowed to name them. More elements may be discovered in the future.

Of course, new discoveries will be tested. If they do not fit well with what is already accepted, they may be criticized. If in the long run they do work well, then they should help predict new findings. If not, they will be discarded.

Atomic Mass

The center of an atom is called the nucleus. It contains protons and neutrons. An atom is very small, but it has mass. It would be impossible to measure the mass of an atom using grams, so a special unit of measure is used. It is called the **atomic mass unit (amu)**.

One proton has the mass of one amu. A neutron also equals one amu. The **atomic mass** of an atom equals the sum of the number of protons and neutrons. For example, a neon atom has 10 protons and 10 neutrons. Its atomic weight equals 20.



What about electrons? They are so small that they add almost no mass to the atom. For the work in this course, the mass of electrons will be ignored.

The atomic mass of atoms is usually compared to the atomic mass of carbon. Carbon has an atomic mass of 12.

Using the Periodic Table

You have already learned that the **periodic table** is arranged by atomic number (the number of protons in an element). The table also gives other important information. (See the periodic table on pages 98-99.)

Group

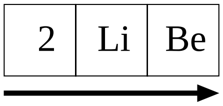
Each column of elements from the top to the bottom is called a **group**. Groups of elements have properties that are alike. The elements have properties that are alike because of their electrons. All the elements in a group have the same number of electrons in their atoms' outer shells. The outer shell is farthest from the nucleus. The electrons in the outer shell can be thought of as being on the outside of the atom.

Each group has a letter and a number. All of the elements in Group 1 have one electron in their atoms' outermost shell.

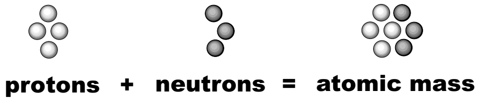
Group 1
H
Li
Na
K
Rb
Cs
Fr

Period

The groups of elements going across on the table are called **periods**. Each period has a number. The elements in a period have different properties. All elements in the left-hand side of a period tend to lose electrons. The atoms of the elements toward the right side of the period tend to gain electrons. All the atoms at the far right neither gain nor lose electrons. Although the elements in a period have very different properties, we can predict these properties.



On most tables, like the one on pages 98 and 99, there is a heavy line going down the right side. It looks like steps. All of the elements to the left of the line are *metals*; all the elements to the right are **nonmetals**. The elements that are manmade have an asterisk (*) in front of the symbol. When you study the table, you will recognize some common elements and their symbols. You will also become familiar with some new elements.



Remember that the atomic number equals the number of protons (which is also the same as the number of electrons in neutral atoms). Atomic mass is the sum of protons and neutrons. The periodic table arranges the elements by atomic number.

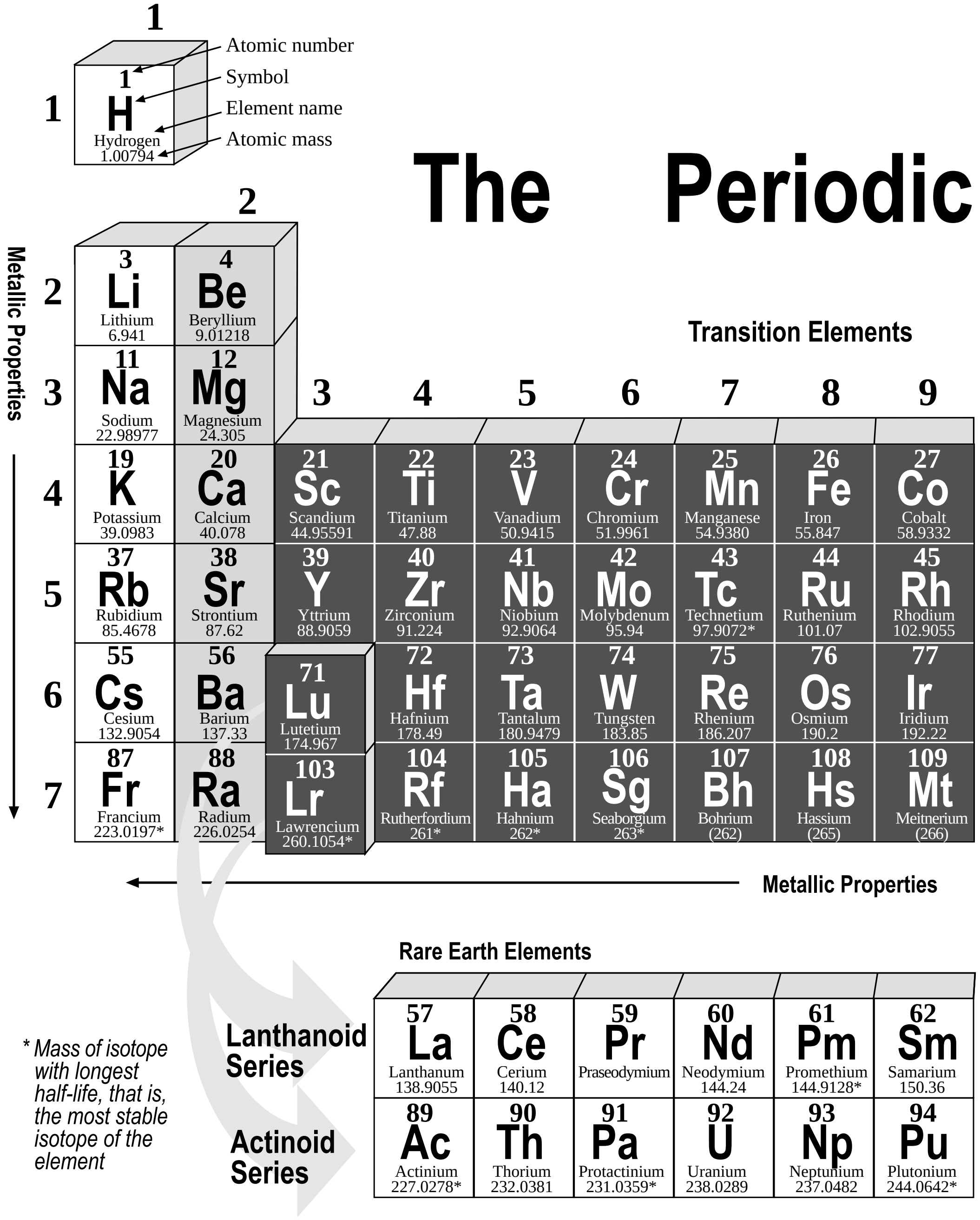
Elements and their symbols are listed in numerical order and grouped based on the atomic number.

Scientists did a great deal of work to create the periodic table. Do you think they knew it would succeed when they started? Although they did not know, they did assume it would work. Chemistry demonstrates one of the fundamental ideas in science. Virtually all scientists see the whole universe as a system. That is, they see it almost as a machine with countless parts.

Your family's car has many parts. A mechanic assumes he can study your car and figure out how to fix it. He assumes this because he knows the different parts relate to each other. In much the same way, scientists believe the parts of the universe affect each other. Sometimes, they work together simply. Other times, the relationship is very complex. However, by studying the relationships, scientist learn. They hope to learn by what rules the universe works. In developing the periodic table, they learned many rules about atoms.

Summary

All atoms have an atomic number equal to the number of protons. In neutral atoms the number of protons and electrons are equal. The periodic table of the elements arranges atoms into groups based on the number of electrons in an atom's outermost shell. Atoms are also arranged by increasing atomic mass. Atomic mass is the sum of the mass of protons and neutrons in a nucleus. The periodic table was developed in many stages. Theories were tried, tested, and discarded, if necessary. Old theories are replaced only when the new is better. The result is an ever-improving view of the universe. Scientists could develop the periodic table only because they assumed they could discover how the universe works. Study the periodic table and chart of symbols and elements that follow.



The Periodic

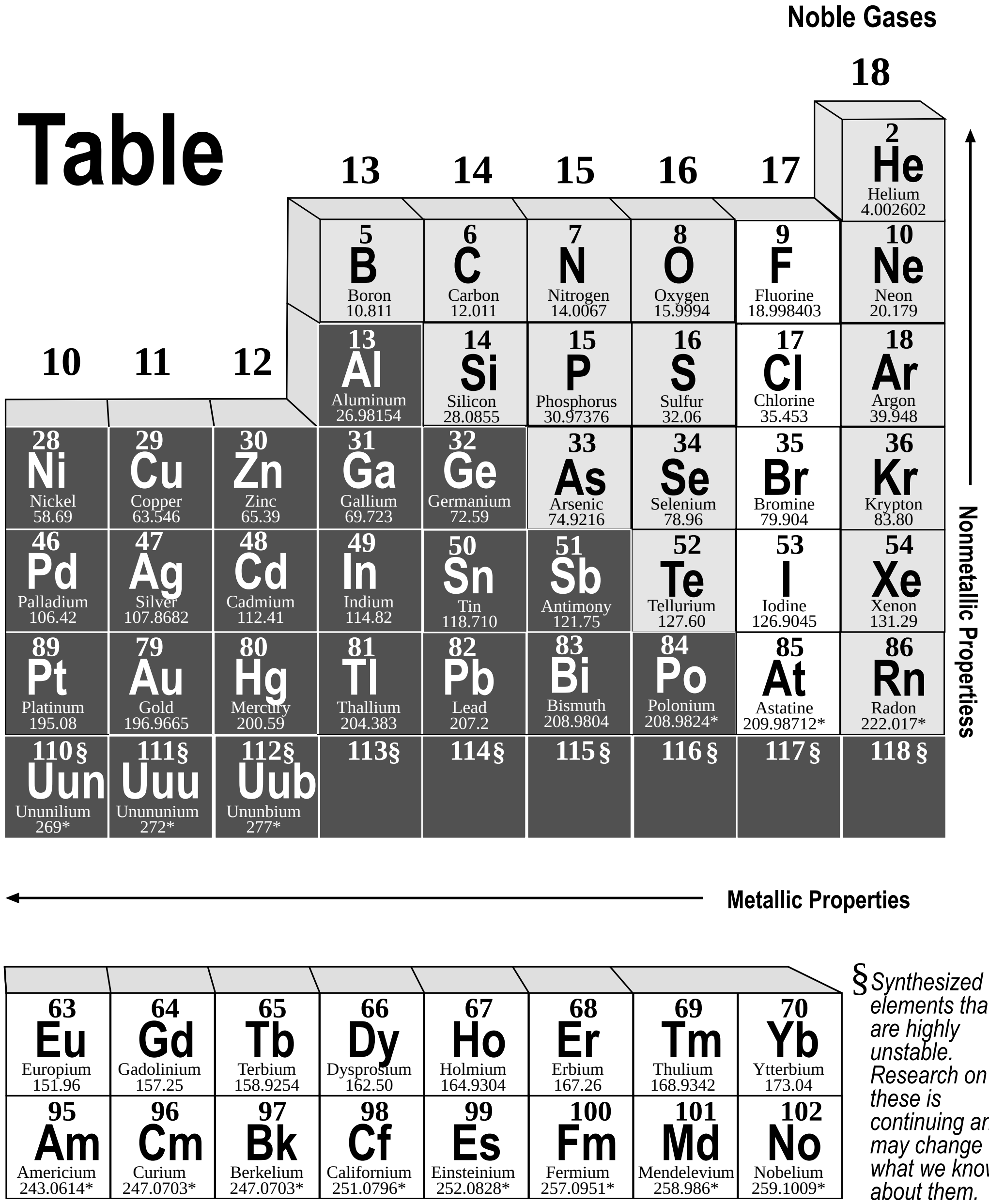
	1	2	3	4	5	6	7	8	9
1	1 H Hydrogen 1.00794								
2	3 Li Lithium 6.941	4 Be Beryllium 9.01218							
3	11 Na Sodium 22.98977	12 Mg Magnesium 24.305							
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.224	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 97.9072*	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055
6	55 Cs Cesium 132.9054	56 Ba Barium 137.33	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22
7	87 Fr Francium 223.0197*	88 Ra Radium 226.0254	103 Lr Lawrencium 260.1054*	104 Rf Rutherfordium 261*	105 Ha Hahnium 262*	106 Sg Seaborgium 263*	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)

Rare Earth Elements

Lanthanoid Series	57 La Lanthanum 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium	60 Nd Neodymium 144.24	61 Pm Promethium 144.9128*	62 Sm Samarium 150.36
Actinoid Series	89 Ac Actinium 227.0278*	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359*	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642*

** Mass of isotope with longest half-life, that is, the most stable isotope of the element*

Table



10	11	12	13	14	15	16	17	18
								2 He Helium 4.002602
			5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.179
			13 Al Aluminum 26.98154	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
28 Ni Nickel 58.69	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.710	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.29
89 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 208.9824*	85 At Astatine 209.98712*	86 Rn Radon 222.017*
110§ Uun Ununilium 269*	111§ Uuu Unununium 272*	112§ Uub Ununbium 277*	113§	114§	115§	116§	117§	118§

63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04
95 Am Americium 243.0614*	96 Cm Curium 247.0703*	97 Bk Berkelium 247.0703*	98 Cf Californium 251.0796*	99 Es Einsteinium 252.0828*	100 Fm Fermium 257.0951*	101 Md Mendelevium 258.986*	102 No Nobelium 259.1009*

§ *Synthesized elements that are highly unstable. Research on these is continuing and may change what we know about them.*

Symbols and Elements

H	Hydrogen (1)
He	Helium (2)
Li	Lithium (3)
Be	Beryllium (4)
B	Boron (5)
C	Carbon (6)
N	Nitrogen (7)
O	Oxygen (8)
F	Fluorine (9)
Ne	Neon (10)
Na	Sodium (11)
Mg	Magnesium (12)
Al	Aluminum (13)
Si	Silicone (14)
P	Phosphorus (15)
S	Sulfur (16)
Cl	Chlorine (17)
Ar	Argon (18)
K	Potassium (19)
Ca	Calcium (20)
Sc	Scandium (21)
Ti	Titanium (22)
V	Vanadium (23)
Cr	Chromium (24)
Mn	Manganese (25)
Fe	Iron (26)
Co	Cobalt (27)
Ni	Nickel (28)
Cu	Copper (29)
Zn	Zinc (30)
Ga	Gallium (31)
Ge	Germanium (32)
As	Arsenic (33)
Se	Selenium (34)
Br	Bromine (35)
Kr	Krypton (36)
Rb	Rubidium (37)
Sr	Strontium (38)
Y	Ytterbium (39)
Zr	Zirconium (40)
Nb	Niobium (41)
Mo	Molybdenum (42)
Tc	Technetium (43)
Ru	Ruthenium (44)
Rh	Rhodium (45)
Pd	Palladium (46)
Ag	Silver (47)
Cd	Cadmium (48)
In	Indium (49)
Sn	Tin (50)
Sb	Antimony (51)
Te	Tellurium (52)
I	Iodine (53)
Xe	Xenon (54)
Cs	Cesium (55)
Ba	Barium (56)
Hf	Hafnium (72)
Ta	Tantalum (73)
W	Tungsten (74)
Re	Rhenium (75)
Os	Osmium (76)
Ir	Iridium (77)
Pt	Platinum (78)
Au	Gold (79)
Hg	Mercury (80)
Ti	Thallium (81)
Pb	Lead (82)
Bi	Bismuth (83)
Po	Polonium (84)
At	Astatine (85)
Rn	Radon (86)
Fr	Francium (87)
Ra	Radium (88)
Rf	Rutherfordium (104)
Ha	Hahnium (105)
Sg	Seaborgium (106)
Bh	Bohrium (107)
Hs	Hassium (108)
Mt	Meitnerium (109)
Uun	Ununilium (110)
Uun	Unununium (111)
Uub	Ununbium (112)

Rare Earth Elements

La	Lanthanum (57)
Ce	Cerium (58)
Pr	Praseodymium (59)
Nd	Neodymium (60)
Pm	Promethium (61)
Sm	Samarium (62)
Eu	Europium (63)
Gd	Gadolinium (64)
Tb	Terbium (65)
Dy	Dysprosium (66)
Ho	Holmium (67)
Er	Erbium (68)
Tm	Thulium (69)
Yb	Ytterbium (70)
Lu	Lutetium (71)

Actinide Series

Ac	Actinium (89)
Th	Thorium (90)
Pa	Protactinium (91)
U	Uranium (92)
Np	Neptunium (93)
Pu	Plutonium (94)
Am	Americium (95)
Cm	Curium (96)
Bk	Berkelium (97)
Cf	Californium (98)
Es	Einsteinium (99)
Fm	Fermium (100)
Md	Mendelevium (101)
No	Nobelium (102)
Lr	Lawrencium (103)

Practice

Use the **periodic table** *on pages 98-99 to complete the following chart.*

element	symbol	atomic number	number of protons	number of electrons
hydrogen	H	1		
calcium		20		20
carbon	C			6
nitrogen		7	7	
oxygen			8	8
iron	Fe	26		
copper			29	

Practice

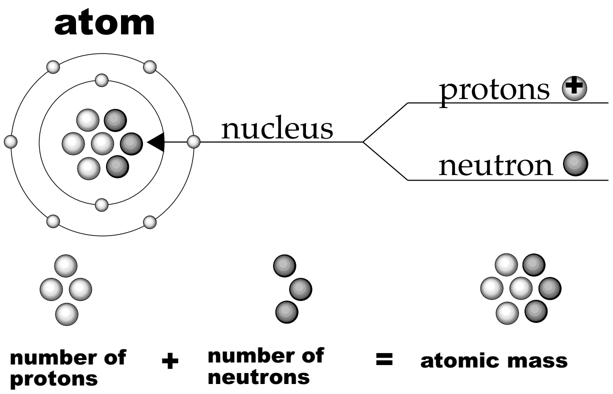
Use the **periodic table** *to write the symbols of 10 elements. Write the name of the* **element** *on the line next to the* **symbol***. Two examples have been given.*

Symbols	Element
Ca	calcium
O	oxygen

1. ____________________ ____________________
2. ____________________ ____________________
3. ____________________ ____________________
4. ____________________ ____________________
5. ____________________ ____________________
6. ____________________ ____________________
7. ____________________ ____________________
8. ____________________ ____________________
9. ____________________ ____________________
10. ____________________ ____________________

Practice

Complete the following chart with the missing numbers. **Remember:** *The* **atomic mass** *is the total number of* **protons** *and* **neutrons** *found in the nucleus of an atom.*



element	number of protons	number of neutrons	atomic mass
cobalt	27	32	59
sodium	11	12	
calcium		20	40
carbon	6	6	
oxygen	8		16
helium		2	4

Practice

Use your **periodic table** *and the charts you completed throughout the unit to answer the following.*

1. List the following elements in order from the lightest to the heaviest: calcium, hydrogen, and iron.

   ____

2. Name another element in the same group as hydrogen.

   ____

3. Name three metals in period 4. ________________________

   ____

   ____

4. Name three nonmetals in period 4. ______________________

   ____

   ____

5. Name another element in the same period as potassium and scandium.

   ____

6. Write the name of each element with the atomic number given below:

   8: ____

   16:____

   82:____

7. **Na** stands for the element ___________________________ .

8. **As** stands for the element ________________________________ .

9. The symbol for helium is ________________________________ .

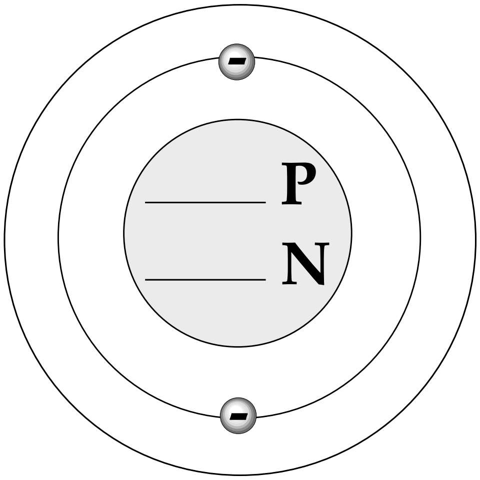
10. The atomic mass for sodium is ________________________________ .

Practice

Use the **periodic table** *on pages 98-99 to answer the following.*

1. What is the symbol for the element carbon? ____________________

2. Write the correct number of protons and neutrons of carbon in the diagram below. Since there are already two electrons in the first shell, draw the correct number of electrons on the outer shell.



3. The atomic mass is ____ .

4. The atomic number is ____ .

5. The number of protons is ____________________________________ .

6. The number of electrons is __________________________________ .

7. The number of neutrons is ___________________________________ .

Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

1
11
79
120
amu
atomic
atomic mass unit
atomic number
atoms
electrons
Greeks
hydrogen
John Dalton
neutron
neutrons
nucleus
protons
sum

1. As long as 2,000 years ago, ____________________ were curious about matter.

2. About 150 years ago, ____________________ set up a theory that said all elements are made of atoms.

3. Dalton's theory said that ____________________ could not be split.

4. There are about ____________________ kinds of atoms.

5. Protons are found in the ____________________ of the atom.

6. The ____________________ of an element tells how many protons are in its atom.

7. If we know the number of protons, we also know the number of ____________________ .

8. Gold has 79 protons, so it has ____________________ electrons.

9. The first element on the periodic table is ____________________ .

10. The atomic number of hydrogen is ____________________ .

11. The elements are arranged on the periodic table in numerical order
based on the ____________________ number.

12. The center of an atom is called its ____________________ .

13. The nucleus of an atom contains ____________________ and
____________________ .

14. A special unit used to measure the mass of atoms is the
____________________ .

15. The abbreviation for atomic mass unit is ____________________ .

16. The mass of a proton is equal to the mass of a
____________________ .

17. A proton and a neutron are both equal to ____________________
amu.

18. The atomic mass of an atom equals the ____________________
of the number of protons and neutrons.

19. An atom with 5 protons and 6 neutrons would have an atomic mass
of ____________________ .

alchemists
different
electrons
elements
fit
group
improves
left
metals
old
outermost
period
predict
right
similar
simple
system

20. ____________________ do not have much mass.

21. The symbols on the periodic table stand for the names of the ____________________ .

22. A set of elements arranged in a vertical column on the periodic table is called a ____________________ .

23. Groups of elements have properties that are ____________________ .

24. The chemical properties of the elements are based on their ____________________ .

25. All the elements in a group have the same number of electrons in their ____________________ shell.

26. A ____________________ contains the elements going across the periodic table.

27. The elements in a period have ____________________ properties.

28. Although elements in a period have very different properties, we can ____________________ their properties.

29. The heavy line on the periodic table separates the ________________ from the nonmetals.

30. The nonmetals are found on the ______________________ side of the line and the metals on the ______________________ side of the line.

31. The periodic table grew in small parts. One early group to work with the elements tried to turn ordinary metals into gold. These were the ______________________ .

32. As time passes, new theories may replace ______________________ theories.

33. Theories are replaced when they do not ______________________ the observations of scientists.

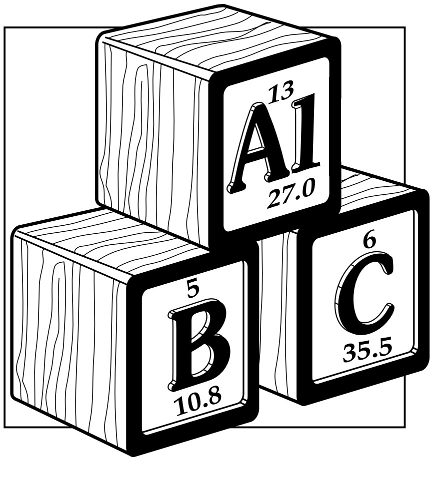
34. This process ______________________ our view of the universe.

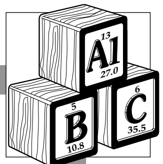
35. Theories that work well fit observations and help ______________________ new findings.

36. One reason the periodic table was made is because scientists assume the universe is a vast ______________________ .

37. The rules of the universe range from ______________________ to complex.

Unit 7: Structure of Matter

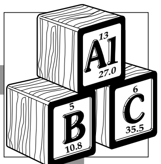




Vocabulary

Study the vocabulary words and definitions below.

compound	a substance formed when two or more elements combine chemically
element	a substance that cannot be broken down into a simpler form by ordinary chemical means
formula	the way a chemist tells how two or more elements are combined to make a compound *Example*: H_2O is the formula for water
hydrogen (H)	the lightest and most abundant of all elements; occurs as a gas when not in other substances
mixtures	two or more substances put together; no chemical reaction takes place and they are easily separated
oxygen (O)	an element found as a gas when not in other substances; it has an atomic number of eight and is involved in burning and rusting
symbols	the letters used by scientists to represent the names of the elements

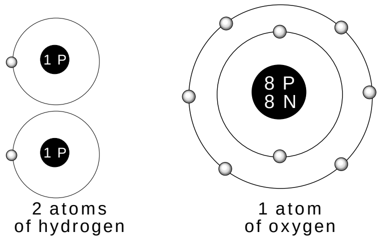


Introduction

You have seen how scientists represent the reactions that create substances. You may have wondered how two substances with **oxygen** in them (like water and sugar) could be so different. In this unit, we will discuss what properties these substances have that make them unique.

Elements

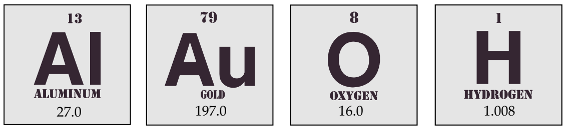
By now we know that matter has mass, volume, and density. We also know that matter can be a solid, liquid, or a gas. We have also learned some of the physical and chemical properties of matter. We experimented to show that chemical changes produce new substances. However, what makes up matter? Think about water. Water can be broken down into **hydrogen** and oxygen. The substances of hydrogen and oxygen cannot be broken down by chemical means. These substances are called **elements**. Elements cannot be broken down by chemical action. All substances are made of elements.



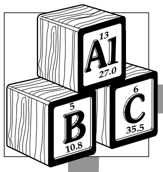
water molecule broken down into its elements

If you look at all the buildings around you, you see that they come in many different shapes and sizes. But there are similarities between the buildings. Think of a pyramid and a castle. Both are made of stone blocks, but the blocks have been arranged in very different ways. By doing this, the builders made the structure they wanted. You can think of elements as building blocks. On Earth, we have discovered about 120 elements. While some of the elements can only be found in very special labs, these are all the elements that we know exist. Everything is made from these elements.

Some substances are made of only a single element. Aluminum (Al), gold (Au), oxygen (O), and hydrogen (H) are examples of substances with a single element.



examples of substances with a single element



Most elements are solid under normal conditions. Few are liquid. The mercury (Hg) used in thermometers is normally liquid.

Many other elements are gases under normal conditions. Oxygen (O) and hydrogen (H) are just two of the elements that are gases at room temperature.

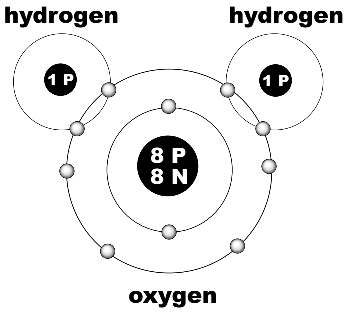
Scientists have a special way of writing the names of elements. They use letters instead of writing the whole word. The letters are called **symbols**. Here are some of the common ones.

Elements	**Symbols**
Copper	Cu
Aluminum	Al
Iron	Fe
Mercury	Hg
Oxygen	O
Hydrogen	H
Silver	Ag
Gold	Au
Carbon	C

Each of the elements has its own symbol. Each element has at least one property that makes it different from another element.

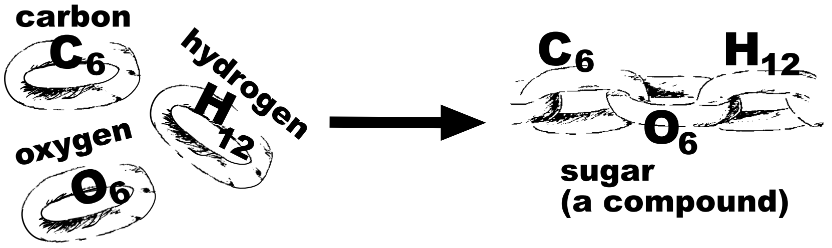
Compounds

Many substances are made from more than one element. Elements can unite with each other. The elements form new substances that are very difficult to separate. The new substances are called **compounds**. A compound has chemical and physical properties that are uniquely its own. It may look totally different from the elements that formed it. As you have seen, the atoms of two elements, hydrogen (H) and oxygen (O), combine to form water.



Water Molecule

Sugar is a compound formed by atoms of carbon (C), hydrogen (H), and oxygen (O).



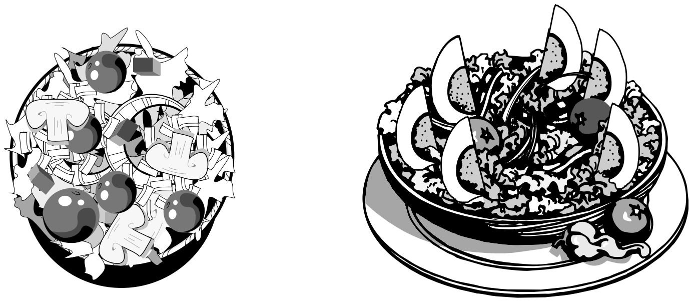
Sugar and water do not look like the elements that formed them. When compounds are formed, the elements always combine in the same proportions. A **formula** tells how elements combine to form compounds. The formula for water is H_2O. Compounds always have formulas.

Mixtures

It is possible to combine two elements or compounds without producing new substances. No chemical change takes place. These substances are called **mixtures**. Mixtures can be separated. Each substance in the mixture keeps its own properties. If you mix iron filings with sand, you could separate them because there has been no chemical reaction. There is no new compound; there is only iron and sand.

If we took hydrogen and combusted it with oxygen, water would be formed. Water does not have the same properties as hydrogen and oxygen because it is a different compound. Water is always made from two hydrogen atoms and one oxygen atom. Water cannot be made any other way because it is not a mixture.

On the other hand, a mixture can be made in many different ways. Air is a mixture. The elements in the air are not always the same. Tossed salad is a mixture too; salads do not always have the same ingredients. Mixtures do not have formulas. They are not formed by chemical changes.



A tossed salad is a mixture too; salads do not always have the same ingredients.

Summary

Now we know that elements are the simplest forms of substance. Gold (Au) is an element. Compounds are formed when a chemical change takes place between two or more elements. Mixtures are formed when two or more substances are put together. No chemical change takes place. The parts of a mixture can easily be separated.

Practice

Use the **periodic table** *of the elements on pages 98-99 to identify each of the elements whose symbols appear below. Write the name and the* **atomic number** *for each* **element** *on the line provided.*

NOTES

element's name & atomic number

1. C ______________________________

2. Au ______________________________

3. Ag ______________________________

4. Hg ______________________________

5. Cu ______________________________

6. Fe ______________________________

7. H ______________________________

8. O ______________________________

9. Al ______________________________

Lab Activity: Part 1

Facts:

- The substances in mixtures do not combine chemically.

Investigate:

- You will differentiate between a compound and a mixture and separate the substances in a mixture using physical means.

Materials:

- sulfur
- paper
- iron filings
- ring stand and clamp
- Bunsen burner
- magnets
- test tube

Part 1

1. Pour some sulfur onto a sheet of paper.
2. Add some iron filings. Mix the sulfur and the iron filings together.

    a. Did a chemical change take place? ________________________

    b. Are any new substances formed? ________________________

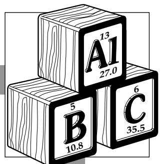
    c. Did the iron and the sulfur keep their own properties? ______

3. Move a magnet near the sulfur and the iron filings.

    a. Can you separate the iron from the sulfur? ________________

    b. Did the iron and the sulfur form a mixture or a compound?

    ____



Lab Activity: Part 2

1. Mix the iron filings and the sulfur on a sheet of paper.
2. Pour the mixture into a test tube.
3. Place the tube in clamp on a ring stand.
4. Heat the tube until it begins to glow.
5. Let the test tube cool.
6. Remove the substance from the test tube.

   a. Can you see the iron? ______________________________

   b. Can you see the sulfur? ______________________________

   c. Could you separate the iron from the sulfur using a magnet?

   ____

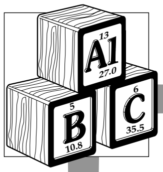
   d. Did you make a new substance? ______________________

   e. Is this new substance a mixture or a compound? __________

   Note: This new substance is called Iron Sulfide.

   f. What are the two elements that formed the substance?

   ____



Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

120
aluminum
carbon
chemical
copper
element
elements
gold
hydrogen
laboratories
liquid
mercury
oxygen
silver

1. An ________________ is a substance that cannot be broken down into a simpler form and from which other substances may be made.

2. There are about ________________ different kinds of elements.

3. All substances are made from ________________ .

4. ________________ is an example of a solid element.

5. Mercury is an element that is normally in a ________________ form or state.

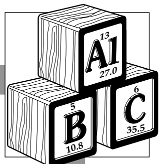
6. ________________ changes produce new substances.

7. Some elements are only found in ________________ .

8. **Au** is the symbol for ________________ .

9. **Cu** is the symbol for ________________ .

10. **C** is the symbol for ________________ .



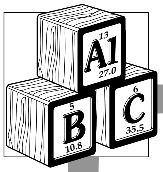
11. **Al** is the symbol for_________________________ .

12. **Ag** is the symbol for_________________________ .

13. **O** is the symbol for_________________________ .

14. **H** is the symbol for_________________________ .

15. **Hg** is the symbol for_________________________ .



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Two or more elements combine chemically to form a substance.

__________ 2. Sugar is a mixture, not an element.

__________ 3. Compounds are very easy to separate.

__________ 4. Hydrogen and oxygen combine to form water.

__________ 5. Compounds have the same properties as the elements from which they are formed.

__________ 6. A compound is formed when two or more substances are put together and no chemical change takes place.

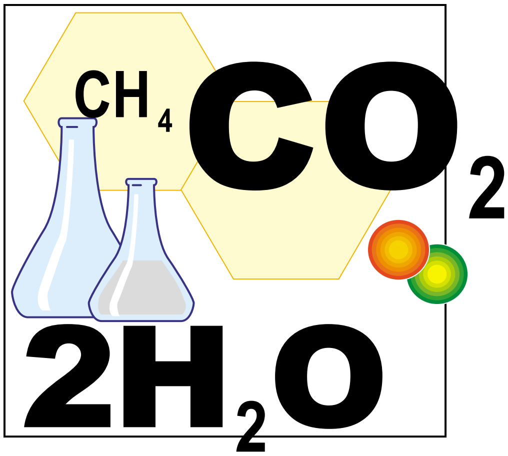
__________ 7. All mixtures have formulas.

__________ 8. Mixtures can easily be separated.

__________ 9. Oxygen is a compound.

_________ 10. Air is a mixture.

Unit 8: Chemical Equations



Vocabulary

Study the vocabulary words and definitions below.

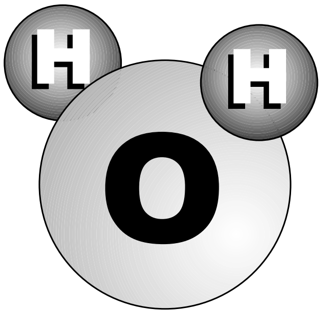
balance	the method by which the numbers and types of atoms on each side of an equation are made equal
chemical equation	a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas *Example*: $\mathbf{NaOH + HCl \longrightarrow NaCl + H_2O}$
coefficient	the number in front of the symbol of an element that tells how many molecules of a substance are involved in a reaction *Example:* $\mathbf{2\ H_2O}$
conservation of mass	matter cannot be created or destroyed during a chemical reaction
formula	a group of symbols used to name a compound *Example:* **NaCl** is the formula for sodium chloride, common table salt
subscript	a number in a chemical formula that tells how many atoms of an element are in a molecule *Example:* $\mathbf{H_2}$
yields	makes or produces

Introduction

You have learned that atoms of different elements can combine to form new compounds. When this takes place, a chemical reaction occurs. For example, sodium metal (Na) reacts with chlorine gas (Cl_2) to form sodium chloride (NaCl). Hydrogen gas (H_2) combines with oxygen gas (O_2) to make water (H_2O). Scientists have a special way to write about these reactions. In this unit, you will learn to **balance** simple **formulas** and equations.

Chemical Formulas

A chemical formula is used to represent a compound. Scientists use formulas as a shorthand way to write compounds. Symbols stand for the elements in compounds. NaCl is the formula for table salt. The formula shows that the compound, table salt, is made from the elements sodium and chlorine. The formula for water is H_2O. This states that the compound water is made up of hydrogen and oxygen. Notice that the formula for water has a small two after the H. That small number is called a **subscript**. It tells how many atoms of the element are in the molecule. H_2O means that it takes two atoms of hydrogen and one atom of oxygen to make a molecule of water. If there is no subscript after the symbol, it means there is only one atom.



The compound *water* is made up of 2 hydrogen atoms and 1 oxygen atom.

The formula NaCl shows that salt is made from one atom of sodium and one atom of chlorine. Let's look at some simple chemical formulas.

Name	Formula	Number of Atoms
hydrogen peroxide	H_2O_2	2 atoms H, 2 atoms O
methane (natural gas)	CH_4	1 atom C, 4 atoms H
carbon dioxide	CO_2	1 atom C, 2 atoms O

When you understand subscripts, it is easy to tell how many atoms are in one molecule of a compound. $C_{12}H_{22}O_{11}$ is the formula for sucrose (common granulated sugar is sucrose). It contains 12 atoms of C, 22 atoms of H, and 11 atoms of O.

Chemical Equations

Elements always combine with each other in a certain way. You know that NaCl is the formula for salt. We could write the sentence, *"Sodium plus chlorine makes sodium chloride."* Scientists use a shorter way to describe this reaction. This shorter way is called a **chemical equation**. Look at the following equation for the formation of sodium chloride:

$$2Na + Cl_2 \longrightarrow 2NaCl$$

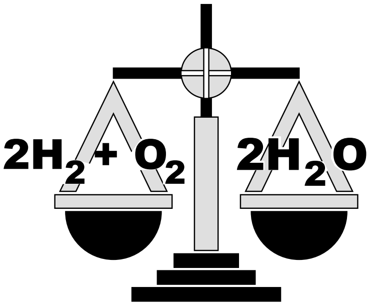
The arrow stands for the word ***makes*** *or* ***yields****.*

The arrow stands for the word *makes* or **yields**. When a chemist reads this equation he might say, *"Sodium plus chlorine yields sodium chloride."* Using equations saves time. Think how long it would take to write the following equation in words:

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

It would be simple if all chemical reactions took place with equal parts of all substances. However, this is not true. You already know that it takes more atoms of H than O to form water. One equation for water looks like this:

$$2H_2 + O_2 \longrightarrow 2H_2O$$



Think of the equation as a balance. The left side of the equation must balance the right side. The number of oxygen atoms on the right side of the equation must equal the number of oxygen atoms on the left side. During a chemical reaction, no matter is made or lost. All atoms must be taken into account. This means that every atom on the left side of the equation must also be on the right side of the equation.

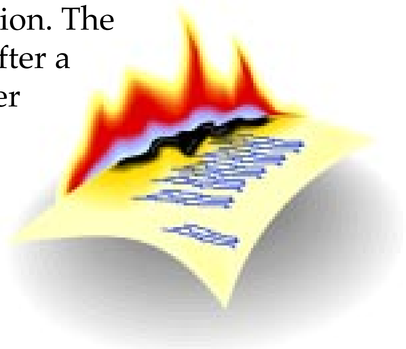
To determine the total number of atoms in a molecule, any **coefficient** is multiplied by the subscript for each element. For example, we could look at **2 H_2**. The coefficient of two means that two molecules of hydrogen are involved. To determine the number of hydrogen *atoms* in two *molecules* of hydrogen, multiply the coefficient (2) by the subscript ($_2$) as follows: Using this method, the equation for water can be broken down like this: 2 molecules x 2 atoms in each molecule = 4 atoms.

$2H_2$	+	O_2	→	$2H_2O$
(2 molecules of hydrogen)	+	(1 molecule of oxygen)	→	(2 molecules of water)
4 atoms	+	2 atoms	→	4 atoms of H + 2 atoms of O
		6 atoms	→	6 atoms

Notice that the numbers of each type of atom on each side of the equation are equal. We say that the equation is balanced.

Conservation of Mass

There are some important laws in chemistry. We know that chemical equations must balance. This is because matter can never be created or destroyed during a chemical reaction. The mass of the substances is the same before and after a reaction. Matter may change form, but it is never destroyed.



Iron rusts and paper burns, but no matter is destroyed in either reaction. There is always the same amount of matter at the end of a reaction as there was in the beginning. This is a law called **conservation of mass**. It states that matter cannot be created or destroyed during a chemical reaction.

Summary

Chemical formulas are used to name a compound. Chemical equations are the shorthand way of telling what happens during a chemical reaction. All equations must balance. The *law of conservation of mass* states that no matter can be created or destroyed.

Practice

Complete the following outline.

I. Chemical formulas

A. Definitions

1. a group of ________________________ used to name a compound
2. tell what ________________________ are in the compound

B. Compounds

1. ________________________ is the formula for table salt.
2. H_2O is the formula for ________________________ .

C. Subscript

1. Definition

   ____

   ____

   ____

2. Example

   a. In the formula H_2O, the 2 is the

   ________________________ .

   b. The 2 shows that there are 2 ________________________ of hydrogen.

II. Chemical equations

A. Definition

____

____

____

B. Chemical equations

1. $2Na + Cl_2 \longrightarrow 2NaCl$ is the ______________________

   for the formation of sodium chloride.

C. Balanced equation

1. Definition

   The method by which the numbers and types of atoms on each side of an equation are made

   ______________________ .

2. Example:

   $2\ H_2 + O_2 \longrightarrow$ ____ H_2O

D. Coefficient

1. Definition

   The number in front of the symbol of an element that tells how many ______________________ of a substance are involved in a reaction.

2. Example

In the equation $2\ H_2 + O_2 \longrightarrow 2\ H_2O$

the large number in front of the H is called a

____________________________ .

E. Conservation of mass

1. Definition

Matter can neither be ____________________________ or

destroyed in a chemical reaction.

2. Example ____

____

____

____

Lab Activity

Facts:

- Matter cannot be created nor destroyed.

Investigate:

- You will balance a given chemical equation, accounting for all matter.

Materials:

- work sheet
- 10 red chips
- 10 blue chips (washers or pennies may be used)

Look at Diagram 1. It shows a chemical reaction for the formation of water.

Balancing an Equation

Diagram 1

$\boxed{H_2} + \boxed{O_2} \rightarrow \boxed{H_2O}$

_____ **H atoms** + _____ **O atoms** → _____ **H atoms**

\+

_____ **O atoms**

Total atoms_____ → **Total atoms**_____

Does this equation balance? ☐ yes ☐ no

1. Use the red chips to stand for H atoms. Use the blue chips to stand for O atoms. Remember that the small number, or subscript, tells the number of atoms. Place the correct number of red chips under the H box. Record the number in the space provided.

2. Place the correct number of blue chips under the O box. Record the number.

3. Count the number of H and O atoms in the far right box. Place the correct number of chips under the box. Record the number.

   a. How many H atoms are on the left side of the equation? _______

   b. How many O atoms are on the left side? ____________________

   c. How many total atoms are on the left side of the equation? ____

   d. How many H atoms are on the right side of the equation? _____

   e. How many O atoms are on the right side of the equation? _____

   f. How many total atoms are on the right side? ________________

   g. Does the number of atoms on the left equal the number

      on the right? ____

   h. Is this equation balanced? _________________________________

4. Check the appropriate box to show if your equation is balanced.

Balancing an Equation

Diagram 2

$\boxed{H_2}\ \boxed{H_2} + \boxed{O_2} \rightarrow \boxed{H_2O}\ \boxed{H_2O}$

_____ **H atoms** + _____ **O atoms** → _____ **H atoms** + _____ **O atoms**

Total atoms_____ → **Total atoms**_____

Does this equation balance? ☐ yes ☐ no

5. Look at Diagram 2. In balancing, you cannot change the number of atoms, but you can change the number of molecules.

6. Place the correct number of H atoms on the left. Record the number.

7. Place the correct number of O atoms on the left side of the equation. Record the number.

8. Place the correct number of H atoms on the right side of the equation. Record the number.

9. Place the correct number of O atoms on the right side of the equation. Record the number.

   a. How many H atoms are on the left? ________________________

   b. How many H atoms are on the right?________________________

   c. Are they equal?____

   d. How many O atoms are on the left side of the equation? _____

   e. How many O atoms are on the right side of the equation?_____

   f. Are they equal? _______________

   g. Is this equation balanced? ________________

10. Check the appropriate box to show if your equation is balanced.

Balancing an Equation
Diagram 3

____ H_2 + ____ O_2 $\rightarrow$ ____ H_2O

Does this equation balance? ☐ yes ☐ no

11. Look at Diagram 3.

    a. Write the correct balanced equation.

    b. Each box in the last exercise stood for one molecule. Use the correct coefficient to show the number of H molecules on the left.

    c. Write the coefficient for the O molecule. (Remember that one is shown by no coefficient.) Write the correct coefficient for the H_2O molecules.

        1. Is this equation balanced? ____________
        2. Has matter been created? ____________
        3. Has matter been destroyed? __________

12. Check the appropriate box to show if the equation is balanced.

13. In the space below, write the balanced equation for the formation of H_2O (water).

Practice

Complete the following statements with the correct answer.

1. A ________________________ is a group of symbols used to name a compound.

2. An ________________________ is a way of telling about a chemical reaction using symbols and formulas.

3. The arrow in an equation stands for makes or ________________________ .

4. The 2 in the formula H_2O is called a ________________________ .

5. The ________________________ is a number in a chemical formula that tells how many atoms of an element are in a molecule.

6. The 2 in front of the H in the following equation is called a ________________________ . $2H_2 + O_2 \longrightarrow 2H_2O$

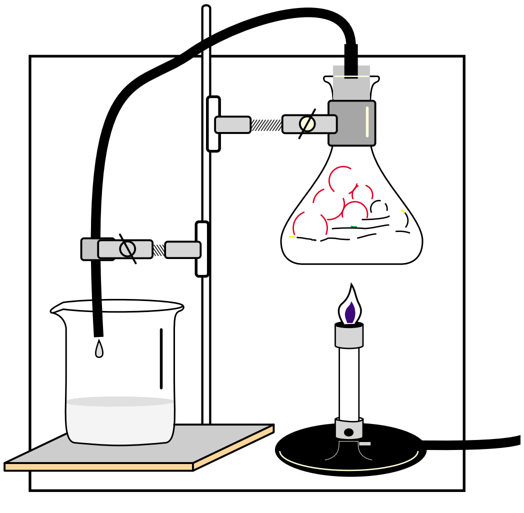
7. When the numbers of each type of atom on each side of the equation are equal, we say that the equation is ________________________ .

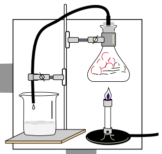
8. All equations must ________________________ .

9. The law of ________________________ states that matter cannot be created or destroyed during a chemical reaction.

10. Chemical formulas are used to name a ________________________ .

Unit 9: Solutions and Suspensions

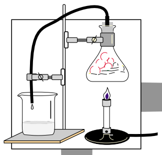




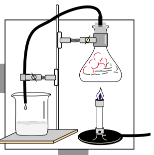
Vocabulary

Study the vocabulary words and definitions below.

filter	a material or a device used to allow certain things to pass through while at the same time stopping others
filtered	passed through a filter
heterogeneous	not consistent and not mixed evenly
homogeneous	consistent and mixed evenly; the same throughout
liquid solution	a liquid mixture where the parts dissolve or become a part of the solution, and spread out evenly, becoming homogeneous
solute	the substance that has dissolved in a solution
solution	a mixture of two or more substances that mix evenly with one another; a homogeneous mixture
solvent	the part of the solution that does the dissolving



suspension	two or more substances that form a cloudy mixture
universal	occurs everywhere



Introduction

We have discussed the phases of matter and compared elements to compounds. We have not considered matter in all its forms, though. Matter occurs in many forms. In this unit, we will examine two conditions in which we find matter.

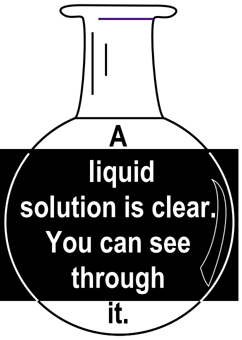
Reviewing Matter

It is time to review some of the things that we have learned about matter.

- Two or more elements combine chemically to form a compound.
- Compounds cannot be separated easily.
- A mixture of two or more substances does not combine chemically.
- Mixtures can be separated using physical means.

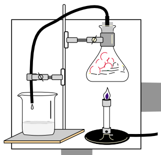
Solutions

Solutions are one of the ways we find matter. Put some water in a flask. Add some salt, put a stopper in the flask, and shake the flask. What happens to the salt? It is still in the flask, but you cannot see it. We say that the salt dissolved in the water. This is an example of a **liquid solution**. A liquid solution is a mixture. It has one substance dissolved into another substance. A **solvent** will dissolve another substance. Water will dissolve many different kinds of substances. Water is a solvent. Sometimes, it is called a **universal** solvent because it dissolves many different substances. Water will not dissolve everything, however, and does not dissolve substances like oil and grease.



- water is clear
- salt water is clear
- soda water is clear
- sugar water is clear

The substance that dissolves is called a **solute**. Sugar will dissolve in water, and it is a solute. It forms a liquid solution with the water. All of the molecules of the sugar spread evenly throughout the solution. In a liquid solution, all of the substances mix evenly with each other. When a solution is evenly mixed and the same throughout, it is **homogeneous**. All solutions are homogeneous.

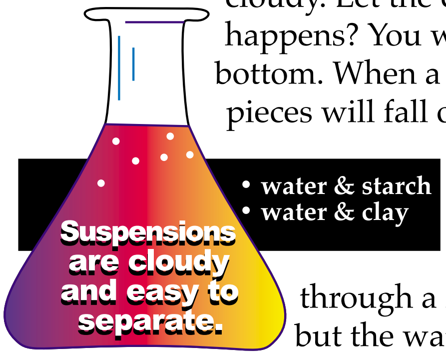


A liquid solution is clear. You can see through it. Salt water is clear. Soda water is a mixture of carbon dioxide and water. Soda water is clear also, and it is a liquid solution.

Suspensions

Some liquid mixtures are cloudy. Add some starch to a beaker of water. Stir it. The mixture is not clear. Instead, it is cloudy. The starch mixes with the water, but it does not make a liquid solution. Remember that a liquid solution is clear. This new, cloudy kind of mixture is called a **suspension**. A suspension happens when one substance does not dissolve or mix evenly throughout when mixed with a liquid. Suspensions are cloudy. Muddy water is a kind of suspension. Not all parts of a suspension are evenly mixed. **Heterogeneous** means that the parts are different and not mixed evenly. Suspensions are heterogeneous.

A suspension is easy to separate. Mix some clay with water. It will be cloudy. Let the clay and water stand overnight. What happens? You will notice that the clay will settle to the bottom. When a suspension is left standing, the solid pieces will fall out or settle out of the suspension.



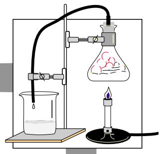
There is another way a suspension can be separated. Suspensions can be **filtered**. Pour the starch and water mixture through a **filter**. The starch will be caught in the filter, but the water will pass through.

Try to filter a beaker of salt water. What happens? You cannot trap the salt. The salt has mixed evenly with the water. It passes through the filter. The salt has dissolved in the water to the point that the pieces of salt are too small to be filtered. Salt water is a liquid solution. Liquid solutions cannot be separated with a filter.

The labels on some products say "Shake well before using." Why do you think this is necessary? The product is probably a suspension. The large parts of the suspension will settle, and you must shake it to remix the substances.

Summary

In this unit, we learned how to identify solutions and suspensions. We have also learned how suspensions can be separated.

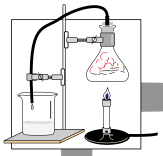


Practice

Use the list below to complete the following statements.

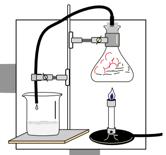
filter
filtered
heterogeneous
homogeneous
liquid
solute
solution
solvent
suspension
universal

1. A solution is a ____________________ mixture of two or more compounds.
2. Suspensions are not homogeneous, but are, instead, ____________________ mixtures.
3. When sugar is dissolved into water, this is an example of a ____________________ solution.
4. When making salt water, salt acts as the ____________________ .
5. Water is often called the ____________________ solvent.
6. Water acts as a ____________________ because so many different materials form solutions in water.
7. Milk is not a ____________________ because it is not clear.
8. A material that separates the compounds in a mixture is a ____________________ .



9. When mud and water are separated by being poured through a filter, they have been ____________________________ .

10. Any liquid mixture that separates easily, such as starch and water, is a ____________________________ .



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. When making a liquid solution, the liquid will be cloudy.

__________ 2. Suspensions are homogeneous.

__________ 3. If the parts of a mixture are evenly distributed, this is homogeneous.

__________ 4. Filters put together the parts of a mixture.

__________ 5. When mixing sugar in water, water is the solute.

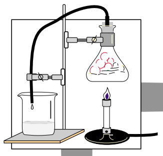
__________ 6. Water is known as the universal solvent because many different materials form solutions in water.

__________ 7. Suspensions separate easily.

__________ 8. Heterogeneous mixtures do not separate easily.

__________ 9. If a suspension is filtered, the different substances will be separated.

_________ 10. Oil floating on top of water is a liquid solution.



Lab Activity

Facts:
- Solutions are evenly mixed and cannot be easily separated.
- Suspensions can be easily filtered.

Investigate:
- You will identify solutions and suspensions from given samples and identify ways to separate a suspension.

Materials:
- beakers
- water
- salt
- filter
- powdered clay

1. Pour water into a beaker. Add a small amount of salt.

2. Fill the second beaker with water. Add powdered clay.

3. Stir each beaker. Observe the results.

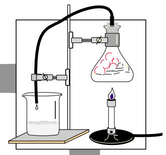
    a. Is the salt water clear or cloudy? ____________________________

    b. Is the clay and water clear or cloudy? ______________________

    c. Which beaker contains a liquid solution? ___________________

    d. Which beaker contains a suspension? ______________________

4. Allow the two beakers to sit for five minutes.



5. Observe the results.

   a. Did the salt settle out of the water? ______________________________

   b. Did the clay settle out of the water? ____________________________

   c. Which separates by settling, a liquid solution or a suspension?

   ____

6. Place a filter in a funnel and the funnel in an empty beaker. Pour a small amount of the salt water through the filter.

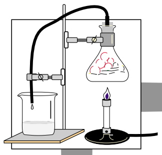
   a. Did the salt get trapped in the filter? __________________________

   b. Can a liquid solution be separated by filtering? _______________

7. Using the same beaker and filter, pour some clay water through the filter.

   a. Did the clay get trapped by the filter? _________________________

   b. Can a suspension be separated by filtering? __________________



Practice

Answer the following using short answers.

1. Using what you have learned, explain how you might clean a muddy pool.

   ____

   ____

   ____

   ____

2. You are stranded on a boat in the ocean. You need drinking water. If you filtered the ocean water, would you have clean water? Tell why or why not.

   ____

   ____

   ____

   ____

3. What would you add to hot tea to make it sweeter?

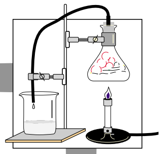
   ____

   a. When you added this ingredient, and mixed it up well with a spoon, would this mixture be a solution or suspension?

      ____

   b. Would the result be homogeneous or heterogeneous?

      ____



Practice

Circle the letter of the correct answer.

1. Salt will __________ in water.

   a. dissolve
   b. not dissolve

2. A __________ will dissolve other substances.

   a. solvent
   b. solute

3. Water is a common __________ .

   a. solution
   b. solvent

4 Salt water is an example of a __________ .

   a. solute
   b. liquid solution

5. A liquid solution is __________ .

   a. cloudy
   b. clear

6. Homogeneous means __________ .

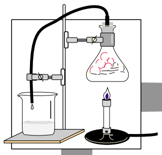
   a. alike
   b. different

7. Salt water is __________ .

   a. homogeneous
   b. heterogeneous

8. A suspension is __________ .

   a. clear
   b. cloudy



9. A suspension will __________ .

   a. not settle out
   b. settle out

10. Suspensions can be separated by __________ .

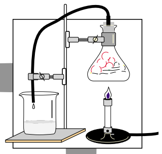
    a. filtering
    b. shaking

11. Solutions can __________ .

    a. be filtered out
    b. not be filtered out

12. Starch in water is an example of a __________ .

    a. solution
    b. suspension



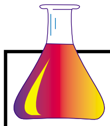
Practice

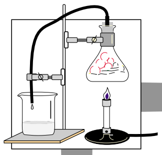
In the lab activity, you mixed **salt** *with* **water** *to form* **salt water***. Complete the chart below, placing each of the substances under the correct category. If the materials do* not *form a* **solution***, put a check mark in the* **suspension** *category.*

1. Use the terms: *salt*, *water*, *salt water*. Place your answers on row A.

2. Repeat the process, classifying *sugar*, *water*, and *sugar water*. Use row B.

3. Repeat the process, classifying *dirt*, *water*, and *muddy water* on row C.

	**solvent**	**solute**	**solution**	**suspension**
A				
B				
C				



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Water is a solvent.

__________ 2. Liquid solutions are cloudy.

__________ 3. A suspension is homogeneous.

__________ 4. Salt water is a liquid solution.

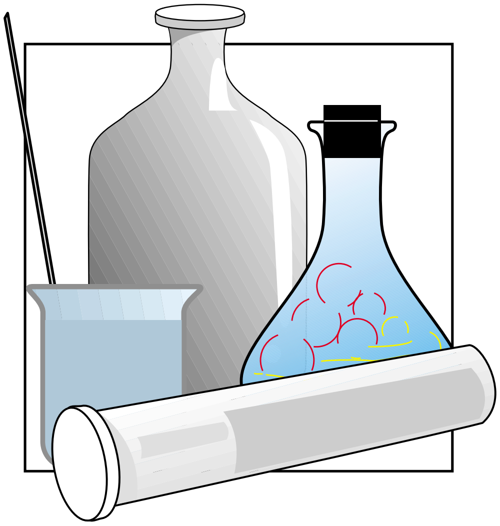
__________ 5. Salt water is heterogeneous.

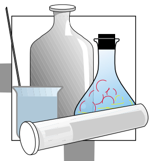
__________ 6. In a suspension, all the parts are evenly mixed.

__________ 7. A suspension can be separated by filtering.

__________ 8. A solution can be separated by settling.

Unit 10: Acids, Bases, and Salts

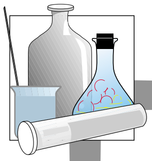




Vocabulary

Study the vocabulary words and definitions below.

acid	any of a group of compounds that produce positively charged hydrogen (H^+) ions when dissolved in water
base	any of a group of compounds that produce negatively charged hydroxide $(OH)^-$ ions when dissolved in water
concentration	the amount of solute per unit of solution *Example*: If a beaker of sugar water has half of its volume made of sugar, then it has a 50% concentration of sugar by volume.
dilute	to decrease the amount of solute as compared to the amount of solvent in a solution *Example*: To dilute sugar water, add water to the solution.
indicator	a chemical that is one color when in the presence of acids and is a different color when in the presence of bases
ion	a charged particle, atom, or molecule



litmus paper	a type of paper used to indicate the presence of acids or bases
neutralization	the reaction between a base and an acid which produces water and a salt
neutral solution	a solution that is neither an acid nor a base
phenolphthalein	a liquid indicator used to show the presence of bases (pronunciation: fee-nol′-thal-e-un)
salt	any of a group of compounds distinguished by being formed from a metal and nonmetal that are ionically bonded *Examples* include: NaCl (sodium chloride, table salt); MgCl (magnesium chloride, Epsom salt); and NaF (sodium fluoride, the active ingredient in many toothpastes)

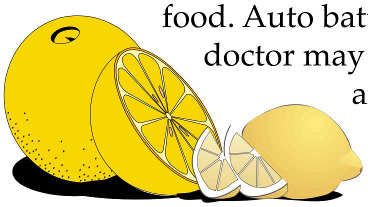
Introduction

This unit will focus on **acids**, **bases**, and **salts**. These compounds are important to our understanding of chemistry and the behavior of ions. These compounds particularly demonstrate the behavior of electrons.

Acids

Acids are a group of many different compounds. Despite the differences in the composition or make-up of acids, they all have similarities. When an acid dissolves in water, it releases a positively charged hydrogen atom (an H^+). This atom is known as an **ion** because it carries an electrical charge. We can tell that it is positively charged because there is a small plus sign (+) written by the ion. It is the ions of acids that make them important to us. Along with this, acids that are safe to eat or drink taste sour. Also, acids react with metals. This reaction produces hydrogen gas (H_2). The hydrogen comes from the acid.

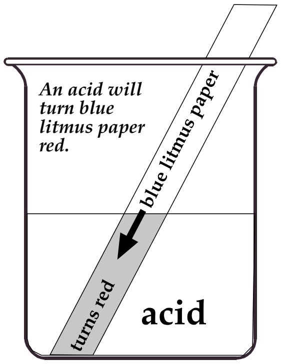
Acids are found in many parts of our daily life. Vinegar contains acetic acid (CH_3COOH). Citrus fruits (such as lemons and oranges) contain citric acid. The hydrochloric acid (HCl) in your stomach helps to digest food. Auto batteries contain sulfuric acid (H_2SO_4). Your doctor may tell you to use a boric acid (HBO_3) solution as an eyewash. If you are given acetylsalicylic acid, don't worry. It's aspirin! Sour milk tastes sour because the sweet sugar lactose has become the bitter lactic acid ($C_3H_6O_3$).



Acids can be harmful. Always use them carefully. Never taste a solution to see if it contains an acid. Many acids are poisonous. They can burn skin, eyes, and other sensitive organs. Many household products contain some acid. Read the label carefully before you use a product.

Acid Indicators

There are simple tests to find out if something contains acid. Dip a piece of blue **litmus paper** in vinegar. The paper will turn red. Litmus is called an **indicator** because it shows if an acid is present.



Another test for acid is the metal test. Acids will wear away metals. You may have seen car parts that were corroded by battery acid. This is an example of a acid wearing or eating away a metal. If you place a piece of metal in acid, a chemical change will take place.

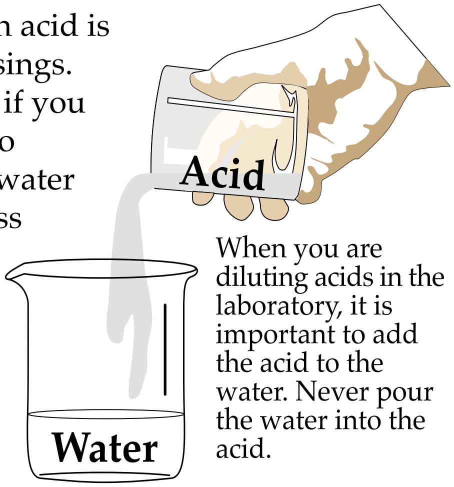
The litmus and the metal test are indicators for acids. They will only work on acids that are dissolved in water.

Diluted and Concentrated

Acids can be harmful. Yet, we know that we have acids in our body. We eat foods containing acids. We even use medicines that are made from acids. The amount of acid being used often determines whether it will be harmful or helpful. The amount of acid in a solution is called its **concentration**. The more acid, the higher the concentration. Think of two solutions. The first solution has five parts water and two parts boric acid. The second solution has five parts water and three parts boric acid. Which solution has the higher concentration of boric acid? The second solution has a higher concentration than the first solution.

As we discussed earlier, the medicine aspirin is actually an acid. If you take aspirin, it goes into your stomach. There it encounters hydrochloric and other acids. If a patient takes too much aspirin, the concentration of the acids will increase. This may make the patient's stomach painful and can even cause bleeding in the stomach. When the aspirin is taken as recommended, however, it is helpful. When the aspirin is in the right concentration, it is helpful.

Sometimes, though, the concentration of an acid is too high or strong. Think about salad dressings. Many salad dressings include vinegar, but if you poured vinegar on a salad it might taste too strong. Instead, the vinegar is mixed with water and oil. The taste of the vinegar is made less strong. This is an example of an acid being **diluted** to make it less powerful. When you are diluting acids in the laboratory, it is important to add the acid to the water. Never reverse this process by pouring the water into the acid because this could cause the solution to splash due to a dangerous reaction.



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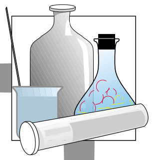
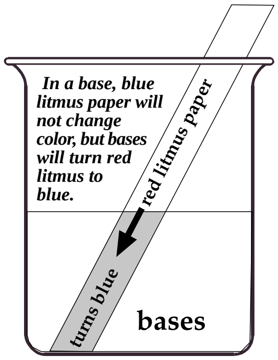


Bases

We know that acids release H^+ ions in water. *Bases* contain a hydroxide (OH), which is a hydrogen and oxygen atom that are bonded together. When bases are dissolved in water, they release the hydroxide as a negatively charged ion (OH^-). Those bases that are safe to eat or drink have a bitter taste. Soapsuds would taste bitter because they contain a base. Also, bases usually feel slippery. Bases are found in such things as lye, ammonia, and milk of magnesia. Deodorants contain the base aluminum hydroxide ($Al[OH_3]$). Like acids, bases can cause burns. They may also be poisonous.



Remember that an acid will turn blue litmus paper red. Blue litmus will not change color in a basic solution. Bases will turn red litmus to blue. **Phenolphthalein** (fee-nol′-thal-e-un) is a useful indicator for bases. Phenolphthalein will stay clear in an acid solution. However, if phenolphthalein is put into a basic solution, it will turn dark pink. Acids wear away metals. Many bases will not wear away metal.

You may see that bases often act as the opposites of acids. In some ways, this is because the ion produced by a base, OH^-, is the opposite of an acid's ion, H^+. Remember that we discussed that sulfuric acid from batteries often corrodes car metal. The sulfuric acid makes the battery work, but some may leak out of the battery. When cleaning around a car battery, some mechanics use a mild solution of baking soda. The baking soda is a base. It reacts with the acid. This stops the acid from corroding the car metal. This is a helpful use of a base; however, if the baking soda were to get into the battery, it would destroy the battery. When using chemicals, both mechanics and students must be careful.

Remember: Because bases act as opposites to acids in many ways, it does not make them more or less dangerous. Nor does it make them more or less helpful. Instead, it means that bases can be as helpful or dangerous as acids, but in different ways.

Neutralization and Salts

Neutralization is a chemical reaction between an acid and a base. When the sulfuric acid of a car battery reacts with the base of the baking soda, this reaction is known as a neutralization. Because the OH^- and H^+ ions have combined, they form water. A *salt* has also been formed. Because the salt is now in the water made by the reaction, it is in solution. When the quantities of H^+ and OH^- ions are the same, then there will be no acid or base left over. Such a solution would be a **neutral solution**. The equation below shows a neutralization. It is the neutralization of hydrochloric acid (HCl) and sodium hydroxide (NaOH):

$$\mathbf{HCl + NaOH \longrightarrow H_2O + NaCl}$$

The type of salt formed in this reaction was sodium chloride, the common table salt with which you are probably familiar. However, sodium chloride (NaCl) is only one type of salt. If we altered the base and acid that we used in the neutralization, then we would produce different salts. Whatever base and acid we use, though, we know we will always produce the following products:

- salt
- water

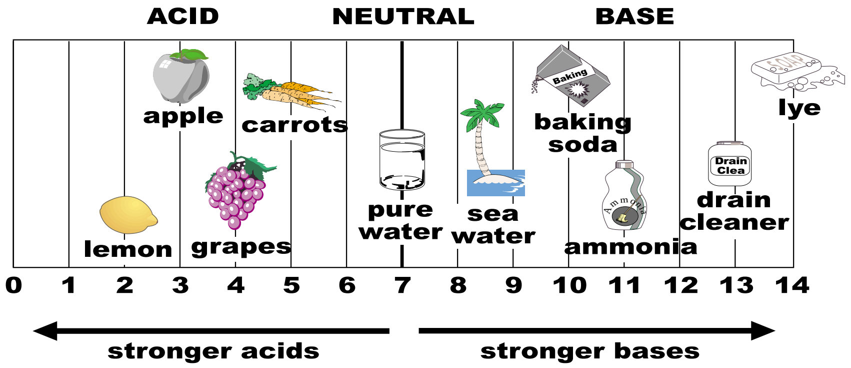
Salt water is a neutral solution that will not react with litmus paper. It is neither acidic nor basic. Although we can produce neutral solutions by the reaction of a base and an acid, some substances are naturally neutral.

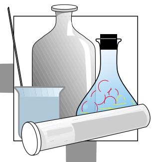
Water that has been distilled is naturally neutral. By distilling water, everything is removed from the water. The water is only H_2O and has no other substances dissolved within it. This makes the water neutral.

Summary

In this unit, we have learned the difference between an acid and a base. We have discussed what a salt is and you have learned that salts and water are products of neutralization reactions.

The chart below shows the measure of acidity of common acids and bases. Distilled water is neutral and is in the middle of the chart.





Practice

Use the list below to complete the following statements.

acid
base
concentration
dilute
indicator
ion
litmus paper
neutralization
neutral solution
phenolphthalein
salts

1. When electrons are added or taken away from an atom, they produce a charged particle, known as an ____________________ .

2. Distilled water with sodium chloride (NaCl) dissolved in it would be a ____________________ because it is neither an acid nor a base.

3. Blue litmus paper is an ____________________ because it changes color when exposed to an acid.

4. Of the many possible indicators, ____________________ can be dissolved to show whether a solution is a base.

5. Red ____________________ turns blue in a basic solution.

6. We know that the compound HCl is an ____________________ because it produces positively charged hydrogen ions (H^+) when dissolved in water.

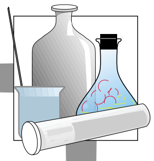
7. A compound that produces an (OH^-) ion in water is a ____________________ .

8. By adding more sugar to a solution of sugar water, we will increase the ________________________ of sugar in the water.

9. If we add more water to a sugar water solution, we will ________________________ the solution.

10. Examples of ________________________ include barium chloride and potassium chloride, ionically bonded compounds made from a metal and a nonmetal.

11. A reaction between an acid and a base is known as a ________________________ because ions combine to form the neutral compound, water.



Practice

Complete the following chart.

Acid	Chemical Formula	Where It Is Found
carbonic acid	H_2CO_3	soda water
	HCl	in the stomach
lactic acid		
	HBO_3	eyewash
sulfuric acid		auto batteries
acetic acid	CH_3COOH	

Use your chart to answer the following.

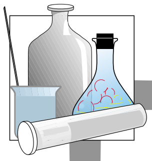
1. The formula for sulfuric acid is ______________________ .

2. Eyewash contains ______________________ acid.

3. Acetic acid is found in ______________________ .

4. HBO_3 is the formula for ______________________ .

5. ______________________ is an acid found in the stomach.



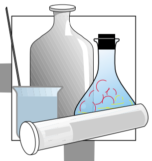
Practice

Complete the following chart.

Property	Acids	Bases
reaction to litmus paper	turns blue litmus red	turns red litmus ____________________
reaction with chemicals	____________________ wear away metals	does not wear away metals
reaction with phenolphthalein	phenolphthalein is clear	phenolphthalein is ____________________
taste	_____________ taste	bitter taste
produces ions in water	____________________	____________________

As the chart above shows, acids have properties that are nearly the

__________________________ of bases.



Lab Activity

Facts:

- An indicator can be used to identify a solution as an acid, a base, or a neutral.

Investigate:

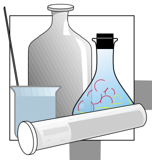
- You will determine if solutions are acids, bases, or neutral.

Materials:

- beakers
- red litmus paper
- blue litmus paper
- white vinegar
- distilled water
- table salt
- baking soda

The chart on the previous page will help you determine whether a solution is an **acid***, a* **base***, or is* **neutral***. Test each solution using the indicators you have been given. Record the information on the chart on page 170.*

1. Pour some water into a beaker. Add baking soda to the water. Stir the mixture until the baking soda has dissolved.
2. Dip the blue litmus paper into the baking soda solution.
   a. Did the blue litmus paper turn red? _______________
   b. Record your answer on the chart under the correct heading.
3. Dip the red litmus paper into the baking soda solution.
   a. Did the red litmus paper turn blue? _______________



b. Record your answer on the chart.

4. Let’s now decide whether this solution is an acid or a base.

   a. If a baking soda solution turns red litmus blue, then would it be classified as an acid or a base? ________________________

   b. Check the correct box on the chart.

5. Pour some white vinegar into another beaker. Follow the same steps to determine whether the white vinegar contains an acid or a base. Use the litmus papers as indicators. Record your information on the chart.

6. Test a small amount of distilled water using the litmus papers.

   a. Did the blue litmus paper turn red? ________________________

   b. Did the red litmus paper turn blue? ________________________

   c. What kind of solution will not change the original colors of the litmus papers?

      ____

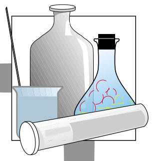
   d. Record the information on your chart.

7. Test a small amount of salt water using the litmus papers.

   a. Is this solution acid, base, or neutral? ________________________

   b. Record the information on your chart.

Type of Solution	Turns Blue Litmus Red	Turns Red Litmus Blue	Neither Litmus Changes	Acid	Base	Neutral
baking soda and water						
white vinegar						
distilled water						
salt water						



Practice

Answer the following using complete sentences.

1. There are many types of substances in the air that cause air pollution. When rain water mixes with some of these substances, acid is formed. We call this "acid rain." Tell how acid rain might be harmful. (Think about what acids can do.)

   ____

   ____

   ____

   ____

2. We know many household products contain acids and bases. Explain how they may be harmful. Tell why it is important to always read the labels of products before using them.

   ____

   ____

   ____

   ____

3. Antacids often contain bases. Explain why an antacid reduces stomach acid.

   ____

   ____

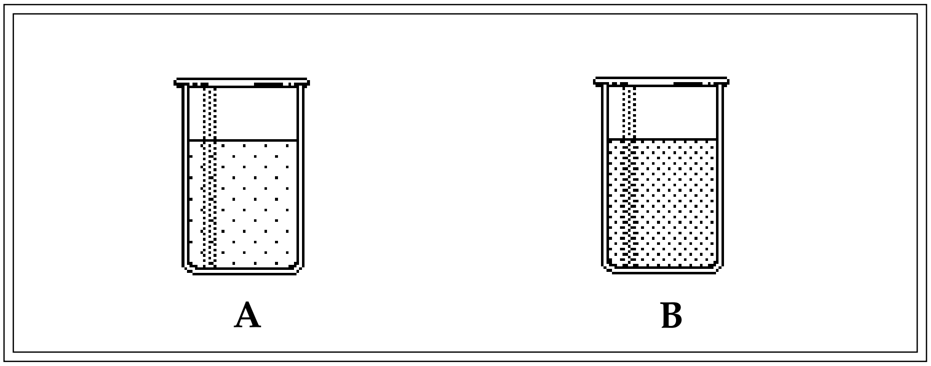
   ____

   ____

   ____

Practice

Use the diagrams below to answer the following questions.

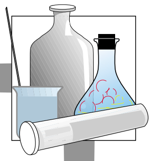


1. Which figure shows a more concentrated solution? ____________
2. Which figure shows a diluted solution? ______________________
3. If you bought a can of concentrated orange juice, how would you dilute it?

   ____

4. If you add more water to a solution of salt and water, would you increase or decrease the concentration of salt?

   ____



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Acids produce OH^- ions in water.

__________ 2. Acids react with metal to release hydrogen gas.

__________ 3. Citrus fruits contain sulfuric acid.

__________ 4. The hydrochloric acid in your stomach helps you digest food.

__________ 5. Auto batteries contain sulfuric acid.

__________ 6. Acids taste sweet.

__________ 7. Many acids are poisonous. You should never taste a solution to see if it contains an acid.

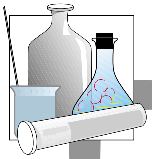
__________ 8. Litmus paper is called an indicator because it shows if an acid or base is present.

__________ 9. We have acids in our body.

_________ 10. Aspirin is an example of an acid.

_________ 11. The strength or power of an acid cannot be diluted to make it less powerful.

_________ 12. When you are diluting acids, it is important to add the acid to the water. Never reverse this process by pouring the water into the acid.



Practice

Use the list below to complete the following statements.

base
blue
burn
clear
color
dark
deodorants
hydrogen
oxygen
phenolphthalein
pink
red
salt
slippery
water

1. Bases contain hydroxide, which is a ________________ and ________________ atom that are bonded.

2. Bases have a ________________ taste.

3. Soapsuds contain a ________________ .

4. ________________ contain the base aluminum hydroxide.

5. Bases usually feel ________________ .

6. Like acids, many bases can ________________ the skin.

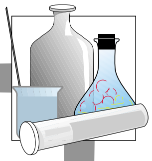
7. An acid will turn blue litmus paper ________________ .

8. A base will turn red litmus paper ________________ .

9. Blue litmus paper will not change ________________ in a basic solution.

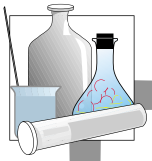
10. ________________ is a special indicator for bases.

11. Phenolphthalein will stay ________________ in an acid solution.



12. When any base and acid react, a ____________________ and ____________________ are produced.

13. Phenolphthalein will turn dark ____________________ in a basic solution.



Practice

Complete the following statements with the correct answer.

1. The term **neutral solution** means ______________________________

   ____ .

2. The term **neutralization** means ______________________________

   ____ .

3. An acid could be made neutral by putting the correct

   _____________________ on it.

4. _____________________ is often used to neutralize acids such as the sulfuric acid from a car battery.

5. _____________________ are used to neutralize an upset stomach caused by too much stomach acid.

6. Neutralization will form a _____________________ and

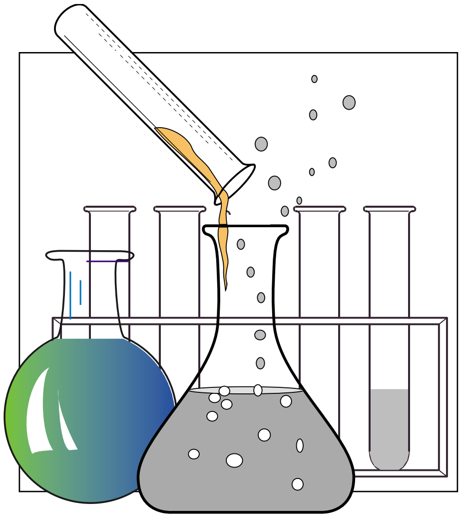
   _____________________ .

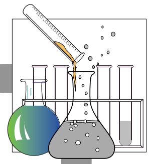
7. Salts are made from a _____________________ and a

   _____________________ that have been ionically bonded.

8. We know that salt water is _____________________ because it does not react with indicators.

Unit 11: Chemical Reactions





Vocabulary

Study the vocabulary words and definitions below.

biochemistry	the study of chemicals directly related to life processes
catalyst	a material or substance that increases the efficiency of a reaction without being consumed within the reaction
covalent bond	a bond between atoms that is made when atoms share their outermost electrons
DNA	a complex molecule that controls many functions of living organisms
electron configuration	the number and location of electrons; it determines how substances react and how much energy is involved in these reactions
electron dot structure	a model that represents the electron configuration of atoms; it can be used to make predictions about the bonds between atoms
ionic bond	a bond between atoms that is formed when atoms gain or lose electrons; by gaining or losing electrons, the atoms become ions

organic	in chemistry, a chemical compound used by living organisms; it contains carbon
pressure	the amount of force acting on a substance *Example*: When divers reach the bottom of a pool, the water exerts force against them. This force is often felt as a push against the ears and other body parts.
valence electrons	the electrons in an atom's outermost shell that are involved in the forming of bonds
valence shell	the outermost shell from the nucleus of an atom that electrons travel as they orbit an atom

Introduction

Chemical equations describe chemical reactions. The simplest type of reaction takes place when two or more elements combine to form a compound. There are other kinds of reactions that occur between elements and compounds. Chemical reactions are the results of the properties and arrangement of electrons. All reactions follow the law of conservation of mass ("Unit 8: Chemical Equations"). This unit will discuss the factors that control and affect reactions.

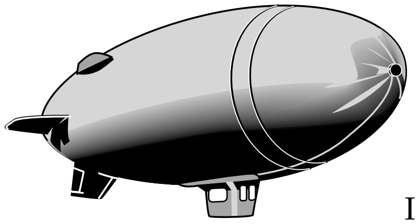
The Role of Electrons

Whenever a reaction takes place, electrons control and determine what will happen. Some atoms have only a few electrons, such as hydrogen (one electron) and lithium (three electrons). Other atoms have many electrons, such as gold (79 electrons) and lead (82 electrons). It is not just the number of electrons, however, that determine how an atom will react. Let's compare two elements, hydrogen and helium, and see how they behave.

The Two Lightest Elements

hydrogen has 1 electron and 1 proton

helium has 2 electrons and 2 protons

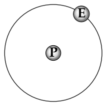


Hydrogen has one electron and one proton. Helium has two electrons and two protons. These are the two lightest elements. You might expect for there to be many similarities between the two elements. Both are gases and both are colorless and odorless. Additionally, both have been used to inflate balloons and zeppelins (sometimes called blimps). In this regard, because both elements are similar, they have similar uses.

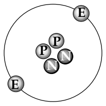
If you take a moment to glance through previous chapters, though, you may notice something. Hydrogen is continually mentioned as being included in other compounds and molecules. The chemical symbol for helium is He. You won't find it in other compounds because of the way its electrons are configured. Hydrogen, on the other hand, is in literally thousands of compounds. Again, this is because of its **electron configuration**.

Electron Configuration

Remember that an atom's electrons are on the outside of the atom. Let's look at the electron configurations of hydrogen and helium:



hydrogen



helium

The space or path that the electrons travel as they orbit the nucleus of the atom is the shell. In the cases of hydrogen and helium, there is only one shell. Because this shell is outermost from the nucleus of the atom, we refer to it as the **valence shell**. Within the valence shell are the **valence electrons**. The valence electrons are the electrons that are involved in making bonds with other atoms. Remember that it is the making and breaking of bonds that causes chemical reactions.

In the case of both hydrogen and helium, we can make some rules about electron configuration. One of the most important rules is a tendency to have two electrons in the valence shell. In some ways, you can almost think of the atoms as "wanting" two electrons. When they have the two electrons, the tendency is fulfilled. In a sense, this might be compared to giving a person something that he wants. It might make him happy.

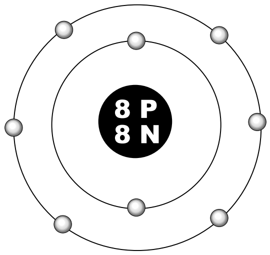
Compare the configuration of hydrogen and helium. Helium already has two electrons. Because of this configuration, helium does not take part in chemical reactions. In fact, it is often used because it will not react. You may have heard of the *Hindenburg*. This was a large zeppelin used to transport people between Europe and the United States. While landing, the hydrogen gas used to inflate the zeppelin ignited. The fire spread quickly, and the zeppelin fell to the ground. Today, modern zeppelins and blimps are inflated with helium. Regardless of the amount of spark or heat, helium will not burn. This makes it safer for use in aviation.

modern blimps are safer for aviation

The reactivity of hydrogen is based on the fact that it has only one electron in its outer shell. This means that it will readily react with other atoms. By doing this it can share an electron and fulfill its tendency to have two electrons. One more rule we can make about hydrogen's and helium's electron configuration is as follows: They can have no more than two electrons. Let's see how this rule works.

Making Water

Hydrogen and oxygen combine to make water. By now, you are familiar with this reaction. To fully understand the properties of water, we must look at the way the molecules of water are made. Let's look at the electron configuration of oxygen.



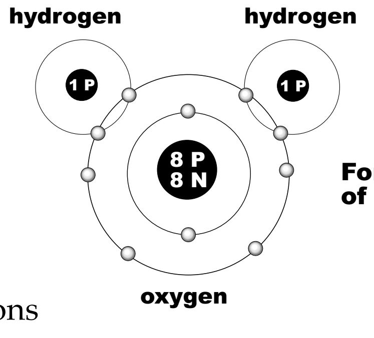
Electron Configuration of Oxygen

You will see that oxygen has two electrons in its innermost shell. Regardless of the element, there can be no more than two electrons in this first shell. Oxygen has eight electrons, so there are six in its outer shell. There are a few other rules describing electron configuration. These apply to other atoms besides those of hydrogen and helium. These rules are as follows:

- Atoms can have up to eight electrons in their outermost shell but no more. Atoms with eight valence electrons cannot react.
- Atoms that have fewer than four electrons in their outer shell tend to give up electrons.
- Atoms that have four or more electrons in their outer shell tend to gain electrons.

Using these rules, what predictions can you make about oxygen? If you said that it will tend to gain electrons you did well. How many electrons could hydrogen have in the case of water? If you said two, you are right.

When water and hydrogen combine to form water, the oxygen shares electrons with hydrogen. The result is that each hydrogen shares one of the oxygen's electrons. This effectively gives each hydrogen two electrons in its outer shell. Because the electrons are being shared, oxygen shares the electrons of hydrogen. The result is that oxygen has eight electrons in its outer shell.

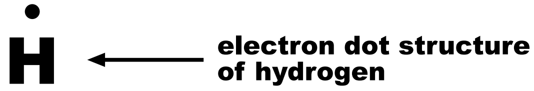


Formation of Water

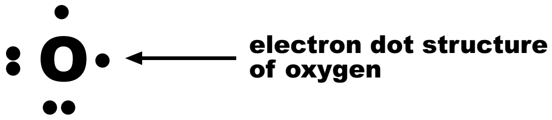
Picturing the way these rules function can be difficult. Because of this, we have a model we can use.

Electron Dot Structures

Electron dot structures model atoms. For instance, hydrogen has one electron. This is the dot structure of hydrogen:

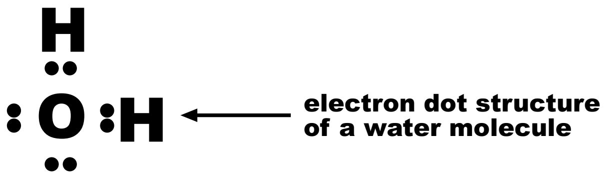


The electron dot structure of oxygen is below:



Notice that the structure only shows six electrons. This is because only six of oxygen’s electrons are in its outer shell. Only electrons in outer shells are involved in chemical reactions. For this reason, the electron dot structure of oxygen does not show oxygen's two innermost electrons.

Now let's look at the electron dot structure of a water molecule:

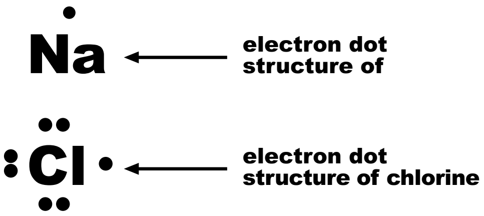


Take a pencil and draw a circle around the electrons that are on the edges of the oxygen molecule. Count the number of electrons. You should have counted eight electrons. Now, choose one of the hydrogen atoms. Circle the electrons that are around the hydrogen atom. Count them. You should have counted two electrons. This is the way that the atoms share the electrons.

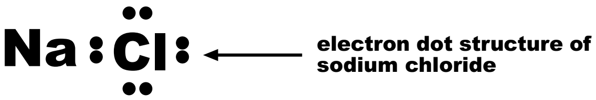
Other Bonds

The first example we have shown was a molecule of water. Remember that a molecule is two or more atoms that share electrons. With the electron dot structures, we showed that hydrogen and oxygen share electrons. The bonds created between oxygen and hydrogen were *covalent*. The valence electrons were shared.

In the cases of salts (covered in "Unit 10: Acids, Bases, and Salts"), the bonds between the atoms are not covalent. In sodium chloride, table salt, chlorine does not share electrons with sodium. Instead, sodium is bonded to chlorine by an ionic attraction. Remember that an atom becomes ionized when it gains or loses electrons. It is the opposite charges of the chlorine and sodium that bond them together. They have an **ionic bond**. To determine which atom has which charge, let's look at their electron dot structures:



Notice that sodium has only one valence electron. Chlorine has seven valence electrons. As our rules about electron configuration tell us, both atoms could have up to eight electrons in their valence shell. The rules also tell us that sodium is more likely to lose one electron than gain seven. Chlorine, on the other hand, is more likely to gain one electron than lose seven. The structure of sodium chloride is below:



In this structure, we see that chlorine now has eight electrons. The chlorine now has one more electron than protons. Because electrons have a negative charge, the chlorine now has a negative charge. The sodium has lost an electron. It now has one more proton than electrons. The sodium has a positive charge. It is the opposite charges of the atoms that bond them.

Properties of Substances

The properties of salts and water are very different. Largely these properties are based on the bonds between the atoms. For instance, water is a molecule because it has **covalent bonds**. These bonds are stable. Water does not spontaneously change into another substance. Table salt, on the other hand, has ionic bonds. When this salt is put in water, the bonds are broken.

The properties of various materials, we see, is in large part based on electrons. Electrons determine when and how bonds will be formed. They determine when a bond will release or absorb energy. They determine what the properties of the materials will be. Chemical reactions are the results of the activity of electrons.

Other Factors Affecting Chemical Reactions

Other factors affect when electrons can or cannot be involved in reactions. Certain conditions make the reactions occur more quickly and completely. These include the following:

Pressure:	When gases are reacting, increasing **pressure** increases the chance that atoms will come in contact. The increase in pressure improves the speed of the reaction.
Temperature:	When temperature rises, atoms more frequently come into contact. Raising temperature will increase the speed of a reaction.
Catalyst:	A **catalyst** will enable a reaction to occur at lower temperature and/or pressure. This saves effort and energy. Catalysts can also improve the speed and completeness of a reaction, but there are not catalysts for all reactions. The lack of a catalyst can slow other reactions that usually require a catalyst.
Concentration:	By increasing the amount of substance in a solution, the speed of a reaction is increased.

Chemistry in the Body

The factors affecting reactions are especially important in **biochemistry**. The study of the chemistry of living organisms is very complex. The human body, for instance, contains thousands of separate chemicals. In order to digest food, think, or move, many reactions must take place.

Thinking, moving, or digesting are all processes. Each is regulated by a complex series of specific chemical reactions. These reactions, however, must be controlled. Imagine what would happen if your digestive system did not function when you ate food. Your food would rot inside you. The effects would be both unpleasant and painful. Fortunately, healthy people have biochemical responses to food. They digest after they have eaten. When the food is digested, the process stops.

You may wonder how this is all coordinated. Within your body is a chemical code that controls such processes. This code is in a complex molecule known as **DNA**. Your DNA came from your parents. Like most other molecules in your body, it is **organic**. Organic molecules are produced or used by living organisms and contain the element carbon. DNA is the code that controls many of your body's functions.

As we noted, DNA is complex. You might imagine it as a thick book of instructions on how to operate a computer. The person who wrote the book didn't know how you would try to use the computer. Instead, the author tried to include instructions for every process. The result is a thick, complicated book. Now, consider the book again. It is made of only 26 letters. Although there are only 26 letters, they can make hundreds of thousands of words.

The substances that comprise DNA are like the letters in the book. They are combined in one way and then recombined in other ways. The result is that your DNA is very long and complex. This complexity allows your body to cope with all of life. Incredibly, though, there are only four basic units in DNA. That is like trying to write your book with only four letters!

These four substances, though, are like many other organic substances. They can serve many purposes. The important thing is how they are combined with other chemicals. Just like other reactions, each new combination has unique properties.

Summary

Chemical reactions occur when atoms share or transfer electrons. The sharing or transferring of electrons is based on the configuration of electrons. Electron dot structures model these configurations. The properties of substances are based on the configurations of their electrons. Factors such as temperature, concentration, pressure, and catalysts affect the speed of reactions. Reactions within a human body also follow biochemical principles. These organic chemicals can be combined and recombined in many ways.

Practice

Answer the following using short answers. Give examples where indicated.

1. What part do electrons play in chemical reactions?

    ____

    ____

    ____

2. What is electron configuration? ________________________

    Example: ______________________________________

    ____

3. What does an electron dot structure model? ______________

    Example: ______________________________________

    ____

4. Which elements have only one shell of electrons? __________

    ____

5. What is the greatest number of electrons the element chlorine can have in its outer shell?

    ____

    Why? ____

    ____

6. What type of bond is formed when atoms share electrons?

    ____

7. What type of bond is formed when atoms transfer electrons and create atoms with charges?

____

8. What causes many of the differences between substances?

____

____

9. How would increasing the pressure of two gases affect the way they react?

____

____

10. What effects might you expect if you added a catalyst to a reaction?

____

____

____

11. Beside factors such as heat and concentration, what principles control the biochemical reaction within bodies?

____

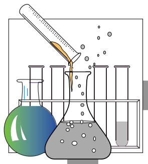
12. DNA, like other organic compounds, contains what element?

____

13. The code of DNA controls what? ______________________

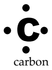
14. The four substances that make up DNA are a good example of how organic compounds can do what?

____________________ and ______________________



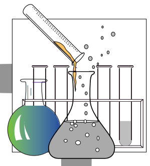
Practice

Use the **electron dot structures** *below to determine if the elements can react with other elements. (Remember, you must know how many* **valence electrons** *an element can possess. Refer to pages 182-185.) Make a check mark in the appropriate box.*

	structure	react	not react
1. helium			
2. sodium			
3. calcium			
4. argon			
5. krypton			
6. carbon			

Predict whether an atom will gain or lose **electrons** *in a* **reaction** *by checking the appropriate box. Again, refer to page 182-185 for assistance.*

	number of electrons	gain	lose
7. carbon	4		
8. magnesium	2		
9. fluorine	7		
10. potassium	1		



Lab Activity

Facts:

- The concentration of substances affects the speed and completeness of reactions.

Investigate:

- You will determine how the concentration of vinegar (an acid) affects its reaction with baking soda (a base).

Materials:

- 120 grams of baking soda
- 2 uninflated balloons
- 150 mL of vinegar
- 50 mL of water
- two 150 mL flasks

1. Place 60 grams of baking soda in 1 balloon.
2. Place 50 mL of vinegar and 50 mL of water in 1 flask.
3. Label the flask as Flask A.
4. Without spilling baking soda into the solution, place the balloon over the mouth of the flask. Set the flask aside.
5. Place 60 grams of baking soda in the second balloon.
6. Place 100 mL of vinegar in the second flask.
7. Label the flask as Flask B.
8. Without spilling baking soda into the solution, place the balloon over the mouth of the flask.

9. Which flask has the greater concentration of vinegar? __________

10. Set both flasks in front of you. Watching carefully, lift both balloons so that the baking soda falls into the vinegar and water solution. Let go of the balloon.

11. Which balloon inflated more quickly? ________________________

12. Using check marks, record your data in the chart below:

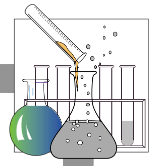
	Flask A	**Flask B**
greater concentration		
lesser concentration		
faster reaction		
slower reaction		

13. What relationship exists between reaction speed and concentration?

____

____

____



Practice

Use the list below to complete the following statements with the correct answer.

biochemical
carbon
catalyst
concentration
covalent
eight
electron dot configuration
electrons
force
increase
ionic bonds
recombine
two
valence

1. Chemical reactions depend on the configurations of ____________________ .

2. Hydrogen and helium can have no more than ____________________ electrons in their outermost shell.

3. The electrons in an atoms outermost shell are known as ____________________ electrons.

4. The atoms of carbon or oxygen may have as many as ____________________ electrons in their outermost shell.

5. ________________________________ can be used to model how the electrons of an atom are arranged.

6. In water, the bonds between hydrogen and oxygen are ____________________ because the electrons are shared.

7. ____________________ can be found in substances such as salts, where electrons are transferred and not shared.

8. Pressure is one way of describing how much __________________________ a substance pushes against a surface.

9. If the pressure of two gases are raised, then the speed of a reaction between them will __________________________ .

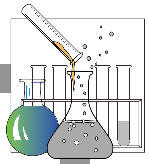
10. If the temperature of substances are lowered, the speed of the reaction will go down. A __________________________ is a substance that may allow the reaction to proceed but will not become part of the products of the reaction.

11. If the speed of a reaction is increased by raising the amount of substances in solution, then the __________________________ has been increased.

12. Body processes involve specific reactions that are controlled by __________________________ principles.

13. Organic molecules are vital to living organisms and all include the element __________________________ .

14. The ability of the compounds in DNA to combine and __________________________ makes it possible for DNA to be highly complex.



Answer the following using short answers.

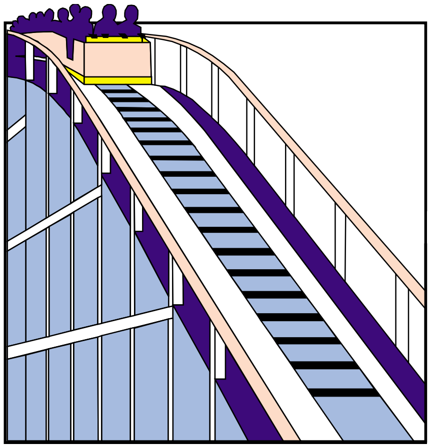
15. By lowering temperature, pressure, or concentration, the speed and completeness of reactions can be lowered. When food spoils, a chemical reaction has taken place. What common method of food storage helps prevent spoilage and why?

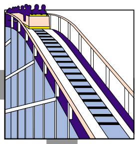
16. Welding aluminum can be difficult because the aluminum reacts with oxygen. To prevent this, the area being welded is flooded with helium gas. The helium displaces the oxygen and prevents the oxygen from reacting with the aluminum. Why doesn't the helium react with the aluminum?

17. Internal combustion engines pressurize the mixture of air and gasoline that react by burning. The burning provides the engine with power. Why does the engine provide more power if the gasoline and air are pressurized?

18. Many industrial chemical reactions involve solutions of acids or bases. In many cases, the speed and completeness of the reaction must be high for the industry to make money. What relationship does this need have with the fact that many industrial chemicals are highly concentrated?

Unit 12: Energy, Work, Force, and Power





Vocabulary

Study the vocabulary words and definitions below.

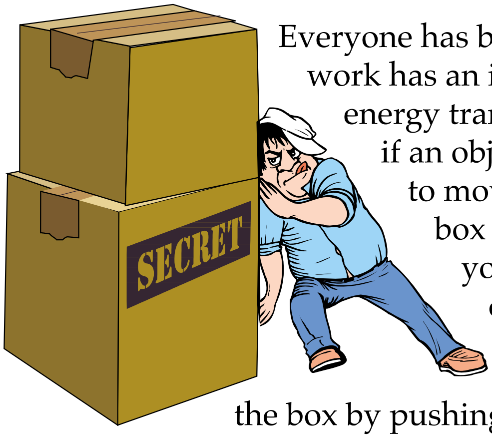
energy	the ability to do work or cause change
force	pressure exerted on an object; a push or a pull
kinetic energy	the energy of motion; the energy of moving things
potential energy	energy that has not been released; stored energy that is waiting to be used
power	the amount of work that can be done in a given amount of time
work	the amount of change caused or energy transferred

Introduction

In this unit, you will begin to learn about physics. Physics is the study of how matter and energy are related.

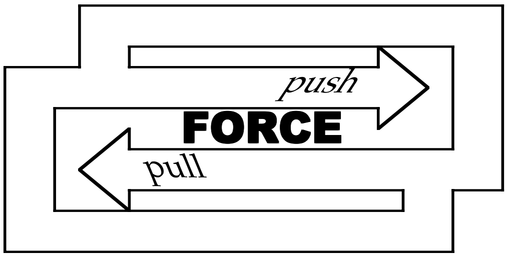
Energy, Work, Force, and Power

What is energy? Look around you. Many things move. A door opens, the hands on the clock move, and a person jogs down the sidewalk. What makes them move? Energy! **Energy** can be defined as the ability to do work or cause change. Energy often produces motion.



Everyone has been told to "get to work." In science, work has an important meaning. **Work** is the result of energy transferred to an object. Work is done only if an object moves. Imagine that you were told to move a large box. You push and pull the box for an hour, and it does not move. Have you done any work? No, because the box did not move.

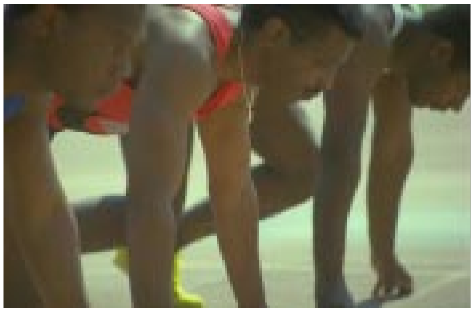
Think about the box. You tried to move the box by pushing and pulling. You used **force**. Force is either a push or a pull. Lifting is a form of pulling. It is difficult to think of a force that cannot be called a push or a pull.

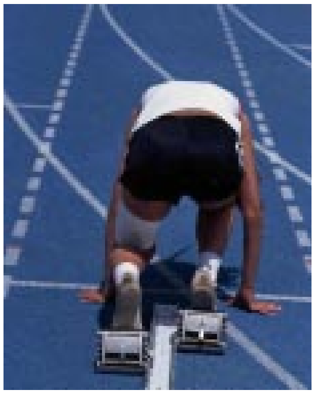


Power is another measure that is related to energy, work, and force. Power is the amount of work that can be done in a given amount of time. The faster work is done, the greater the power. You probably have heard the term "horsepower." It refers to the amount of work an average horse can do. This work was compared to the power of the steam engine. Today, it is common for the power of engines to be measured in horsepower.

Potential and Kinetic Energy

There are two basic kinds of energy—potential and kinetic. Potential means stored. **Potential energy** is energy that has not been released. It is energy that is waiting to be used. A stretched rubber band has potential energy. A brick placed on the edge of a window sill has potential energy. What happens if the rubber band is snapped or the brick falls? The potential energy of the objects is changed into kinetic energy.

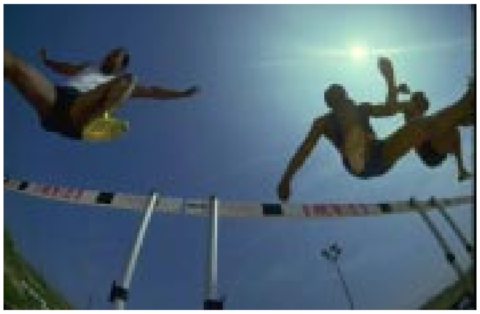




Potential Energy

Kinetic energy is the energy of motion. All moving objects have kinetic energy. If a moving object is stopped, its kinetic energy is made zero.

The object may then have potential energy.



Kinetic Energy

Summary

Energy is the ability to do work. Work is done if an object moves. The push or pull on an object is defined as force. Power tells how much work can be done in a certain amount of time. Potential energy is energy at rest or waiting to be used. When an object is moving, it has kinetic energy. Energy can change back and forth between potential and kinetic energy.

Practice

Look at the paired pictures below. Decide which **type of energy** *is being demonstrated. Write one of the following terms on the line provided.*

potential energy or **kinetic energy**

Figure A

Figure B

1. A. ______________________ B. ______________________

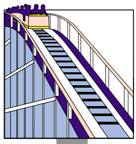
Figure A

Figure B

2. A. ______________________ B. ______________________

3. Can energy change back and forth between potential and kinetic energy?

____



Lab Activity

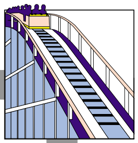
Facts:
- Potential energy is stored energy.
- Kinetic energy is energy in motion.

Investigate:
- You will differentiate between objects having potential and kinetic energy.

Materials:
- assorted classroom objects

1. Look around the classroom. Observe objects around you.
2. On the chart below, list five examples of potential energy and five examples of kinetic energy.

potential energy	**kinetic energy**
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. the ability to do work or cause change

______ 2. the amount of work that can be done in a given amount of time

______ 3. an example of kinetic energy

______ 4. energy of motion

______ 5. stored energy; energy that is waiting to be used

______ 6. an example of potential energy

______ 7. the result of energy

______ 8. a push or pull

A. a brick on the edge of a window sill

B. a brick that is falling

C. energy

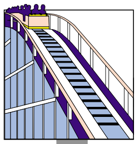
D. force

E. kinetic energy

F. potential energy

G. power

H. work



Practice

Write **P** *if it is an example of* **potential energy** *or* **K** *if it is an example of* **kinetic energy** *on the line provided.*

__________ 1. a large rock on top of a mountain

__________ 2. a rock rolling down the side of a mountain

__________ 3. a log falling

__________ 4. a log on the ground

__________ 5. a match being lit

__________ 6. a match in a matchbox

__________ 7. a hammer lying on a counter

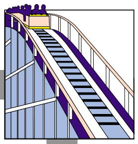
__________ 8. a hammer striking a nail

__________ 9. charcoal on a grill

_________ 10. burning charcoal

_________ 11. a bird in a nest

_________ 12. a bird flying



Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

energy
force
kinetic
potential
power
stored
work

1. ____________________ can be defined as the ability to do work.

2. ____________________ is the product of energy.

3. ____________________ is the pressure placed on an object in the form of pushing or pulling.

4. ____________________ is the amount of work that can be done in a given amount of time.

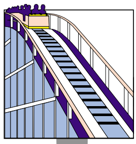
5. ____________________ energy has not been released.

6. Potential energy is ____________________ energy that is waiting to be released.

7. ____________________ energy is energy in motion.

8. Things that are moving have ____________________ energy.

9. Things that are not yet moving, or have just stopped moving, may have ____________________ energy.



Practice

Write one example of **potential energy** *and one example of* **kinetic energy**.

1. potential energy: ____
2. kinetic energy: ____

For each of the following, use a **W** *to indicate if* **work** *was done or an* **X** *to indicate* **no work** *was done.*

______ 3. Pushing against a mountainside that does not budge.

______ 4. Moving a paper clip with your finger.

______ 5. Slowly forcing a couch up a flight of stairs.

______ 6. Leaning against a pole to keep it from falling.

______ 7. Tapping your toes in time to music.

Answer the following using short answers.

8. Which has more power? A horse that hauls 50 kilograms across a field in 1 minute *or* a mule that hauls 100 kilograms across a field in 1 minute?

   ____

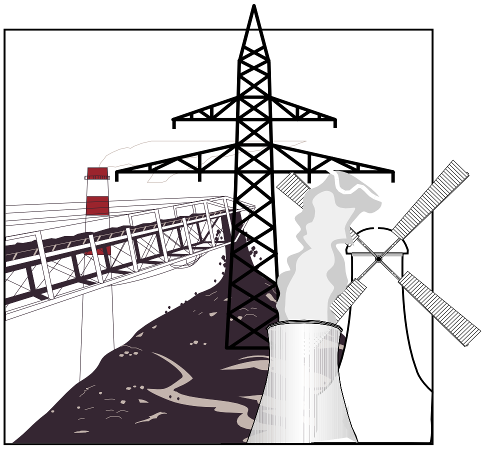
9. Which has more power? A train full of passengers that carries them across the state *or* the same train without any passengers as it makes the trip?

   ____

10. What must you have to do more work in the same amount of time?

   ____

Unit 13: Forms of Energy



Vocabulary

Study the vocabulary words and definitions below.

atomic energy	energy that is stored in the nucleus of every atom; sometimes called nuclear energy
chemical energy	the energy that is stored in chemicals
electrical energy	the energy of moving electrons; the energy of moving charged particles
energy conversion	when energy changes from one form to another
heat energy	the energy of moving molecules; the energy responsible for causing changes in temperature
law of conservation of energy	the law that energy cannot be made or destroyed, but only changed in form
light energy	the energy of the electromagnetic spectrum in the range of light
mechanical energy	the energy of moving things
sound energy	the energy of vibrating materials as detected by human ears

Introduction

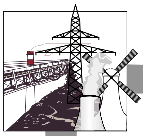
You have learned that energy is the ability to do work or cause change. There are many different forms of energy. We may use one form of energy to run our cars, another to heat our homes, and still another to send television pictures. People use large amounts of energy to help them perform work. Scientists are always looking for new available energy. In this unit, the different forms of energy will be introduced.

Kinds of Energy

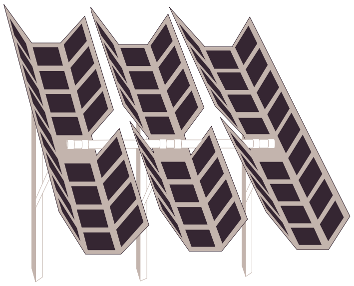
The energy in moving things is **mechanical energy**. The movement of pistons in a car is mechanical energy. The energy of a hammer is mechanical energy. Wind can also be thought of as having mechanical energy.

Electrical energy is caused by the flow of electric currents. Many of the appliances we use every day run on electrical energy—the energy of moving electrons. The energy in magnets is a result of the same force that causes electricity.

Your body gets energy from the food you eat. This is a form of **chemical energy**. Many chemicals have stored energy. When coal burns, chemical energy is released. The energy was stored in the coal when the coal was formed millions of years ago.



Heat energy is responsible for causing changes in temperature. The form of matter can be changed by heat energy. Remember that heat can change a solid to a liquid or a liquid to a gas. Almost all matter contains some heat energy.

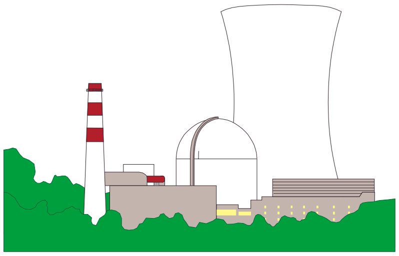


solar panels

Light energy is very common. Some light energy comes from the sun to Earth. Radio waves and x-rays are light energy since they spread out and pass through space.

Sound can also be a form of energy. Sound can make objects move. Thunder, for example, is **sound energy**. When you hear thunder, what you experience are small movements in the air. The small movements are detected by your ears and translated by your brain as sound.

Locked deep inside every atom is a powerful form of energy. **Atomic energy** or *nuclear energy* can be used to run power plants. It can also be used for destructive purposes. Nuclear energy is the energy that holds the nucleus of an atom together, and it is very great.



nuclear power plant

Most energy that we use on a daily basis has its recent origins in chemical energy. The electricity we use comes from releasing the chemical energy in coal or oil. The cars and buses in which we ride convert chemical energy to mechanical energy. With chemical energy, it takes large amounts of matter to make large amounts of energy. This is not true of nuclear energy. The forces which hold together an atom are so great that a small amount of matter can release a large amount of energy. It is because of this that nuclear energy can be both useful and destructive.

Changing Energy

Energy does not exist in only one form. It also does not stay in only one form. It can change from one form to another. When you light a match, its chemical energy changes to heat and light. The mechanical energy in wind can be *converted* by a windmill to electrical energy.

Conservation of Energy

Where does energy go when it is used? When a runner runs a long race, he uses large amounts of energy. Most of the energy is changed into heat. Saw a piece of wood. Feel the blade and the wood. Both will feel warm. The mechanical energy was changed into heat.

Whenever energy changes its form, some of it is converted to heat. The more times a source of energy is converted, the more energy becomes heat. Usually this heat energy is wasted, but scientists try to find ways to keep from wasting this energy, such as using newer models of engines which give off less heat than older models. By giving off less energy as heat, more energy is available for motion. Scientists are also looking for ways to use the heat energy. In one experiment, the heat given off by people in a room was used to heat another part of the building.

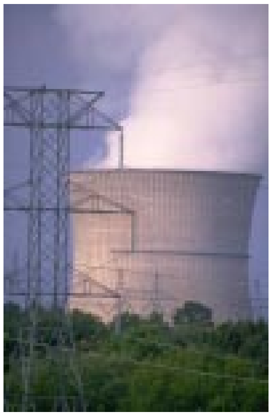
You have already learned that matter cannot be created or destroyed. What about energy? It can change form, but it is never destroyed. The **law of conservation of energy** states that energy is never created or destroyed—only changed from one form to another.

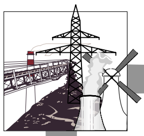
The Importance of Energy

Without energy, nothing would change. Of course, scientists of all types study change and its causes. In effect, scientists study energy. This is true of all scientists. Imagine that you are a marine biologist (who studies life in the oceans). You would not work for very long before you realized that all fish and corals and turtles—all life—would not exist without energy. An understanding of energy is a basic part of all sciences. It is fundamental to understanding how the universe works.

Summary

Mankind uses large amounts of energy. Energy can exist in various forms, such as mechanical, chemical, electrical, heat, sound, and nuclear. Energy can be converted from one form to another. When energy is used, heat energy is formed. Some amount of energy is always lost as heat. Energy can never be created or destroyed. An understanding of energy is fundamental to all branches of science.





Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

atomic
change
chemical
converted
electrical
fundamental
heat
light
mechanical
nuclear
sound
work

1. Energy is the ability to do ____________________ or cause ____________________ .

2. The main forms of energy are ____________________ , ____________________ , ____________________ , ____________________ , ____________________ , ____________________ and ____________________ .

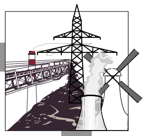
3. The energy of moving things is called ____________________ energy.

4. Energy that comes from the sun is called ____________________ .

5. Energy that is stored in chemicals is called ____________________ energy.

6. The energy of moving molecules is called ____________________ energy.

7. The energy of moving charged particles is called ____________________ energy.



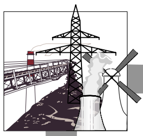
8. The energy of the vibration of air is called ____________________ energy.

9. Energy that is stored in the nucleus of every atom is called either ____________________ or ____________________ energy.

10. When energy is changed from one form to another, we say that it has been ____________________ .

11. Whenever energy changes forms, some is lost as ____________________ .

12. An understanding of energy is ____________________ to science.



Practice

Complete the following statements with the correct **type of energy** *to show the conversion.*

Remember: Energy can change easily from one form to another.

1. When you turn on a power drill, ______________________ energy is changed to ______________________ energy.

2. When you light a candle, ______________________ energy is changed to heat and ______________________ .

3. When you slam a door, ______________________ energy is changed to ______________________ energy.

4. When coal burns, ______________________ energy is changed to ______________________ energy.

5. When you play a piano, ______________________ energy is changed to ______________________ energy.

Lab Activity

Facts:

- Chemical energy is stored in substances and can be released.

Investigate:

- You will determine that energy stored in chemicals can be released.

Materials:

- test tubes
- stopper to fit test tubes
- baking soda
- vinegar

1. Fill the test tube a little less than ½ full with baking soda.

2. Add vinegar almost to the top of the test tube.

3. Place the stopper in the test tube.

4. Set the test tube down in a rack.

   (CAUTION: Aim the test tube away from your eyes or your lab partners' eyes.)

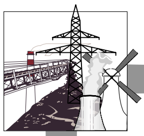
5. Observe the results.

   a. Did you notice any activity? ________________________________

   b. Is this activity a form of energy? ____________________________

   c. What happened to the stopper? ______________________________

   d. Was work done? ____



6. Let's see if you understood the experiment.

   a. Did you add any outside energy to the reaction? ____________

   b. Do you think the energy came from the substances? _________

   c. The substances are chemicals. What kind of energy is stored in chemicals?

   ____

   d. Was the energy released from the chemicals? _______________

7. Use the information that you have learned to complete the following information.

   ________________________ energy is stored in chemicals and can be

   ________________________ .

8. Think about this one! Write your response.

   Drain cleaner is put down a drain. Water is added. A reaction takes place. The pipe feels hot. Why?

   ____

   ____

   ____

Practice

Use the list below to write the correct **type of energy** *for each definition on the line provided.*

atomic energy
chemical energy
electrical energy
heat energy
light energy
mechanical energy
nuclear energy
sound energy

________________________ 1. the energy of moving things

________________________ 2. another name for nuclear energy

________________________ 3. the energy of moving charged particles

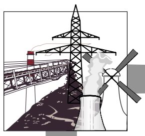
________________________ 4. the energy of vibrating material as detected by the ear

________________________ 5. energy that is stored in the nucleus of every atom

________________________ 6. energy that comes from the sun to Earth

________________________ 7. energy that is stored in chemicals

________________________ 8. the energy of moving molecules



Practice

Energy can change forms. Use the list below to show what type of **change in energy** *is taking place. One or more terms will be used more than once.*

atomic
chemical
electrical
heat
light
mechanical
nuclear
sound

1. When you strike a match, chemical energy changes to

   ____________________ and ____________________ energy.

2. Wind can be converted by a windmill from mechanical energy to

   ____________________ energy.

3. When a hammer hits a nail, some of the mechanical energy is

   changed into ____________________ energy.

4. The muscles in our body change the chemical energy of food into

   ____________________ energy.

5. When you blow air through a whistle, mechanical energy is

   converted into ____________________ energy.

6. In a light bulb, electrical energy is converted into

   ____________________ and ____________________ energy.

7. Some power plants produce electricity from

   ____________________ or ____________________ energy.

8. Turning on a mixer will convert electrical energy into

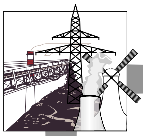
__________________________ energy.

9. Playing the guitar will convert mechanical energy into

__________________________ .

10. Turning on a fan will change electrical energy into

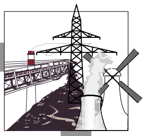
__________________________ energy.



Practice

Complete the following statements with the correct answer.

1. ____________________ energy causes changes in temperature.
2. Heat can change a solid into a ____________________ .
3. Heat can change a liquid into a ____________________ .
4. Almost all matter contains some ____________________ energy.
5. Whenever energy changes form, some of it is always converted to ____________________ and cannot be used.
6. Energy conversion is ________________________________ ____ .
7. The law of conservation of energy means ____________________ ____ .



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. another name for atomic energy

______ 2. when energy changes from one form to another

______ 3. the law that energy cannot be made or destroyed, only changed in form

______ 4. the energy of moving molecules

______ 5. the energy of moving things

______ 6. the energy of moving charged particles

______ 7. energy caused by vibration

______ 8. the energy that is in the nucleus of an atom

______ 9. the energy that is stored in chemicals

______ 10. energy that comes from the sun to Earth

A. atomic energy

B. chemical energy

C. electrical energy

D. energy conversion

E. heat energy

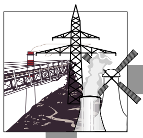
F. law of conservation of energy

G. light energy

H. mechanical energy

I. nuclear energy

J. sound energy



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Energy is the ability to do work or cause change.

__________ 2. Many of the appliances that we use every day run on electrical energy.

__________ 3. Food has chemical energy.

__________ 4. Heat can change a solid to a liquid.

__________ 5. Atomic or nuclear energy can be used to run power plants.

__________ 6. Energy exists in only one form.

__________ 7. The energy of a hammer is light energy.

__________ 8. The mechanical energy of wind can be converted by a windmill to electrical energy.

__________ 9. When energy changes form, some of it is always converted to heat.

_________ 10. Energy cannot be created or destroyed, but it can change from one form to another.

Practice

Complete the following statements with the name of the correct **type of energy** *to show the conversion.*

1. When you light a candle, ____________________ energy is
   changed to heat and ____________________ energy.

2. When you play the banjo, ____________________ energy is
   changed to ____________________ energy.

3. Some power plants convert ____________________ energy to
   ____________________ energy.

4. Turning on an electric mixer will convert ____________________
   energy into ____________________ energy.

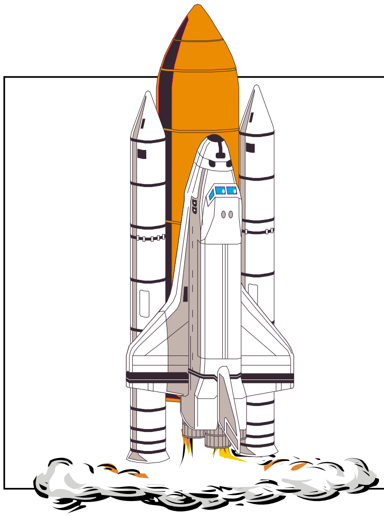
5. A stereo converts ____________________ energy into
   ____________________ energy.

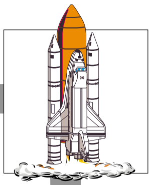
6. The muscles in our body change the ____________________
   energy of food into ____________________ energy.

7. When you saw a piece of wood, the blade of the saw is hot. You have
   converted the ____________________ energy into
   ____________________ energy.

8. When you strike a match ____________________ energy is
   changed to ____________________ and
   ____________________ energy.

Unit 14: Forces and Motion

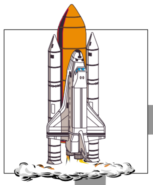




Vocabulary

Study the vocabulary words and definitions below.

acceleration	any change in speed or direction
balanced	when opposing forces are equal and do not cause movement
force	any push or pull
friction	a type of resistance caused when one surface touches another surface
gravity	the attraction of matter toward another body of matter *Example*: Earth's gravity holds us on its surface.
inertia	a property of matter by which an object keeps its present state of motion unless acted upon
laws of motion	the laws that state the relationship between force and motion
lubrication	the greasing of surfaces that rub against each other in order to reduce friction



mass	the amount of matter in a substance
motion	movement of an object from one place to another; any change in location or alignment
newton	the Systeme Internationale (SI) unit of force; it is abbreviated as N
resistance	any force that prevents or slows down motion
speed	the distance an object moves in a certain amount of time
Systeme Internationale (SI)	the international system of measurement that includes metrics for distance, mass, and volume, and the Celsius scale for units of temperature
unbalanced	when one force overpowers another force; the forces are not equal; causes movement
velocity	speed in a definite direction
weight	the measure of the force of gravity

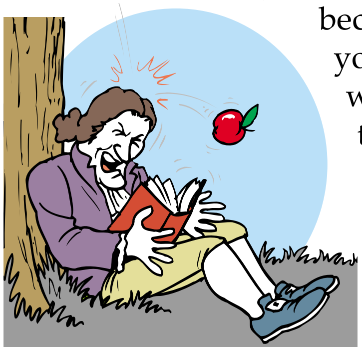
Introduction

You have learned that **force** is any push or pull on an object. Force does not always cause an object to move. Press down as hard as you can on your desk. The desk does not move. That's because your force is equal to the force of the desk pushing against your hand. When forces are equal, they are **balanced** and do not cause movement. Forces on an object are not always equal. One force can overpower another force. The force of two horses pulling one end of a rope would overpower a man pulling on the other end of the rope. This is an example of **unbalanced** forces. Unbalanced forces cause an object to move. In this unit, forces and motion will be discussed.

Gravity

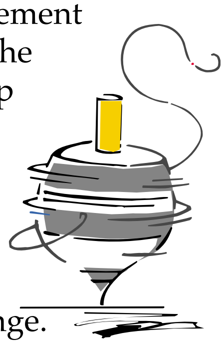
There are many different kinds of forces. **Gravity** is the force that attracts any two bodies with mass toward each other. Earth pulling on an object is gravity. About 300 years ago, Isaac Newton explained the way the force of gravity works. He stated that the force of gravity on an object depends on the mass of the object and how far the object is from Earth. Remember that **mass** is how much there is of a material. This means that **weight** is based on mass. As mass increases, the force due to gravity increases. As distances increases, however, the force due to gravity decreases in proportion to the square of the distance.

Weight is the measure of the force of gravity. As you travel away from Earth, your mass will not change, but your weight will. This is because of the way gravity behaves. Every time you double your distance from Earth, your weight becomes one fourth what it was. This is because the force acting on you grows weaker as you move away from it. On the moon, you would weigh ⅙ what you do on Earth. This is because the moon has only ⅙ of Earth's mass. The result is it has less force to pull on you. In the **Systeme Internationale (SI)** there is a special unit to measure force. This unit is called a **newton** or *N*. Of course, it was named after Sir Isaac Newton, who first described force.



Sir Isaac Newton

Motion



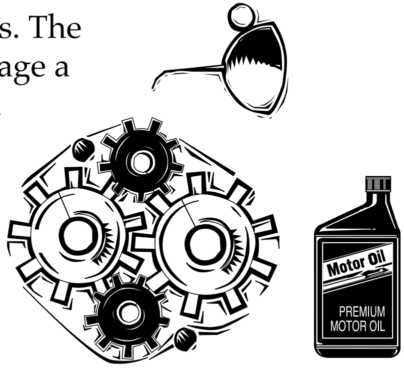
Forces are responsible for motion. **Motion** is simply a movement of an object from one place to another. Motion can also be the change in direction or alignment of an object. Think of a top spinning on a desk. As it spins, it may not move anywhere across the desk. It still has motion, though, because it is constantly changing directions. Other terms are needed to help us understand motion. **Speed** tells us the distance an object moves in a certain amount of time. **Velocity** is speed in a definite direction. Speed and direction may change. Any change in either speed or direction is called **acceleration**.

Friction

There are also forces that stop or slow down motion. Any force that prevents or slows down motion is called **resistance**. Push a box across the floor. Let go. It may move a little way and then stop. Why didn't the box keep moving? Friction made it stop. **Friction** is a type of resistance caused when one surface touches another surface. Friction is a force that makes objects slow down. Whenever we try to move something, friction pushes against it. The movement of objects through air causes a type of friction. Airplanes and cars are shaped so they can overcome some of the friction caused by air.

Friction produces heat. What happens if you drag a piece of wood across asphalt? It feels warm to the touch. Car tires heat up during a trip because of friction. The higher the friction, the greater the amount of heat produced. Rough surfaces produce more friction than smooth surfaces.

The force of friction can be reduced. Reducing friction is important to the reliable operation of machines. The friction caused by its moving parts could damage a machine. **Lubrication** reduces this friction. Oil and grease are used on surfaces that rub against each other. This kind of lubrication is common in cars, bicycles, lawn mowers, and gasoline engines. The use of rollers and ball bearings will also reduce friction. Think about pushing the box across the floor. It would be easier to move it if you put rollers between the floor and the box.

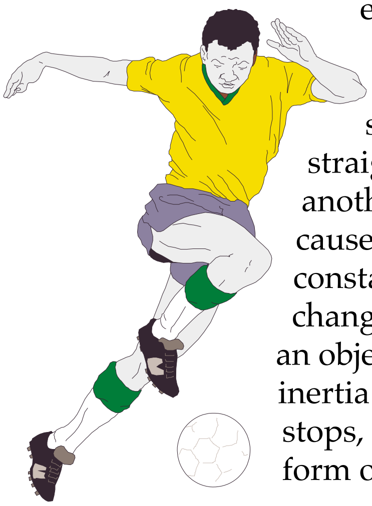


Oil is used as a lubrication to reduce friction on moving parts of machines.

Friction can be a helpful force. Without it, objects would slide around. Walking would be difficult. Imagine walking on ice. You might need to increase the friction between your feet and the ice to keep from falling. On the other hand, you could reduce the friction by putting on skates. Could you go faster on skates or on foot?

Laws of Motion

Sir Isaac Newton developed three basic **laws of motion** that explain the relationship between force and motion. His *first law of motion* states that every object tends to remain at rest or move in a straight line until an outside force acts on it. For example, a soccer ball will stay still until someone kicks it. Once kicked, it will travel in a straight line unless another player hits it or it hits another object. **Inertia** is the property of matter that causes the velocity or speed of an object to be constant as long as there is no outside force to change that speed. That is to say that inertia means an object tends to keep its present state of motion. The inertia of an object is related to its mass. When a car stops, your body continues to move forward. This form of inertia can be overcome by using seat belts.



The *second law of motion* explains how speed and force are related. It states that the acceleration of an object is set by the size of the force acting on it. This is easy to understand. A strong force will move an object faster than a weak force. The direction of the force will also affect the object. Picture two men trying to move a refrigerator. If they push in the same direction, the refrigerator will move. If six men try to move the refrigerator, it will move faster. What would happen if three men pushed from the front and three men pushed from the side? The direction of the refrigerator would change. A part of this law also states that a large mass will need a large force to make it follow a curved path. A moving car requires a large force to keep it on a curved road.

Newton also discovered that forces do not exist alone. His *third law of motion* explains that for every action, there is an equal and opposite reaction. This is not difficult to understand. You know that gravity exerts a force on you. It pulls you toward Earth. Your weight is the "equal, but opposite" force that pushes down on Earth.

Sending astronauts into space is possible because of our understanding of the laws of force and motion. Car and airplane designs are also affected by these laws.

Summary

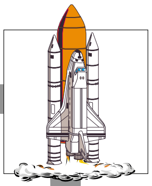
Unbalanced forces cause motion. Friction is a form of resistance that slows objects down. Gravity is the force that pulls an object to Earth. Sir Isaac Newton developed three laws that explain how force and motion are related.

Newton's 3 Laws of Motion

1. The ***first law of motion*** states that every object tends to remain at rest or move in a straight line until an outside force acts on it.

2. The ***second law of motion*** states that the acceleration of an object is set by the size of the force acting on it.

3. The ***third law of motion*** states that for every action, there is an equal and opposite reaction.



Practice

Circle the letter of the correct answer.

1. Motion is caused by ____________ .

   a. gravity
   b. resistance
   c. inertia
   d. force

2. Forces that slow or stop motion are called ____________ .

   a. gravity
   b. resistance
   c. inertia
   d. force

3. One type of resistance is ____________ .

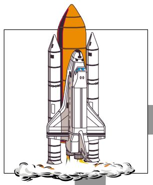
   a. lubrication
   b. motion
   c. inertia
   d. friction

4. Tires on the road show how friction produces ____________ .

   a. lubrication
   b. heat
   c. gravity
   d. force

5. Friction may be reduced with ____________ .

   a. lubrication
   b. resistance
   c. gravity
   d. force



6. ____________ developed the three laws of motion.

   a. Newton
   b. Galileo
   c. Lavoisier
   d. Olivier

7. Seat belts help to overcome ____________ .

   a. gravity
   b. resistance
   c. inertia
   d. motion

Match each example of a **law of motion** *with the correct law of motion. Write the letter on the line provided.*

______ 8. the footprint left in sand as gravity pulls against you

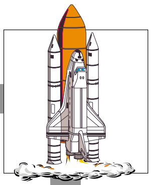
______ 9. a soccer ball at rest

______ 10. a water skier rounding a curve

A. 1st law of motion

B. 2nd law of motion

C. 3rd law of motion



Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

decreased
Earth
equal
far
friction
gravity
increases
mass
move
movement
N
newton (N)
pull
push
resistance
Sir Isaac Newton
unbalanced
weight

1. Force is any ____________________ or ____________________ on an object.

2. Balanced forces are ____________________ and do not cause ____________________ .

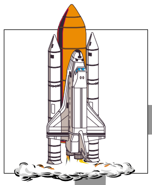
3. If one force overpowers another force, we would say that the forces are ____________________ .

4. Unbalanced forces cause an object to ____________________ .

5. ____________________ is the force that pulls objects with mass toward one another.

6. About 300 years ago, ____________________ described how gravity worked.

7. Isaac Newton stated that the strength of gravity on an object depends on the ____________________ of the object and how ____________________ the object is from ____________________ .



8. As mass increases, the force of gravity ____________________, but as distance is increased, the force of gravity is ____________________ proportional to the square of the distance.

9. ____________________ is the measure of the force of gravity.

10. In SI, the unit to measure force is called a ____________________.

11. The abbreviation for newton is ____________________.

12. Any force that prevents or slows down motion is called ____________________.

13. ____________________ is a type of resistance caused when one surface touches another surface.

acceleration
action
direction
do not
faster
force
heat
inertia
lubrication
reaction
rough
size
slow down
speed
three

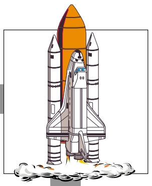
14. Friction is a force that makes objects ____________________.

15. Friction produces ____________________.

16. ____________________ surfaces produce more friction than smooth surfaces.

17. ____________________ will reduce friction.

18. Sir Isaac Newton developed ____________________ basic laws that explain the relationship between force and motion.



19. His first law of motion stated that every object tends to remain at rest or move in a straight line, until an outside __________________________ acts on it.

20. __________________________ is the idea that an object tends to keep its present state of motion.

21. Newton's second law of motion explains how __________________________ and __________________________ are related.

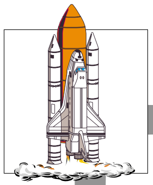
22. Newton's second law of motion states that the __________________________ of an object is set by the __________________________ of the force acting on it.

23. A strong force will move an object __________________________ than a weak one.

24. The __________________________ of the force will also affect the object.

25. Newton also discovered that forces __________________________ exist alone.

26. Newton's third law of motion explains that for every __________________________, there is an equal and opposite __________________________.



Lab Activity

Facts:

- Friction is a force.

Investigate:

- You will determine that lubrication will reduce friction.

Materials:

- block of wood
- 2 screws
- screwdriver
- bar of soap

1. Use the screwdriver to drive a screw into a block of wood.

   a. Was work done? ______________________________

   b. Did the screw move? ______________________________

   c. What force made it difficult to move the screw?

   ____

   d. Can this force be reduced? ______________________________

2. Coat the second screw with soap. Use the screwdriver to drive the screw into the block of wood.

   a. Was it easier or harder to drive the second screw into the wood?

   ____

b. What force was reduced? ______________________________

c. What substance was applied to the screw to reduce the force?

____

d. The soap acted as a ____________________________________.

e. Lubrication will reduce ________________________________.

Practice

Read each problem below and answer the questions that follow.

1. You have a ring stuck on your finger. How can you get it off? What force will you overcome?

   ____

   ____

   ____

2. Why do objects of the same mass weigh less on the moon than on the Earth?

   ____

   ____

   ____

3. State which law of motion applies in each of the following examples. Draw a picture of each example.

   When you place a skateboard on a flat, level surface, it will not move until you or some other force move it.

   Law: ____

   As the boy jumped from the canoe into the water, the canoe backed away from the boy.

   Law: ____

On the first trip, one girl pulled a large crate up the hill. On the second trip, three girls pulled the same crate up the hill. Which trip was easier? Why?

____

____

____

Law: ____

4. If you have a mass of 100 kg, then the force of gravity on Earth is 980 N. Would you weigh less flying in an airplane? The sun has more mass than the Earth. If you could stand on the surface of the sun, would you weigh more? Explain your answers.

____

____

____

____

____

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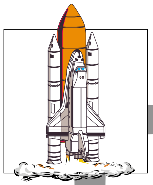
____



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. any push or pull on an object

______ 2. the laws that state the relationship between force and motion

______ 3. when forces are equal and do not cause movement

______ 4. the idea that an object keeps its present state of motion

______ 5. the force of Earth's gravity pulling on an object

______ 6. when one force overpowers another force; the forces are not equal; causes movement

______ 7. the SI unit to measure force

______ 8. the attraction between any two objects with mass

______ 9. abbreviation for newton

______ 10. a type of resistance caused when one surface touches another surface

______ 11. any force that prevents or slows down motion

______ 12. the greasing of surfaces that rub against each other in order to reduce friction

A. balance force

B. force

C. friction

D. gravity

E. inertia

F. laws of motion

G. lubrication

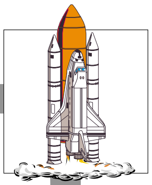
H. N

I. newton

J. resistance

K. unbalanced force

L. weight



Practice

Answer the following using short answers.

1. Are all forces equal? ________________________________

2. Can one force overpower another force? ____________________

3. What term do we give to forces that are equal? ______________

4. What term do we give to forces that are not equal?

   ____

5. What name is given to the force of Earth pulling on an object?

   ____

6. What is the special unit in the metric system that measures force?

   ____

7. Are forces responsible for motion? _______________________

8. What do we call any force that prevents or slows down motion?

   ____

9. What is the type of resistance caused when one surface touches another surface?

   ____

10. Is friction a force? _________________________________

11. Do rough surfaces produce more friction than smooth surfaces?

    ____

12. How can the force of friction be reduced? ____________________

____

13. What are two substances used as lubricants? _________________

____

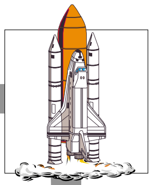
14. Who developed the three basic laws of motion? ______________

____

15. What is inertia? _______________________________________

____

____



Practice

Write the three **laws of motion**.

1. First law of motion: ______________________________

   ____

   ____

   ____

   ____

   ____

2. Second law of motion: ______________________________

   ____

   ____

   ____

   ____

   ____

3. Third law of motion: ______________________________

   ____

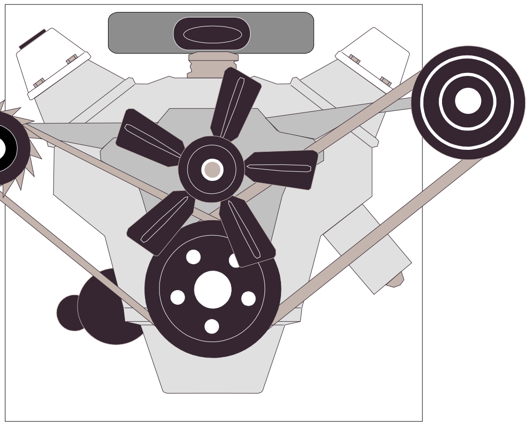
   ____

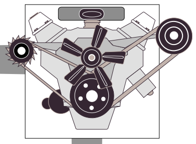
   ____

   ____

   ____

Unit 15: Machines

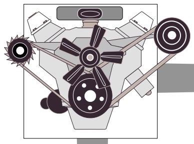




Vocabulary

Study the vocabulary words and definitions below.

block and tackle	a system of pulleys
compound machines	machines built by putting two or more machines together
efficiency	the measure of work input to work output
effort	amount of force
effort arm	the distance between the fulcrum and the point at which effort is applied
fixed pulley	a pulley that does not move; it only changes the direction of the force
fulcrum	the point about which a lever turns
gentle slope	an upward or downward slant with a gradual rise
inclined plane	a flat surface that has been raised at one end
lever	a rigid bar that moves around a point



machine	any device that makes work easier by changing speed, direction, or strength of a force
mechanical advantage (MA)	the number of times a force is multiplied by a machine
movable pulley	a pulley that moves; it increases force
pulley	a wheel with a grooved rim that rotates on a rod called an axle
resistance	an opposing force
resistance arm	the distance between the fulcrum and the object to be moved
screw	a simple machine with an inclined plane that winds around a center
slope	an upward or downward slant
wedge	a type of inclined plane with sloping sides that come to a point
wheel and axle	simple machine consisting of a large wheel rigidly attached to a smaller one
work input	the amount of work put into a machine
work output	the amount of work a machine produces

Introduction

Early man had to depend on his own body to do any form of work. If he wanted to move something, he had to push or pull it himself. Man searched for ways to make work easier. Ancient Egyptians were able to build huge stone pyramids without modern **machines**. How did they move and lift the giant stones? They probably used simple machines. They used the principles of these machines to do work that may have seemed impossible. Simple and compound machines will be introduced in this unit.

Simple Machines

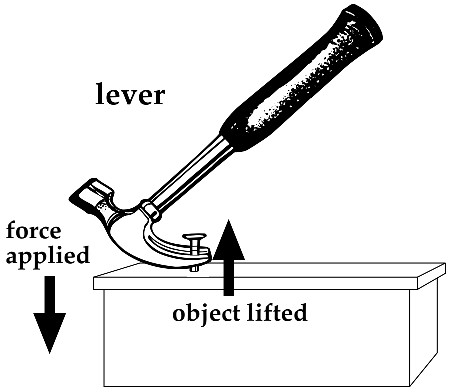
A *machine* is something that makes work easier and more efficient. A machine can change the size of a force, direction of a force, or the distance a force moves. Sometimes it may seem that a machine can create energy. This is not true. A machine cannot increase the amount of energy, it can only transfer energy.

There are six kinds of simple machines. Each one has a special way of making a force stronger. The six simple machines are as follows:

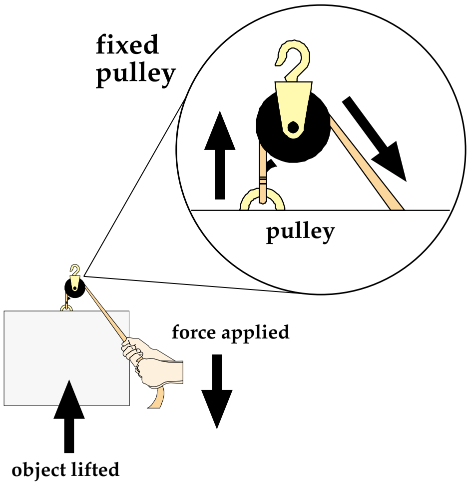
Six Kinds of Simple Machines

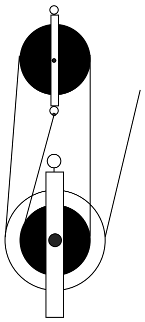
- lever
- pulley
- inclined planes
- wedge
- screw
- wheel and axle

Have you ever used a crowbar or a shovel or used the claw end of a hammer? They are examples of levers. A **lever** is a stiff bar that turns on a fixed point. It is used to change the direction of a force. It may also increase the size of the force. Suppose you wanted to move a large rock. You could not do it alone. Now, put a lever under the rock and push down. The rock will move. The lever transferred your force. It did not create new energy. No machine can ever put out more energy than what was put into it.

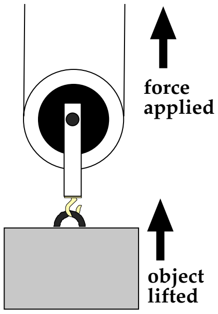


A **pulley** is a very common simple machine. It changes the direction of the force used. It also can increase the force. It is actually a kind of lever. A **fixed pulley** does not move. It does not multiply force. It only changes the direction of the force. When you pull down on a rope around a fixed pulley, the force will go up.





block and tackle

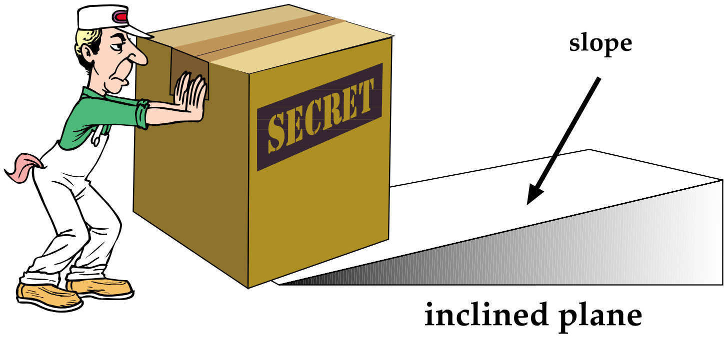


movable pulley

A **movable pulley** moves. It can increase force. When the rope is pulled, both sides of the rope apply force. The force is multiplied.

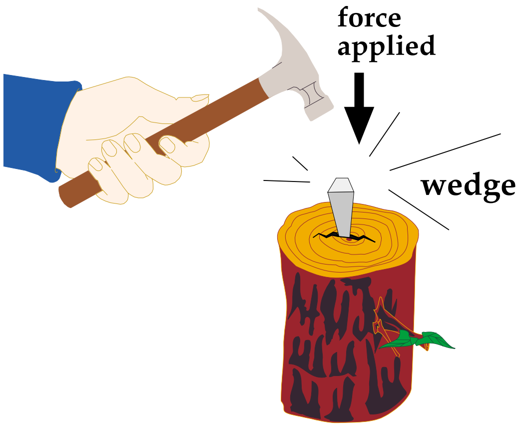
Fixed and movable pulleys can be used together. This type of arrangement is called a **block and tackle**. A block and tackle can be used to lift very heavy objects. A mechanic may use a block and tackle to lift an engine out of a car. A block and tackle can multiply force many times.

An **inclined plane** is a flat surface that has been raised at one end. An inclined plane does not move. A ramp is an inclined plane. How does an inclined plane make work easier? It redirects and multiplies force. It is much easier to push a box up an inclined plane than to carry it up a ladder. The height and length of the plane determine how much a force is multiplied. Work is easier on a gentle **slope**.



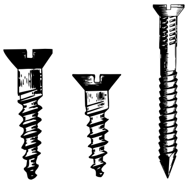
A **gentle slope** has an upward or downward slant with a gradual rise. A *steep slope* has an upward or downward slant with a sharp rise.

A **wedge** is a type of inclined plane. It has sloping sides. A wedge moves. It multiplies force. Suppose you want to split a log. Place a pointed wedge on the log. Hit the wedge with a hammer. The downward force of the hammer will hit against the wedge. The wedge will move downward, and the log's sides will move outward. The log will split.



Wedges do more than multiply force. A wedge slid under a door will stop movement. A chisel, a knife, and a hatchet are kinds of wedges. Wedges make work easier.

A **screw** is another form of an inclined plane. A screw is a simple machine with an inclined plane that winds around a center. It looks a little like a spiral staircase.



screw

The inclined plane on a screw is called a *thread*. Screws multiply force. However, they also multiply distance. If you look closely at the screw, you will see that the threads form a tiny ramp that runs around the screw from its tip to near its top. Think about putting a screw into wood. You have to turn the screw a lot in order to move it a short distance into the wood. Screws hold things together very tightly.

A screw can also be used to raise objects or hold objects. A vise is a type of screw. Some stools are raised or lowered by turning screws. Large jackscrews can lift sides of buildings.

A **wheel and axle** also make work easier. A wheel and axle is a form of lever. A wheel turns through a larger diameter than the axle. The diameter of a wheel is measured from the center to the outside. A gear is a wheel with teeth.

wheel and axle

The difference in size between the wheel and axle increases force. However, the distance that the force must move increases. When the axle turns a few times, the wheel will turn a greater distance. Bicycles, cars, eggbeaters, and doorknobs all have wheels and axles.

All simple machines have some things in common. They make work easier. They make force stronger. Anything that makes force stronger is called a machine.

Compound Machines

Some machines are built by putting together two or more simple machines. These machines are called **compound machines**. For example, sewing machines have wheels, axles, wedges, and levers. Can openers, bicycles, washing machines, and engines are examples of compound machines. The purpose of a compound machine is to make work easier.

Efficiency

Machines do work. However, work or energy must be put into a machine before it can do any work. **Work input** is the amount of work put into a machine. **Work output** is a measure of the amount of work done by the machine. Work input never equals work output. Why? The reason is that some of the work input will be used to overcome friction and **resistance**. Any surfaces that touch will have friction. This energy will be lost as heat. This means that you will get less work out of a machine than you put into it. The force put into the machine, though, will be less than the force put out. This means that the work will be easier.

Efficiency is the measure of work input to work output. An ideal machine would have work input equal to work output. Scientists study ways to improve the efficiency of machines. Natural resources like oil can be saved if machines become more efficient.

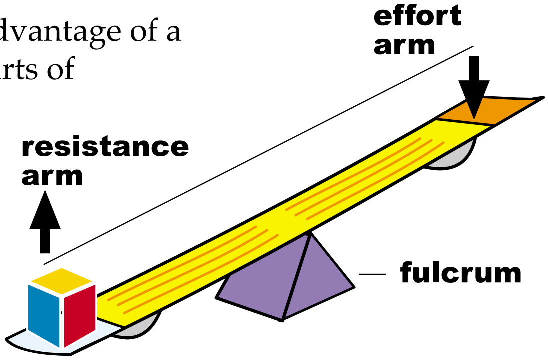
Mechanical Advantage

You have learned that a machine multiplies force, but not all machines multiply force equally. The number of times a force is multiplied is called **mechanical advantage**. There is a formula for finding the mechanical advantage. Mechanical advantage (MA) is equal to resistance (R) divided by effort (E). **Effort** is the amount of force. Resistance is the opposing force or the weight of the object that must be moved. For example, a 100-newton box must be moved. It takes a 50-newton force to move it.

$$\mathbf{MA} = \frac{\mathbf{100\ n\ \ (R)}}{\mathbf{50\ n\ \ (E)}} = \mathbf{2}$$

The mechanical advantage is 2.

It is easy to figure the mechanical advantage of a lever. First you need to know the parts of a lever. A **fulcrum** is the point about which a lever turns. Think of a seesaw. On a seesaw, the fulcrum is in the middle, but the fulcrum can be located anywhere. The **effort arm** is the part of the lever between the fulcrum and the force being applied. The **resistance arm** is the part of the lever between the fulcrum and the object to be moved (resistance).



For levers, we rewrite the equation for mechanical advantage. It looks like this:

$$\text{MA} = \frac{\text{Length of Effort Arm}}{\text{Length of Resistance Arm}}$$

If an effort arm is 40 cm and the resistance arm is 80 cm, what is the MA?

$$\text{MA} = \frac{\text{Length of Effort Arm}}{\text{Length of Resistance Arm}} \qquad \text{MA} = \frac{40\text{ cm}}{80\text{ cm}} = \frac{1}{2}$$

What happens if you increase the length of the effort arm?

Try this: The effort arm is 120 cm and the resistance arm is 60 cm.

What is the mechanical advantage?

It is 2.

$$\text{MA} = \frac{120\text{ cm}}{60\text{ cm}} = 2$$

The longer the effort arm, the greater the mechanical advantage. The longer the resistance arm, the lower the mechanical advantage.

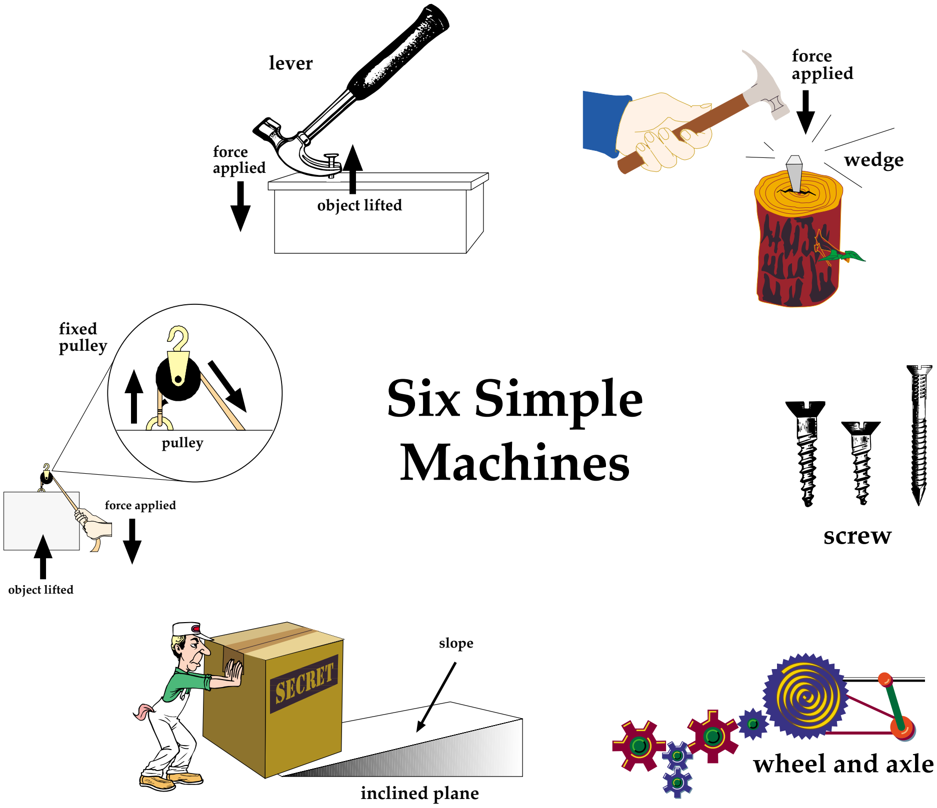
The mechanical advantage for all simple machines can be computed. Each simple machine has its own formula for finding mechanical advantage. However, you can find the mechanical advantage of any machine if you divide the force of the resistance by the effort it takes to move it. In essence,

$$\mathbf{MA} = \frac{\mathbf{Resistance}}{\mathbf{Effort}}$$

Remember that machines do not reduce the amount of work. They multiply a force. As a "price" for multiplying a force, the distance the effort force must move is also increased.

Summary

A machine changes the strength, direction, or distance of a force. Machines do not create energy. There are six types of simple machines. Two or more simple machines working together make a compound machine. The efficiency of a machine measures how well a machine uses its work input. Mechanical advantage tells how many times a machine multiplies force.



Practice

Solve the following word problems using the formula below for **mechanical advantage**. *Remember that the* **newton** *is the* **unit for force**.

$$\textbf{Mechanical Advantage} = \frac{\textbf{Resistance}}{\textbf{Effort}}$$

Example: A man lifted a crate weighing 150 newtons using a block and tackle. He used 50 newtons of effort. What is the mechanical advantage?

$$\textbf{MA} = \frac{\textbf{150}}{\textbf{50}} \qquad \textbf{MA} = \textbf{3}$$

1. A man pushes a 1,000-newton box up an inclined plane. He uses 500 newtons of effort. What is the mechanical advantage?

   ____

   ____

2. Using a lever, a woman raised a 600-newton box. She used 200 newtons of effort. How many times was the force multiplied?

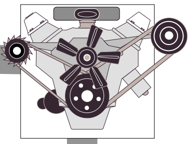
   ____

   ____

3. Two boys used 60 newtons of effort to raise a 60-newton box on a fixed pulley. What is the mechanical advantage?

   ____

   ____



4. Using a movable pulley, a 4,000-newton crate was raised. It took 1,000 newtons of effort. What was the MA?

   ____

   ____

5. A block and tackle was used to lift a 3,000-newton car and 1,000 newtons of effort were used. What is the MA?

   ____

   ____

6. Here is a tricky one! The mechanical advantage of a certain inclined plane is 3. The resistance was 300 newtons. How much effort was used?

   ____

   ____

Lab Activity

Fact:

- Machines make work easier.

Investigate:

- You will demonstrate the use of a single lever.

Materials:

- book
- ruler
- pencil

1. Place a book flat on the table. Try to lift it with one finger.

   Were you able to lift the book? ______________________________

2. Slide a ruler about 1 inch under the book.

3. Place a pencil under the ruler about 1 inch from the free end.

4. Use one finger. Press on the end of the ruler near the pencil.

   a. Were you able to lift the book? ___________________________

   b. Was it easy or hard to move the book? _____________________

5. Keep the pencil under the ruler. Move it so that it is about 1 inch from the book.

6. Use one finger. Press the end of the ruler.

   a. Did the book move? ____

   b. Was it easier or harder to move the book this time? __________

   c. A lever is a simple machine. Did the lever make work easier?

7. Repeat the experiment using a stack of two or three books. Try moving the pencil to different places under the ruler. Is it easier to move the books when the pencil is closer to or farther from the book?

   ____

Practice

Use the list below to complete the following statements about the lab activity.

effort
effort arm
fulcrum
lever
mechanical advantage
resistance
resistance arm

1. The ruler and pencil made a simple machine called a

   ______________________ .

2. The pencil was the ______________________ .

3. The weight of the book was the ______________________ .

4. The pressure of your finger was the ______________________ .

5. The distance from the pencil to the book was the

   ______________________ .

6. The distance from where you pushed to the pencil was the

   ______________________ .

7. The experiment shows that a lever makes work easier or has

   ______________________ .

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

body
change direction
change speed
fixed
inclined plane
lever
machines
make a force stronger
movable
multiplies
pulley
screw
transfer
wedge
wheel and axle

1. Early man had to depend on his ________________________ to do any form of work.

2. ________________________ help us perform very hard jobs.

3. Three things a machine can do are ________________________ , ________________________, and ________________________ .

4. A machine cannot increase the amount of energy; it can only ________________________ energy.

5. The six types of simple machines are ________________________ , ________________________ , ________________________ , ________________________ , ________________________ , and ________________________ .

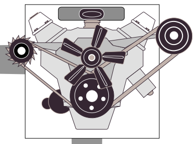
6. A ________________________ is a rigid bar that moves around a point.

7. A ________________________ is a wheel with a grooved rim that rotates on a rod called an axle.

8. A ________________________ pulley does not move. It only changes the direction of the force.

9. A ________________________ pulley moves and increases force.

10. Another way to say that a machine increases force is to say that it ________________________ force.



Practice

Circle the letter of the correct answer.

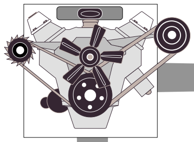
1. A ____________ is a system of pulleys.
   a. fulcrum
   b. block and tackle
   c. resistance arm
   d. wheel and axle

2. A(n) ____________ is a flat surface that has been raised at one end.
   a. resistance arm
   b. block and tackle
   c. inclined plane
   d. wheel and axle

3. A ____________ slope is an upward slant with a gentle rise.
   a. transfer
   b. steep
   c. fixed
   d. gentle

4. A ____________ is a type of inclined plane with sloping sides that come to a point.
   a. wedge
   b. fulcrum
   c. screw
   d. lever

5. A ____________ is a simple machine with an inclined plane that winds around a fixed center.
   a. wedge
   b. fulcrum
   c. screw
   d. lever



6. The inclined plane on a screw is called a ____________ .

   a. wedge
   b. thread
   c. pulley
   d. lever

7. Machines that are built by putting together two or more simple machines are called ____________ .

   a. mechanical advantages
   b. wheel and axles
   c. sewing machines
   d. compound machines

8. ____________ are examples of compound machines.

   a. sewing machines and washing machines
   b. resistance arms and sewing machines
   c. washing machines and block and tackles
   d. resistance arms and effort arms

9. Not all machines multiply force the same amount or as efficiently. All machines, however, should make work ____________ .

   a. effortless
   b. balanced
   c. difficult
   d. easier

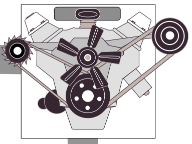
10. The formula for mechanical advantage is ____________ .

   a. $MA = \frac{\text{efficiency}}{\text{effort}}$

   b. $MA = \frac{\text{effort}}{\text{resistance}}$

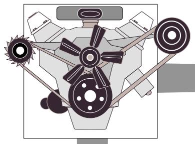
   c. $MA = \frac{\text{resistance}}{\text{effort}}$

   d. $MA = \frac{\text{resistance}}{\text{efficiency}}$



11. The longer the ____________ , the greater the mechanical advantage.
    a. resistance arm
    b. inclined plane
    c. wheel and axle
    d. effort arm

12. The longer the ____________ , the lower the mechanical advantage.
    a. resistance arm
    b. inclined plane
    c. wheel and axle
    d. effort arm



Practice

Match each definition with the correct term. Write the letter on the line provided.

_____ 1. something that makes a force stronger

_____ 2. the weight of the object that must be moved

_____ 3. the amount of work or energy put into a machine

_____ 4. the steady point around which a lever moves

_____ 5. the measure of work input to work output

_____ 6. the number of times that a machine multiplies a force

_____ 7. the distance between the fulcrum and the weight to be moved

_____ 8. the amount of work produced by a machine

_____ 9. the amount of force

_____ 10. the distance between a fulcrum and the point at which effort is applied

A. efficiency

B. effort

C. effort arm

D. fulcrum

E. machine

F. mechanical advantage

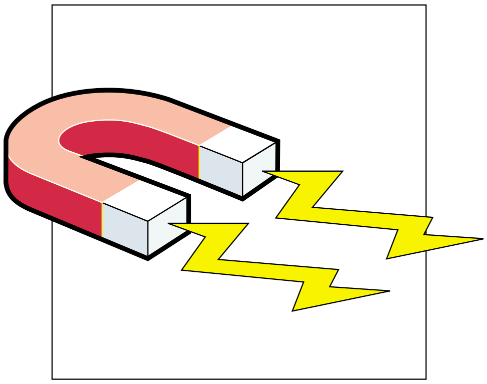
G. resistance

H. resistance arm

I. work input

J. work output

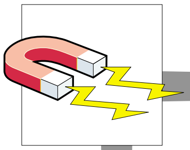
Unit 16: Magnetism



Vocabulary

Study the vocabulary words and definitions below.

attract	to draw or pull toward itself (e.g., a magnet attracts iron)
compass	an instrument with a magnetized needle that points to magnetic north; used to determine direction
demagnetize	to remove the magnetic properties from a magnet
electromagnet	a device that creates a magnetic field made by connecting a coil of wire to an electric current
electromagnetic effect	the tendency of flowing electrons (electricity) to produce magnetic fields and the tendency of moving magnetic fields to cause electrons to flow
induced	caused, created, or produced
law of magnetic poles	like magnetic poles repel and unlike magnetic poles attract
like poles	the same poles; the poles of magnets that repel each other



lines of force	imaginary lines that show a magnetic field
magnet	a substance that attracts or pulls on other substances, especially those made of or including iron
magnetic	of or relating to a magnet or to magnetism
magnetic field	the space around a magnet where a force is noticeable
magnetic north	the magnetic pole located in the north about 800 miles from the North Pole; also known as the North Magnetic Pole
magnetic south	the magnetic pole located near the South Pole; also called the South Magnetic Pole
magnetic variation	for navigational purposes; the angle between the North Magnetic Pole and the actual geographic North Pole
magnetism	a property of matter that creates forces that attract or repel certain substances
magnetize	to become magnetic; to make into a magnet
nonmagnetic	anything that is not attracted to a magnet

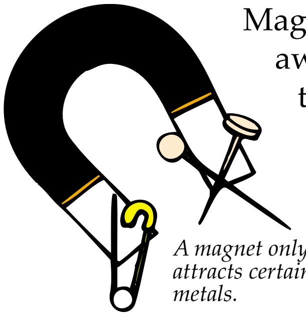
North Pole	the northern end of Earth's axis
north pole	the end of the magnet that points to the north (if free to move)
northern lights	lights that are sometimes seen in the skies of the northern regions and are thought to be caused by the ejection of charged particles into the magnetic field of Earth
poles	the ends of a magnet where the magnetic field is strongest
repel	to push away
South Pole	the southern end of Earth's axis
south pole	the end of the magnet that points to the south (if free to move)
unlike poles	the opposite poles; the poles of magnets that attract each other

Introduction

Magnetism is a special type of force. Magnetism is a special property of matter. In this unit, you will learn how magnets are created. You will also discover how to make a **compass** and describe how it works. Magnetism is a force that affects many areas of everyday living.

What Is a Magnet?

A **magnet** is a substance that **attracts** or pulls on other substances. Iron, cobalt, and nickel are **magnetic** metals because they are attracted to a magnet. Anything that is not attracted to a magnet is **nonmagnetic**. Tin, copper, paper, and wood are nonmagnetic.



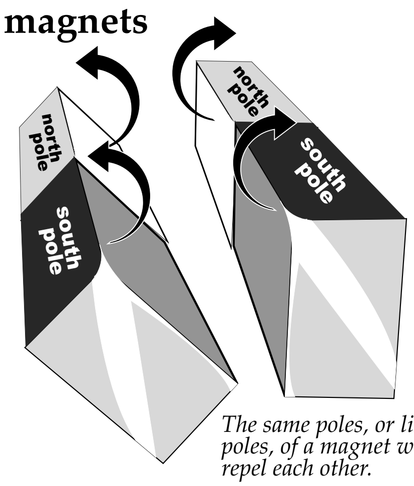
A magnet only attracts certain metals.

Magnetic force can also **repel**. Two magnets can push away from each other when their ends are put together. The ends of a magnet where the force is strongest are called **poles**. The poles of a magnet are found by determining which ends have the strongest force. Pass a bar magnet over a box of pins. Most of the pins will stick to the ends of the magnet.

One pole, or end of a magnet, is called the **north pole**. The other end is called the **south pole**. All magnets have a north and south pole.

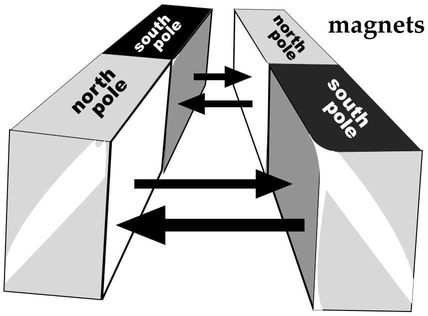
Pick up two magnets. Put the north pole of one next to the north pole of the other. What happens? They repel each other. Try placing a south pole next to a south pole. Again, the magnets will repel each other.

Now put a north pole next to a south pole. Do they repel each other? No, they



The same poles, or like poles, of a magnet will repel each other.

attract each other. This is called the **law of magnetic poles**. The same poles, or **like poles**, of a magnet will repel each other. The opposite poles, or **unlike poles**, of a magnet will attract each other.



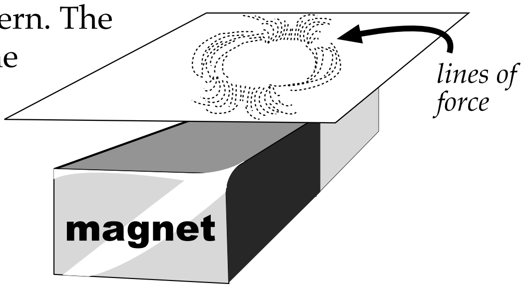
The opposite poles, or unlike poles, of magnets will attract each other.

Explaining Magnetism

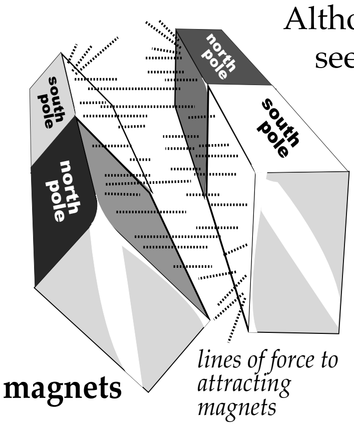
You know that atoms make up matter. Some atoms are like little magnets. In cobalt, iron, and nickel, the atoms may line up in a special way. When most of the atoms face the same way, the material will be magnetic. In nonmagnetic material, the poles cancel each other out. This is because they are not lined up in the same direction.

Magnetic Field

You already know that the force of a magnet is strongest at the poles. The rest of the magnet also has some force. Put a piece of paper over a bar magnet. Place some iron filings on top of the paper. Shake the paper slightly. The iron filings will make a pattern. The lines you see are called **lines of force**. The whole pattern is the **magnetic field**. A magnetic field is the space around a magnet where a force is noticeable.



When you get too far away from a magnet, the force will not be noticeable

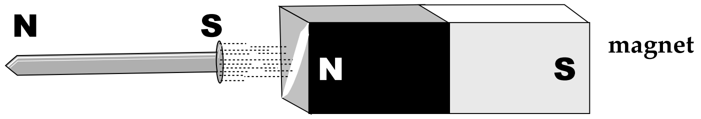


Although magnetism seems like a strong force, we see that it quickly gets weak with distance.

What would the lines of force look like in attracting magnets? What would happen to the lines of force if two like magnets were placed together? Remember, opposite forces attract and like forces repel.

Making a Magnet

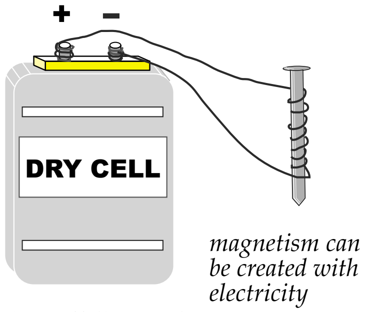
Magnetism can be **induced**, or created, in some materials. There are three ways to make a magnet. Place an iron nail against the north pole of a magnet. The force in the magnet will begin to pull at the atoms in the nail. They will line up in straight lines. This will make the nail temporarily magnetic. The end of the nail closest to the magnet's north pole will become the south pole. The other tip of the nail will be the north pole.



You can also **magnetize** some materials by rubbing them with a magnet. Run a magnet along the side of a needle. Keep rubbing in the same direction. The atoms in the needle will begin to line up. This will make the needle into a magnet. The longer you rub, the stronger the magnetism will become. Both induced magnets will lose their magnetic force after awhile.

Magnetism can also be created with electricity. Connect a wire to the (+) side of a dry cell or battery. Coil the wire around a nail. Attach it to the (-) side of the dry cell.

This will create an **electromagnet**. The nail will act like a magnet. This kind of magnet has many advantages over ordinary magnets. Electromagnets can be turned on and off. Their strength can be controlled. This kind of magnet is used in doorbells, electric motors, and telephones.



magnetism can be created with electricity

dry cell (battery)

The Electromagnetic Effect

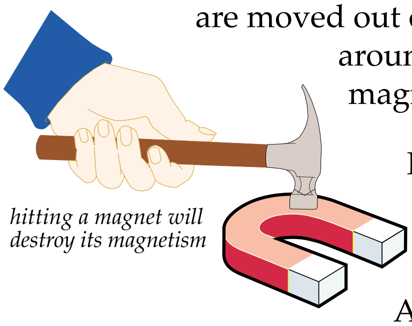
You saw that in the first two examples, a magnet was used to create a new magnet. In this last example, we did not use a magnet. Instead, we used electricity. Electricity is electrons that are flowing in a particular direction. Because these particles are charged, when they flow past the nail it causes a magnetic field to be created. It is this field that makes the nail act as a magnet. When you unplugged the wires, the electrons stopped. This also shut off the magnet.

This effect was first described by Michael Faraday. He called it the **electromagnetic effect**. This means that, as we've seen, electricity can create magnets. Magnets, however, can also be used to create electricity, the flow of electrons. Electrons move from areas of negative charge to areas of positive charge. By moving magnets past a length of metal, electrons are made to move. This is how electricity is generated. Electricity and magnetism are closely related and are usually found together. In many ways, they cannot be separated and are just two versions of the same force.

Demagnetizing a Magnet

When the physical appearance of a magnet is changed, the property of magnetism may or may not change. If a magnet is cut in half, it will not destroy the magnet. There will just be two smaller magnets. Each one will have a north and a south pole.

However, magnetism can be destroyed. A magnet can be **demagnetized** by removing properties from a magnet. Remember that the atoms in a magnet are lined up in a row. Magnetism will be destroyed if the atoms are moved out of line. Heating will cause atoms to move around. If a magnet is held over a flame, its magnetism will be lost.



hitting a magnet will destroy its magnetism

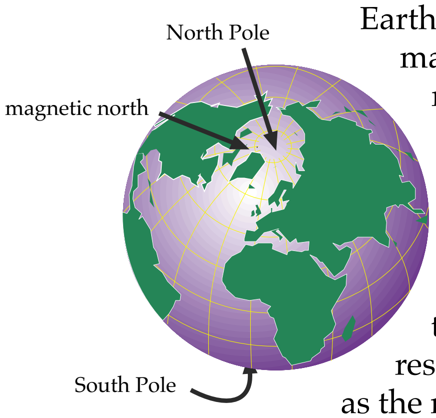
Hitting a magnet with a hammer will also destroy its magnetism. The force of the hammer will move the atoms out of line.

A magnet that is dropped over and over again will also lose its magnetism. Each time the magnet is dropped, more atoms will move out of line.

Earth as a Magnet

What makes one pole of a magnet point north? It must be attracted to something. Earth can be thought of as a large magnet. Look at a globe of Earth. The very top is called the **North Pole**. The opposite side is called the **South Pole**. These spots are not the magnetic poles. **Magnetic north** is located almost 800 miles from the North Pole. **Magnetic south** is located near the South Pole.

Why is magnetic north important? Scientists discovered the magnetic force of Earth could be used to determine direction. Sailors began using compasses to find their way. A compass has a magnetized needle that points to magnetic north. Any direction can be located if you know which way is north. For advanced navigation, it is important to know that there is a slight shift in north as you approach the North Pole. This shift is called **magnetic variation**.



Earth acts as a huge magnet. It also has a magnetic field. Earth's magnetic field is responsible for the phenomenon called the **northern lights**. Remember that magnets are closely related to electricity. Because of this, they have effects on charged particles. When charged particles come into Earth's atmosphere near the poles, they interact with the magnetic pole. The result is a release of energy. We see this energy as the northern lights or bright-colored areas in the sky.

Summary

Magnetism is a force that attracts or repels substances. Magnets have north and south poles. Poles that are the same repel each other. Unlike poles attract. Lines of force surround a magnet. Magnets can be created when atoms line up. The electromagnetic force can be used to create magnets or electricity. Applying heat, hitting, or dropping a magnet will destroy its magnetism. Earth acts as a magnet. A compass helps locate direction by pointing to the magnetic north.

Practice

Answer the following using complete sentences.

1. What are three ways to make a magnet? ______________________

   ____

   ____

   ____

2. What are three ways to demagnetize a magnet? _______________

   ____

   ____

   ____

3. How does an electromagnet work? __________________________

   ____

   ____

4. Earth has two magnetic poles. What are they called? ___________

   ____

   ____

5. Are the magnetic poles mentioned above the same as the North and South geographic poles of Earth? Explain.

   ____

   ____

   ____

   ____

Lab Activity 1: Part 1

Facts:

- The magnetic field is the space around a magnet where a force is noticeable.
- The lines of force are lines that show the magnetic field.

Investigate:

- You will make a map of a magnetic field and diagram the lines of force for attracting and repelling magnets.

Materials:

- 2 bar magnets
- iron filings
- a sheet of paper

1. Place one bar magnet on your desk.
2. Cover the magnet with a sheet of paper.
3. Sprinkle iron filings on the entire paper.
4. Observe what happens.
5. In the space below, draw a diagram of what you observed.

Answer the following about the Lab Activity 1: Part 1. Use the term **poles** *or* **middle** *to correctly complete the statements.*

6. At the end of the experiment, most of the iron filings were at the

   ______________________ .

7. At the end of the experiment, there were fewer iron filings in the

   ________________________ .

8. From this experiment, you can see that a magnet is strongest at the

   ________________________ .

9. You can also see that a magnet is weakest in the

   ________________________ .

Lab Activity 1: Part 2

Continuing with Lab Activity 1, answer the following.

1. Remove the bar magnet from beneath the sheet of paper.

2. Shift the sheet of paper until the iron filings are in one pile in the middle of the paper. Move the paper to the side of your desk. We will use it in a moment.

3. Pick up two bar magnets. Hold one in each hand. Move the north pole of one of the magnets toward the north pole of the second magnet. Observe what happens.

   a. Did the poles attract or repel? ____________________

   b. Do like poles attract or repel? ____________________

4. Reverse one of the magnets so that the south pole of one is pointing toward the north pole of the other magnet. Move the magnets together. Observe what happens.

   a. Did the north pole attract or repel the south pole? _____________

   b. Do opposite poles attract or repel? __________________

5. Put the magnets on your desk so that the north poles of each are about one hand's width away pointing toward each other. Place the sheet of paper with the iron filings on top of the two north poles. Observe what happens.

6. In the space below, draw a diagram of what you observed.

You have just drawn the magnetic field between like magnets.

7. Carefully pick up the sheet of paper and iron filings. Change the direction of one of the magnets so that the north pole on one is facing the south pole of the other.

8. Place the paper and iron filings on the magnets. Observe what happens.

9. In the space below, draw a diagram of what you observed.

You have just drawn the magnetic field between unlike magnets.

10. The law of magnetic poles states that like poles

____________________ and unlike poles ____________________ .

Lab Activity 2

Facts:

- Earth is a huge magnet.
- All magnets point to the magnetic north.

Investigate:

- You will magnetize a simple needle to create a simple compass.

Materials:

- bar magnet
- steel needle
- thin piece of cork
- bowl
- water
- a compass

1. Fill a shallow bowl with water.
2. Rub a needle with a bar magnet. Be sure to rub in only one direction.
3. Lay the needle on the piece of cork.
4. Place the needle and cork in a bowl of water.
5. Observe what happens.

   You know that the needle is pointing north and south, but which end is pointing to the north?

   ____

   ____

6. Set a compass a few feet away. Check the needle for north.

7. What happened when you rubbed the needle with the magnet?

____

____

8. In which direction did the needle point when you placed it on the cork in the water? (north and south or east and west)

____

9. Why does the needle of a compass point north?

____

____

____

10. If Earth did not have magnetic poles, would a compass work? Why or why not?

____

____

____

Practice

Use the list above each section to complete the statements in that section.

attract
like
magnet
magnetic
magnetism
nonmagnetic
north pole
poles
repel
south pole
unlike

1. A property of matter that creates forces that attract or repel certain substances is called ______________________ .

2. A ______________________ is a substance that attracts or pulls on other substances.

3. Anything that is attracted to a magnet is called ______________________ .

4. Anything that is not attracted to a magnet is called ______________________ .

5. The ends of a magnet are called ______________________ .

6. The end of the magnet that always points to the north (if free to move) is called the ______________________ .

7. The end of the magnet that always points to the south (if free to move) is called the ______________________ .

8. The law of magnetic poles states that like poles ______________________ and unlike poles ______________________ .

9. The north pole of one magnet and the north pole of another magnet would be considered ____________________ poles. (like or unlike)

10. The north pole of one magnet and the south pole of another magnet would be considered ____________________ poles. (like or unlike)

compass
demagnetize
electromagnet
induced
lines of force
magnetic field
magnetic north pole
magnetize
North Pole
South Pole

11. A ____________________ is the space around a magnet where a force is noticeable.

12. The ____________________ are the lines that show a magnetic field.

13. Magnetism that is caused by an object touching or being placed near a magnet is called ____________________ magnetism.

14. To make something into a magnet is to ____________________ it.

15. A device that creates a magnetic field made by connecting a coil of wire to an electric current is called an ____________________ .

16. To remove the magnetic properties from a magnet is to

_________________________ .

17. The northern end of Earth's axis is called the

_________________________ .

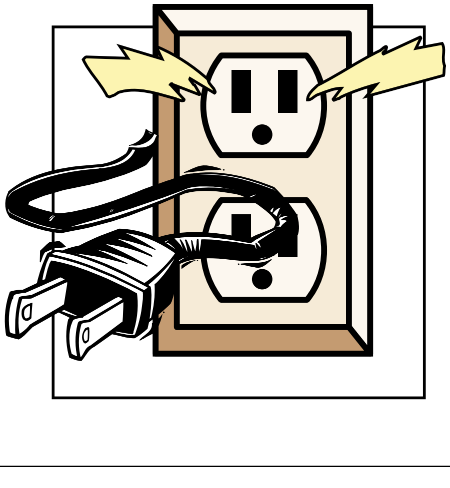
18. The southern end of Earth's axis is called the

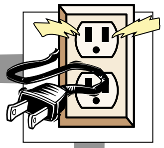
_________________________ .

19. The magnetic pole located in the north about 800 miles from the North Pole is called _________________________ .

20. A _________________________ is an instrument with a magnetized needle that points to the magnetic north.

Unit 17: Electricity

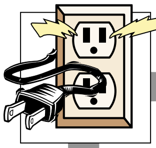




Vocabulary

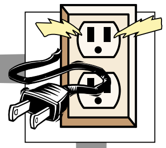
Study the vocabulary words and definitions below.

alternating current	electrical current that flows in one direction, then in the other direction; changes direction many times every second; abbreviated *AC*
ammeter	a device used to measure amperes
amperes	the number of electrons that are moving past a certain point in a circuit within a given time; the rate of flow; abbreviated as *amp*
armature	the coil inside the generator
battery	a group of two or more electric cells used to create or store electricity
cell	a device that uses chemical reactions to store and produce electricity
circuit	the path a current follows through a conductor
closed circuit	a complete path or circuit which allows electricity to move along it



conductor	a material that allows electricity to pass through it
current	the flow of electrons along a path
direct current	electrical current that flows in only one direction; abbreviated *DC*
electricity	a form of energy in which electrons are flowing
electrocute	to kill by passing electric current through a body
electromagnetic induction	producing a current by moving a coil of wire across a magnetic field
electromotive force	the force needed to make electrons move; abbreviated *EMF*
generator	a machine that changes mechanical energy into electricity
insulator	a material that will not allow electricity to pass through it
ohm	a unit that measures the amount of resistance to electric current

open circuit	an incomplete path or circuit that does not permit the flow of electricity
parallel circuit	a circuit that provides more than one path for electricity to follow
resistance	the force that slows down electron flow
series circuit	a circuit that has only one path for electricity to follow
static electricity	the form of electricity caused by a charged (+) or (-) particle; it does not move in a path
volt	unit for measuring electromotive force

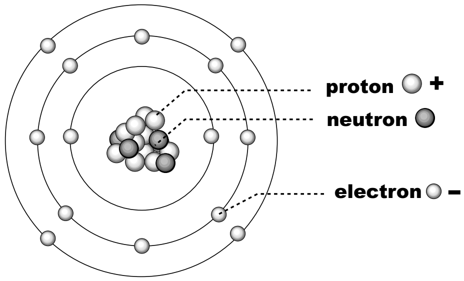


Introduction

It is difficult to imagine what our lives would be like without **electricity**. As little as 100 years ago, there was no electricity in homes and factories. Today, we depend on electricity to run everything from small radios to satellite tracking stations. Some of the general properties of electricity will be introduced in this unit.

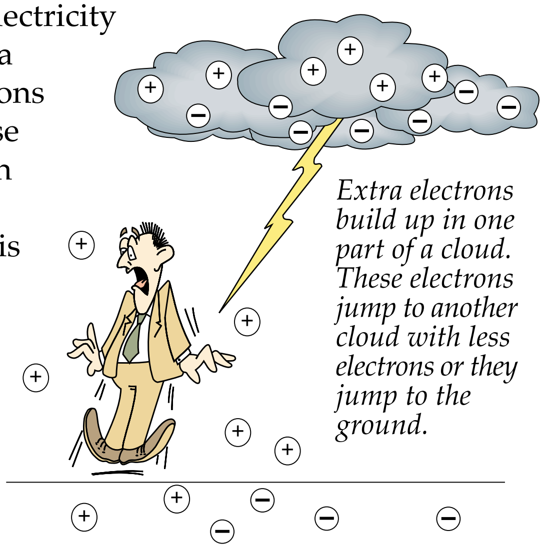
What Is Electricity?

Electricity is a form of energy. All matter contains some electricity. Matter is made from atoms. Atoms contain protons that have a positive charge (+), neutrons that are neutral or have no charge, and electrons that carry a negative charge (-). Most matter has the same number of protons as it does electrons; this makes the matter neutral. An atom can gain or lose electrons. If an atom gains extra electrons, it will become negatively charged (-). A loss of electrons will create a positive charge. Between any objects with charge, there is always electrical force. In fact, it is these electrical forces within molecules and atoms that cause most observable forces. Your ability to throw a ball, the blooming of a flower, and the working of your car are examples of forces in action. Each of these can be traced back to electrical force. This idea is fundamental to most sciences. This unit will discuss how the flow of electrons causes electric **current**. Electricity is electrons in motion. Electrons move from a place that has gained electrons to a place that has lost electrons. We can say this another way: electrons move from areas of negative charge to areas of positive charge.



Electrons Orbiting a Nucleus

When matter becomes positively or negatively charged, we sometimes call this **static electricity**. Run a brush through your hair. Take a nylon shirt out of a dryer. What happens? A small shock is felt or a crackle is heard. This indicates *static electricity*. At first, there was a charge, but the electrons did not move. Then, when you heard the crack or felt the shock, the electrons moved. The electricity did not move in a path. Because it does not move along a path, static electricity cannot run appliances. Lightning is a form of static electricity. Extra electrons build up in one part of a cloud. These electrons jump to another cloud with less electrons or they jump to the ground. When this happens, the air is heated and the sky is filled with bright light. Lightning is dangerous and kills or disables hundreds of people every year.


Extra electrons build up in one part of a cloud. These electrons jump to another cloud with less electrons or they jump to the ground.

Wires that carry electric power can be dangerous. If you touch bare wires, enough charge may flow through your body to hurt you. You may even be **electrocuted** by it. Electrocution means death by exposure to electricity. You have not been electrocuted, but you may have been shocked. Electricity at home must be used with care. Never use anything with loose or broken electric wires. When there is lightning outside, stay off the telephone and away from electrical appliances. The lightning can send an electric current through these various wires and then through you!

Most usable electricity is different from static electricity. It moves along a path. It is a flow or a stream, and it is the kind of electricity that we use to run appliances.

Producing Electricity

There are many different sources of electricity. Some electricity comes from **cells** or batteries. A cell is a device that uses chemical reactions to store and produce electricity. The kind of **battery** used in a flashlight is formed from two or more cells. These cells are usually dry. That is to say that the chemicals in them are not dissolved in water. A dry cell has a carbon rod set in the center of a zinc can. The rest of the can is filled with a special paste or gel. The chemicals in the paste react with the zinc. Electrons are released and flow to the carbon rod. This flow of electrons is electricity.

A **generator** also produces electricity. It contains magnets and a large coil of wire called an **armature**. The armature turns between the magnets. As the armature turns, it moves across the magnetic field, producing electrical current in the coil. This process is called **electromagnetic induction**. Generators rely on the fact that electricity and magnetism are two aspects of the same force. Just as we use magnets to produce electricity, we use electricity to make magnets. Generators change the mechanical energy of different sources into electricity. They can be turned by different sources of energy, such as steam, solar, atomic, and even water. When a generator stops turning, it no longer produces electricity.

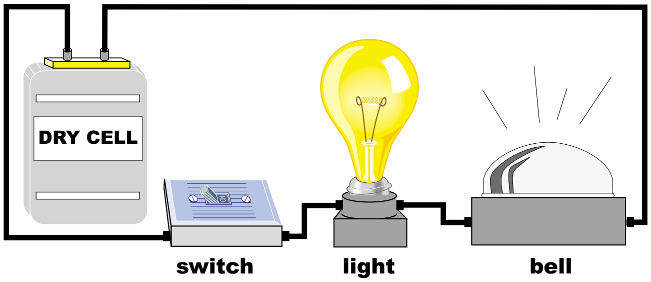
Circuits

You know that electricity is a flow of electrons. Current electricity must follow a path. The path a current follows is called a **circuit**.

An electric circuit can be either *open* or *closed*. A **closed circuit** will allow electricity to move through it. A closed circuit is a complete path. An **open circuit** will not allow electricity to move through it. An open circuit is an incomplete path. Turn on the light switch in the room. The circuit is complete and electricity will flow. Turn the light switch off. The circuit is open and no electricity will flow.

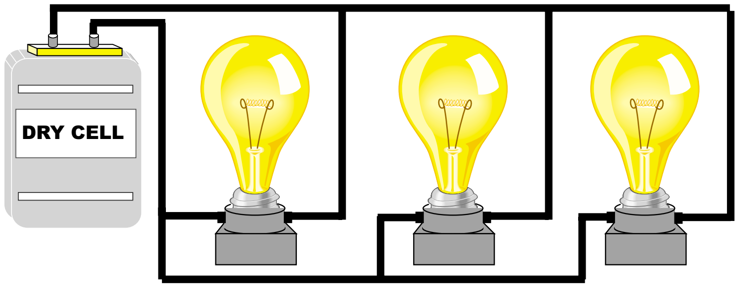
There are two basic kinds of circuits. Circuits may be either series or parallel. In a **series circuit**, electricity only has one path to follow. Connect a switch, a light, and a bell to a battery. Close the switch. The bell and the light will work. What happens if the light burns out? The circuit will be open. The electricity cannot get past the burned-out light. The bell will not work. When one thing in a series circuit burns out, everything else in the series will also stop working. They are not damaged; however, no electricity will flow, so they still will not work. Imagine what would happen if everything in your school was connected to one series circuit.

Series Circuit



A **parallel circuit** has more than one path for electricity to follow. The current splits up to flow through different branches. Parallel circuits have the advantage that when one branch of the circuit is opened, such as when you turn off a light, the current continues to flow through the other branches. If one thing on a parallel circuit burns out, the rest of the things will keep working. It is the kind of circuit used in homes and offices.

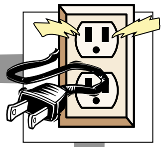
Parallel Circuit



Currents

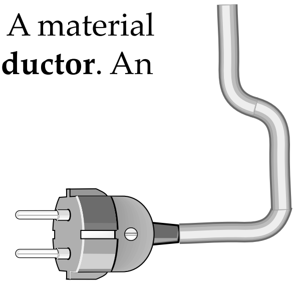
There are two kinds of currents. One type is **direct current** (*DC*). The second type is **alternating current** (*AC*). A direct current flows in only one direction. A dry cell or battery produces a direct current. Direct currents can lose power if they travel long distances through a wire. Remember that electromagnetic induction produces a current using a magnetic field. The magnetic field produced by a DC current is aligned in only one direction. If you use a compass, you can detect the direction in which the field is aligned. When you place the compass along the path the electrons follow, it will always point the same way.

Alternating currents (AC) change direction many times every second. This is the type of current used in homes and offices. Most household current changes direction 60 times each second. This means that the charges change 60 times each second. Alternating currents can be sent long distances through wires without losing much power. The magnetic fields produced by AC currents are different from those of DC. Because the direction of the current changes, so does the direction of the magnetic field. The result of this is that the field moves away from the wire in first one direction and then another. This varying direction of the electricity and the magnetic field creates an electromagnetic wave. This form of energy moves away from the circuit. Because it moves away from its source, we say it radiates. We will discuss electromagnetic waves of many sorts in “Unit 20: Waves.”



Conductors and Insulators

Electricity flows. Can it go everywhere? No, it cannot. A material that allows electricity to pass through it is called a **conductor**. An **insulator** will not allow electricity to flow through it.



Think about the wire that carries electricity to your television set. What keeps the electricity in the wire? The rubber coating around the wire is a good insulator. It resists the flow of electricity through it. Glass, rubber, and plastic are good insulators. There is no perfect insulator, however, so remember to use caution.

Electricity will travel through a conductor. Copper wire is a good conductor. Silver wire also conducts electricity very well, but is more costly to use than copper. Most metals will conduct electricity. Air and water will also conduct electricity.

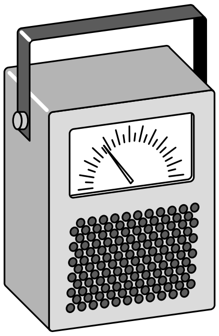
Measuring Electricity

Electricity can be measured. Electric current flows through wires. **Amperes**, or *amps*, tell how much current is flowing. Amps measure the number of electrons that move past a point in one second. An **ammeter** is used to measure amps.

Electricity moves. You know that some type of force is needed to make things move. **Electromotive force** *(EMF)* moves electricity. Electromotive force is measured in **volts**. The current in a house is usually being pushed by 110 to 120 volts. A dry cell used to run a flashlight has about 1.5 volts.

Moving objects usually have to overcome some form of **resistance**. Resistance is the force that slows down electron flow. Electricity also meets resistance. Resistance measures how hard it is for an electric current to pass through a material. A unit of resistance is called an **ohm**. A large amount of resistance will lower the number of amps that can flow through a wire. This means that the current will be less. High resistance also produces heat. The burner coils on an electric stove have a high resistance. When you turn the knob to control the heat, you are really controlling how much current enters the coil. The more current, the more heat.

an ammeter is used to measure amps



A volt tells how much force is used to push the current through a wire. An amp tells the rate of the current's flow. An ohm tells how much resistance the conductor is giving the current. An ohm is the unit of measure of the conductor's resistance.

Summary

Electricity is caused by a flow of electrons. Static electricity is caused by (+) or (-) charged materials. Electrical forces exist between charged objects. Current electricity moves along a path or circuit. A direct current (DC) only moves one way. Alternating current (AC) moves back and forth. Alternating currents cause electromagnetic waves. A circuit can be either series or parallel.

Practice

Answer the following using complete sentences.

1. What is electricity? ____

   ____

   ____

2. What is static electricity? ___________________________________

   ____

   ____

   ____

3. How are static electricity and current electricity different?

   ____

   ____

   ____

4. Describe how electrical forces are the source of most forces we observe.

   ____

   ____

   ____

   ____

5. Do household appliances use static or current electricity?

____

6. What is a dry cell? ________________________________

____

____

7. How does a dry cell produce electricity? ________________

____

____

8. What is a generator? ______________________________

____

____

9. Describe how a generator uses the electromagnetic effect.

____

____

____

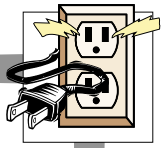
10. What is a circuit? ________________________________

____

____

11. Which type of circuit is complete and will allow electricity to move along it?

____



12. Which type of circuit is incomplete and blocks the flow of electricity?

    ____

13. Which type of circuit has only one path for electricity to follow?

    ____

14. Which type of circuit has many paths for electricity to follow?

    ____

15. Which type of circuit is used in schools and homes? __________

16. Define the term *direct current.* ________________________

    ____

17. Define the term *alternating current.* ____________________

    ____

18. Describe the difference between direct current and alternating current.

    ____

    ____

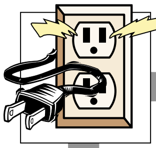
    ____

19. Describe the difference in the magnetic field produced by DC and the field produced by AC.

    ____

    ____

    ____



20. What name is given to material that allows electricity to pass through it?

____

21. Name three conductors of electricity. ____________________

____

22. What name is given to material that will not allow electricity to pass through it?

____

23. Name three insulators of electricity.______________________

____

24. What is an electromotive force? ________________________

____

25. What does a volt measure? ___________________________

____

26. What does an amp measure?___________________________

____

27. What does an ohm measure?___________________________

____

28. Describe how AC causes an electromagnetic wave to radiate.

____

____

____

____

Lab Activity 1

Facts:

- Objects may acquire a positive or a negative charge.

Investigate:

- You will demonstrate static electricity.

Materials:

- plastic ruler
- bits of paper
- piece of wool
- balloon (optional)

1. Hold a plastic ruler over a pile of small bits of paper.

    a. Did the ruler attract the paper? ______________________________

    b. Does the ruler have a charge? ______________________________

    c. Do objects with no charge attract each other? ________________

2. Rub the ruler with a piece of wool a few times.

3. Hold the ruler near the paper.

    a. Does the ruler attract the paper? _____________________________

    b. Does the ruler have a charge? ______________________________

    c. Where did the ruler get the charge? _________________________

    d. This is an example of _________________________ electricity.

4. Optional Activity: Repeat the experiment using a comb or inflated balloon instead of the ruler.

Lab Activity 2

Facts:

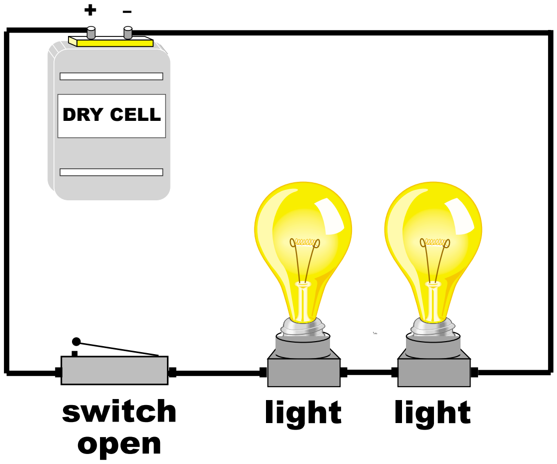
- Electricity follows a path called a circuit.

Investigate:

- You will construct a series and a parallel circuit.

Materials:

- dry cell
- insulated copper wire
- switch
- 2 light bulbs in bases (lamps)



1. Connect the wire to the (+) pole on the dry cell.

2. Connect the wire to one side of the switch. Leave the switch open. Connect the wire to the other side of the switch.

3. Attach the wire to one side of the first bulb. Connect it to the other side. Run the wire to the second bulb.

4. Connect the second bulb in the same way.

5. Connect the end of the wire to the (-) pole on the dry cell.

6. Check your set up with the diagram on page 310.

7. Close the switch (right).

   a. What happens to the light bulbs? ______________________________

   b. Is the circuit complete? ____

8. Open the switch (right).

   a. What happens to the light bulbs? ______________________________

   b. Is the circuit complete? ____

9. Unscrew the first light bulb.

10. Close the switch.

    a. What happens to the other light bulb? _________________________

    b. What kind of circuit did you construct, series or parallel?

    ____

11. Rewire the circuit using the following outline.

    a. Leave the wire on the (+) pole of the dry cell.

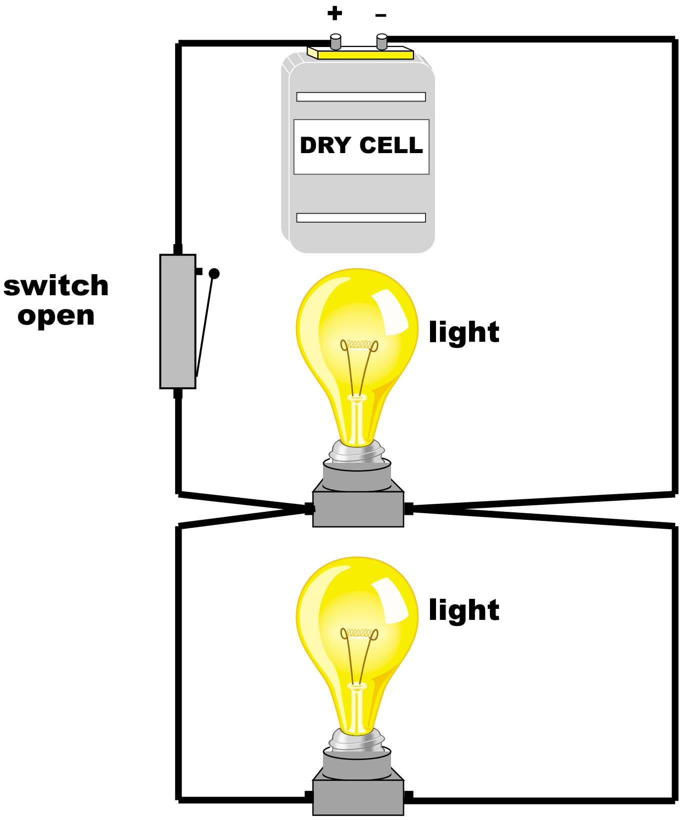
    b. Leave the switch connected.

    c. Leave the switch open.

    d. Connect the wire to one side of the first bulb. Continue the wire to one side of the second bulb.

e. Attach the second wire to the other side of the second bulb. Continue the wire to the other side of the first bulb.

f. Check your circuit with this diagram:



12. Close the switch.

a. What happens to the bulbs? ______________________________

b. Is the circuit complete? ___________________________________

13. Open the switch.

a. What happens to the light bulbs? __________________________

b. Is the circuit complete? ___________________________________

14. Unscrew the first light bulb.

15. Close the switch.

    a. What happens to the other light bulb? ______________________

    b. Is this a series or a parallel circuit? _________________________

16. Which kind of circuit would you use to wire the lights in a hotel hallway? Why?

    ____

    ____

Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

alternating
armature
cell
chemical
closed
current
direct
dry cell
electrical
electricity
electromagnetic wave
electrons
open
parallel
series
static

1. ________________________ is a form of energy made of flowing electrons.

2. ________________________ electricity is the form of electricity caused by a (+) or (-) charged object.

3. ________________________ electricity does not move in a path.

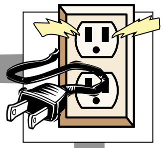
4. ________________________ electricity is a form of electricity caused by a flow of electrons along a path.

5. Lightning is a form of ________________________ electricity.

6. The type of electricity used to run appliances in your home is ________________________ electricity.

7. A ________________________ is a device that utilizes chemicals to create or store electricity.

8. The kind of cell used in a flashlight is a ________________________ .



9. A dry cell is a device that changes ____________________ energy to ____________________ energy.

10. A ____________________ is a machine that produces electricity by means of mechanical energy.

11. A generator contains magnets and a large coil of wire. This coil is called an ____________________ .

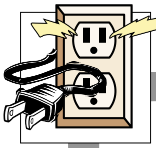
12. The armature of a generator turns between the magnets, using electromagnetic induction to cause a flow of ____________________ .

13. An ____________________ circuit is an incomplete path or circuit that blocks the flow of electricity.

14. A ____________________ circuit is a complete path or circuit which allows electricity to move along it.

15. There are two basic kinds of circuits. A ____________________ circuit has only one path for electricity to follow. A ____________________ circuit provides more than one path for electricity to follow.

16. In a ____________________ circuit, when one thing stops working, everything stops working.



17. A ____________________ circuit is the kind of circuit used in homes and offices.

18. There are two kinds of currents. A ____________________ current flows in only one direction. An ____________________ current flows in one direction, then in the other direction. It changes direction many times every second.

19. Alternating current can cause an ____________________ to radiate away from the circuit.

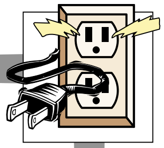
AC
ammeter
atoms
conductor
copper
DC
electromotive force (EMF)
forces
glass
insulator
ohm
plastic
resistance
rubber
silver
volt

20. ____________ is the abbreviation for direct current.
____________ is the abbreviation for alternating current.

21. A ____________________ is a material that allows electricity to pass through it.

22. An ____________________ is a material that will not allow electricity to pass through it.

23. Two examples of conductors are ____________________ and ____________________ .



24. Three examples of insulators are ____________________ ,
____________________ , and ____________________ .

25. ____________________ is the force needed to make electricity move.

26. Moving objects usually move to overcome some type or form of ____________________ .

27. A ____________________ is a unit of measurement used to tell how hard electric current is being pushed.

28. A volt measures ______________________________ .

29. An ____________________ tells how much current is being pushed.

30. An ____________________ is a unit that measures the amount of resistance to electric current.

31. One reason electricity is important is that electrical ____________________ exist between any two charged objects.

32. This electric force is the cause of most observable forces. The force is found between the molecules and ____________________ of objects.

Practice

Circle the letter of the correct answer.

1. ____________ current flows in only one direction.
    a. electrical
    b. direct
    c. parallel
    d. alternating

2. ____________ current flows in one direction, then in the other direction. It changes direction many times each second.
    a. electrical
    b. direct
    c. parallel
    d. alternating

3. ____________ is the abbreviation for direct current.
    a. EC
    b. DC
    c. PC
    d. AC

4. ____________ is the abbreviation for alternating current.
    a. EC
    b. DC
    c. PC
    d. AC

5. A material that allows electricity to pass through it is called a(n) ____________ .
    a. conductor
    b. insulator
    c. current
    d. series

6. A material that will *not* allow electricity to pass through it is called a(n) ____________ .

   a. conductor
   b. insulator
   c. current
   d. series

7. Objects usually move to overcome some type or form of ____________ .

   a. ampere
   b. electromotive force
   c. resistance
   d. conductance

8. A ____________ is a unit of measure used to tell how hard electric current is being pushed.

   a. ampere
   b. ohm
   c. resistance
   d. volt

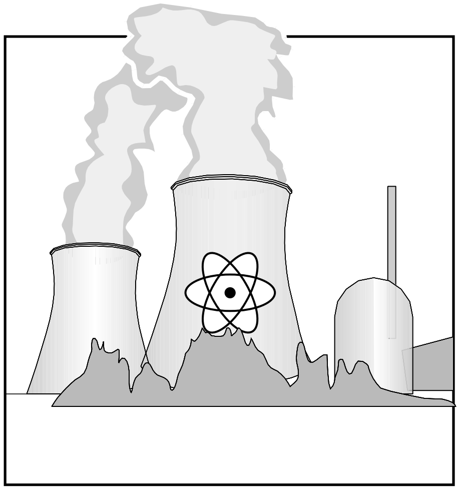
9. A(n) ____________ measures how much current is flowing.

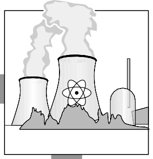
   a. ampere
   b. ohm
   c. resistance
   d. volt

10. A(n) ____________ measures how much resistance the conductor is giving the current.

    a. ampere
    b. ohm
    c. resistance
    d. volt

Unit 18: Nuclear Energy





Vocabulary

Study the vocabulary words and definitions below.

chain reaction	a self-sustaining nuclear reaction; it continues without the addition of outside energies
control rod	a barrier that slows a nuclear reaction by absorbing excess radiation
fission	splitting the nucleus of an atom into two lighter parts
fission reactor	a type of nuclear reactor that splits the nuclei of atoms
fusion	a nuclear reaction in which two or more nuclei are pushed together to form one large nucleus
fusion reactor	a type of nuclear reactor that would combine atoms
isotope	an atom or group of atoms with the same atomic number but different atomic mass than other atoms of a specific element; this difference in mass is based on a difference in the number of neutrons within the nucleus of the atom

nuclear energy	the energy that holds the nuclei of atoms together; it is released in nuclear reactions and may be used to produce heat, electricity, or other forms of energy
nuclear reaction	a reaction that occurs when an atom is split; large amounts of energy are released
nuclear reactor	a machine used to control or create a nuclear chain reaction
nucleus	the center of the atom; plural: nuclei
radiation	the movement of energy as a wave
radioactive	describing those elements or isotopes that spontaneously decompose and give off radiation
radioactive waste	the waste produced by a nuclear reactor; though unusable it still releases radiation
radioactivity	forms of energy given off by nuclear material
theory of relativity	the theory that there is a fundamental relationship between matter and energy; $E=mc^2$ (E stands for energy, m stands for mass, and c stands for the speed of light.)

Introduction

There are many forms of energy in the world. As you learned in the last unit, many of these are derived from the forces of electromagnetism. Gasoline that burns, muscles that contract, and electrons that flow are all the result of this electromagnetic force. Although we use this force constantly, it is relatively weak when compared to nuclear forces. Just as with electromagnetic forces, nuclear forces produce energy. The sun is the ultimate source of almost all our energy. The energy of the sun comes from **nuclear energy**.

Nuclear energy involves the nuclei of atoms. Subatomic particles in the **nucleus** of atoms are called *neutrons* and *protons*. These particles are matter. In “Unit 8: Chemical Equations,” you learned that matter cannot be created nor destroyed. What about energy? Energy can change form, but can never be destroyed. This is called the *law of conservation of energy*. (Covered in “Unit 13: Forms of Energy”). This law applies to the energy you use every day.

Electromagnetic forces provide us with most of the energy we use on a daily basis. Most of this energy has originated in sunlight. For example, sunlight is used by plants. Wheat plants store this energy as chemical energy. The chemical energy comes to you as flour or bread. You use the chemical energy for many purposes. You will produce heat, may make sound, or use mechanical energy. The energy you use, though, originated in the sun's light. This unit discusses how nuclear reactions only appear to break the laws of conservation of mass and energy and how the result is all the energy you use.

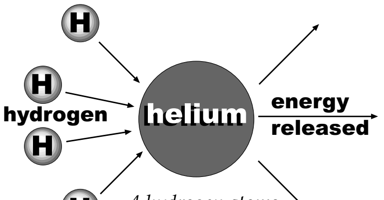
What Is Nuclear Energy?

Most of the electromagnetic energy we know comes from the outer portions of atoms, the electrons. Within the center of the atom, however, is the nucleus. The energy that holds tightly together the nucleus of atoms is nuclear energy. Compared to the electromagnetic forces of the atom, the nuclear energy is immense. By releasing some of this energy, the sun creates light. The sun's light gives us energy that runs the world.

Most of the energy sources we use today are derived from sunlight. Oil and natural gas, and even wood for fires, are the products of sunlight. Unfortunately, this is not a very efficient way to use the sun's energy. Much of the energy of the sun is lost as heat. Because the world's population grows every day, we find that we need more and more energy. Nuclear energy may be one way of providing that energy. With the use of nuclear energy also comes the serious risk of the escape of harmful radiation, such as in the disaster in 1986 at a nuclear power plant in Chernobyl, in the Ukraine. Many safeguards must be taken to prevent accidents.

How Does the Sun Work?

There are two main ways to release nuclear energy. The sun uses a process known as **fusion**. The sun is made of light gases being held together by gravity. Most of this gas is the lightest of elements, hydrogen. In the center of the sun, the hydrogen gas is being pushed together by gravity. This pressure is incredibly high. Because of this pressure, there is also a large amount of heat. Under the pressure and heat, the hydrogen changes. Four hydrogen atoms will combine to form one helium atom! When this happens, energy is released.



4 hydrogen atoms combine to form 1 helium atom - energy released

You should remember that the law of conservation of energy says energy can neither be created nor destroyed. From where did the energy come? When the four hydrogen atoms were changed into one helium atom, a small part of their mass was lost. Compare the mass of four hydrogen atoms to one helium atom. The hydrogen atoms have a mass of 4.03188. The mass of the helium is 4.0026. In this case, it looks like we lost a mass of 0.02928. What has actually happened is that this mass has been changed to nuclear energy. The mass was not destroyed, and the energy was not created. They were just changed. The small amount of mass becomes the large amount of energy that comes from the sun.

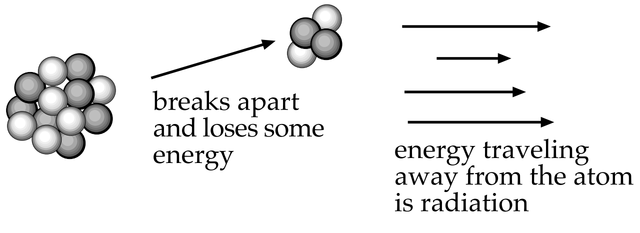
The process of taking these lighter elements and making a heavier element is called fusion. Fusion powers the sun and releases large amounts of energy. Because of the heat and pressure needed, however, scientists have not been able to control fusion. So far, the only use of fusion by humans has been to create highly destructive weapons. No one knows if we will ever find a peaceful use for fusion.

What Is Fission?

In the previous section, you learned about one way to release nuclear energy, fusion. This section will examine another way of releasing nuclear energy, **fission**. Fission occurs when the nucleus of an atom splits and releases some of its nuclear energy. To understand how and why this happens, we need to look at the nucleus of atoms.

Remember that the nucleus is made of neutrons and protons. In any given element, the number of protons in a nucleus never changes. This is not true of the number of neutrons. Consider carbon. Most atoms of carbon have six neutrons as well as six protons. This will give the nucleus a mass of 12. Because the chemical symbol of carbon is C, then this type of atom is called C12. Some carbon atoms, however, may have seven neutrons. The nucleus of such an atom would have a mass of 13 and is called C13. The element is still carbon, but the atom is a little heavier. Other than that, the atom behaves just like an atom with six neutrons, C12. However, if we add another neutron, for a total of eight, the atom will behave differently. This atom will have a nucleus with a mass of 14, but it will still be carbon. It is known as C14. How is C14 different? If left by itself, the nucleus will break apart and lose some energy. The energy will travel away from the atom, and we know this as **radiation**. Radiation is any form of energy that travels in a wave. Nuclear radiation, however, is sometimes dangerous because it has such high energy.

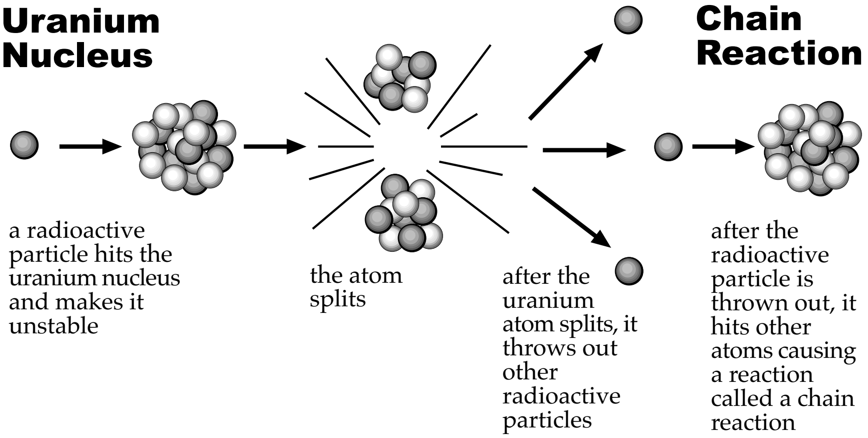
Carbon Atom or C14



You may be wondering if there is a special name for atoms with a different number of neutrons. The name for these are **isotopes**. We discussed three isotopes of carbon. Most isotopes of atoms are harmless. Some are

radioactive. That is, some isotopes, like the C14 isotope, spontaneously produce radiation. Radioactive material has nuclei that break down and release energy and neutrons. The element uranium is naturally radioactive and constantly releases energy and radioactive particles. These radioactive particles are made from the protons, neutrons, and electrons of the atom.

Where do the particles go? The particles travel outward. When the uranium nucleus is hit with a particle, it becomes unstable. Eventually it will split in two. Splitting an atom is called fission. When the atoms split they lose a small amount of matter that is changed into a large amount of energy. Not all elements have atoms that can be split. When the uranium atom splits, it throws out more radioactive particles. These particles will split other atoms. This will continue to happen. This reaction is called a **chain reaction**. Besides uranium, there are many other elements that spontaneously produce radiation. These include plutonium, radium, and cesium.

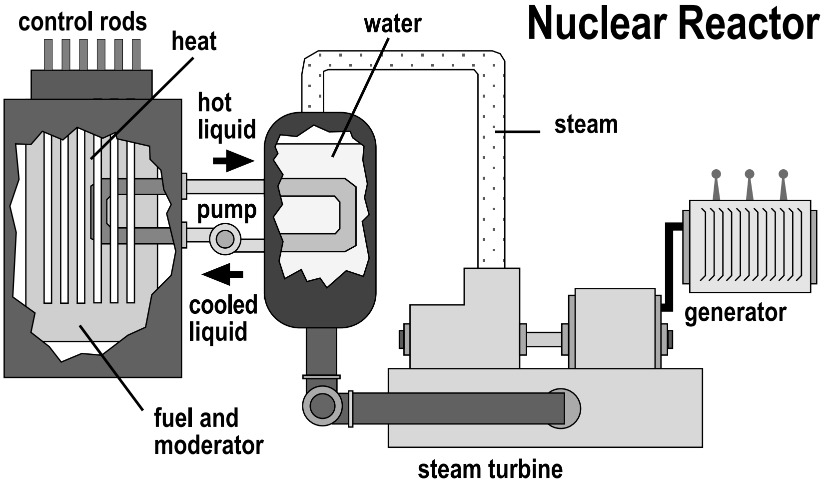


Controlling Nuclear Reactions

Large amounts of energy are released by fission and fusion reactions. Why can't this energy be used to run generators? It can, but first it must be controlled. After learning how to use nuclear energy to destroy, scientists found ways to control it.

Fission can be controlled. It must take place slowly, but at a steady speed. In this way, fission can be used to produce useful energy. A **nuclear reactor** is used to control a nuclear chain reaction. All reactors currently running are **fission reactors**. These use uranium atoms for fuel. They are hit with neutrons. When the reaction begins, a **control rod** is used. A control rod is made of a substance that absorbs neutrons. Control rods can be used to slow down fission reactions. By absorbing some of the neutrons, the chain reaction does not become explosive. If the reaction must be speeded up, the rods are removed.

A nuclear reactor produces heat. This heat can be used to run generators. It takes a very small amount of nuclear fuel to produce large amounts of energy. Is this the answer to man's energy needs? There are nuclear power plants being used today. Unfortunately, nuclear fission creates some problems. **Radioactive wastes** is one of these problems.



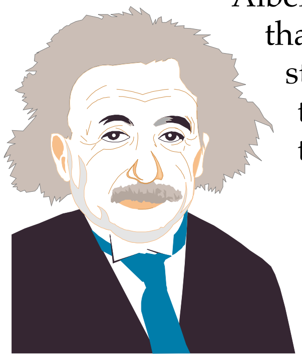
Radioactive Material

Radioactive wastes are no longer useful as fuel, but they are still radioactive. **Radioactivity** can damage or kill living cells. Large doses of radiation can cause severe burns. On the other hand, radiation also has helpful uses. It can be used to kill cancer cells. Low levels of radiation can be used to find tumors in people.

Think about the nuclear reactor. It uses uranium for fuel. Uranium is radioactive. A nuclear reactor produces waste that is radioactive. This radioactive waste is harmful to living things. What happens to this waste? It cannot be destroyed. Some radioactive material may require millions of years to decay. A measure of time required for substances to decay is called *half-life*. The half-life is the amount of time it takes for half of the atoms in the radioactive substance to decay. Some of the radioactive waste is stored in underground tanks. Some is sunk deep in the ocean. People worry that these methods of disposal might leak.

Fusion reactors would not produce radioactive waste. Remember that fusion needs high temperatures. Scientists have not yet figured out how to produce and control these high temperatures. It is hoped that in the future, man may be able to solve some of the problems of nuclear energy.

Albert Einstein and Nuclear Power



Albert Einstein

Albert Einstein was a physicist. He created the theory that stated mass and energy were related. His theory stated that the energy of matter was equivalent to the mass of the object multiplied by the square of the speed of light. This equation is written as:

$$E=mc^2$$

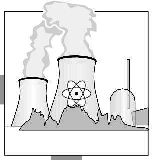
E represents energy. The *m* stands for mass. The speed of light is represented by a *c*. This theory led to many outcomes.

When Einstein first conceived of this theory, it was not seen as a formula for making energy. At first, there was resistance to the concept. Had the theory not shown itself to be accurate, it would surely have been rejected. Yet, the **theory of relativity** was not rejected. Despite this, it took decades before the theory could be applied. Its first application was in the creation of atomic bombs. Many other scientists had to add theories and knowledge. Sometimes such knowledge is expected. At other times, it is unexpected.

Again, the application of the theory for bombs was not what Einstein had envisioned. He simply developed a theory. The development of bombs and nuclear reactors and an understanding of the sun were not necessarily expected. Although Albert Einstein made these things possible, he did not have them in mind when working on the theory of relativity.

Summary

Atoms store huge amounts of energy. This energy can be released by fission or fusion. Fusion is the combining of light elements into heavier elements. The sun uses fusion. Nuclear reactors control the speed of fission reactions. Fission is the splitting of atoms. Nuclear power plants produce energy and dangerous radioactive waste. Scientists are searching for ways to eliminate the problems of using nuclear energy. As Einstein's theory of relativity demonstrates, ideas in science are limited by the purpose for which they are conceived, are sometime rejected, may grow from unexpected discoveries, and often grow slowly from many contributors.



Lab Activity

Facts:

- Chain reactions can be controlled or uncontrolled.

Investigate:

- You will demonstrate that chain reactions can be blocked.

Materials:

- set of dominoes or domino-like chips
- chalkboard eraser

1. Stand 10 to 20 dominoes on one end, one behind the other. (Leave about ½ inch between each one.)

2. Push the first one down.

   a. What happens to the rest? ________________________________

   b. Was this reaction controlled or uncontrolled? ______________

3. Line the dominoes up again. Place a chalkboard eraser after the 5th or 6th domino. Continue to line up the rest of the dominoes.

4. Push the first domino.

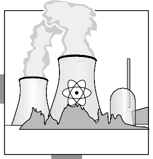
   a. Did all the dominoes fall? ________________________________

   b. What stopped the dominoes? _____________________________

c. What controlled the reaction? ______________________________

d. What part of a nuclear reactor is represented by the eraser?

____



Practice

Use the list below to complete the following statements.

chain reaction
fission
fusion
nuclear energy
nuclear reaction
nuclear reactor
nucleus
theory of relativity

1. The form of energy released by splitting or combining atoms is __________________________ .

2. The center of the atom is its __________________________ .

3. A reaction that continues until material is used up or the reaction is stopped is a __________________________ .

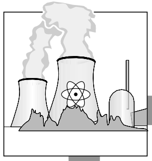
4. The splitting of an atom is called __________________________ .

5. A __________________________ is a reaction that occurs when the energy in the nucleus of an atom is released. Large amounts of energy are produced.

6. __________________________ is a nuclear reaction in which four atoms are pushed together to form one large atom.

7. A __________________________ is a machine used to control or create a nuclear chain reaction.

8. The __________________________ demonstrates how scientific knowledge is limited by the conditions under which it is conceived and often grows slowly.



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. energy that travels through space with wave properties

______ 2. a barrier that slows a nuclear reaction by absorbing excess radiation

______ 3. a type of nuclear reactor that would combine atoms

______ 4. forms of energy given off by nuclear material

______ 5. the waste produced by a nuclear reactor

______ 6. describing those elements or isotopes that spontaneously decompose and give off radiation

______ 7. an atom or group of atoms with the same atomic number but different mass than other atoms of a specific element

______ 8. the theory that there is a fundamental relationship between matter and energy

A. control rod

B. fusion reactor

C. isotope

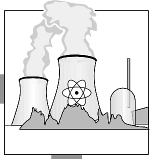
D. radiation

E. radioactive

F. radioactive waste

G. radioactivity

H. theory of relativity



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. "Nuclei" is the plural of "nucleus."

__________ 2. Very small amounts of energy are released by fission and fusion.

__________ 3. The first atomic bomb was a fission reaction.

__________ 4. Fission can be controlled using a nuclear reactor. In this way, fission can be used to produce useful energy.

__________ 5. A nuclear reactor cannot produce heat.

__________ 6. Nuclear power plants produce energy.

__________ 7. Nuclear fission creates radioactive wastes.

__________ 8. Radioactivity can damage or kill living cells.

__________ 9. All isotopes of carbon have the same number of neutrons.

_________ 10. Radioactive waste cannot be destroyed. It must be stored.

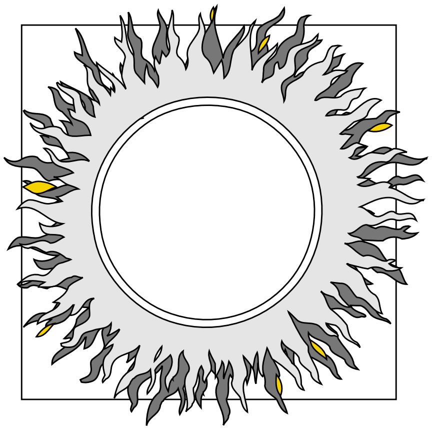
Practice

Answer the following questions using complete sentences.

1. What are two positive reasons for the continued development of the nuclear fission reactor?

2. What are two reasons against the continued development of the nuclear fission reactor?

Unit 19: Heat



Vocabulary

Study the vocabulary words and definitions below.

Celsius	the SI temperature scale with the boiling point of water at 100°, the freezing point of water at 0°, and body temperature at 37°
conduction	the movement of heat through a solid substance
conductor	an object that heats up easily; allows electricity to pass through it
contract	to make smaller
convection	the movement of heat through fluids, either a liquid or a gas
convection current	an up and down movement of air that works to equalize the temperature between two areas
expand	to increase in size
Fahrenheit	a temperature scale with the boiling point of water at 212°, the freezing point at 32°, and normal body temperature at 98.6°

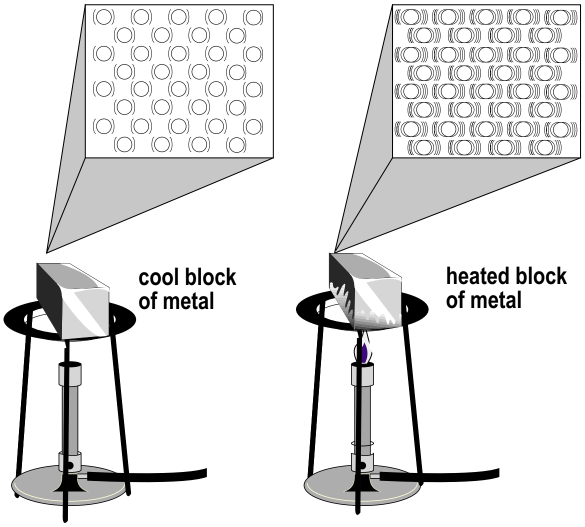
first law of thermodynamics	this law states that the amount of work done, plus the amount of heat produced, is equal to the energy used; as energy is changed, some of it will become heat
friction	a type of resistance to movement caused when one surface touches another surface
heat	the form of energy that causes a random motion of molecules or atoms
insulator	poor conductor of heat; it prevents temperature change by keeping heat from moving
radiation	the movement of energy as a wave; specifically, the way heat moves through a vacuum
temperature	a measure of the amount of heat in a substance; a measure of how fast molecules are moving in their random motion
thermometer	an instrument that measures temperature
vibrate	to move back and forth very quickly

Introduction

When you sit next to a campfire, you notice **heat**. Heat is all around us, and all matter has some heat. In this unit, the properties of heat will be discussed.

What Is Heat?

You have learned that many things produce heat. Chemical reactions give off heat. **Friction** generates heat. Whenever energy changes form, some of it is always lost as heat. Heat is a form of energy. It causes molecules in matter to **vibrate**. We feel this vibration as heat. If the molecules vibrate fast, the object will be hot. As the molecules slow down, the object will become cooler.



From Where Does Heat Come?

Most of the heat on Earth comes from the sun. When the sun's light reaches Earth it produces heat. This heat is needed for life. Heat also comes from burning fuels. Coal and oil give off heat as they burn. Remember that when fuels are burned, this is a chemical change. The heat produced by friction is usually not wanted. This heat can damage machines. Lubrication, as you learned, is to help prevent this heat. Also, you have seen how **radiation** can be used to produce heat.

It is important to remember that every time energy is changed, some of it becomes heat. When we do work, we change forms of energy. These changes of energy are another source of heat. When heat energy enters matter, it causes the molecules or atoms to vibrate. The laws of thermodynamics describe interesting aspects of heat and energy. The **first law of thermodynamics** states that the amount of work done, plus the amount of heat produced, is equal to the energy used; as energy is changed, some of it will become heat. The more we change forms of energy, the more of it becomes heat. This also means that less is available for work. The total amount of energy, though, is still the same.

Heat Affects the Phases of Matter

Heat has some interesting effects on matter. Heat can cause objects to **expand** or get larger. When the molecules in matter vibrate, they move away from one another. This causes the heated matter to become a little larger or expand. When the matter is cooled, it has lost some heat. In cooled matter the molecules move closer together or **contract**. Imagine that a lid is stuck on a jar. How could you remove it? Put the lid under hot water. The lid will expand a little. Now it will be easier to remove the lid. This effect of heat can be a problem. Road surfaces can expand and crack during hot summer days.

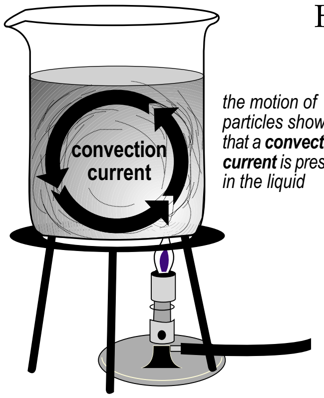
A gas will expand as it is heated. Liquids expand as they are heated. As liquids and gases cool, they contract. The movement of the molecules makes matter expand and contract.

Ice seems like an exception to the idea that as objects cool, they contract. As water cools from around room temperature (25°C), it does contract. Finally, at 4°C, it finishes contracting. Because the water molecules have slowed, they begin to stick. As they stick to each other, they form ice. The ice takes up more volume than the water. The ice is also a different phase of matter than liquid water.

Heat can change the size of matter. It can also change the phase of matter. Heat can turn a liquid into a gas. It can also turn a solid into a liquid.

Movement of Heat

Feel the handle of a spoon resting in a cup of hot coffee. It will feel warm. Why? Heat can travel through solids. The molecules in the solid that are closest to the heat will begin to vibrate. These vibrating molecules push against other molecules close to them. These new molecules begin to vibrate. Soon, most of the molecules will be vibrating. This is the way heat moves through a solid. It is called **conduction**. Objects that heat up easily are called **conductors**. Metals are good conductors of heat. Poor conductors of heat are called **insulators**. Wood, Styrofoam, and plastic are insulators.



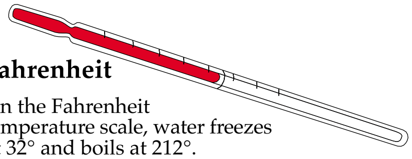
the motion of particles shows that a ***convection current*** *is present in the liquid*

Heat can also move through a liquid or a gas. This process is called **convection**. When a liquid or a gas is heated, the molecules closest to the heat begin to vibrate. They move faster and faster and move away from the heat. Cooler molecules take their place. As this happens over and over, all of the molecules are heated. This process helps to explain how air moves. When air is heated, it rises. Cooler air moves in to take its place. This type of air movement is called a **convection current**. Convection currents are important to meteorologists. People who design air conditioning and heating systems must also think about convection.

Most of the heat on Earth comes from the sun. How does it get here? The sun is about 150 million kilometers away from Earth. Its heat must pass through empty space. It moves by radiation. No matter is needed. Heat from other sources also travels by radiation. For instance, coal stoves and electric heaters also radiate heat.

Temperature

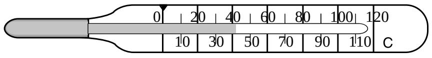
Temperature and heat are not the same. Temperature tells the amount of heat in matter. It is a measure of how fast the molecules are moving. Temperature is the average of how many molecules are moving and how fast they move. A **thermometer** measures temperature. Thermometers are filled with substances



Fahrenheit

On the Fahrenheit temperature scale, water freezes at 32° and boils at 212°.

Celsius



On the Celsius temperature scale, water freezes at 0° and boils at 100°.

that expand when they are heated. You have learned about **Fahrenheit** and **Celsius** scales. Scientists use the Celsius scale to measure temperature. Water boils at 100°C and freezes at 0°C.

Uses for Heat

Heat is a very common form of energy. It was one of the first forms used by early man. Heat cooks food and warms our houses. High temperatures will kill germs that cause disease. Heat is needed to produce glass and other products. Metals are heated to a liquid state. They are combined with other elements to form stronger materials. Steel, for example, is formed this way. Heat is used to run generators. You can probably think of many other ways heat energy is used.

Summary

Heat is a form of energy. It causes matter to expand and contract. Heat also causes matter to change phase. Temperature measures the amount of heat. Whenever energy changes form, some of it becomes heat. Heat moves through matter by conduction and convection. Heat moves through space by a process called radiation. There are many important uses for heat energy.

Practice

Answer the following using complete sentences.

1. What is heat? ____

   ____

   ____

   ____

2. What causes heat? ____________________________________

   ____

   ____

3. Where does most of the heat on Earth come from?

   ____

   ____

4. Does friction cause heat? ______________________________

5. What are two effects that heat has on matter? ____________

   ____

   ____

   ____

6. Which liquid expands when it is cooled from 4°C to 0°C?

   ____

   ____

7. What happens to the amount of heat when energy changes forms?

____

____

8. How does heat travel through solids? (Describe the process.)

____

____

____

9. What name is given to the way that heat moves through solids?

____

____

10. What name is given to objects that heat up easily?

____

____

11. What name is given to materials that keep heat from moving to where it is not wanted?

____

____

12. What are three common insulators? ________________________

____

____

13. How does heat move through liquids or gases? (Describe the process.)

____

____

____

14. What name is given to the way that heat moves through liquids or gases?

____

____

____

15. What is radiation? _________________________________

____

____

16. What is temperature? _______________________________

____

____

____

____

Lab Activity

Facts:

- Heat can pass through liquids and gases by a process called convection.

Investigate:

- You will demonstrate convection in a liquid.

Materials:

- beaker
- Bunsen burner or candle
- ring stand
- food coloring
- eyedropper
- water

1. Fill a beaker about ½ full of water. Set it on a ring stand. Let it stand for a few minutes until all movement stops.

2. Place 2 drops of food coloring into the water. Do not shake or stir the water. Observe.

   Did the color spread evenly through the water? ________________

3. Place a lighted Bunsen burner or candle under the beaker. Heat the water gently. Observe.

   a. Did the color begin to move through the water? _____________

   b. What was the only thing that was added to the experiment?

   ____

c. Did the heat cause the water to move? ____________________

d. As the water closest to the flame was heated, what happened?

____

e. The color showed that the water was moving. This movement was caused by the heat.

What is the name for the way that heat moves through a liquid?

____

Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

coal
contract
expand
heat
hot
oil
phase
size
slow down
sun
vibrating

1. Heat causes molecules to ________________________ .

2. All matter has some ________________________ because molecules are always ________________________ .

3. If molecules vibrate fast, the object will be ________________________ .

4. As the molecules ________________________ , the object will be less hot.

5. Most of the heat on Earth comes from the ________________________ .

6. Two fuels that give off heat when they burn are ________________________ and ________________________ .

7. When the molecules in matter vibrate, they spread out. This causes the heated matter to ________________________ or get larger.

8. When matter is cooled, the molecules move closer together or ________________________ .

9. Heat can change the ________________________ and the ________________________ of matter.

10. ____________________ can travel through solids.

away
closest
conduction
conductors
convection
cooler
insulators
molecules
plastic
Styrofoam
vibrate
vibrating
wood

11. The way that heat moves through a solid is called ____________________ .

12. Objects that heat up easily are called ____________________ .

13. During conduction, the molecules in the solid that are closest to the heat begin to ____________________ . These vibrating ____________________ push against others close to them. The new molecules begin to ____________________ . Soon most of the molecules will be ____________________ .

14. Poor conductors of heat are called ____________________ .

15. Three common insulators are ____________________ , ____________________ , and ____________________ .

16. The way that heat moves through a liquid or gas is called ____________________ .

17. During convection, the molecules ____________________ to the heat begin to vibrate. They move ____________________ from the heat. ____________________ molecules take their place.

air
Celsius
convection current
Fahrenheit
fast
kill
liquid
radiation
rises
temperature
thermodynamics
thermometer

18. When air is heated, it ____________________ . Cooler ____________________ moves in to take its place. This type of air movement is called a ____________________ .

19. ____________________ is the way that heat travels through empty space.

20. ____________________ tells the amount of heat that is in matter. It is a measure of how ____________________ molecules are moving.

21. A ____________________ measures temperature.

22. Two types of temperature scales are ____________________ and ____________________ .

23. The first law of ____________________ relates how energy changes and work are related to heat. As more energy changes form, more heat is produced.

24. High temperatures will ____________________ germs that cause disease.

25. Metals are heated to a ____________________ state and are combined with other elements to form stronger materials.

Unit 20: Waves

Vocabulary

Study the vocabulary words and definitions below.

amplitude	half the distance between the crest and trough of a wave
crest	high point of a wave
frequency	the measure of the number of waves that pass a point in a second
hertz	the unit of measure for frequency; one wave per second is one hertz; abbreviated Hz
kinetic energy	the energy in moving things
reflection	the process in which a wave is thrown back after hitting a barrier that does not absorb, or take up, some of the energy of the wave
refraction	a change in the direction of a wave caused by its change in speed
speed	how fast a point of a wave moves
trough	the low point of a wave

wave	a disturbance that is caused by energy moving from one location to another
wavelength	the distance between the crest of one wave and the wave that follows it

Introduction

What happens when a rock is dropped into a calm lake? A circular pattern will form on the surface. This pattern is made up of **waves**. You know that a rock has **kinetic energy**. When the rock hits the water, some energy is transferred to the water. The wave moves the energy away from the rock. Although the water moves up and down, it does not move away from the rock. Only the energy moves outward in the form of a wave. There are many kinds of waves. Waves can be produced by different kinds of energy. Some of the properties of waves will be discussed in this unit.

A circular pattern is formed when a rock is dropped into a calm lake.

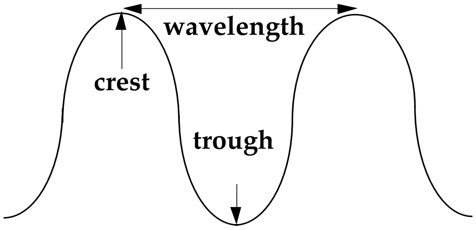
Features of Waves

Waves are caused by energy. Waves carry energy from one place to another. You can see waves that travel across the surface of water. Some waves also move through gases, solids, and vacuums. Sound and light are types of waves. Sound can travel through gases, liquids, and solids. Light, however, can travel through gases, liquids, solids, and vacuums.

It is easy to show what one type of wave looks like. Tie a rope to the leg of a chair. Snap the rope up and down. Watch what happens. A wave will pass through the rope. Did the rope move from one place to another? No, only the energy moved. All waves carry energy. Waves have other similarities. Waves can change direction. They also can have an effect on each other.

Basic Properties of Waves

There are four basic properties of waves—wavelength, speed, frequency, and amplitude—that will be described. Imagine the beach and the waves in the ocean. The waves have high points and low points. The high point of a wave is called a **crest**. The distance between the crest of one wave and the next is called a **wavelength**.

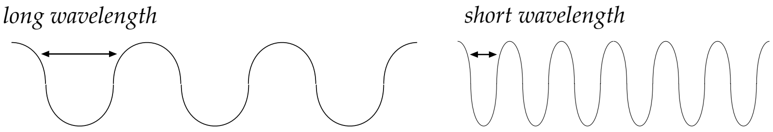


Parts of a Wave

Remember that the waves on the ocean have both high and low points. The low points are called **troughs**. Half the distance between the crest and trough of a wave is the wave's **amplitude**. Amplitude can vary. Imagine listening to the radio. You are hearing sound waves. If you want the waves to be stronger, you turn up the volume. This does not change their speed, frequency, or wavelength. It increases the amplitude of the wave and the amount of energy of the wave.

Remember that waves move. **Speed** tells how fast a point on a wave moves. For example, watch one crest of a wave. The number of meters that it moves in one second can be measured. All waves have speed.

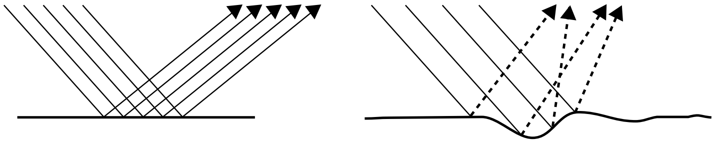
Because the waves have speed and wavelength, only a certain number can pass a point in a certain time. **Frequency** is the measure of the number of crests that pass a point in one second. The unit of measure for frequency is called **hertz** *(Hz)*. Frequency and wave length are related in an inverse way. A wave with a great wavelength has a low frequency. A wave with a small wavelength has a high frequency.



low frequency **high frequency**

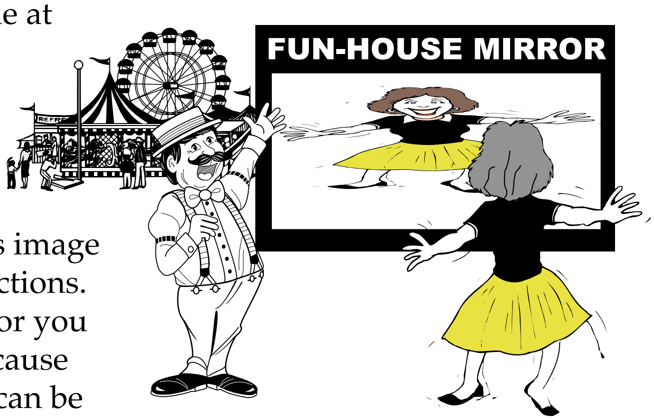
Wave Motion

Waves move energy. Waves can move in different directions. The waves at the beach usually move in a straight line. If the speed of part of a wave changes, the direction of the wave will also change. This is known as **refraction**. Think about the waves at the beach. They move in a straight line until they hit shallow water. Shallow water will slow down the bottom of the wave. The direction of the wave will change. It will crash on itself. The speed of other waves depends on what the wave passes through. Gases, liquids, and solids all affect the speed of a wave.

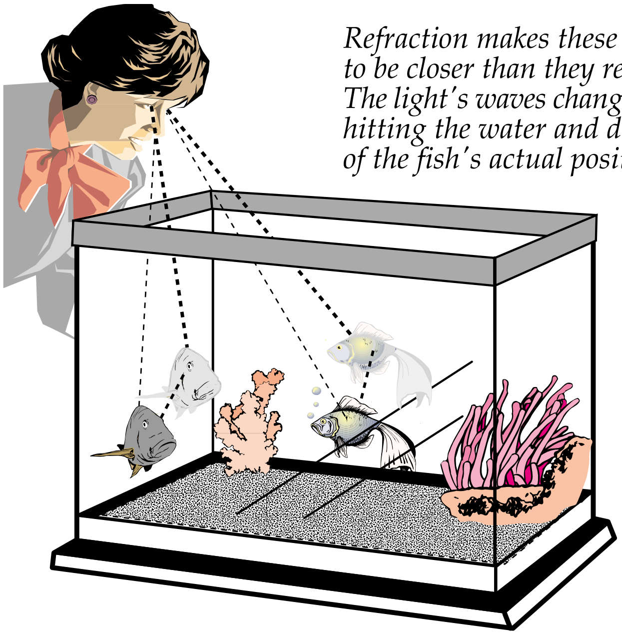


Waves are reflected at the same angle they are received, unless they are reflected off a rough surface.

Sometimes a wave will hit a barrier or a wall. A barrier can absorb or take up some of the energy of the wave. The rest of the energy is bounced away. This is called **reflection**. Picture an ocean wave hitting a seawall. The seawall is a barrier. The wave is reflected back into the ocean. Of course, you are more familiar with your own reflection. The image that you see is light that has bounced off the mirror. If you look in a fun-house mirror, however, the image may be very different because of the way waves are reflected. The angle at which light strikes the reflecting surface is the angle at which it will leave. When you look at a mirror that is curved, different parts of your body's image get reflected in different directions. You may look short, or thin, or you may look unrecognizable because light behaves like a wave. It can be reflected and refracted.



Anyone who wears glasses relies on the wavelike behavior of light. The light that enters the lens of the glasses is bent and makes the image clearer for the eyes. The material (glass or plastic) and how thick it is determines how the light will bend. All types of waves are affected by refraction and reflection. Different kinds of matter affect waves in different ways.



Refraction makes these two fish appear to be closer than they really are located. The light's waves change direction upon hitting the water and distort the image of the fish's actual position.

Waves and Matter

We have discussed waves as a way for energy to move, but waves can describe other things. For instance, consider the electron. Remember that the electron is always moving and always has energy. The electron is sometimes described as a particle, a very small piece of matter. Sometimes, though, the electron acts more like a wave. It behaves as if it has a frequency and a wavelength. Because this small piece of matter sometimes acts like a wave, understanding waves is very important to physicists. Physicists have learned that sometimes matter acts like particles, sometimes acts like waves, and sometimes behaves differently from either.

Waves are reflected at the same angle they are received. Rough surfaces cause diffusion of waves and images, resulting in weaker reflections.

Summary

Waves are caused by energy. Waves move energy from one place to another. All waves have wavelength, speed, frequency, and amplitude. Waves are affected by refraction and reflection. Different waves can move through different forms of matter and/or vacuum. Sound and light are types of waves. Matter can act as a wave, a particle, or something different.

Practice

Complete the following outline.

Waves

A. Definition ____

____

____

B. Features of waves

1. Waves carry ____________________ from one place to another.
2. Waves travel through ____________________ , ____________________ , ____________________ , and vacuums.
3. ____________________ and light are types of waves.

C. Basic properties of waves

1. Wavelength
    a. (definition): ____________________________________

    ____

    ____

    b. All waves have high points and low points. The high points are called ____________________ . The low points are called ____________________ . Half the distance between these is called ______________ .

2. Speed

(definition): ____

____

3. Frequency

a. (definition): ____

____

____

b. ________________________ is the unit of measure for

frequency.

D. Wave motion

1. Refraction
(definition): ____

____

____

2. ____

(definition): the process in which a wave is thrown back after hitting a barrier that does not absorb, or take up, some of the energy of the wave

E. Waves and matter

1. Matter can behave as a ________________________ , a particle,

or something else.

2. An example of matter that has wave properties is an

________________________ .

Lab Activity

Facts:

- Waves move energy from one place to another.
- Waves can be reflected by a barrier.

Investigate:

- You will create a wave and demonstrate wavelength, speed, frequency, amplitude, and reflection.

Materials:

- 6 foot length of rope

1. Attach a length of rope to a table leg or doorknob.
2. Snap the free end of the rope in an up and down movement.
    a. What did you create that moved along the rope? ____________

    ____

    b. What was moved from one place to another? _______________

    ____

3. Experiment with the rope. Try to make waves with long or short wavelengths. Change the speed of the waves. Try to make a wave that has many crests.
    a. A wave with a long wavelength moves __________________ .

    b. A wave with short wavelengths has a high __________________ .

4. Snap the rope once. Watch the wave travel down the rope. (Make sure you snap the rope hard.)

   a. What happened to the wave as it hit the table or doorknob?

      ____

      ____

      (If the wave stopped, repeat the snap.)

   b. When a wave is bounced back, ________________________ has happened.

5. Move your hand up and down only a small amount in a rhythm.

   How many wavelengths are there on the rope? ________________

6. Using the same rhythm, move your hand up a down a large amount.

   How many wavelengths are there on the rope? ________________

7. What did you change? ________________________________

8. How did this change affect the frequency? ____________________

   ____

   The wavelength? ________________________________

   The speed? ________________________________

Practice

Use the list below to complete the following statements. One or more terms will be used more than once.

amplitude
crest
frequency
hertz
reflection
refraction
speed
trough
wave
wavelength

1. A ____________________ is a disturbance that is caused by energy moving from one location to another.

2. The properties of waves include ____________________ , ____________________ , ____________________ , and ____________________ .

3. The high point of a wave is called a ____________________ .

4. The low point of a wave is called a ____________________ .

5. The distance between the crest of one wave and the next wave that follows it is called the ____________________ .

6. The ____________________ of a wave tells how fast a point on a wave moves.

7. ____________________ is the measure of the number of crests that pass a point in one second.

8. The unit of measure for frequency is called a ____________________ .

9. Hz is the abbreviation for the word ____________________ .

10. ____________________ is the process in which a wave changes direction because its speed has changed.

11. ____________________ is the process in which a wave is thrown back after hitting a barrier that does not absorb some of the energy of the wave.

12. Matter can act as a particle, a ____________________ , or something entirely different.

Practice

Match each definition to the correct term. Write the letter on the line provided.

______ 1. the process in which a wave is thrown back after hitting a barrier that does not absorb, or take up, some of the energy of the wave

______ 2. a disturbance that is caused by energy moving from one location to another

______ 3. a change in the direction of a wave caused by its change in speed

______ 4. the energy in moving things

______ 5. the unit of measure for frequency

______ 6. the low point of a wave

______ 7. the measure of the number of crests that pass a point in a second

______ 8. the distance between the crest of one wave and the next

______ 9. how fast a wave moves

______ 10. high point of a wave

______ 11. abbreviation for hertz

A. crest

B. frequency

C. hertz

D. Hz

E. kinetic energy

F. reflection

G. refraction

H. speed

I. trough

J. wave

K. wavelength

Practice

Answer the following using short answers.

1. What are the four properties of waves? ____________________

   ____

   ____

   ____

   ____

2. What are two types of waves? ____________________________

   ____

   ____

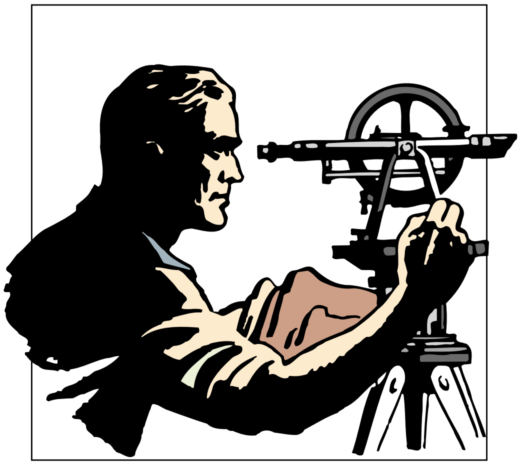
3. A wave with a long wavelength has what kind of frequency?

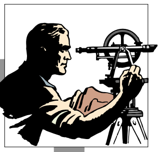
   ____

4. A wave with a short wavelength has what kind of frequency?

   ____

Unit 21: Science, Society, and the World

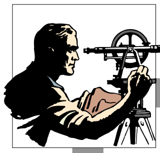




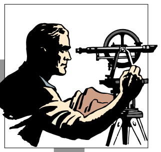
Vocabulary

Study the vocabulary words and definitions below.

acid rain	rain that has a pH (a measure of acidity in a solution) below that of seven because it carries dissolved acids; this rain causes problems such as the rapid corrosion of various substances
bias	a preference than can hinder impartial judgement
by-product	a product or result of a process that is not the one intentionally sought
economy	the system by which money, ownership, and wealth are controlled
grant	money that is awarded for a specific purpose
industry	the people and machines used to produce products
peer	a person who is on the same level as another; people who have similar knowledge, background, and goals



society	the way people live together, interact, and rely on one another
technology	the knowledge, skill, and tools that allow people to perform tasks of increasing complexity

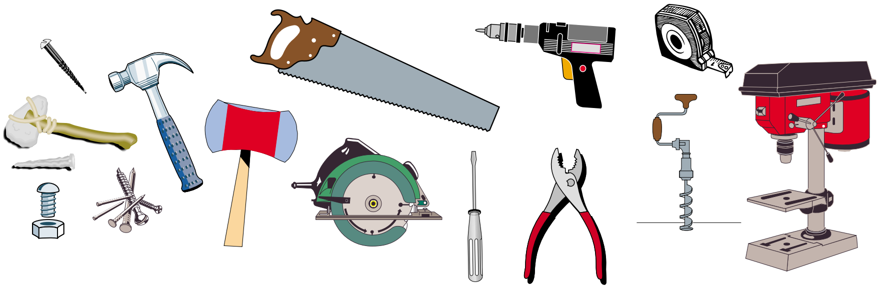


Introduction

We began our study of the physical sciences with the scientific method. To understand how science developed, you needed to know how it worked. Scientists are people who live and work like everyone else. What they do has an impact on the world. Of course, the world affects them, too. We will conclude our study by examining the ways in which science and scientists interact with the world.

Technology in Society

In a **society**, people use many tools. Think of the many tools it takes to build a house. Each of these tools and the ways they are used was created by humans. The development of these tools is one form of **technology**. When humans first began building houses, houses were not very complex. The house might be made of mud, sticks, and some stones. Compare building a house like that to building a modern home. The change in levels of technology is great. Where only a few materials were used before, hundreds of materials are now used. Building a modern house is a complex job which has been made easier by technology. It requires many people with highly developed skills. All of these skills and the tools that are used were created by people. This technology is a part of our society.

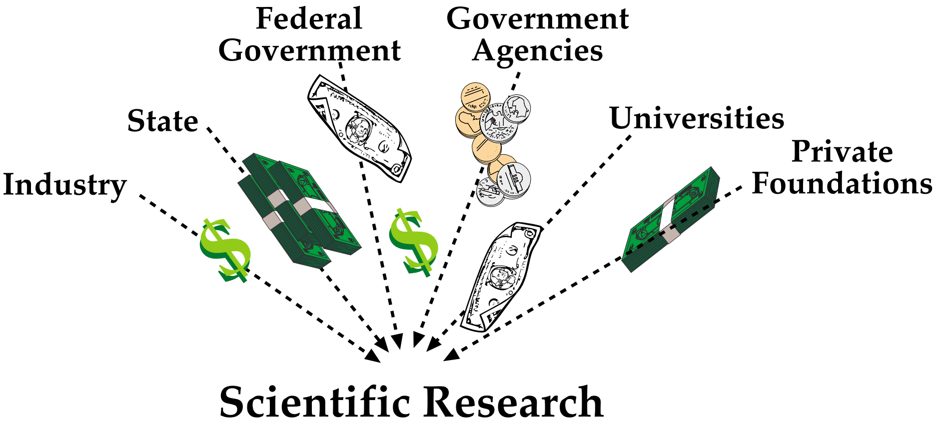


Each of these tools was created by humans and is a form of technology.

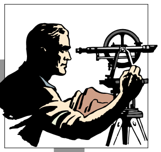
Changes in Technology

There is not a sharp boundary between science and technology. Scientific discoveries lead to technological inventions, and inventions may lead to further discoveries. Recently, our society has required some changes in house-building technology. Concerns about diminishing resources are among the greatest causes. As we have discussed, energy is a resource. It allows us to do things and change things. People began to view losing energy as a problem. In a home, we lose energy through windows and walls and in many other areas. People began to demand new ways to prevent energy from being lost.

The people and machines that build homes are part of the housing **industry**. The industry recognized the demand of people. Because industries are larger than a single company, the resources of an industry are greater than that of a single business. The industry began to fund research. The research focused on ways to conserve energy in the home. Scientists performed this research. The research was geared specifically to energy conservation in homes. One aspect of knowledge, however, is that it can be used in many ways. The result is that technological problems often provide us with new knowledge.



This new knowledge can be paid for by many sources. Industry, state and federal government agencies, universities, and private foundations all fund scientific research in our society. One way that research is funded is through **grants**. These grants are sums of money awarded to groups and individuals for scientific research. Imagine our example about energy conservation. Can you think of a government agency that might offer a grant for energy conservation? Agencies that deal with housing, energy, or the environment might top your list. Now, think about bubble gum. Can you think of any government agency that is highly concerned with bubble gum? Because there probably is none, there are probably no grants for bubble gum research.



The result is that scientists do not usually pay for the research they do. Instead, others provide the money needed. Sometimes, no source can be found to fund a particular area of research. In these cases no research will be done. The **economy** of the world controls when money is available for certain activities. If the bubble gum industry became powerful, the economy would reflect this. If there were then a problem with bubble gum technology, money would probably be available for research.

When an area of public and social concern arises, research is often conducted. Scientists apply their analytical skills, their knowledge, and their insights to these problems. When the process is effective, scientists can then help the public understand both the causes and likely outcomes. Consider **acid rain**. Because the problem of acid rain became a public priority, scientists have studied it. We now know many of its sources and many of the effects it has created. We also have many predictions about what acid rain may yet do.

Much acid rain is a **by-product** of many of our forms of technology. When you turn on an electrical appliance, you don't intend to create acid rain. The electricity you use, however, may be generated from coal. When coal is burned, acid rain is a by-product. The acid rain may cause the bass you like to fish for to die. You don't intend for this to happen, but it may happen. Technology has impacts on areas of our lives that we often don't foresee. Sometimes the impacts of technology are beneficial, and sometimes they are not beneficial.

Technology is based on scientific knowledge. We now have a certain amount of knowledge about acid rain. Scientists and others who work with technology are using their knowledge. They are trying to solve this problem. One solution might be to stop burning the fuels that result in acid rain. Would this be practical? Most people would not want to part with their appliances and cars. When solving problems, the scientists have to consider such things. They must take human values and abilities into account. If they do not, their solutions will not be successful nor publicly accepted.

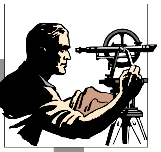
For many people, the ability to have numerous electrically powered appliances is of great value. They like this aspect of technology. Sometimes though, they may feel differently. Other people may not value numerous electric appliances. They may feel them to be a nuisance. Although the technology is the same, the responses of different people are not the same.

If you worked as an engineer for an electrical company, you might have a certain **bias**. That is, you would probably not like the idea of doing away with electricity. As a scientist, you would be expected to know your own bias. You would be expected to design your research and investigation to compensate for your bias.

At the end of your research, you would submit your ideas to your **peers**. One of the most important aspects of science is that it is open for all to review. Other scientists would review your work. If they found it was done well and was accurate, they would say so. It is important to allow others to review all aspects of the scientific process. This allows the methods to be approved and the outcomes verified. The public could then be notified of your findings. The result may be a new technology.

Summary

Many problems encountered in the world are the result of technology. The search for the solution to problems like acid rain involves many engineers, designers, scientists, and others. The search for solutions advances scientific knowledge. Scientists bring this knowledge to the public and inform them. Scientists must be aware of their own biases. They must make their findings available for review by peers. Scientists must consider how the new technology they create will change the world. Funds for such research come from many government and private sources. The value of such technology and research, however, varies for different people and at different times.



Practice

Circle the letter of the correct answer.

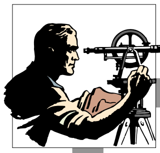
1. The increasing ability of humans to perform complex tasks is made possible by advances in __________ .
   a. tectonics
   b. technology
   c. bias
   d. peers

2. Everything that people do is related to the __________ in which they live.
   a. technology
   b. grants
   c. society
   d. by-product

3. Industry includes not only one business or one machine, but all the __________ involved in producing a certain type of product.
   a. people
   b. acid rain
   c. industry
   d. by-product

4. Although we think of technology as making life easier, technology also causes __________ for which scientists seek solutions.
   a. economy
   b. problems
   c. bias
   d. grant

5. The __________ controls when money may be available for technology research.
   a. technology
   b. grant
   c. bias
   d. economy



6. One way industries and the government fund research is through ____________ .

   a. grants
   b. technology
   c. peers
   d. bias

7. When a material is produced unintentionally, it may be called a

   ____________ .

   a. acid rain
   b. by-product
   c. grant
   d. technology

8. One by-product of using coal for generating electricity is ____________ .

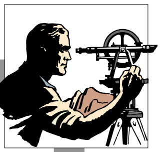
   a. acid rain
   b. by-product
   c. grant
   d. technology

9. A person's preference that can hinder impartial judgement is known as ____________ .

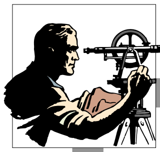
   a. peer
   b. technology
   c. bias
   d. economy

10. One of the foundations of scientific research is the commitment to review of findings by ____________ .

    a. bias
    b. peers
    c. industry
    d. technology



11. Engineers and others that work with technology use __________ to predict possible outcomes.
    a. science
    b. peers
    c. bias
    d. by-products



Lab Activity

Facts:

- One by-product of the industrial world is acid rain.
- Acids dissolve calcium carbonate.
- Chalk is made from calcium carbonate.

Investigate:

- You will try to develop a technology to prevent the acid from dissolving chalk.

Materials:

- small piece of latex
- beaker of vinegar or other acid
- 1 stick of chalk, broken in 2 pieces
- paper towel
- rubber band

1. Place a piece of chalk in the beaker containing vinegar or another acid.

   Does the chalk begin to dissolve? ______________________________

2. Predict which material you think will protect the second piece of chalk from the acid.

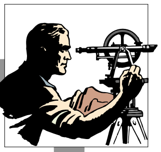
   ____

3. Wrap the material in #2 around the chalk. Hold it on with the rubber band.

4. Watch the solution.

   Does your second piece of chalk appear to be dissolving?

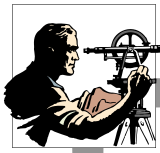
   ____



5. Will the technology you developed prevent the chalk from dissolving?

6. Limestone and marble are stones used in building. They both contain the mineral calcium carbonate. What impact might acid rain have on buildings made with these materials?

7. Describe how you could adapt your chalk-protecting technology to protect buildings from acid rain.



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a product or result of a process that is not the one intentionally sought

______ 2. the knowledge, skill, and tools that allow people to perform tasks of increasing complexity

______ 3. the way people live together, interact, and rely on one another

______ 4. the people and machines used to produce products

______ 5. money that is awarded for a specific purpose

______ 6. a tendency to see all things in a certain way

______ 7. a person who is on the same level as another; people who have similar knowledge, background, and goals

______ 8. rain that has a pH below that of seven because it carries dissolved acids

______ 9. the system by which money, ownership, and wealth are controlled

A. acid rain

B. bias

C. by-product

D. economy

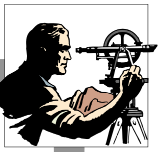
E. grant

F. industry

G. peer

H. society

I. technology



Practice

Use the list below to complete the following statements.

abilities
acid rain
government agencies
grants
knowledge
peers
predict
preference
research
scientific
society
technology
value

1. The change from relatively simple homes to complex homes is an example of a change in the level of ____________________ .

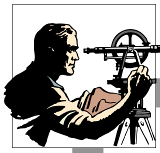
2. Technology often creates a demand for new ____________________ and this requires scientist to begin new ____________________ .

3. Money for research is often provided in the form of ____________________ that are provided by state and federal ____________________ as well as industry.

4. ____________________ establishes the rules for how all people interrelate and behave toward each other.

5. By being committed to allowing ____________________ to review their research and by making the information public, scientists bring insight to problems for society.

6. Science can describe the causes of problems and ____________________ the possible future results.



7. While one person may be fond of computers, another person may dislike this technology. This demonstrates how technology has different ________________________ for different people.

8. Engineers and scientists that try to solve practical, everyday problems. They use ________________________ knowledge and an understanding of human values and ________________________ when making recommendations.

9. The human tendency for bias means that scientists must take into account their own ________________________ that can hinder impartial judgement when doing research.

10. An example of a problem created by technology is ________________________ , which is the result of using coal and other fuels.

Appendices

Index

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Macromedia Freehand 5.0. San Francisco: Macromedia.

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