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ABSTRACT

This teacher's guide and student guide unit contains supplemental readings, activities, and methods adapted for secondary students who have disabilities and other students with diverse learning needs. The materials are designed to help these students succeed in regular education content courses and include simplified text and smaller units of study. The curriculum correlates to Florida's Sunshine State Standards and is divided into the following 21 units of study: (1) scientific method; (2) scientific measurements; (3) matter; (4) changes in matter; (5) introduction to the atom; (6) atomic theory; (7) structure of matter; (8) chemical equations; (9) solutions and suspensions; (10) acids, bases, and salts; (11) chemical reactions; (12) energy, work, force, and power; (13) forms of energy; (14) forces and motions; (15) machines; (16) magnetism; (17) electricity; (18) nuclear energy; (19) heat; (20) waves; and (21) science, society, and the world. The teacher's guide includes a general description of each unit's content focus, provides suggestions for enrichment, and contains an assessment to measure student performance. Appendices describe instructional strategies, list enrichment suggestions, contain suggestions for specific strategies to facilitate inclusion, and contain a chart describing standards and benchmarks. The student guide includes practices and lab activities. (Contains 32 references.) (CR)

Physical Science.
Teacher's Guide [and Student Guide].
Parallel Alternative Strategies for Students (PASS).

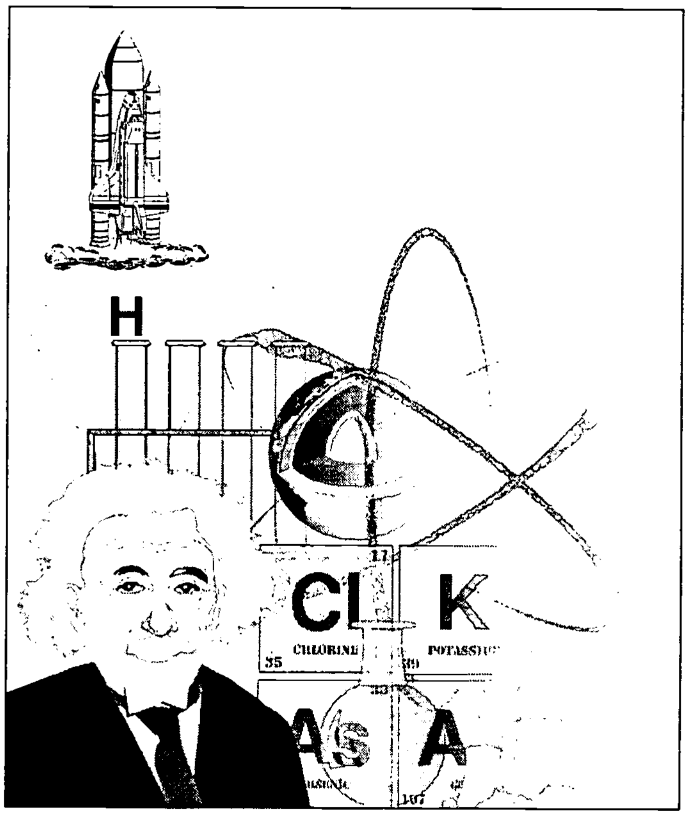
Greg Danner, Editor
Sue Fresen, Editor

Parallel Alternative Strategies for Students

Teacher's Guide

Physical Science

Course No. 2003310



1999

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PASS Book Evaluation Form

Parallel Alternative Strategies for Students

PASS Volume Title: ______________________ Date: ____________

Your Name: ______________________ Your Position: ____________

School: ______________________

School Address: ______________________

____

Directions: *We are asking for your assistance in clarifying the benefits of using the PASS book as a supplementary text. After using the PASS book with your students, please respond to all the statements in the space provided; use additional sheets if needed. Check the appropriate response using the scale below. Then, remove this page, fold so the address is facing out, attach postage, and mail. Thank you for your assistance in this evaluation.*

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Content					
1. The content provides appropriate modifications, accommodations, and/or alternate learning strategies for students with special needs.	❑	❑	❑	❑	❑
2. The content is at an appropriate readability level.	❑	❑	❑	❑	❑
3. The content is up-to-date.	❑	❑	❑	❑	❑
4. The content is accurate.	❑	❑	❑	❑	❑
5. The content avoids ethnic and gender bias.	❑	❑	❑	❑	❑
Presentation					
6. The writing style enhances learning.	❑	❑	❑	❑	❑
7. The text format and graphic design enhance learning.	❑	❑	❑	❑	❑
8. The practice/application activities are worded to encourage expected response.	❑	❑	❑	❑	❑
9. Key words are defined.	❑	❑	❑	❑	❑
10. Information is clearly displayed on charts/graphs.	❑	❑	❑	❑	❑
Student Benefits					
11. The content increases comprehension of course content.	❑	❑	❑	❑	❑
12. The content improves daily grades and/or tests scores.	❑	❑	❑	❑	❑
13. The content increases mastery of the standards in the course.	❑	❑	❑	❑	❑

Usage

The simplified texts of *PASS* are designed to be used as an additional resource to the state-adopted text(s). Please check the ways you have used the *PASS* books. Feel free to add to the list:

- ❑ additional resource for the basic text
- ❑ pre-teaching tool (advance organizer)
- ❑ post-teaching tool (review)
- ❑ alternative homework assignment
- ❑ alternative to a book report
- ❑ extra credit
- ❑ make-up work
- ❑ outside assignment
- ❑ individual contract
- ❑ self-help modules
- ❑ independent activity for drill and practice
- ❑ general resource material for small or large groups
- ❑ assessment of student learning
- ❑ other uses: ______________________

Overall

Strengths:

Limitations:

Other comments:

Directions: Check each box that is applicable.

I have daily access at school to:	☐ A computer	☐ A printer	☐ The Internet	☐ A CD-ROM drive
All of my students have daily access at school to:	☐ A computer	☐ A printer	☐ The Internet	☐ A CD-ROM drive
I would find it useful to have PASS on:	☐ The Internet	☐ CD-ROM	☐ Mac	☐ PC/IBM

- Fold Here -

- Fold Here -

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Physical Science

Teacher's Guide

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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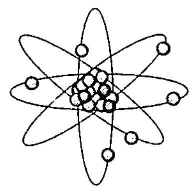

Physical Science

Teacher's Guide

Course No. 2003310

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Curriculum Improvement Project
IDEA, Part B, Special Project

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Exceptional Student Education

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Table of Contents

Acknowledgments

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Foreword

Parallel Alternative Strategies for Students (PASS) books are content-centered packages of alternative methods and activities designed to assist secondary teachers to meet the needs of students of various achievement levels in the basic education content courses. Each *PASS* offers teachers supplementary activities and strategies to assist students with disabilities and diverse learning needs.

The alternative methods and activities found in the *PASS* materials have been adapted to meet the needs of students with diverse learning needs or other exceptionalities and are included in content classes. The *PASS* materials provide basic education teachers and exceptional education teachers with a modified approach for presenting the course content.

The content in *PASS* differs from standard textbooks and workbooks in several ways: simplified text; smaller units of study; reduced vocabulary level; increased frequency of drill and practice; concise directions; less cluttered format; and presentation of skills in small, sequential steps.

As material to augment the curriculum for students with disabilities and diverse learning needs, *PASS* may be used in a variety of ways. For example, some infusion strategies for incorporating this text into the existing program are as follows:

- additional resource to the basic text
- pre-teaching tool (advance organizer)
- post-teaching tool (review)
- alternative homework assignment
- alternative to a book report
- extra credit
- make-up work
- outside assignment
- individual contract
- self-help modules
- independent activity for drill and practice
- general resource material for small or large groups
- assessment of student learning

The initial work on *PASS* materials was done in Florida through Project IMPRESS, an Education of the Handicapped Act (EHA), Part B, project funded to Leon County Schools from 1981–1984. Four sets of modified content materials called *Parallel Alternate Curriculum* (*PAC*) were disseminated as parts two through five of *A Resource Manual for the Development and Evaluation of Special Programs for Exceptional Students, Volume V-F: An Interactive Model Program for Exceptional Secondary Students.* Project IMPRESS patterned the *PACs* after the curriculum materials developed at the Child Service Demonstration Center at Arizona State University in cooperation with Mesa, Arizona, Public Schools.

A series of 19 *PASS* volumes was developed by teams of regular and special educators from Florida school districts who volunteered to participate in the EHA, Part B, Special Project, Improvement of Secondary Curriculum for Exceptional Students. This project was funded by the Florida Department of Education, Bureau of Education for Exceptional Students, to Leon County Schools during the 1984 through 1988 school years. Basic education subject area teachers and exceptional education teachers worked cooperatively to write, pilot, review, and validate the curriculum packages developed for the selected courses.

Continuation efforts have been maintained through the Curriculum Improvement Project. Beginning in 1989 the Curriculum Improvement Project contracted with Evaluation Systems Design, Inc., to design a revision process for the 19 *PASS* volumes. First, a statewide survey was disseminated to teachers and administrators in the 67 school districts to assess the use of and satisfaction with the *PASS* volumes. Teams of experts in instructional design and teachers in the content area and in exceptional education then carefully reviewed and revised each *PASS* volume according to the instructional design principles recommended in the recent research literature.

Neither the content nor the activities are intended to be a comprehensive presentation of any course. These *PASS* materials, designed to supplement textbooks and other instructional materials, are not intended to be used alone. Instead, they should serve as a stimulus for the teacher to design alternative strategies for teaching the Sunshine State Standards to the mastery level to the diverse population in a high school class.

The *PASS* volumes provide some of the print modifications necessary for students with diverse learning needs to have successful classroom experiences. To increase student learning, these materials must be supplemented with additional resources that offer visual and auditory stimuli, including computer software, videotapes, audiotapes, and laser videodiscs.

User's Guide

The *Physical Science PASS* and accompanying *Teacher's Guide* are designed as supplementary resources for teachers who are teaching science to secondary students of various achievement levels and diverse learning needs. The content of the *Physical Science PASS* book is based on the *Florida Curriculum Frameworks* and correlate to the Sunshine State Standards.

The Sunshine State Standards are made up of *strands*, *standards*, and *benchmarks*. A *strand* is the most general type of information and is a label for a category of knowledge. The strands for Physical Science are as follows: 1) The Nature of Matter; 2) Energy; 3) Force and Motion; 4) Processes of Life; 5) How Living Things Interact With Their Environment; and 6) The Nature of Science. A *standard* is a description of general expectations regarding knowledge and skill development. A *benchmark* is the most specific level of information and is a statement of expectations about student knowledge and skills. Correlation information to the Sunshine State Standards for *Physical Science*, course number 2003310, is given in a correlation matrix in Appendix D.

The *Physical Science PASS* is divided into 21 units of study which correspond to the science strands. The content focuses on concepts, instructional text, and lab activities that promote learner expectations as identified in the course description. It is suggested that expectations for student performance be shared with the students before instruction begins.

Each unit in the *Teacher's Guide* includes the following components:

- **Overview:** Each unit contains a general description of the unit, purpose, and student goals.
- **Suggestions for Enrichment:** Each unit contains activities which may be used to encourage, to interest, and to motivate students by relating concepts to real-world experiences and prior knowledge.
- **Unit Assessments:** Each unit contains an assessment which provides the means for teachers to measure student performance.
- **Keys:** Each unit contains an answer key for each practice and lab activity in the student book and for the unit assessments in the *Teacher's Guide*.

The appendices contain the following components:

- **Appendix A** contains instructional strategies which may be used to aid in meeting the needs of students with diverse learning needs.
- **Appendix B** lists teaching suggestions to help in achieving mastery of the Sunshine State Standards and Benchmarks.
- **Appendix C** contains suggested accommodations and/or modifications of specific strategies for inclusion of students with disabilities and diverse learning needs. The strategies may be tailored to meet the individual needs of students.
- **Appendix D** contains a unit correlation chart of the relevant benchmarks from the Sunshine State Standards associated with course requirements for *Physical Science.* These course requirements describe the knowledge and skills the students will have once the course has been successfully completed. The chart may be used in a plan book to record the dates as the benchmarks are addressed.
- **Appendix E** is a list of reference materials and software used to produce *Physical Science.*

Physical Science is designed to correlate classroom practices with the Florida Curriculum Frameworks. No one text can adequately meet all the needs of all students—this *PASS* is no exception. It is recommended that teachers use *PASS* with other instructional materials and strategies to aid comprehension and provide reinforcement.

Unit 1: The Scientific Method

Overview

In this unit students will learn the steps of the scientific method and how they are used to solve problems. Students will be introduced to the unifying concepts and processes of science. Equipment used in the labs in this text will be identified and described.

Purpose

Describe the scientific method and how it is used in solving problems.

Student Goals

1. Explain the steps of the scientific method.
2. Select one or more appropriate science process skills for problem solving.
3. Identify common apparatus used in the laboratory.
4. State safe laboratory practices.
5. Recognize the scientific method being used in everyday problems.
6. Recognize that scientific thought undergoes shifts.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Discuss ways that everyday problems are solved. Use some personal or familiar examples. Compare and contrast the way these problems are solved with the scientific method. Point out the similarities. For instance, fixing a car or planting a garden may involve the same processes.

Pose the question "Why study science?" Point out in the discussion that science is a way of obtaining knowledge and understanding—not just gathering data. Discuss why science cannot be content to refuse to consider or accept change.

Ask the school's guidance counselor or occupational specialist for materials related to careers in science. Present this information to stimulate thinking about the future. Bring in professionals from technological fields such as computers, medicine, chemistry, or engineering.

Display pieces of equipment used in the lab. Name the pieces and have students identify them. Team competition could be used to increase interest.

Demonstrate the use of lab equipment. Demonstrations and experiments should pique students' interest. Verify each student's use of appropriate techniques.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Identify a problem in your community. Have the class investigate how the problem is being addressed. Analyze the approach and compare with the scientific method. Have the class follow the progress during a defined period of time.

Use the scientific method to answer questions in the classroom or laboratory setting. Pose questions, develop hypotheses, design and conduct experiments, collect and interpret data, draw conclusions, or solve the problem identified.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Possible Investigation

- Which type of paper airplane is superior and why?
- How could you find out how high the clouds are?
- What type of nuts provide the most energy?

Lab Safety Contract

I, ______________________________, have read and do understand the safety rules of the science laboratory and agree to follow them at **all** times. I will follow all instructions given by the teacher and behave responsibly in the science laboratory.

____
Date

____
Student's Signature

____
Parent's Signature

____
Teacher's Signature

Safety Guidelines

1. Read and follow all directions while working in the laboratory.
2. Wear protective gear, such as aprons, at all times. Wear goggles when working with dangerous or hot chemicals, or any time your teacher instructs you to do so.
3. NEVER taste or directly inhale chemicals. Test the smell of a substance by wafting or fanning some of the odor to your nose with your hand. Your teacher can show you how.
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. Dress in a way that helps you work safely and efficiently in the lab. Tie your hair back. Wear cotton—it doesn't catch fire as easily as nylon or polyester. Always keep your shoes on while in the lab. Roll up long or loose sleeves.
8. DO NOT look directly down into the mouth of a test tube. DO NOT point the mouth of a test tube at another student. 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. Remain calm and do not alarm others by shouting or running.
11. Know the location of the safety shower, eye wash, and fire blanket. Know how to use these important pieces of safety equipment.
12. Turn off gas burners and gas outlets when no one is using them. NEVER leave a lit burner unattended.
13. Use tongs or gloves to handle hot objects.
14. DO NOT look directly at the sun, with or without equipment, as it may damage your eyes.
15. Keep lab tables clean and neat to prevent accidents. Wipe all areas at the end of the lab.
16. MAKE SAFETY A HABIT!

Unit Assessment

Use the list below to complete the following statements.

apparatus	**graduated cylinder**	**temperature**
Bunsen burner	**mortar and pestle**	**tongs**
funnel	**pipet**	

1. A ____________________ is used to grind chemicals.

2. Equipment and tools used in science laboratories are called ____________________ .

3. A ____________________ is used when pouring liquids into a container.

4. A ____________________ is used to transfer small amounts of liquid.

5. A ____________________ measures a liquid volume.

6. ____________________ have two arms and are used to grasp and hold objects.

7. A thermometer measures ____________________ .

8. A ____________________ makes a hot, blue flame.

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

_________ 9. Experiments always prove the hypothesis to be correct.

_________ 10. A good hypothesis can be tested.

_________ 11. A hypothesis explains the relationship among observed facts.

_________ 12. A hypothesis only deals with known or existing facts.

_________ 13. Careful observation is an important step in scientific study.

_________ 14. Data is opinion.

_________ 15. Logical reasoning has no part in a scientific experiment.

_________ 16. If you get positive results from your experiment the first time, it is okay to stop and report your results.

_________ 17. It is best to keep the results of your experiment a secret so that no one may steal your ideas.

_________ 18. Observation is done solely with the eyes.

_________ 19. A theory can be disproved if new discoveries are made.

_________ 20. The experiment is the last step of the scientific method.

Use complete sentences to list at least five **laboratory safety rules**.

21. ______________________________

____

22. ______________________________

____

23. ______________________________

____

24. ______________________________

____

25. ______________________________

____

Use the list below to complete the following statements.

analogs	**law**	**small**
control	**repeated**	**unethical**
every	**scale**	

26. Occasionally, large shifts in scientific thought occur. More frequently, the shifts are ______________________.

27. If you wanted to study how varying amounts of water affect plants, you could experiment. The plant that always got the same amount of water would be your ______________________.

28. One reason to observe rather than experiment is because it would be impractical or ______________________ to experiment in some instances.

29. Building a small replica of a car to study crashes is an example of using a ______________________ model.

30. Computer simulations are often used because an experiment can be ______________________ many times.

31. When scientists experiment with systems that have similarities, we say they are using ______________________.

32. One reason theories are never proven true is that we cannot test ______________________ condition.

33. When a set of theories is supported over a long time and through many tests, it may become a ______________________.

Keys

Practice (pp. 12-13)

1. Scientists
2. investigate
3. ideas
4. predict
5. conclusions
6. Galileo
7. small
8. controlled
9. behavior
10. Computer simulation; models; analogs

Practice (p. 14)

1. B
2. C
3. A
4. E
5. D

Practice (p. 15)

1. False
2. False
3. True
4. False
5. False
6. True
7. True
8. False
9. False
10. True

Practice (p. 16)

1. scientific method
2. data
3. hypothesis
4. conclusion
5. laboratory
6. safety
7. goggles
8. taste
9. Cotton
10. accidents

Practice (pp. 17-20)

1. b
2. a
3. a
4. b
5. c
6. d
7. c
8. a
9. b
10. d
11. c
12. a
13. c
14. d
15. d
16. a
17. c
18. d
19. b
20. c

Practice (p. 21)

1. A
2. G
3. C
4. B
5. E
6. D
7. F
8. H
9. J
10. I

Unit Assessment (pp. 5-8TG)

1. mortar and pestle
2. apparatus
3. funnel
4. pipet
5. graduated cylinder
6. tongs
7. temperature
8. Bunsen burner
9. False

Keys

10. True
11. True
12. False
13. True
14. False
15. False
16. False
17. False
18. False
19. True
20. False
21. Answers will vary.
22. Answers will vary.
23. Answers will vary.
24. Answers will vary.
25. Answers will vary.
26. small
27. control
28. unethical
29. scale
30. repeated
31. analogs
32. every
33. law

Unit 2: Scientific Measurement

Overview

All scientific work requires accurate measurements of matter. In this unit students will use the metric system of measurement to determine length, volume, mass, and temperature.

Purpose

Use the international units of measurement (SI)—the metric system and manipulate various kinds of equipment and instruments in various laboratory activities.

Student Goals

1. Measure the length of various items accurately using meters, centimeters, and millimeters.
2. Measure liquids accurately using liters and milliliters.
3. Accurately find mass in milligrams, grams, and kilograms.
4. Explain the differences between mass, weight, and volume.
5. Read Fahrenheit and Celsius thermometers.
6. Know that temperature is a measure of the random movement of particles.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Bring in common products with metric units on the labels and compare with the customary measurements.

Help students associate common objects with a metric unit to aid memory or example, a golf club and a meter; a large bottle soft drink and two liters; a paper clip and a gram.

Have students find their own height and mass in metric units.

Set up a spring balance, a set of metric weights, a meter stick, and a graduated cylinder. Show how they are used for measurement.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Pour water from a 1,000 mL flask into a quart milk carton to see the size of a liter. Weigh a nickel (about five grams). Obtain a liter cube that separates to show the relationship between a milliliter (mL) and a liter. Demonstrate that a liter of water has a mass of one kilogram (kg) and that one gram equals one cubic centimeter (cc) or milliliter (mL).

Provide many opportunities for use of the metric terms and require students to use them instead of the customary terms. Immersion in the SI system is often required for students to gain familiarity.

The history of some of the common units of measurement is of interest to selected students. Some may research the history and discover interesting background information. For instance, an inch is the length of three kernels of barleycorn placed end to end. A yard was defined as the distance from the king's nose to the tip of his finger on his outstretched arm. For such students, you may ask them to compare these highly variable quantities to our more standard quantities. Ask them to explore how this might have affected trade, economics, or even religion.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

Circle the letter of the correct answer.

1. The basic unit of length in the metric system is the ________.

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

2. If you divide a meter into 100 parts, each new part is called a ________.

   a. centimeter
   b. millimeter
   c. kilometer
   d. decimeter

3. An example of a metric unit is a ________.

   a. pound
   b. inch
   c. meter
   d. yard

4. A prefix that means $\frac{1}{10}$ is ________.

   a. milli-
   b. centi-
   c. kilo-
   d. deci-

5. One hundred centimeters equal one ________.

   a. yard
   b. meter
   c. kilometer
   d. centimeter

32

6. A metric measurement used for long distance is the ___________.

   a. kilogram
   b. mile
   c. kilometer
   d. centimeter

7. The abbreviation or symbol for liter is ___________.

   a. lL
   b. cL
   c. mL
   d. L

8. Ten centimeters equals ___________ millimeters.

   a. 1
   b. 100
   c. 1,000
   d. 10

9. Water boils at ___________.

   a. 0°C
   b. 212°C
   c. 100°C
   d. 100°F

10. Ten milliliters equals ___________.

    a. one centiliter
    b. one liter
    c. one meter
    d. two liters

Follow the directions given below.

11. Write the given units in order from the smallest to the largest.

centimeter	**meter**	**millimeter**

a. ______________________________ (smallest)

b. ______________________________

c. ______________________________ (largest)

12. Write the following units in order from the smallest to the largest.

liter	**milliliter**	**centiliter**

a. ______________________________ (smallest)

b. ______________________________

c. ______________________________ (largest)

34

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

_________ 13. The metric system is a system of measurement based on the decimal system.

_________ 14. Volume is the amount of space matter takes up.

_________ 15. A liter measures mass.

_________ 16. A meter is used to measure distance.

_________ 17. Weight is the measure of the force of gravity on an object.

_________ 18. Water freezes at 100°C.

_________ 19. The meter would be a convenient measurement to use to measure the length of a paper clip.

_________ 20. Grams are used to measure temperature.

_________ 21. Temperature is a measurement of how fast molecules move in their random motion.

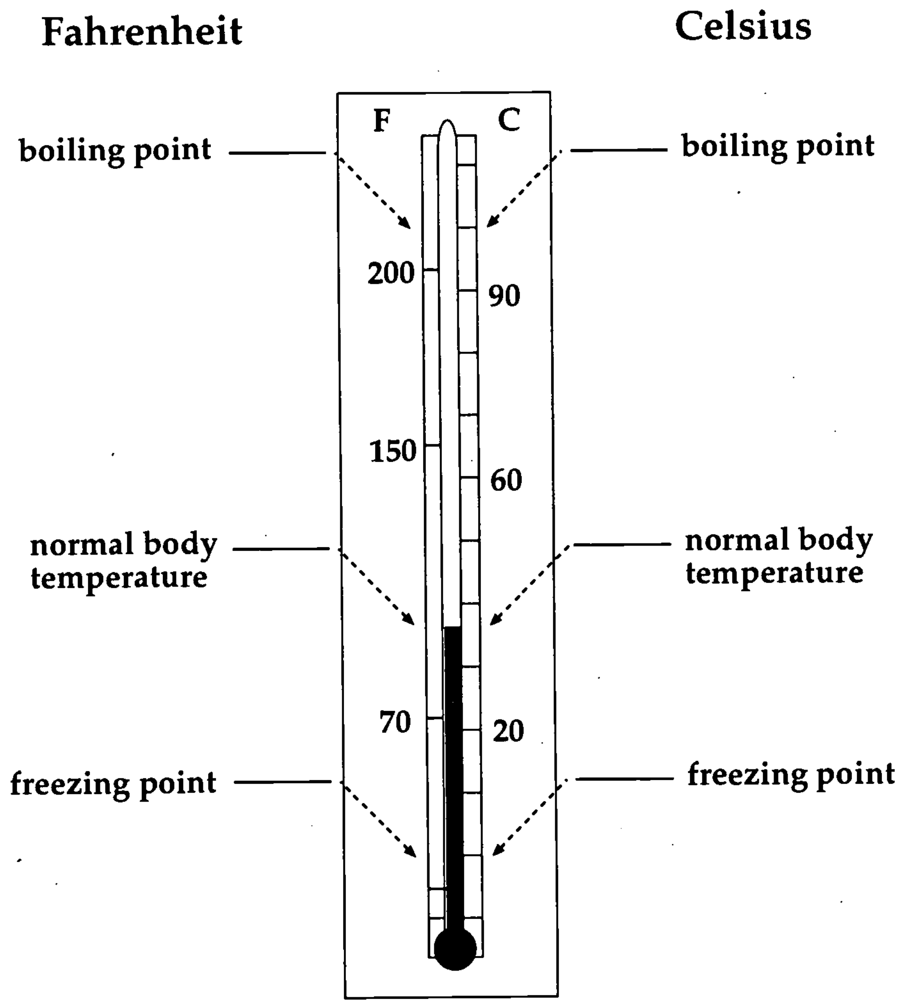
Measure the following lines to the nearest **centimeter**.

_________ 22. ______________________

_________ 23. ________________________________

_________ 24. ____

Fill in the temperature scales. Indicate the temperature for **freezing, boiling,** *and* **normal body temperatures** *in both* **Fahrenheit** *and* **Celsius**.



36

Keys

Practice (p. 32)

These answers may vary slightly due to flaws in measuring devices.

1. 4.5 cm
2. 45 mm
3. 6.5 cm
4. 65 mm
5. 2 cm
6. 20 mm
7. 9 cm
8. 90 mm
9. 8 cm
10 80 mm
11. 40 mm
12. 58 mm
13. 26 mm
14. 90 mm
15. 79 mm

Lab Activity 1 (pp. 33-34)

Answers will vary.

Practice (p. 35)

1. b
2. a
3. c
4. c
5. d

Practice (p. 36)

1. 1 liter
2. 1 milliliter
3. A 2-kiloliter bottle of cola
4. 10 liters of water
5. 10 deciliters
6. 1 kiloliter
7. 100 kiloliters

Lab Activity 2 (p. 37)

Answers will vary.

Lab Activity 3 (p. 38)

1. milliliters
2. one
3. 100
4. 100

Practice (p. 39)

1. A
2. E
3. B
4. C
5. D
6. J
7. I
8. G
9. F
10. H

Practice (p. 40)

1. 4 decigrams
2. 2 milligrams
3. 1,000 grams
4. 10 decigrams
5. 100 centigrams
6. 1,000 milligrams
7. 1,000 grams
8. mg
9. kg
10. dg
11. cg
12. g

Lab Activity 4 (p. 41)

1. 1,000 milligrams = 1 gram
   1,000 grams = 1 kilogram
2. Correct answers will be determined by the teacher.

Keys

Practice (pp. 42-43)

1. b
2. b
3. a
4. c
5. c
6. b
7. c
8. a

Lab Activity 5 (p. 44-45)

1. 0°
2. 32°
3. 100°
4. 212°
5. 100°
6. 180°
7. Celsius
8. Answers will vary.
9. Answers will vary.
10. 0°C

Practice (p. 46-47)

1. meter
2. kilometers
3. centimeters
4. millimeters
5. centimeter
6. 1,000
7. 1,000
8. liter
9. Temperature
10. 212°; 100°
11. 32°; 0°

Practice (p. 48)

1. D
2. A
3. E
4. C
5. B
6. J
7. G
8. F
9. L
10. H
11. I
12. K

Unit Assessment (pp. 13-17TG)

1. b
2. a
3. c
4. d
5. b
6. c
7. d
8. b
9. c
10. a
11. a. millimeter
    b. centimeter
    c. meter
12. a. milliliter
    b. centiliter
    c. liter
13. True
14. True
15. False
16. True
17. True
18. False
19. False
20. False
21. True
22. 5
23. 7
24. 9
25.

Fahrenheit	Celsius
212°	100°
98.6°	37°
32°	0°

Unit 3: Matter

Overview

In this unit students will learn to recognize the three phases of matter and how matter may change from one phase to another. The physical and chemical properties of matter are discussed.

Purpose

Restate the concept that says the environment consists of matter in different phases which can be changed from one to another.

Student Goals

1. Demonstrate, through the use of scientific instruments, that matter occupies space and has mass.
2. Differentiate between physical and chemical properties.
3. Name the phases of matter and describe their characteristics.
4. Know that phase changes involve energy transfer.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Have students make a chart of physical properties of common household objects or foods. Note that physical properties are ones that are observed by using one of the five senses.

Using one volume of water and different-sized containers, show how the liquid takes the shape of the various containers.

Use a balance to find the mass of selected items. Compare the results.

Discuss the importance of plasma and the impossibility of working with it. Emphasize that though plasma is common in stars, we are more commonly concerned with the gas, liquid, and solid phases of matter.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Explore the question: Can all matter appear in all the phases? Demonstrate selected choices.

Have students look up one or more of the following words in an encyclopedia and write a paragraph about the research in their own words.

1. gravity
2. matter
3. volume
4. mass
5. physical properties
6. density

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

40

Unit Assessment

Circle the letter of the correct answer.

1. The pull of gravity on matter is __________ .
   a. mass
   b. weight
   c. size
   d. color

2. The amount of material in an object is its __________ .
   a. mass
   b. weight
   c. matter
   d. state

3. __________ is the amount of a material in a certain volume.
   a. Mass
   b. State
   c. Density
   d. Temperature

4. As the force of gravity decreases, the weight of an object __________ .
   a. increases
   b. decreases
   c. stays the same
   d. doubles

5. A __________ has a definite shape and a definite volume.
   a. gas
   b. liquid
   c. solid
   d. balloon

6. A liquid __________.

   a. has a definite shape
   b. has no definite shape
   c. has no definite volume
   d. always fills the container

7. Water vapor is an example of __________.

   a. a liquid
   b. gravity
   c. a solid
   d. a gas

8. The ability to react with oxygen and burn is __________.

   a. a physical property
   b. a chemical property
   c. measurement
   d. rusting

9. Size is an example of __________.

   a. a chemical property
   b. a change in phase
   c. a physical property
   d. a change in matter

10. All matter must __________.

   a. have no shape
   b. occupy space
   c. be able to be seen
   d. have a definite shape

11. A phase change is a physical change. It is caused by a __________.

   a. chemical change
   b. change in the amount of heat energy
   c. change in weight
   d. gain in cold

12. When objects cool, they ___________ .

a. lose heat
b. gain heat
c. lose cold
d. gain cold

13. Draw a picture of a room that has no gravity. Include solids, liquids, and gasses in your picture. Use the reverse side of the test if you need more room.

Keys

Practice (pp. 56-57)

1. matter
2. weight
3. volume; mass
4. a. True
   b. False
5. solid; liquid; gas; plasma
6. shape; volume
7. Answers will vary.
8. volume; shape
9. Answers will vary.
10. shape
11. fill
12. solid; liquid
13. water (or acceptable answer)
14. 100°
15. physical
16. boiling water
17. solid
18. add
19. False
20. True

Lab Activity: Part 1 (p. 58)

3. a. When the balloon was inflated.
   b. It had been filled with air.
   c. yes

Lab Activity: Part 2 (p. 59)

3. Answers will vary.
4. greater than
5. no
6. The volume of the weight displaced the water.
7. yes
8. yes
9. weight; space

Practice (p. 60)

1. liquid
2. solid
3. gas
4. gas
5. liquid
6. liquid
7. solid
8. liquid
9. solid
10. liquid

Unit Assessment (pp. 23-25TG)

1. b
2. a
3. c
4. b
5. c
6. b
7. d
8. b
9. c
10. b
11. b
12. a
13. Drawings will vary.

44

Unit 4: Changes in Matter

Overview

In this unit students will learn to identify physical and chemical changes and understand the difference between the two kinds of changes.

Purpose

State the difference between physical and chemical changes in matter.

Student Goals

1. Differentiate between physical and chemical changes through laboratory experiences.

2. State that chemical changes produce new substances.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Using chalk as one example, demonstrate what would happen if the chalk was continually broken into smaller and smaller pieces. Compare this with ashes from burning a piece of paper in the lab. Emphasize that the utility of objects often depends on chemical properties.

Demonstrate a chemical change. Heat a small amount of sugar in a test tube. Point out to students the drops of water than collect around the top of the test tube. This demonstrates the change in the substance.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Have students make a chart of chemical properties of common household objects or perhaps foods. Note that chemical properties are ones that are observed by allowing the substances to react.

Give a home assignment. Observe one chemical change and one physical change. Have students write their observations on paper and report in class.

Explore the question: What role does heat energy (or temperature) have in affecting chemical changes? Demonstrate selected reactions.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

________ 1. Matter does not always stay the same.

________ 2. Matter cannot be changed.

________ 3. Matter can be changed by temperature or pressure.

________ 4. During a physical change, no new substances are formed.

________ 5. During a chemical change, no new substances are formed.

Use the list below to complete the following statements.

chemical	**heat**	**substance**
composition	**physical**	

6. Any change in the form or phase of matter is a ____________________ change.

7. New substances are made when a ____________________ change takes place.

8. The makeup of a substance is its ____________________.

9. Another word for matter is ____________________.

10. ____________________ is involved during a chemical change or a phase change.

47

Write the type of change that occurs when the following actions take place. Use the terms **physical** *or* **chemical**.

____________________ 11. breaking a piece of chalk

____________________ 12. squeezing a ball of clay

____________________ 13. cooking a piece of meat

____________________ 14. burning a sheet of paper

____________________ 15. mixing vinegar and baking soda

Keys

Practice (p. 67)

1. physical
2. chemical
3. changes
4. carbon dioxide
5. phase

Lab Activity (pp. 68-69)

1. a. yes
   b. water/liquid
   c. no
   d. physical
   e. See chart below.
2. a. yes
   b. no
   c. physical
   d. See chart below.
3. a. yes
   b. no
   c. no
   d. chemical
   e. See chart below.

Physical Change	Chemical Change
1. ice melting	1. mixing vinegar and baking soda
2. breaking chalk	2. none

f. chemical change

Practice (p. 70)

1. A
2. D
3. F
4. C
5. G
6. E
7. B

Unit Assessment (pp. 31-32TG)

1. True
2. False
3. True
4. True
5. False
6. physical
7. chemical
8. composition
9. substance
10. Heat
11. physical
12. physical
13. chemical
14. chemical
15. chemical

Unit 5: Introduction to the Atom

Overview

In this unit students will learn the basic structure of an atom. They will identify the parts of an atom and the charges. The difference between an atom and a molecule is described.

Purpose

Explain that atoms are the fundamental unit of structure in the universe and that atoms combine to form more complex structures.

Student Goals

1. Define these terms: atoms, ions, molecules, protons, neutrons, nucleus, and electrons.
2. Create, through laboratory activities, simple models of molecules.
3. Describe the structure of an atom and the behavior of charged particles.
4. Locate protons, electrons, and neutrons in an atom model.
5. Recognize that the properties of substances are based on the molecular forces.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Build a model of an atom, using different colored beads or clay.

Have a student report on the discovery of the proton, electron, or neutron.

Introduce the basic structure of an atom by showing a film or filmstrip.

Use magnets to represent the behavior of charged particles.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Have students draw diagrams of carbon, oxygen, or magnesium, for example, showing the protons and neutrons in the nucleus and the electrons in the shells.

Have students make a three-dimensional model of an atom as a special project. A mechanical model with spinning electrons is available from science supply houses. Your media center may have one.

Have the class model the behavior of an atom like oxygen. Students portray neutrons, electrons and protons. Emphasize that as one electron moves, it affects the position of all electrons.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

51

Unit Assessment

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

______ 1. the charge of an electron

______ 2. the charge of a proton

______ 3. a property of an object that causes it to be affected by a magnetic field

______ 4. the smallest unit of an element that is still that element

______ 5. two or more atoms that have a bond of shared electrons

______ 6. having no charge

______ 7. the middle part of a atom

______ 8. the space that electron(s) occupy while in a certain orbit

______ 9. the path that the electron follows around the center of an atom

______ 10. to move away from

______ 11. to move toward each other

______ 12. the negatively charged particle of an atom

______ 13. the neutral particle found in the nucleus of an atom

______ 14. the attraction that holds two or more molecules together

______ 15. positively charged particle of an atom

A. atom

B. attract

C. bond

D. charge

E. electron

F. molecule

G. negative charge

H. neutral

I. neutron

J. nucleus

K. orbit

L. positive charge

M. proton

N. repel

O. shell

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

_________ 16. All substances are made of atoms.

_________ 17. A molecule is always made of two or more atoms.

_________ 18. All atoms have protons, neutrons, and electrons.

_________ 19. A proton has a negative charge.

_________ 20. A neutron has no charge.

_________ 21. An electron has a positive charge.

_________ 22. Like charges push away or repel each other.

_________ 23. Unlike charges attract each other.

_________ 24. If a negative charge was placed near a positive charge, they would repel each other.

_________ 25. Elements are made of only one kind of atom.

_________ 26. Molecules have bonds of shared electrons.

_________ 27. The different properties of substances are chosen by the fact that all molecules are held together in the same way.

_________ 28. Water is a compound.

_________ 29. Salts are examples of compounds that have molecules.

_________ 30. Hydrogen is a component of water that behaves just like water.

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).*

_________________ 31. ⊕ ⊖

_________________ 32. ⊖ ⊕

_________________ 33. ⊖ ⊖

_________________ 34. ⊕ ⊕

Keys

Lab Activity (pp. 79-81)

Oxygen Molecule

4. a. two
   b. yes
   c. oxygen

Water Molecule

1. compound
5. three
6. Models will vary.

Illustrations

1. Answers will vary.
2. Answers will vary.
3. toothpicks

Practice (p. 82)

1. electron
2. proton
3. neutron
4. orbit or shell
5. nucleus

Practice (p. 83)

1. repel
2. repel
3. attract
4. attract

Practice (pp. 84-86)

1. atom
2. molecule
3. distance
4. forces
5. apart
6. together
7. phase
8. electrons
9. nucleus
10. Electrons
11. orbit
12. shell
13. positive
14. negative
15. no
16. Neutral
17. repel
18. repel
19. attract
20. away
21. toward
22. one

Practice (pp. 87-88)

1. negative charge
2. positive charge
3. atom
4. molecule
5. charge
6. proton
7. shell
8. orbit
9. nucleus
10. neutron
11. electron
12. bond

Unit Assessment (pp. 37-39TG)

1. G
2. L
3. D
4. A
5. F
6. H
7. J
8. O
9. K
10. N
11. B
12. E
13. I
14. C
15. M

Keys

16. True
17. True
18. False
19. False
20. True
21. False
22. True
23. True
24. False
25. True
26. True
27. False
28. True
29. False
30. False
31. attract
32. attract
33. repel
34. repel

Unit 6: Atomic Theory

Overview

In this unit students will learn how to use the periodic table and how the table is organized.

Purpose

The student will demonstrate knowledge of atomic structure through the use of the periodic table.

Student Goals

1. Understand the organization of the periodic table by groups and families.
2. Identify certain elements by their symbols.
3. Find information necessary to construct a diagram showing the atomic structure of an element.
4. Determine the atomic masses and numbers of certain elements when given the essential data.
5. Discuss how theories in science develop and evolve, how theories are accepted or rejected, and how theories are based on certain assumptions.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Have students bring newspaper articles about nuclear energy to class. As citizens they will be called upon to make responsible informed decisions about energy production. (See "Unit 18: Nuclear Energy.")

Discuss the splitting of the atom and the atomic bomb. Show a film on the explosion of the atomic bomb and discuss it in class.

Discuss the various models of the atoms and describe how each evolved, how each was developed, and/or how each was discarded. Compare the hard, solid model of the Greeks with the current view of orbitals, clouds, and nuclear forces.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Distinguish between radiation and radioactivity. Discuss safe sources of radiation, such as luminous dials on clocks and wristwatches and smoke alarms. Compare with the harmful effects of radioactivity.

Build models of various atoms, showing the nucleus with protons and neutrons and the electrons in orbit.

Use the library to research how we use atomic energy today. Write a short research paper on your findings.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

58

Unit Assessment

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

______	1. an element that does not have the properties of a metal	A. amu
______	2. a horizontal row of elements on the periodic table	B. atomic mass
______	3. table arrangement of the elements	C. atomic mass unit
______	4. abbreviation for atomic mass unit	D. atomic number
______	5. a number used to identify an element and represent its placement in the periodic table	E. group
______	6. a unit of mass equal to the mass of a proton or a neutron	F. metal
______	7. elements located in a vertical column on the periodic table	G. nonmetal
______	8. a chemical element that is usually solid or shiny when it is pure or polished	H. period
______	9. total number of protons and neutrons	I. periodic table

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

_________ 10. There are around 120 kinds of atoms.

_________ 11. Protons are found in the nucleus of an atom.

_________ 12. The atomic number of an element tells how many neutrons are in its atom.

_________ 13. If we know the number of protons in an atom, we also know the number of electrons.

_________ 14. The elements are arranged on the periodic table in numerical order based on their atomic numbers.

Use the list below to complete the following statements.

electrons	**group**	**period**	**sum**
elements	**neutron**	**protons**	

15. The nucleus of an atom contains _________________________ and neutrons.

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

17. The atomic mass of an atom equals the _________________________ of the protons and the neutrons.

18. _________________________ do not have much mass and do not count in atomic mass.

19. The symbols on the periodic table stand for the names of the _________________________ .

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

21. A ____________________ names the elements going across the periodic table.

Answer the following using the **periodic table** *and the* **symbols and elements chart**.

22. What are two metals in period 6? ____________________

____

23. What are two nonmetals in period 6? ____________________

____

24. What is one element in the same group as lithium and sodium?

____

25. What is one element in the same period as iron and cobalt? ____

____

26. What is the name of the element with the atomic number given below?

    26: ____________

    88: ____________

    79: ____________

27. Sn stands for ____________________.

28. The symbol for sulfur is ____________________.

29. Give the following information for carbon:

atomic number: ______________________________

atomic mass: ______________________________

symbol: ______________________________

Use the list below to complete the following statements.

alchemists	**new**	**rules**
discarded	**predict**	**view**

30. The ____________________ were a group of people who searched for a way to turn ordinary metals into gold and provided us with the basis for chemistry.

31. From time to time, ____________________ theories replace old.

32. When theories don't fit observations, they will be ____________________ .

33. By discarding theories, replacing the old with the improved, we gain a better ____________________ of the universe.

34. One test of a theory is its ability to ____________________ new findings.

35. Because scientists assume the universe is a vast system, they expect to find ____________________ that range from the simple to the complex.

Keys

Practice (p. 101)

hydrogen	H	1	1	1
calcium	Ca	20	20	20
carbon	C	6	6	6
nitrogen	N	7	7	7
oxygen	O	8	8	8
iron	Fe	26	26	26
copper	Cu	29	29	29

Practice (p. 102)

Answers will vary.

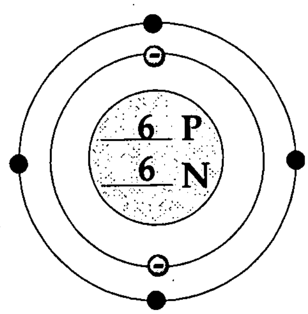
Practice (p. 103)

cobalt	27	32	59
sodium	11	12	23
calcium	20	20	40
carbon	6	6	12
oxygen	8	8	16
helium	2	2	4

Practice (pp. 104-105)

1. hydrogen, calcium, iron
2. Answers will vary.
3. Answers will vary.
4. Answers will vary.
5. Answers will vary.
6. 8: oxygen; 16: sulfur; 82: lead
7. sodium
8. arsenic
9. He
10. 22.987 (23)

Practice (p. 106)

1. C
2. 

3. 12 (12.011)
4. 6
5. 6
6. 6
7. 6

Practice (pp. 107-110)

1. Greeks
2. John Dalton
3. atoms
4. 120
5. nucleus
6. atomic number
7. electrons
8. 79
9. hydrogen
10. 1
11. atomic
12. nucleus
13. protons; neutrons
14. atomic mass unit or amu
15. amu
16. neutron
17. 1
18. sum
19. 11
20. Electrons
21. elements
22. group
23. similar
24. electrons

Keys

25. outermost
26. period
27. different
28. predict
29. metals
30. right; left
31. alchemists
32. old
33. fit
34. improves
35. predict
36. system
37. simple

Unit Assessment (pp. 45-48TG)

1. G
2. H
3. I
4. A
5. D
6. C
7. E
8. F
9. B
10. True
11. True
12. False
13. True
14. True
15. protons
16. neutron
17. sum
18. Electrons
19. elements
20. group
21. period
22. Answers will vary.
23. Answers will vary.
24. Answers will vary.
25. Answers will vary.
26. 26: iron; 88: radium; 79: gold
27. tin
28. S
29. atomic number: 6
    atomic mass: 12.011
    symbol: C
30. alchemists
31. new
32. discarded
33. view
34. predict
35. rules

Unit 7: Structure of Matter

Overview

In this unit students will learn that all matter is made up of about 120 elements. Some matter is made of only one element. Elements combine physically to form mixtures or chemically to form compounds.

Purpose

Explain the differences among elements, compounds, and mixtures.

Student Goals

1. Define the terms elements, compounds, and mixtures.
2. Demonstrate, through laboratory activities, the differences between compounds and mixtures.
3. Recognize common elements by their symbols.
4. Identify different elements and understand where certain substances originate.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Inspect a handful of soil with the students. Place some on an overhead projector to show the different kinds of material found in soil.

Think about a loaf of bread. How is bread made? Is it a mixture or a compound? Is it different before and after it is baked? Make a loaf of bread.

Mix sugar with sand or salt with sugar or sand, as a demonstration. Ask students whether the result is a mixture or a compound. Continue with other demonstrations, as needed.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Display an assortment of elements, mixtures, and compounds. Have students sort, classify, and explain the categories.

Prepare mixtures such as powdered chalk and sugar or powdered iron and salt. Ask the students how these could be separated. Do the same with some compounds. What is the smallest part of a compound? (molecule)

Display elements such as mercury, gold, iodine, lead, etc. Ask the students how they can be separated. What is the smallest part of an element? (atom)

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

66

Unit Assessment

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

_______ 1. two or more substances put together in which no chemical reaction takes place

_______ 2. a substance that cannot be broken down into a simpler form and from which other substances may be made

_______ 3. the lightest of all elements

_______ 4. the means by which a chemist tells how two or more elements combine to make a compound

_______ 5. the substance formed when two or more elements combine chemically

_______ 6. the letters used by scientists to represent the names of the elements

_______ 7. the element involved in burning and rusting

A. compound

B. element

C. formula

D. hydrogen

E. mixture

F. oxygen

G. symbols

Use the list below to complete the following statements.

120	**mixture**
compound	**solid**
elements	**substances**
liquid	**water**

8. There are about ____________________ different kinds of elements.

9. All substances are made from ____________________.

10. Gold is an example of a ____________________ element.

11. Mercury is an example of a ____________________ element.

12. Chemical changes produce new ____________________.

13. Hydrogen and oxygen combine to form ____________________.

14. If you shake a container of iron and sulfur, you form a ____________________.

Use a periodic table supplied by your teacher to write the **symbol** *for each* **element** *on the line provided.*

C	**Au**	**Ag**	**H**	**O**	**Cu**	**Al**	**Hg**	**Fe**

__________ 16. copper

__________ 17. aluminum

__________ 18. iron

__________ 19. mercury

__________ 20. oxygen

__________ 21. hydrogen

__________ 22. silver

__________ 23. carbon

__________ 24. gold

Keys

Practice (p. 119)

1.	carbon	6
2.	gold	79
3.	silver	47
4.	mercury	80
5.	copper	29
6.	iron	26
7.	hydrogen	1
8.	oxygen	8
9.	aluminum	13

Lab Activity: Part 1 (p. 120)

2. a. no
   b. no
   c. yes
3. a. yes
   b. mixture

Lab Activity: Part 2 (p. 121)

6. a. no
   b. no
   c. no
   d. yes
   e. compound
   f. sulfur; iron

Practice (pp. 122-123)

1. element
2. 120
3. elements
4. Answers will vary but may include one of the following: aluminum, carbon, copper, gold, or silver.
5. liquid
6. Chemical
7. laboratories
8. gold
9. copper
10. carbon
11. aluminum
12. silver
13. oxygen
14. hydrogen
15. mercury

Practice (p. 124)

1. True
2. False
3. False
4. True
5. False
6. True
7. False
8. True
9. False
10. True

Unit Assessment (pp. 53-55TG)

1. E
2. B
3. D
4. C
5. A
6. G
7. F
8. 120
9. elements
10. solid
11. liquid
12. substances
13. water
14. mixture
15. compound
16. Cu
17. Al
18. Fe
19. Hg
20. O
21. H
22. Ag
23. C
24. Au

70

Unit 8: Chemical Equations

Overview

In this unit students will learn to identify chemical formulas and equations. Both sides of the equations balance because of the law of conservation of mass.

Purpose

Explain the law of conservation of mass.

Student Goals

1. Recognize the difference between a chemical formula and a chemical equation.
2. Identify a simple balanced chemical equation.
3. Identify chemical equations that are examples of the law of conservation of mass.
4. Cite evidence, determined from an experiment using chemical equations, to support the law of conservation of mass.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Discuss some common chemical changes (reactions). List the reactants and products. Have student teams supply formulas and equations.

Provide a matching activity on the chalkboard with the left and right side of equations in scrambled order. Have students determine the correct pairs.

Let students work on the computer with appropriate software.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Use concrete materials to represent the number of atoms on each side of the equation. Have students count to verify the law of conservation of mass.

Provide a list of equations that are not all balanced. Have students identify correct and incorrect equations.

Practice writing chemical formulas and equations.

Provide sample equations and have students read or write them in words.

Compare the similarities in recipes to formulas. Ask students to "balance" recipes by changing either the ingredients or yield. Let students demonstrate recipes.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

2	formula	symbols
3	NaCl	subscript
atoms	symbol	

1. Scientists use ______________________ to stand for the names of elements.

2. **Fe** is the ______________________ for iron.

3. A ______________________ is the shorthand way to write the name of a compound.

4. A ______________________ tells what elements are in a compound.

5. ______________________ is the formula for sodium chloride (table salt).

6. **H_2O** is the ______________________ for water.

7. The small number after the **H** in H_2O is called a ______________________ .

8. A subscript tells how many ______________________ of the element are contained in the compound.

9. There are ________________ atoms of hydrogen in the formula H_2O.

10. There are ________________ atoms in a molecule of water (H_2O).

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

balance	**coefficient**	**equation**	**yields**

11. A chemical ______________________ describes a chemical reaction.

12. The $\longrightarrow$ stands for "makes" or ______________________ .

13. $2Na + Cl_2 \longrightarrow 2NaCl$ is an example of a chemical

______________________ .

14. In an equation, the left side must equal or ______________________ the right side.

15. A ______________________ tells how many molecules of an element are needed to balance the equation.

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

__________ 16. During a chemical reaction, matter can be lost or destroyed.

__________ 17. All equations must balance.

__________ 18. Mass cannot be created during a chemical reaction.

__________ 19. The law of conservation of mass states that mass cannot be made or lost.

__________ 20. When iron rusts, no mass is lost.

Match each **formula** *to its* **equation** *by writing the correct letter on the line provided.*

21. $C + O_2 \longrightarrow$	________	A.	$NaCl$
22. $2H_2 + O_2 \longrightarrow$	________	B.	CO_2
23. $2Na + Cl_2 \longrightarrow$	________	C.	H_2O
24. $H_2 + Cl_2 \longrightarrow$	________	D.	HCl
25. $Mg + Cl_2 \longrightarrow$	________	E.	$MgCl_2$

Balance the following **equations** *on the line provided.*

26. $H_2 + Cl_2 \longrightarrow HCl$ ____________________

27. $C + H_2 \longrightarrow CH_4$ ____________________

28. $CH_4 + 2O_2 \longrightarrow CO_2 + H_2O$ ____________________

Keys

Practice (pp. 133-135)

I. Chemical formulas

A. 1. symbols
   2. elements

B. 1. NaCl
   2. water

C. 1. a number in a chemical formula that tells how many atoms of an element are in a molecule
   2. a. subscript
      b. atoms

II. Chemical equations

A. a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas

B. 1. chemical equation

C. 1. equal
   2. 2

D. 1. molecules
   2. coefficient

E. 1. created
   2. Answers may vary.

Lab Activity (pp. 136-139)

Balancing an Equation
Diagram 1

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

_2_ H atoms + _2_ O atoms → _2_ H atoms + _1_ O atoms

Total atoms _4_ → Total atoms _3_

Does this equation balance? ☐ yes ☑ no

3. a. 2
   b. 2
   c. 4
   d. 2
   e. 1
   f. 3
   g. no
   h. no

Balancing an Equation
Diagram 2

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

_4_ H atoms + _2_ O atoms → _4_ H atoms + _2_ O atoms

Total atoms _6_ → Total atoms _6_

Does this equation balance? ☑ yes ☐ no

9. a. 4
   b. 4
   c. yes
   d. 2
   e. 2
   f. yes
   g. yes

Balancing an Equation
Diagram 3

_2_ H_2 + ___ O_2 → _2_ H_2O

Does this equation balance? ☑ yes ☐ no

11. c. 1. yes
       2. no
       3. no

13. $2H_2 + O_2 \rightarrow 2H_2O$

Practice (p. 140)

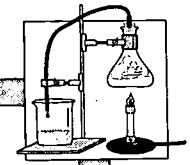
1. formula
2. equation
3. yields
4. subscript
5. subscript
6. coefficient
7. balanced
8. balance
9. conservation of mass
10. compound

Keys

Unit Assessment (pp. 61-63TG)

1. symbols
2. symbol
3. formula
4. formula
5. NaCl
6. formula
7. subscript
8. atoms
9. 2
10. 3
11. equation
12. yields
13. equation
14. balance
15. coefficient
16. False
17. True
18. True
19. True
20. True
21. B
22. C
23. A
24. D
25. E
26. $H_2 + Cl_2 \longrightarrow 2HCl$
27. $C + 2H_2 \longrightarrow CH_4$
28. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_20$

77



Unit 9: Solutions and Suspensions

Overview

In this unit students will learn to differentiate between a solution and a suspension.

Purpose

Identify solutions and suspensions and their properties.

Student Goals

1. Identify solutions and suspensions from given samples.
2. List ways to separate the two types of mixtures as demonstrated through laboratory activities.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Dissolve a spoonful of sugar in a glass of water. Ask the students how to separate the two. Identify the solute (sugar), solvent (water), and solution.

Compare the solubility of salt and sugar. (The solubility of sugar is much greater.) Discuss the reasons for this.

Discuss dilute, concentrated, and saturated solutions.

The problem of water pollution is related to the ability of water to dissolve almost everything. (Water is called the universal solvent.) Have students collect articles or pictures from the local newspaper or take photographs of local water pollution problems. Discuss the problems and solutions.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Set a glass of cold water on the desk. As it warms up, bubbles will collect on the sides of the glass. Discuss the solubility of gases in liquids. Use carbonated beverages as examples, too.

Compare the speed at which a solute dissolves with the temperature of the solvent.

Collect some lake or river water and put it in a clear, glass jar. Observe suspended matter. Discuss organic and inorganic matter found in water. Discuss "mineral water."

Put tap water in an evaporating dish. Place a watch glass over it and bring to boiling; let water evaporate. After the water has evaporated, look at the watch glass. Repeat using distilled water. Compare observations.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

______	1. passed through a filter	A. filter
______	2. a mixture of two or more substances that is homogenous	B. filtered
______	3. a material or a device that allows certain things to pass through while stopping others at the same time	C. heterogeneous
______	4. the part of the solution that does the dissolving	D. homogeneous
______	5. a liquid mixture in which the parts dissolve, or become a part of the solution, and spread out evenly	E. liquid solution
______	6. the parts are different and do not mix evenly	F. solute
______	7. mixed evenly; the same throughout	G. solution
______	8. the substance that has dissolved in a solution	H. solvent
______	9. occurs everywhere	I. suspension
______	10. two or more substances that form a cloudy mixture	J. universal

Use the list below to complete the following statements.

clear	**dissolved**	**homogeneous**	**solute**
cloudy	**filtering**	**liquid**	**solvent**

11. A liquid solution has one substance ____________________ into another substance.

12. A ____________________ will dissolve another substance.

13. Salt water is an example of a ____________________ solution.

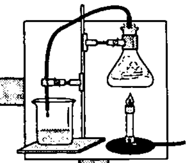
14. A liquid solution is ____________________.

15. Sugar will dissolve in water and is termed a ____________________.

16. When a mixture is evenly mixed and the same throughout, it is ____________________.

17. A suspension is ____________________.

18. A suspension can be separated by the ____________________ process.



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

__________ 19. Water is a common solvent.

__________ 20. Salt water is a homogeneous solution.

__________ 21. Clay water is a heterogeneous solution.

__________ 22. A solution will settle out.

__________ 23. A suspension will settle out.

__________ 24. Solutions can be separated by filtering.

__________ 25. Suspensions can be separated by filtering.

26. In the lab activity, you mixed salt and water to form salt water. Fill in the chart below, placing each of the **substances** under the correct category. Use the following three items: salt, water, salt water

SOLVENT	SOLUTE	SOLUTION

Answer the following using short answers.

27. Name one homogeneous mixture you've observed or know of at home.

    ____

28. Name one heterogeneous mixture you've observed or know of at home.

    ____

Keys

Practice (pp. 147-148)

1. homogeneous
2. heterogeneous
3. liquid
4. solute
5. universal
6. solvent
7. solution
8. filter
9. filtered
10. suspension

Practice (p.149)

1. False
2. False
3. True
4. False
5. False
6. True
7. True
8. False
9. True
10. False

Lab Activity (pp. 150-151)

3. a. clear
   b. cloudy
   c. the first one (salt water)
   d. the second one (clay and water)
5. a. no
   b. yes
   c. suspension
6. a. no
   b. no
7. a. yes
   b. yes

Practice (p. 152)

1. Answers will vary.
2. No. Filtering does not separate the parts of a solution.
3. sugar, honey, etc.
   a. solution
   b. homogeneous

Practice (pp. 153-154)

1. a
2. a
3. b
4. b
5. b
6. a
7. a
8. b
9. b
10. a
11. b
12. b

Practice (p. 155)

solvent	solute	solution	suspension
A. water	salt	saltwater	
B. water	sugar	sugar water	
C.			√

Practice (p. 156)

1. True
2. False
3. False
4. True
5. False
6. False
7. True
8. False

Keys

Unit Assessment (pp. 69-72TG)

1. B
2. G
3. A
4. H
5. E
6. C
7. D
8. F
9. J
10. I
11. dissolved
12. solvent
13. liquid
14. clear
15. solute
16. homogenous
17. cloudy
18. filtering
19. True
20. True
21. True
22. False
23. True
24. False
25. True
26. **solvent** - water
    solute - salt
    solution - salt water
27. Answers will vary.
28. Answers will vary.

Unit 10: Acids, Bases, and Salts

Overview

In this unit students will learn the difference between an acid and a base. They will also learn that when an acid and a base are mixed, neutralization takes place, forming water and a salt.

Purpose

Identify acidic, basic, and neutral solutions. State the properties of each.

Student Goals

1. Identify a given solution as acidic, basic, or neutral.
2. Differentiate between a concentrated solution and a diluted solution.
3. Name two types of indicators used to identify acids, bases, and neutral solutions.
4. Recognize that neutralizations involve ions.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Test some foods with litmus paper to determine acidic, basic, or neutral properties. Compare fresh milk to soured milk. Test combinations of foods.

Do a classroom demonstration with baking powder and water. Baking powder contains a base (sodium bicarbonate) and a weak acid. The acid reacts slowly with the sodium bicarbonate in the presence of water to produce a salt, water, and carbon dioxide.

Caution: Students should use extreme care when handling acids and bases. Never use the "taste" test.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Have students identify some acidic solutions in the home such as orange juice, lemon juice, carbonated beverages, and vinegar. Bring in a list of products found and discuss their properties and uses.

Use litmus paper to test some foods to determine if the properties are acidic, basic, or neutral.

Write a message on a piece of paper using very dilute sulfuric acid as ink and a glass stirring rod as a pen. Carefully heat the paper after the message dries and discover what happens.

Discuss the importance of household chemistry. For example, do not mix bleach and ammonia because the combination forms a poisonous gas.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

______	1. the process of mixing an acid with a base	A.	acid
______	2. a liquid indicator for the presence of a base	B.	base
______	3. any of a group of compounds that produce H^+ ions when dissolved in water	C.	concentration
______	4. to weaken the solution	D.	dilute
______	5. a solution that is neither an acid nor a base	E.	indicator
______	6. the amount of solute per unit of solution	F.	litmus paper
______	7. a chemical that will change color in acids or bases	G.	neutralization
______	8. any of a group of compounds that are formed from a metal and nonmetal ionically bonded	H.	neutral solution
______	9. any of a group of compounds that produce OH^- ions when dissolved in water	I.	phenolphthalein
______	10. a type of paper used to indicate the presence of acids or bases	J.	salt

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

__________ 11. Citric fruits contain citric acid.

__________ 12. Many acids are poisonous. You should never taste a solution to see if it contains an acid.

__________ 13. The litmus and the metal tests will only work on acids that are dissolved in water.

__________ 14. 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.

__________ 15. Both acids and bases can burn the skin.

__________ 16. Acids wear away metals.

__________ 17. Acids can be harmful.

__________ 18. Phenolphthalein will stay clear in an acid solution.

__________ 19. Phenolphthalein will turn blue in a basic solution.

__________ 20. The products of any neutralization include water and sodium chloride.

Use the list below to complete the following statements.

bitter	**diluted**	**salt**
blue	**ions**	**sour**
color	**red**	

21. Acids have a ________________________ taste.

22. Bases have a ________________________ taste.

23. An acid will turn blue litmus paper ________________________.

24. A base will turn red litmus paper ________________________.

25. Blue litmus paper will not change ________________________ in a basic solution.

26. The strength or power of a solution can be ____________________ to make it less powerful.

27. Neutralization will form a ________________________ and water.

28. The salt formed in a neutralization is the product the ________________________ created when the base and acid were dissolved.

Answer the following using short answers.

29. What are two types of indicators used to identify acids, bases, and neutrals?

____

____

30. Does distilled water contain an acid or a base or is it neutral?

____

sour milk? ____

milk of magnesia? __________________________________

Keys

Practice (pp. 165-166)

1. ion
2. neutral solution
3. indicator
4. phenolphthalein
5. litmus paper
6. acid
7. base
8. concentration
9. dilute
10. salts
11. neutralization

Practice (p. 167)

Acid	Chemical Formula	Where It Is Found
hydrochloric acid		
	$C_3H_6O_3$	sour milk
boric acid		
	H_2SO_4	
		vinegar

1. H_2SO_4
2. boric
3. vinegar
4. boric acid
5. Hydrochloric acid

Practice (p. 168)

Property	Acids	Bases
		blue
	corrode	
		dark pink
	sour	
	H^+	OH^-

opposite

Lab Activity (pp. 169-170)

2. a. no
3. a. yes
4. a. base
6. a. no
   b. no
   c. neutral
7. a. neutral
   b. See chart below.

no	yes	—		x	
yes	no	—	x		
no	no	yes			x
no	no	yes			x

Practice (p. 171)

1. Answers will vary.
2. Answers will vary.
3. When acids and bases react, water and a salt are produced. This reaction reduces the amount of acid in the stomach.

Practice (p. 172)

1. B
2. A
3. add water
4. decrease

Practice (p. 173)

1. False
2. True
3. False
4. True
5. True
6. False
7. True
8. True

92

Keys

9. True
10. True
11. False
12. True

Practice (pp. 174-175)

1. hydrogen; oxygen
2. bitter
3. base
4. Deodorants
5. slippery
6. burn
7. red
8. blue
9. color
10. Phenolphthalein
11. clear
12. salt; water
13. pink

Practice (p. 176)

1. a solution in which there are no H^+ or OH^- ions
2. to have a base and an acid react and form water
3. base
4. Baking soda
5. Antacids
6. salt; water
7. metal; nonmetal
8. neutral

Unit Assessment (pp. 77-80TG)

1. G
2. I
3. A
4. D
5. H
6. C
7. E
8. J
9. B
10. F
11. True
12. True
13. True
14. True
15. True
16. True
17. True
18. True
19. False
20. False
21. sour
22. bitter
23. red
24. blue
25. color
26. diluted
27. salt
28. ions
29. Any two of these three answers litmus paper, phenolphthalein, metal test are correct.
30. distilled water - neutral
    sour milk - acid
    milk of magnesia - base

Unit 11: Chemical Reactions

Overview

Students will learn about the factors that control and affect chemical reactions. They will learn to represent the configurations of electrons for atoms and compounds and learn how this configuration determines what reactions are possible. Students are introduced to some concepts in biochemistry and are shown how biochemical reactions follow other chemical laws.

Purpose

Understand the importance of electrons to all aspects of chemical reactions. Predict how other physical factors (concentration, pressure, etc.) affect the rates of reactions. Correlate the chemistry of living organisms to that of inorganic systems.

Student Goals

1. Know that electron configuration in atoms determines how a substance reacts and how much energy is involved.

2. Explain how physical factors affect the rates of reactions.

3. Determine the electron dot structures for selected atoms and molecules and discuss how the electrons determine what type of bond is formed.

4. Know that it is diversity in the bonds between atoms that determine the properties of molecules.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Compare the physical structure of puzzles, building blocks, and locks and keys to the electron structures of atoms. Have students develop puzzle-piece electron dot models of some atoms to aid in predicting bonds.

View a video on DNA or use software that allows students to view the complexity of a molecule based on a few base pairs. Explain how the electron configurations of those pairs determines their qualities.

Perform electrolysis on water. Ask the students to use their equation balancing abilities to predict the quantities of gases produced (two times as much hydrogen as oxygen). Ignite the hydrogen, and ask the students to make predictions about this. Ask them where the product of the reaction (water) went and why.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Perform simple reaction experiments with reagents that have been refrigerated and compare those to the same reactions at room temperature.

Discuss how automobiles make use of the various physical factors that affect reactions. Ask the students to make predictions about the car's performance given hypothetical problems with engine, fuel, and thermostat problems.

Have students go to the library to research various topics in biochemistry or organic chemistry. Ask them to write a paper that compares their findings with what they have learned in this unit.

Assign the students to teams. Have each team construct a three-dimensional model of one or two atoms and show how the electron configurations of each determines the physical shape of the molecule. Ask them to make predictions about the properties of molecules.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

Use the list below to complete the following statements.

biochemical	eight	ionic	recombined
catalyst	electron	organic	shared
concentration	four	pressure	valence
configuration	increases		

1. ________________ configuration determines how an atom will react as well as how much energy is involved in the reaction.

2. Hydrogen and helium can have no more than two electrons in their outermost shells. The other atoms can have no more than ________________ electrons in their outermost shells.

3. The electrons involved in reactions are those farthest from the nucleus and are known as ________________ electrons.

4. Electron dot structures are models that show the ________________ of electrons around an atom's nucleus.

5. The word covalent describes the bonds created when electrons are ________________ .

6. When an atom has ________________ or more electrons, it is likely to gain electrons in chemical reactions.

7. ________________ bonds are formed between atoms when electrons are not shared.

8. Another word for describing the amount of force a substance applies to a surface is ____________________ .

9. Car engines increase the forces acting on gases, and this ____________________ the rate of the reaction between the gases.

10. One way to increase the rate of a reaction or lower the temperature at which it occurs is to introduce a ____________________ to the reaction.

11. When allowing chemicals in solutions to react, the rate can be decreased by lowering the ____________________ of the chemicals.

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

13. One similarity between all ____________________ compounds is that they contain carbon.

14. DNA, like other organic chemicals in the body, has been combined and ____________________ in many ways, and it is this that has allowed it to be very complex.

Answer the following using complete sentences.

15. Krypton has eight electrons in its valence shell and is symbolized as Kr. Draw its electron dot structure and predict how and why krypton reacts with other elements.

16. Discuss why sealing a pot's lid causes food to cook more quickly.

17. There are only four compounds in all of your DNA. Every creature on Earth has the same four compounds in its DNA. Explain how it is possible for DNA to be made from such simple compounds but still create enormous complexity.

Keys

Practice (pp. 188-189)

1. They determine how substances will react and how much energy will be involved.
2. the arrangement of electrons
   Example: Answers will vary.
3. electron configuration
   Example: Answers will vary.
4. hydrogen and helium
5. eight
   Elements can have no more than eight valence electrons.
6. covalent bond
7. ionic bond
8. The arrangement of electrons in molecules and atoms.
9. It would increase the speed of the reaction.
10. The rate or speed might increase, the reaction might take place at a lower temperature or pressure.
11. biochemical
12. carbon
13. body functions
14. combine; recombine

Practice (p. 190)

	structure	react	not react
1. helium	He		√
2. sodium	Na	√	
3. calcium	·Ca	√	
4. argon	:Ar:		√
5. krypton	:Kr:		√
6. carbon	·C·	√	

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

Lab Activity (pp.191-192)

9. Flask B
11. Flask B
12. See chart below.

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

13. The greater the concentration, the greater the speed of the reaction.

Practice (pp. 193-196)

1. electrons
2. two
3. valence
4. eight
5. Electron dot configuration
6. covalent
7. Ionic bonds
8. force
9. increase
10. catalyst
11. concentration
12. biochemical
13. carbon
14. recombine
15. Refrigeration slows down reaction (other answers may vary).
16. Helium's electron configuration means it will not combine with other elements.
17. Reaction rate increases as pressure on the gases increase.
18. Increasing concentration of substance increase the rate of the reaction.

Keys

Unit Assessment (pp. 85-87TG)

1. Electron
2. eight
3. valence
4. configuration
5. shared
6. four
7. Ionic
8. pressure
9. increases
10. catalyst
11. concentration
12. biochemical
13. organic
14. recombined
15. :K̈:

    Because it has eight valence electrons, it cannot react with other elements. It can form no bonds.
16. Sealing the lid will raise the pressure and the temperature. When these increase, the rate of the reaction (cooking) will increase.
17. DNA, like other organic compounds can be combined in various ways. Once combined, it can be reorganized (that is, recombined) to form vastly complex strings of a molecule.

Unit 12: Energy, Work, Force, and Power

Overview

In this unit students will learn that energy is the ability to do work. They will learn the relationship among energy, work, force, and power. Two kinds of energy—potential and kinetic energy—are described.

Purpose

Describe the relationships among energy, work, force, and power.

Student Goals

1. Define energy, work, force, and power.
2. Distinguish between potential energy and kinetic energy by citing examples of each.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Discuss work, energy, and power in the technical sense. Give common examples of *work* such as climbing stairs, lifting an object, getting up from a seated position, etc. Stress the idea that motion must be involved for work to take place. One formula for work is W = f x d. If there is no motion, there is no work.

Does sitting and reading your textbook in the class or at home constitute work? Not in the scientific sense because there is no force or motion. Does walking require work? How does walking compare to running? What if a hill is involved?

The rate at which *work* is done is called *power*. The formula for *power* is power = work ÷ time. Calculate several examples with students on the amount of work done and the amount of power. The unit of power in the metric system is the *watt* (W) and the *kilowatt* (kW). One horsepower equals about ¾ kW. Discuss *horsepower* and relate to various motors found around the house or in a garage.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Explain or demonstrate, if possible, how water can do work. Talk about a dam holding back water. When the water is released and falls through pipes to hit turbine blades, kinetic energy is changed to mechanical energy. The turbine blades turn, thus changing mechanical energy to electrical energy to do work in our homes and factories.

Visit a dam or power plant near your school. Discover the use and operation of the dam or power plant and how it serves your community.

Have students describe the various kinds of energy needed in a moving car. The kinetic energy of the car comes from burning fuel, which is chemical energy converted into heat and mechanical energy. Mechanical energy from the expanding gases is changed, thus moving the car. Assign each step of the process to a different student, and have a group report with visual aids.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

energy	**kinetic**	**power**	**work**
force	**potential**	**stored**	

1. ______________________ is the amount of work that can be done in a given amount of time.

2. Potential energy is ______________________ energy that is waiting to be released.

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

4. ______________________ can be defined as the ability to do work.

5. ______________________ is the product of energy.

6. ______________________ energy has not been released.

7. ______________________ energy is energy in motion.

8. Things that are not yet moving or have just stopped moving, have ______________________ energy.

9. Things that are moving have ______________________ energy.

10. Energy can change back and forth between ______________________ and ______________________ energy.

Decide what type of **energy** *each example represents. Write either* **potential** *or* **kinetic** *on the line provided.*

________________ 11. a log on the ground

________________ 12. a hammer striking a nail

________________ 13. a log falling

________________ 14. a large rock on top of a mountain

________________ 15. a hammer lying on a counter

________________ 16. a match in a matchbox

________________ 17. a match being lit

________________ 18. a rock rolling down the side of a mountain

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

19. potential energy: ________________________________

20. kinetic energy: ________________________________

Keys

Practice (p. 203)

1. A. kinetic energy
   B. potential energy
2. A. potential energy
   B. kinetic energy
3. yes

Lab Activity (p. 204)

2. Chart:
   Answers will vary.

Practice (p. 205)

1. C
2. G
3. B
4. E
5. F
6. A
7. H
8. D

Practice (p. 206)

1. P
2. K
3. K
4. P
5. K
6. P
7. P
8. K
9. P
10. K
11. P
12. K

Practice (p. 207)

1. Energy
2. Work
3. Force
4. Power
5. Potential
6. stored
7. Kinetic
8. kinetic
9. potential

Practice (p. 208)

1. Answers will vary.
2. Answers will vary.
3. X
4. W
5. W
6. X
7. W
8. a mule that hauls 100 kilograms across a field in one minute
9. a train that is full of passengers and carries them across the state
10. power

Unit Assessment (pp. 93-94)

1. Power
2. stored
3. Force
4. Energy
5. Work
6. Potential
7. Kinetic
8. potential
9. kinetic
10. potential; kinetic
11. potential
12. kinetic
13. kinetic
14. potential
15. potential
16. potential
17. kinetic
18. kinetic
19. Answers will vary.
20. Answers will vary.

Unit 13: Forms of Energy

Overview

In this unit students will learn that energy can exist in various forms such as mechanical, chemical, electrical, heat, sound, and nuclear. Energy can be converted from one form to another but never created or destroyed.

Purpose

Identify different forms of energy, their sources, and their uses.

Student Goals

1. Explain how energy can be changed from one form to another.
2. Give examples of energy conversion.
3. Explain chemical energy and demonstrate it through laboratory experiences.
4. Describe the sources of nuclear energy, magnetic and electrical forces, and heat, and understand how the laws of thermodynamics are related to all.
5. State that energy cannot be created or destroyed.
6. Discuss the importance of energy to all branches of science and comprehend how the structure of the universe is the result of energy and matter.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Brainstorm ideas about the kinds of energy that are used in our daily lives. All students use heat, magnetism, light, sound, chemical, electrical, and mechanical energy daily. Guide them in the discovery of how and share everyday examples. Discuss the importance of energy and the relevance of the law of conservation of energy.

Differentiate between conservation and conversion of energy. Students could easily confuse these similar terms.

View a documentary film or read books which explain the interactions between energy and matter at both the macro and quantum levels.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Investigate different types of energy: heat, electromagnetic, chemical, electric, mechanical, solar, radiant, and nuclear. Compare and contrast these. Classify and describe various uses for each. Have students find familiar examples and report on these in class.

Ask the students to find out more about renewable and nonrenewable energy sources.

Use the library to research how coal is used to generate electricity today. Have students write a short research paper on the findings.

Investigate the use of solar energy in your community.

Read about nuclear energy and its benefits and dangers.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

______	1. another name for atomic energy	A. atomic energy
______	2. the energy of moving charged particles	B. chemical energy
______	3. the energy of moving molecules	C. electrical energy
______	4. energy that comes from the sun to Earth	D. energy conversion
______	5. the law that energy cannot be made or destroyed, only changed in form	E. heat energy
______	6. the energy that is stored in chemicals	F. law of conservation of energy
______	7. energy caused by the vibration of air	G. light energy
______	8. when energy changes from one form to another	H. mechanical energy
______	9. the energy that is in the nucleus of an atom	I. nuclear energy
______	10. the energy of moving things	J. sound energy

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

__________ 11. Food has chemical energy.

__________ 12. Matter cannot be created or destroyed, but it can change from one form to another.

__________ 13. Energy is the ability to do work or cause motion.

__________ 14. Heat can change a solid to a liquid.

__________ 15. Atomic or nuclear energy can be used to run power plants.

__________ 16. The energy of a hammer is light energy.

__________ 17. Energy exists in only one form.

__________ 18. The mechanical energy of wind can be converted by a windmill to electrical energy.

__________ 19. When energy changes form, some of it is always converted to heat.

__________ 20. Many of the appliances that we use every day run on electrical energy.

Use the list below to complete the following statements with the name of the correct **energy forms** *to show the conversion. One or more terms will be used more than once.*

atomic	**electrical**	**light**	**nuclear**
chemical	**heat**	**mechanical**	**sound**

21. When you saw a piece of wood, the blade of the saw is hot.

    You have converted the ____________________ energy into ____________________ energy.

22. A radio converts ____________________ energy into ____________________ energy.

23. When you strike a match ____________________ energy is changed to ____________________ and ____________________ energy.

24. Some power plants convert ____________________ or ____________________ energy to ____________________ energy.

25. Turning on an electric mixer will convert ____________________ energy into ____________________ energy.

26. When you play the banjo, ____________________ energy is changed to ____________________ energy.

27. The muscles in our body change the ______________________

energy of food into ______________________ energy.

28. When you light a candle, ______________________ energy is

changed to heat and ______________________ energy.

Keys

Practice (pp. 216-217)

1. work; change
2. mechanical, electrical, chemical, heat, light, sound, and atomic or nuclear
3. mechanical
4. light
5. chemical
6. heat
7. electrical
8. sound
9. atomic; nuclear
10. converted
11. heat
12. fundamental

Practice (p. 218)

1. electrical; mechanical
2. chemical; light
3. mechanical; sound
4. chemical; heat
5. mechanical; sound

Lab Activity (pp. 219-220)

5. a. yes
   b. yes
   c. It blew off.
   d. yes
6. a. no
   b. yes
   c. chemical energy
   d. yes
7. Chemical; released
8. When energy changes form, some is always released as heat.

Practice (p. 221)

1. mechanical energy
2. atomic energy
3. electrical energy
4. sound energy
5. nuclear energy or atomic energy
6. light energy
7. chemical energy
8. heat energy

Practice (pp. 222-223)

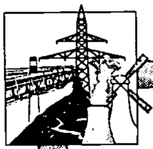
1. heat; light
2. electrical
3. heat or sound
4. mechanical or heat
5. sound
6. heat; light
7. atomic; nuclear
8. mechanical
9. sound
10. mechanical

Practice (p. 224)

1. Heat
2. liquid
3. gas
4. heat
5. heat
6. any change in the type of energy.
7. that energy can change form but not be created nor destroyed.

Practice (p. 225)

1. I
2. D
3. F
4. E
5. H
6. C
7. J
8. A or I
9. B
10. G



Keys

Practice (p. 226)

1. True
2. True
3. True
4. True
5. True
6. False
7. False
8. True
9. True
10. True

Practice (pp. 227-228)

1. chemical; light
2. mechanical; sound
3. atomic or nuclear; electrical
4. electrical; mechanical
5. electrical; sound
6. chemical; heat or mechanical
7. mechanical; heat
8. chemical; heat; light

Unit Assessment (pp. 99-102TG)

1. I
2. C
3. E
4. G
5. F
6. B
7. J
8. D
9. A or I
10. H
11. True
12. True
13. True
14. True
15. True
16. False
17. False
18. True
19. True
20. True
21. mechanical; heat
22. electrical; sound
23. chemical; heat; light
24. atomic or nuclear; electrical
25. electrical; mechanical
26. mechanical; sound
27. chemical; heat or mechanical
28. chemical; light

Unit 14: Forces and Motion

Overview

In this unit students will learn Isaac Newton's three laws of motion. Motion, friction, gravity, and inertia will be described.

Purpose

Explain how force and motion are related.

Student Goals

1. Define gravity, friction, weight, resistance, and inertia and give examples of each.
2. Describe how acceleration due to gravity varies with mass and distance.
3. Describe the advantages and disadvantages of friction.
4. State how friction can be reduced.
5. Give examples of Newton's three laws of motion.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Bring two stones of different sizes and weights to class. Drop them at the same time from the same height. Observe the speed with which they fall. Drop a tennis ball and a piece of paper. Observe. Ask the students to explain what they saw. Crumple the paper, and repeat the drop. Ask the students if their hypotheses supported the results.

Inflate a balloon. Release the air as you suddenly let go of the balloon. Talk about Newton's third law.

Place a coin on top of an index card and place the card on top of a glass. Flick away the card by releasing your index finger from your thumb. Compare what happens to the coin with what happens when you pull the card slowly off of the glass. Discuss inertia.

Reinforcement

Provide other opportunities for practice and hands-on activities.

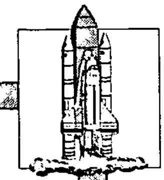
Have students investigate how race cars are designed recognizing the second law of motion.

Research the various kinds of friction and explain or illustrate with examples of each. Have students make reports and demonstrate or show illustrations. Kinds of friction include: static friction, sliding friction, rolling friction, and fluid friction. Give examples of why friction is important to us (e.g., stopping a car, walking).

Follow news reports on current space vehicles. Relate these space vehicles to Newton's third law. Use examples to illustrate momentum.

Discuss the principles of friction and how they are related to an automobile (e.g., tires, oil, design, etc.).

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.



Unit Assessment

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

______ 1. the laws that state the relationship between force and motion

______ 2. the tendency of an object to keep its present state of motion

______ 3. any push or pull

______ 4. the attraction of matter toward another body of matter

______ 5. when opposing forces are equal and do not cause movement

______ 6. when one force overpowers another force; the forces are not equal

______ 7. speed in a definite direction

______ 8. the measure of the force of gravity

______ 9. a type of resistance caused when one surface touches another surface

______ 10. the SI unit of force

______ 11. any change in speed or direction

______ 12. the abbreviation for newton

______ 13. any force that prevents or slows down motion

______ 14. the greasing of surfaces that rub against each other in order to reduce friction

A. acceleration

B. balanced

C. force

D. friction

E. gravity

F. inertia

G. laws of motion

H. lubrication

I. N

J. newton

K. resistance

L. unbalanced

M. velocity

N. weight

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

__________ 15. A force is any push or pull on an object.

__________ 16. All forces are equal.

__________ 17. Forces are responsible for motion.

__________ 18. Balanced forces are equal and do not cause movement.

__________ 19. If one force overpowers another force, we would say that the forces are unbalanced.

__________ 20. Unbalanced forces cause an object to move.

__________ 21. About 300 years ago, Isaac Newton described the force of gravity.

__________ 22. Sir Isaac Newton developed three laws of motion.

__________ 23. Friction is a type of force that makes objects move easier.

__________ 24. Friction produces heat.

__________ 25. Lubrication will increase the force of friction.

__________ 26. Oil and grease are types of lubricants.

__________ 27. According to Isaac Newton, every object remains at rest or moves in a straight line until an outside object acts on it. This is called inertia.

_________ 28. As the mass of an object increases, the force of gravity on it does not change.

_________ 29. As the distance between two objects doubles, the force of gravity between them is reduced in proportion to the square of the distance.

_________ 30. Newton's third law of motion stated there is not always an equal and opposite reaction for every action.

Keys

Practice (pp. 237-238)

1. d
2. b
3. d
4. b
5. a
6. a
7. c
8. C
9. A
10. B

Practice (pp. 239-241)

1. push; pull
2. equal; movement
3. unbalanced
4. move
5. Gravity
6. Sir Isaac Newton
7. mass; far; Earth
8. increases; decreased
9. Weight
10. newton (N)
11. N
12. resistance
13. Friction
14. slow down
15. heat
16. Rough
17. Lubrication
18. three
19. force
20. Inertia
21. speed; force
22. acceleration; size
23. faster
24. direction
25. do not
26. action; reaction

Lab Activity (pp. 242-243)

1. a. yes
   b. yes
   c. friction
   d. yes
2. a. easier
   b. friction
   c. soap
   d. lubricant
   e. friction

Practice (pp. 244-245)

1. Answers will vary.
2. The moon has only ⅙ Earth's mass, and therefore can exert less force.
3. Drawings will vary.
   first law of motion (inertia)
   third law of motion (action and reaction)
   The second trip was easier. More force made the trip easier.
   second law of motion
4. Yes, because I would be farther from Earth. As you move away, the force of gravity decreases.
   Yes, because the force of gravity increases as the mass of the objects increase.

Practice (p. 246)

1. B
2. F
3. A
4. E
5. L
6. K
7. I or H
8. D
9. H
10. C
11. J
12. G

Keys

Practice (pp. 247-248)

1. no
2. yes
3. balanced force
4. unbalanced force
5. weight
6. newton (N)
7. yes
8. resistance
9. friction
10. yes
11. yes
12. lubrication
13. oils and greases (water is acceptable)
14. Sir Isaac Newton
15. The tendency of an object to keep its present state of motion.

Practice (p. 249)

1. First law of motion: objects tend to remain at rest, or move in a straight line, until outside forces act on them
2. Second law of motion: the motion of an object is set by the size of the force acting on it
3. Third law of motion: for every action there is an equal and opposite reaction

Unit Assessment (pp. 107-109TG)

1. G
2. F
3. C
4. E
5. B
6. L
7. M
8. N
9. D
10. J or I
11. A
12. I
13. K
14. H
15. True
16. False
17. True
18. True
19. True
20. True
21. True
22. True
23. False
24. True
25. False
26. True
27. True
28. False
29. True
30. False

Unit 15: Machines

Overview

In this unit students will learn the function of machines. There are six simple machines. These may be combined to make compound machines. Efficiency and mechanical advantage will be discussed.

Purpose

Explain how machines are used to perform work.

Student Goals

1. List simple machines and define their functions.
2. Define a compound machine and give at least two examples.
3. Define efficiency.
4. Design a simple experiment to determine mechanical advantage.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Use a bottle opener to demonstrate a simple machine—a first-class lever or a second-class lever.

Display a bicycle and discuss all the simple machines that make up the bicycle.

Observe derricks, cranes, or tow-cars in action, if possible. Have students draw and label the block-and-tackle machinery.

Reinforcement

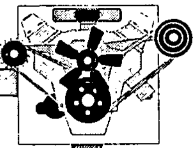
Provide other opportunities for practice and hands-on activities.

Have students bring in pictures of machines. Identify the simple machines that make up the compound machines.

Compare actual mechanical advantage (AMA) and ideal mechanical advantage (IMA). Work problems in class.

Discuss how machines rely on the concept of action/reaction. Identify the sources of the energy used by machines.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.



Unit Assessment

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

_____ 1. a wheel with a grooved rim that rotates on a rod called an axle

_____ 2. a flat surface that has been raised at one end

_____ 3. a simple machine with an inclined plane that winds around a center

_____ 4. the number of times a force is multiplied by a machine

_____ 5. the measure of work input to work output

_____ 6. an opposing force

_____ 7. machines built by putting two or more machines together

_____ 8. a type of inclined plane with sloping sides that come to a point

_____ 9. a simple machine consisting of a large wheel rigidly attached to a smaller one

_____ 10. amount of force

_____ 11. any device that makes work easier by changing speed, direction, or strength of a force

_____ 12. a rigid bar that moves around a point

A. compound machines

B. efficiency

C. effort

D. inclined plane

E. lever

F. machine

G. mechanical advantage

H. pulley

I. resistance

J. screw

K. wedge

L. wheel and axle

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

________ 13. Early man had to depend on his own body to do any form of work.

________ 14. Machines help us perform very hard jobs.

________ 15. A machine cannot increase the amount of energy; it can only transfer energy.

________ 16. A compound machine is made from a combination of simple machines.

________ 17. Another way to say that a machine increases force is to say that it multiplies force.

Answer the following using short answers.

18. What are the six simple machines? ________________________

____

____

____

____

19. What are two examples of a compound machine? ____________

____

____

____

Use the list below to complete the following statements.

block and tackle	**gentle**	**steep**	**work output**
fixed	**movable**	**threads**	
fulcrum	**slope**	**work input**	

20. A pulley that does not move, but only changes the direction of the force is called a ____________________ pulley.

21. A pulley that moves and increases force is called a ____________________ pulley.

22. A ____________________ is a system of pulleys.

23. A surface with an upward or downward slant is called a ____________________.

24. A ____________________ slope has an upward slant with a gradual rise.

25. A ____________________ slope has an upward slant with a sharp rise.

26. The inclined plane or ridges on a screw are called ____________________.

27. ____________________ is the amount of work put into a machine.

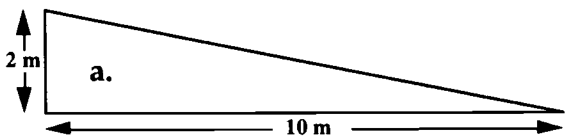
28. ____________________ is the amount of work a machine produces.

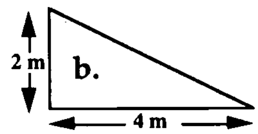
29. A ____________________ is the point about which a lever turns.

Answer the following using short answers.

30. Write the formula for mechanical advantage.________________

31. Find the MA of each of these ramps. (Remember that the effort is to lift an object.)

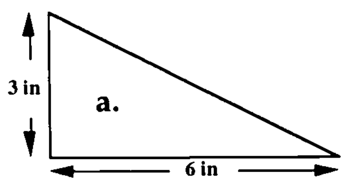


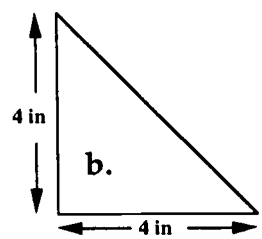


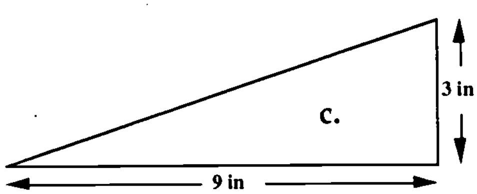
MA =______________.   MA=______________.

32. Which of the following ramps has the smallest mechanical advantage?

____







Explain your answer. ________________________________

____

____

____

Keys

Practice (pp. 262-263)

1. $MA = \frac{1000}{500} = 2$
2. $MA = \frac{600}{200} = 3$
3. $MA = \frac{60}{60} = 1$
4. $MA = \frac{4000}{1000} = 4$
5. $MA = \frac{3000}{1000} = 3$
6. $MA = \frac{R}{E} \quad 3 = \frac{300}{E} \quad E = \frac{300}{3} = 100\ N$

Lab Activity (pp. 264-265)

1. no (Point out to students that they cannot use their fingernails. The fingernails would act as a lever.)
4. a. yes
   b. hard
6. a. yes
   b. easier
   c. yes
7. closer

Practice (p. 266)

1. lever
2. fulcrum
3. resistance
4. effort
5. resistance arm
6. effort arm
7. mechanical advantage

Practice (pp. 267-268)

1. body
2. Machines
3. make a force stronger; change direction; change speed
4. transfer
5. pulley; wedge; inclined plane; lever; screw; wheel and axle
6. lever
7. pulley
8. fixed
9. movable
10. multiplies

Practice (pp. 269-271)

1. b
2. c
3. d
4. a
5. c
6. b
7 d
8. a
9. d
10. c
11. d
12. a

Practice (p. 272)

1. E
2. G
3. I
4. D
5. A
6. F
7. H
8. J
9. B
10. C

Unit Assessment (pp. 115-118TG)

1. H
2. D
3. J
4. G
5. B
6. I
7. A

Keys

8. K
9. L
10. C
11. F
12. E
13. True
14. True
15. True
16. True
17. True
18. lever, pulley, inclined plane, wedge, screw, and wheel and axle
19. Answers will vary.
20. fixed
21. movable
22. block and tackle
23. slope
24. gentle
25. steep
26. threads
27. Work input
28. Work output
29. fulcrum
30. $MA = \frac{\text{resistance}}{\text{effort}} = \frac{R}{E}$
31. $MA = \frac{10}{2} = 5$

    $MA = \frac{4}{2} = 2$
32. b

    The resistance (the horizontal) is equal to the effort (the vertical) and you get no mechanical advantage.

Unit 16: Magnetism

Overview

In this unit students will learn that magnetism is a force that attracts or repels substances. Magnets have north and south poles. Like poles repel; unlike poles attract. Magnets can be created when atoms line up. Heat, hitting, or dropping a magnet will destroy its magnetism. Earth acts like a magnet. A compass helps locate direction by pointing to the magnetic north.

Purpose

Identify sources of electricity and uses of magnetism.

Student Goals

1. Diagram the lines of force for attracting and repelling magnets.
2. Relate magnetic force to Earth.
3. State the law of magnetic poles.
4. Name three ways to make a magnet.
5. Name three ways to demagnetize a magnet.
6. Explain how an electromagnet works, and relate the connection between electricity and magnetism.
7. Understand how to use a compass.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Give students magnets. Let them explore and learn about some of the properties of magnets by discovery.

Demonstrate the magnetic field of a bar magnet using an overhead projector, a bar magnet, iron filings, and a transparency. Place the bar magnet on the overhead projector. Put the transparency over the magnet. Sprinkle the iron filings on top. The magnetic field will be shown when the filings align.

Use a compass to test various steel objects for magnetism.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Make a compass using a magnetized needle pushed through a cork. Float the cork in water.

Some students may wish to build bells and buzzers that operate with electromagnets.

Use the library to research how electricity is generated by magnetism in a generator and explain the process to the class. Ask them to research Michael Faraday.

Display Lenz's law by performing an Eddy experiment. Use a copper tube and two masses. One mass should be a neodymium magnet of a slightly smaller diameter than the inside of the pipe. Drop both masses down the tube and ask the students to predict the results. The magnet will not fall at the same rate. Ask the students to explain what they've seen.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

______	1. an instrument with a magnetized needle that points to the magnetic north	A. compass
______	2. imaginary lines that show a magnetic field	B. demagnetize
______	3. to make into a magnet	C. electromagnet
______	4. the space around a magnet where a force is noticeable	D. lines of force
______	5. a device that creates a magnetic field made by connecting a coil of wire to an electric current	E. magnet
______	6. of or relating to a magnet or magnetism	F. magnetic
______	7. a substance that attracts or pulls on other substances	G. magnetic field
______	8. a property of matter that creates forces that attract or repel certain substances	H. magnetism
______	9. anything that is not attracted to a magnet	I. magnetize
______	10. to remove the magnetic properties of a magnet	J. nonmagnetic

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

attract	**like**	**repel**
compass	**north pole**	**south pole**
induced	**poles**	**unlike**

11. The ends of the magnets are called ______________________ .

12. The end of the magnet that always points to the north (if free to move) is called the ______________________ .

13. The end of the magnet that always points to the south (if free to move) is called the ______________________ .

14. The north pole of one magnet and the north pole of another magnet would be considered ______________________ poles.

15. The north pole of one magnet and the south pole of another magnet would be considered ______________________ poles.

16. Two north poles or two south poles of magnets will ______________________ .

17. A north pole and a south pole of two magnets will ______________________ .

18. The law of magnetic poles states that unlike poles ______________________ and like poles repel.

19. Magnetism that is caused by an object touching or being placed near a magnet is called ________________ magnetism.

20. A ________________ is an instrument that has a magnetized needle that points to the magnetic north.

21. The northern end of Earth's axis is called the

________________.

22. The southern end of Earth's axis is called the

________________.

Answer the following using short answers.

23. What are the two magnetic poles of Earth? ________________

____

____

24. Are the magnetic poles mentioned above the same as the North and South geographic poles of Earth?

____

25. What are three ways to make a magnet? ________________

____

____

____

____

26. What are three ways to demagnetize a magnet? ______________

____

27. How does an electromagnet work? ______________________

____

____

____

____

Keys

Practice (p. 284)

1. attaching a metal object to a magnet; rubbing it with a magnet; using electricity to make an electromagnet
2. heating; hitting; dropping
3. the electrons traveling through the wire induce a magnetic field
4. north magnetic pole; south magnetic pole
5. no
   The actual north magnetic pole is about 800 miles from the north geographic pole.

Lab Activity 1: Part 1 (pp. 285-286)

5. Diagrams will vary.
6. poles
7. middle
8. poles
9. middle

Lab Activity 1: Part 2 (pp. 286-287)

3. a. repel
   b. repel
4. a. attract
   b. attract
6. Diagrams will vary.
9. Diagrams will vary.
10. repel; attract

Lab Activity 2 (pp. 288-289)

5. The end of the needle that was rubbed with the bar magnet.
7. It became magnetized.
8. north and south
9. It has a magnetic attraction to Earth's magnetic north pole.
10. No. The compass needle would not point to magnetic north.

Practice (pp. 290-292)

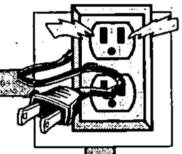
1. magnetism
2. magnet
3. magnetic
4. nonmagnetic
5. poles
6. north pole
7. south pole
8. repel; attract
9. like
10. unlike
11. magnetic field
12. lines of force
13. induced
14. magnetize
15. electromagnet
16. demagnetize
17. North pole
18. South pole
19. magnetic north pole
20. compass

Unit Assessment (pp. 123-126TG)

1. A
2. D
3. I
4. G
5. C
6. F
7. E
8. H
9. J
10. B
11. poles
12. north pole
13. south pole
14. like
15. unlike
16. repel
17. attract
18. attract
19. induced
20. compass

Keys

21. North Pole
22. South Pole
23. magnetic north; magnetic south
24. no
25. place in contact with a magnet; rub with a magnet; make an electromagnet
26. heating; hitting; dropping
27. As electrons flow through a wire, they induce a magnetic field in a core.



Unit 17: Electricity

Overview

In this unit students will learn that electricity is caused by a flow of electrons. Static electricity is caused by (+) or (-) charged materials. Current electricity moves along a path or circuit. A direct current (DC) only moves one way. Alternating current (AC) moves back and forth. A circuit can be either series or parallel. Students will learn that electricity can cause electromagnetic waves to be produced.

Purpose

Describe the general characteristics of electricity.

Student Goals

1. Describe how objects may acquire positive or negative charges, based on experiments with static electricity.
2. Describe how a dry cell produces electricity.
3. Explain how a generator works.
4. Describe the difference between direct and alternating current.
5. List three conductors and three insulators.
6. Explain the difference between static and current electricity.
7. Construct series and parallel circuits.
8. Relate electricity to electromagnetic radiation.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Show how a charged comb attracts and picks up small pieces of paper. You may also try vinyl rubbed with wool or acetate rubbed with cotton.

Students are very familiar with a wide variety of electronic devices (e.g., TV, radio, VCR, camcorder, video games, calculators, computers, telephones, etc.). Knowledge of how this equipment works can be very useful.

Obtain a voltmeter and an ammeter and demonstrate for the class.

Compare the flow of an electric current to the flow of water through the pipes. With wiring, a light bulb, a switch, and a battery, set up a simple electric circuit. Ask the students what will happen when the switch is open or closed. Test the hypothesis.

Bring in professionals from the electronics industry. Ask them to discuss their educational background and their job descriptions.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Have a student gather information on Thomas Edison, Michael Faraday, or other pioneers in electricity for a class presentation.

Test the skin resistance of students using an ohmmeter.

An old dry cell can be sawed in half lengthwise. Observe its construction. Have students draw a diagram.

Have students find out the wattage of various home appliances, such as the refrigerator, oven microwave, toaster, television, clothes dryer, hair dryer, etc. Calculate the cost per hour of operation. Project monthly fees.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

_____ 1. the path a current follows

_____ 2. a form of energy in which electrons are flowing

_____ 3. an incomplete path or circuit that blocks the flow of electricity

_____ 4. a complete path or circuit which allows electricity to move along it

_____ 5. the form of electricity caused by a charged (+) or (-) particle

_____ 6. the flow of electrons along a path

A. circuit

B. closed circuit

C. current

D. electricity

E. open circuit

F. static electricity

Answer the following using short answers.

7. What is the difference between static and current electricity?

____

____

____

8. Lightning is a form of what kind of electricity? _______________

____

9. What type of electricity is used to run appliances in your home?

____

Use the list below to complete the following statements.

alternating	**battery**	**dry cell**	**parallel**
armature	**direct**	**generator**	**series**

10. A ____________________ is a group of cells that use chemicals to create or store electricity.

11. The kind of battery used in a flashlight is a ____________________ .

12. A ____________________ is a machine that produces electricity by means of mechanical energy.

13. A generator contains magnets and a large coil of wire. This coil is called an ____________________ .

14. A ____________________ circuit has only one path for electricity to follow.

15. A ____________________ circuit provides more than one path for electricity to follow.

16. A ____________________ current is an electrical current that flows in only one direction.

17. An ____________________ current is an electrical current that flows in one direction, then in the other direction. It changes direction many times every second.

Answer the following using short answers.

18. What is the difference between direct and alternating currents?

____

____

____

____

19. What kind of current does a dry cell produce? ________________

____

20. What type of current is used in homes and offices? ____________

____

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

__________ 21. A conductor is a material that allows electricity to pass through it.

__________ 22. An insulator is a material that will allow electricity to pass through it.

__________ 23. Electric current cannot flow through wires.

__________ 24. Electromotive force moves electricity.

__________ 25. Electricity can be measured.

__________ 26. Alternating current can cause an electromagnetic wave to radiate.

Identify the **conductors** *and* **insulators** *from the list below. Write* **C** *if it is a conductor and* **I** *if it is an insulator.*

_________ 27. swimming pool

_________ 28. Styrofoam

_________ 29. plastic

_________ 30. copper wire

_________ 31. silver

_________ 32. glass

_________ 33. rubber

Use the list below to complete the following sentences.

amp	**ohm**	**volt**

34. A ____________________ measures electromotive force.

35. An ____________________ tells how much current is being pushed.

36. An ____________________ is a unit that measures the amount of resistance.

Answer the following using complete sentences.

37. Explain how a dry cell produces electricity. ______________________

____

____

____

____

____

____

____

____

____

38. Explain how a generator works. ______________________________

____

____

____

____

____

____

____

____

____

39. Describe the relationship between electricity and magnetism.

Keys

Practice (pp. 305-308)

1. Electrons that are flowing.
2. A build up of charges between two objects.
3. Static electricity does not follow a path, but current electricity does.
4. The actions of most forces we observe are the result of charges built up between atoms and/or molecules.
5. current electricity
6. A device that uses dry chemicals to store and produce electricity.
7. The chemicals react and electrons are released to flow.
8. A device that changes mechanical energy into electrical energy.
9. The generator spins the armature between magnets and this induces the flow of electrons.
10. The path taken through a conductor.
11. closed circuit
12. open circuit
13. series circuit
14. parallel circuit
15. parallel circuit
16. A current that always travels in the same direction.
17. A current where the direction changes several times each second.
18. Direct current loses power over long distances while AC does not; DC is unidirectional but AC is not.
19. The magnetic field of DC is always aligned in the same direction; AC currents change directions 60 times each second and so does the direction of the magnetic field.
20. conductor
21. Answers will vary.
22. insulator
23. Answers will vary.
24. the force that causes electrons to move
25. electromotive force
26. the amount of current
27. the amount of resistance
28. As the current changes direction, the magnetic field changes. The result is an electromagnetic wave that moves away from the source.

Lab Activity 1 (p. 309)

1. a. no
   b. no
   c. no
3. a. yes
   b. yes
   c. from the wool
   d. static

Lab Activity 2 (pp. 310-313)

7. a. The light bulbs light up.
   b. yes
8. a. The light bulbs go off.
   b. no
10. a. It doesn't light.
    b. series
12. a. The light bulbs light up.
    b. yes
13. a. The light bulbs go off.
    b. no
15. a. The other light bulb lights up.
    b. parallel
16. You wouldn't want the entire hallway dark because one bulb burned out.

Practice (pp. 314-317)

1. Electricity
2. Static
3. Static
4. Current
5. static
6. current

Keys

7. cell
8. dry cell
9. chemical; electrical
10. generator
11. armature
12. electrons
13. open
14. closed
15. series; parallel
16. series
17. parallel
18. direct; alternating
19. electromagnetic wave
20. DC; AC
21. conductor
22. insulator
23. copper; silver
24. glass; plastic; rubber
25. Electromotive force (EMF)
26. resistance
27. volt
28. electromotive force (EMF)
29. ammeter
30. ohm
31. forces
32. atoms

Practice (pp. 318-319)

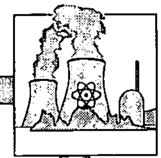
1. b
2. d
3. b
4. d
5. a
6. b
7. c
8. d
9. b
10. b

Unit Assessment (pp. 131-136TG)

1. A
2. D
3. E
4. B
5. F
6. C
7. Static electricity is an unmoving charge and currents move.
8. static electricity
9. current electricity
10. battery
11. dry cell
12. generator
13. armature
14. series
15. parallel
16. direct
17. alternating
18. alternating current changes direction several times each second, while the direct current does not
19. direct cell
20. alternating current
21. True
22. False
23. False
24. True
25. True
26. True
27. C
28. I
29. I
30. C
31. C
32. I
33. I
34. volt
35. amp
36. ohm
37. The cell contains chemicals that react. As they react, electrons are released. These electrons travel through a conductor to complete the chemical reaction.
38. The armature of the generator is spun through a magnetic field. This causes a current to be induced. Generators make use of the electromagnetic effect.

Keys

39. Electricity and magnetism are the result of a single force, the electromagnetic force. This is seen by the relationship between magnetic and electric current induction and the creation of magnetic fields by electricity.



Unit 18: Nuclear Energy

Overview

In this unit students will learn that atoms store huge amounts of energy. This energy can be released by fission or fusion. Nuclear power plants produce energy and dangerous radioactive waste. Scientists are searching for ways to eliminate the problems associated with nuclear energy. Students will further explore how scientific ideas are conceived and developed.

Purpose

Describe the nature of nuclear changes and their impact on living things.

Student Goals

1. Develop an understanding of the nature, properties, types, and uses of nuclear radiations.

2. Describe how nuclear fission and fusion may be used as forces of energy.

3. Define chain reaction, nuclear reactor, control rod, and describe how they interact in nuclear power plants.

4. State positive and negative reasons about the continued development of the nuclear fission reactor.

5. Define radioactivity.

6. Understand the process by which scientific ideas are conceived and developed.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Show films on atom smashing or particle accelerators.

Discuss the use of nuclear energy as a possibility for our future.

Bring a luminous watch to class. With a Geiger counter, demonstrate the radiation.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Marie and Pierre Curie discovered two new radioactive elements. Write a short report about this discovery. Examine the effects of radiation on their lives.

Write a letter to the local power company. Ask for information on nuclear power plants. Make a list of some of the advantages and disadvantages of nuclear power. Use the information to make a poster on nuclear power.

Find out the uses of radioisotopes in agriculture, industry, and medicine. Have students prepare a chart for display.

Have students report on early atomic scientists such as Enrico Fermi, Lise Meitner, and Otto Hahn.

Present Einstein's energy-mass equation, showing the relationship between nuclear reactions and his predictions. Take the time to discuss other implications of relativity.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

_____ 1. the movement of energy as a wave

_____ 2. a barrier that stops a nuclear reaction

_____ 3. splitting an atom

_____ 4. the center of an atom

_____ 5. a nuclear reaction in which two or more nuclei are pushed together to form one large nucleus

_____ 6. a reaction that occurs when one atom is split

_____ 7. describing elements or isotopes that spontaneously decompose

_____ 8. the form of energy that holds the nuclei of atoms together

_____ 9. theory that describes the fundamental relationship between matter and energy

_____ 10. a self-sustaining nuclear reaction

_____ 11. a machine used to control or create a nuclear chain reaction

_____ 12. an atom or group of atoms with a different atomic mass

_____ 13. the waste produced by a nuclear reactor

_____ 14. forms of energy given off by nuclear material

A. chain reaction

B. control rod

C. fission

D. fusion

E. isotope

F. nuclear energy

G. nuclear reaction

H. nuclear reactor

I. nucleus

J. radiation

K. radioactive

L. radioactive waste

M. radioactivity

N. theory of relativity

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

________ 15. Large amounts of energy are released by fission and fusion.

________ 16. Fission can be controlled using a nuclear reactor. In this way, fission can be used to produce useful energy.

________ 17. A nuclear reactor produces heat.

________ 18. Nuclear power plants produce energy.

________ 19. A nuclear power plant produces radioactive wastes which cannot be destroyed and may be harmful.

________ 20. Ideas in science are usually limited and grow slowly but sometime spring from unexpected findings.

Answer the following using complete sentences.

21. What are two arguments for continued development of nuclear fission reactors?

____

____

____

____

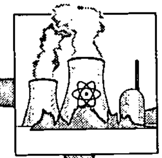
____

____

____

____

22. What are two arguments against the continued development of the nuclear fission reactor?



Keys

Lab Activity (pp. 331-332)

2. a. they fall
   b. uncontrolled
4. a. no
   b. the chalkboard eraser
   c. the chalkboard eraser
   d. the control rods

Practice (p. 333)

1. nuclear energy
2. nucleus
3. chain reaction
4. fission
5. nuclear reaction
6. Fusion
7. nuclear reactor
8. theory of relativity

Practice (p. 334)

1. D
2. A
3. B
4. G
5. F
6. E
7. C
8. H

Practice (p. 335)

1. True
2. False
3. True
4. True
5. False
6. True
7. True
8. True
9. False
10. True

Practice (p. 336)

Answers will vary.

Unit Assessment (pp. 143-146TG)

1. J
2. B
3. C
4. I
5. D
6. G
7. K
8. F
9. N
10. A
11. H
12. E
13. L
14. M
15. True
16. True
17. True
18. True
19. True
20. True
21. Answers will vary.
22. Answers will vary.

Unit 19: Heat

Overview

In this unit students will learn that heat is a form of energy. It causes matter to expand and contract. Heat also causes matter to change form. Temperature measures the amount of heat. Heat moves through processes called conduction, convection, and radiation. Heat energy has many important uses. Thermodynamic relationships will be discussed.

Purpose

Describe the nature of heat and its uses.

Student Goals

1. Describe and compare temperature and heat.
2. Describe conduction, convection, and radiation.
3. Describe the effect of heat on the states of matter.
4. Understand that thermodynamics describes the relationship between heat and work and that usable energy is lost as heat is produced.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Set up a demonstration to distinguish between heat and temperature. Equipment needed: two Styrofoam coffee cups, two thermometers, a pan, a heat source, a large bundle of nails tied together with string, and a single nail. Place the nails into a pan of water and heat the water until it boils. Fill each of the two cups about ⅔ full of cool water. Measure the temperature of the water and record. Using tongs, put the bundle of nails into one cup of water and the single nail into the other cup. Put a thermometer into each cup and record the readings every 30 seconds for five minutes. Note: both objects will have the same temperature, but the larger mass has far more heat. It will transfer the heat to the water and raise the water's temperature more rapidly.

Reinforcement

Provide other opportunities for practice and hands-on activities.

Take a flat copper strip and hold it over a flame. Explain how heat travels by conduction.

Use dry ice and show some of the effects on different forms of matter.

Make a display of various kinds of insulating materials.

Display bimetallic strips. Ask the students to hypothesize uses for this technology other than in thermometers.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

_______ 1. a temperature scale with the boiling point of water at 100°, the freezing point of water at 0°, and body temperature at 37°	A. Celsius
_______ 2. a form of energy that causes a random motion of molecules or atoms	B. conduction
_______ 3. to move back and forth very quickly	C. convection
_______ 4. poor conductor of heat	D. Fahrenheit
_______ 5. the way that heat moves through a solid	E. friction
_______ 6. the way that heat moves through a liquid or gas	F. heat
_______ 7. a type of resistance caused when one surface touches another surface	G. insulator
_______ 8. how heat travels through empty space	H. radiation
_______ 9. a temperature scale with the boiling point of water at 212°, the freezing point of water at 32°, and the normal body temperature at 98.6°	I. temperature
_______ 10. a measure of the amount of heat in a substance; a measure of how fast molecules are moving in their random motion	J. vibrate

Use the list below to complete the following statements.

coal	**convection**	**radiation**
conduction	**expand**	**sun**
conductors	**insulators**	**vibrate**
contract	**oil**	

11. When molecules in matter ____________________, this is caused by heat.

12. Most of the heat on earth comes from the ____________________.

13. Two fuels that give off heat as they burn are ____________________ and ____________________.

14. When molecules in matter vibrate, they spread out. This causes the heated matter to become a little larger, or ____________________.

15. When the matter is cooled, the molecules move closer together, or ____________________.

16. The passing of heat from molecule to molecule in solids is known as ____________________.

17. Objects that heat up easily are known as ____________________.

18. Wood, Styrofoam, and plastic are poor conductors of heat. Poor conductors of heat are called ____________________.

19. When a liquid or a gas is heated, the molecules closest to the heat begin to vibrate. They move faster and faster. They move away from the heat. Cooler molecules take their place. This process is known as

______________________ .

20. Heat moves through outer space by means of

______________________ .

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

__________ 21. Only molecules in liquids vibrate.

__________ 22. Heat causes molecules to vibrate faster.

__________ 23. Cooling causes molecules to vibrate faster.

__________ 24. All of our energy comes from coal.

__________ 25. Heat and temperature are the same.

__________ 26. We measure temperature with a thermometer.

__________ 27. Temperature tells us how quickly molecules vibrate.

__________ 28. Temperature is measured in degrees.

Answer the following using complete sentences.

29. What are the two types of temperature scales? ________________

____

____

____

30. Describe the difference between *heat* and *temperature*.

____

____

____

____

____

____

____

31. Describe what happens to the amount of energy in a system when energy is transformed. Discuss usable energy.

____

____

____

____

____

____

Keys

Practice (pp. 345-347)

1. Heat is a form of energy that causes particles to move randomly.
2. Heat is caused by the random movement of particles.
3. Most of Earth's heat comes from the sun.
4. Yes, friction does cause heat.
5. Heat can cause matter to expand and change phase. (Other answers possible.)
6. Water expands when it is turned to ice.
7. The amount of heat increases when energy changes form.
8. Particles transfer energy to one another after colliding.
9. Conduction is the movement of heat through a solid object.
10. Objects that heat up easily are called conductors.
11. Insulators are poor conductors of heat.
12. Wood, styrofoam, and plastic are three common insulators. Answers will vary.
13. Heated particles move away and are replaced by cooler molecules.
14. Convection is the way that heat moves through liquids or gases.
15. Radiation is the way that heat moves through a vacuum.
16. Temperature is a measurement of the amount of heat in a substance and how fast the molecules are moving in their random motion.

Lab Activity (pp. 348-349)

2. no
3. a. yes
   b. heat
   c. yes
   d. it moved away
   e. convection

Practice (pp. 350-352)

1. expand
2. heat; vibrating
3. hot
4. contract
5. sun
6. coal; oil
7. expand
8. slow down
9. size; phase
10. Heat
11. conduction
12. conductors
13. vibrate; molecules; vibrate; vibrating
14. insulators
15. wood; Styrofoam; plastic
16. convection
17. closest; away; Cooler
18. rises; air; convection current
19. Radiation
20. Temperature; fast
21. thermometer
22. Fahrenheit; Celsius
23. thermodynamics
24. kill
25. liquid

Unit Assessment (pp. 151-154TG)

1. A
2. F
3. J
4. G
5. B
6. C
7. E
8. H
9. D
10. I
11. vibrate
12. sun
13. coal; oil
14. expand
15. contract

Keys

16. conduction
17. conductors
18. insulators
19. convection
20. radiation
21. False
22. True
23. False
24. False
25. False
26. True
27. True
28. True
29. Fahrenheit; Celsius
30. Heat is a form of energy that causes random motion; temperature measures the speed at which particles vibrate randomly.
31. The amount of energy stays the same but some is lost to heat. The amount of usable energy drops.

Unit 20: Waves

Overview

In this unit students will learn that 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. Waves can move through different forms of matter. Sound and light are types of waves. The relationship of waves and matter is discussed.

Purpose

Explain the basic properties of waves.

Student Goals

1. Describe a wave as a movement of energy.
2. Define wavelength, speed, frequency, and amplitude.
3. Discuss how matter may behave as a particle, a wave, or other form.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Use a coiled spring (like a Slinky toy) to demonstrate a longitudinal wave.

Have students describe some of their own experiences with waves at lakes, rivers, or the ocean.

Tie a rope to a door knob and shake the loose end rather hard. Waves will be seen moving along the rope to the door and then back from the door.

Locate an oscilloscope and demonstrate wave patterns to the class. The effects of frequency and amplitude can be shown with it. Use a microphone and tuning forks or other instruments to "display" sound.

Reinforcement

Provide other opportunities for practice and hands-on activities.

A ripple tank (or a fish tank) will be useful in this unit to show reflection and refraction of waves.

Float a cork in water. Strike the water and observe the waves and the motion of the cork. The cork's motion shows the wave pattern.

Earthquakes produce both longitudinal and transverse waves. Show a film on earthquakes or have students find articles and stories about earthquakes. Explain how the seismograph uses waves to locate the epicenter of the earthquake.

Invite the school band director to demonstrate how different musical instruments produce tones.

Have some students research how bats use sound waves to direct them in flight. Report to the class.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.

Unit Assessment

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

______	1. half the distance between the crest and trough	A. amplitude
______	2. 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	B. crest
______	3. a disturbance that is caused by energy moving from one location to another	C. frequency
______	4. a change in the direction of a wave because its speed has changed	D. hertz
______	5. how fast a wave moves	E. Hz
______	6. the energy of moving things	F. kinetic energy
______	7. the unit of measure for frequency	G. reflection
______	8. high point of a wave	H. refraction
______	9. the low point of a wave	I. speed
______	10. the measure of the number of crests that pass a point in a second	J. trough
______	11. the distance between the crest of one wave and the next	K. wave
______	12. abbreviation for hertz	L. wavelength

Answer the following using complete sentences.

13. What are the four properties of waves? ______________________

____

____

____

____

14. What are two types of waves? ______________________

____

____

15. What kind of frequency does a wave have with a long wavelength?

____

____

16. What kind of frequency does a wave have with a short wavelength?

____

____

17. An electron is matter. What about it makes it seem like a wave?

____

____

____

____

Keys

Practice (pp. 362-363)

A. a disturbance that is caused by energy moving from one location to another

B. 1. energy
   2. solids; liquids; gases
   3. Sound

C. 1. a. the distance between the crest of one wave and the wave that follows it
      b. crests; troughs; amplitude
   2. how fast a point of a wave moves
   3. a. the measure of the number of waves that pass a point in a second
      b. Hertz

D. 1. a change in the direction of a wave caused by a change in its speed
   2. reflection

E. 1. wave
   2. electron

Lab Activity (pp. 364-365)

2. a. a wave
   b. energy
3. a. slowly
   b. frequency
4. a. reflected/it moved back down the rope
   b. reflection
5. Answers will vary.
6. Answers will vary.
7. amplitude
8. it did not change it
9. no change
10. no affect

Practice (pp. 366-367)

1. wave
2. frequency; speed; amplitude; wavelength
3. crest
4. trough
5. wavelength
6. speed
7. Frequency
8. hertz
9. hertz
10. Refraction
11. Reflection
12. wave

Practice (p. 368)

1. F
2. J
3. G
4. E
5. C
6. I
7. B
8. K
9. H
10. A
11. D

Practice (p. 369)

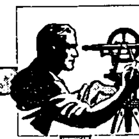
1. frequency; speed; amplitude; wavelength
2. Answers will vary.
3. low frequency
4. high frequency

Unit Assessment (pp.159-160TG)

1. A
2. G
3. K
4. H
5. I
6. F
7. D or E
8. B
9. J
10. C
11. L

Keys

12. E
13. frequency; speed; amplitude; wavelength
14. Answers will vary.
15. low frequency
16. high frequency
17. It behaves as if it has wavelength, amplitude, and frequency.



Unit 21: Science, Society, and the World

Overview

Students will learn about the relationships between industry, economics, government, technology, scientists, and society. Human values and abilities will be related to increasing levels of technology. Natural bias and peer review will be described.

Purpose

Students will understand unifying concepts and processes in science, technology, and society.

Student Goals

1. Understand that scientists in one area tend to see issues in similar ways. Discuss methods for overcoming this bias.

2. Describe what technology is, how it progresses, and the forces that control its creation and development.

3. Discuss the relationship between technology and the values of both a society and individuals within that society.

Suggestions for Enrichment

Choose one or more ways to create interest in the unit.

Bring in a variety of tools that show levels of technology from very simple to highly complex (e.g., a mortar and pestle as compared to a microcomputer). Have students choose one tool and research the development of this implement.

Ask students to do current-events research to identify one area of technology that is creating problems. Have them identify the reasons for this problem, and ask them to find ways in which scientists or others are striving to solve the problem. Will a new technology be a solution for the problems of this older technology?

Ask a contractor, architect, or other construction professional to present information on the techniques used in constructing a variety of buildings. Encourage students to ask questions about careers and education.

Reinforcement

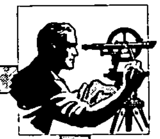
Provide other opportunities for practice and hands-on activities.

Assign students the task of finding three "problems" in their own home. Ask them to get into groups and brainstorm techniques for solving these problems. Have the students pick the best problem and solution and present this technology to the class.

Have the students write short science-fiction stories that describe a future problem. The students should leave the problem unsolved. Let the class discuss possible technologies to solve the problem.

Design a puzzle for the students to solve. Give each student one vital piece of information. Ask them to predict the difficulty of solving the problem.

See Appendices A, B, and C for other instructional strategies, teaching suggestions, and accommodations/modifications.



Unit Assessment

Use the list below to complete the following statements.

abilities	hinder	people	scientists
by-product	industry	predict	society
electricity	peers	research	technology
grant			

1. The increasing ability of humans to perform complex tasks is made possible by advances in ____________________ .

2. The ____________________ in which people live has an impact on practically every aspect of their lives.

3. ____________________ includes not only one business or machine but all the people involved in producing a certain type of product.

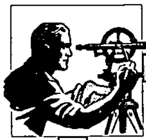
4. Technology can make life easier but can also cause problems that ____________________ and others have to solve.

5. The economy of the world controls when money may be available for ____________________ .

6. An amount of money awarded for solving a specific problem is known as a ____________________ .

7. Acid rain is an example of a ____________________ .

8. Acid rain is a result of technology used to generate ____________________ .



9. Bias is a preference that can ____________________ impartial judgement.

10. Those scientists that test the accuracy of findings by reviewing the work of other scientists are known as ____________________.

11. One of the powerful uses of science is its ability to ____________________ future events and problems.

12. Technology has different value for different ____________________.

13. If a technological solution does not take into account the ____________________ and values of people, then it will not succeed.

Answer the following using complete sentences.

14. Describe an older technology that has been adapted to our modern world. Predict ways in which there may be problems with the technology and what solutions there may be to that problem.

____

____

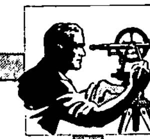
____

15. Describe how scientists and other technology workers rely on peer review and other processes to bring scientific insight to public and social concerns and to form possible solutions.

____

____

____



Keys

Practice (pp. 379-381)

1. b
2. c
3. a
4. b
5. d
6. a
7. b
8. a
9. c
10. b
11. a

Lab Activity (pp. 382-383)

1. yes
2. Answers will vary.
4. Answers will vary.
5. Answers will vary.
6. (Teacher - Students should be able to predict that acid rain may cause aesthetic and/or structural damage.)
7. (Teacher - Students should be able to infer that protective coatings [e.g., paint] protect many products from corrosion.)

Practice (p. 384)

1. C
2. I
3. H
4. F
5. E
6. B
7. G
8. A
9. D

Practice (pp. 385-386)

1. technology
2. knowledge; research
3. grants; government agencies
4. Society
5. peers
6. predict
7. value
8. scientific; abilities
9. preference
10. acid rain

Unit Assessment (pp. 165-166TG)

1. technology
2. society
3. Industry
4. scientists
5. research
6. grant
7. by-product
8. electricity
9. hinder
10. peers
11. predict
12. people
13. abilities
14. Answers will vary.
15. By publishing results so that others can test and verify them, scientists accelerate the rate of learning. This allows new knowledge to be considered when investigating problems. This broader knowledge increases the likelihood that acceptable solutions can be found.

Appendices

Instructional Strategies

Classrooms draw from a diverse pool of talent and potential. The challenge is to structure the learning environment so that each student has a way to benefit from his or her unique strengths. Instructional strategies that couple student strengths with diverse learning needs are provided on the following pages as examples that you might use, adapt, and refine to best meet the needs of your students and instructional plans.

Cooperative Learning Strategies—to promote individual responsibility and positive group interdependence for a given task.

Jigsawing: each student becomes an "expert" and shares his or her knowledge so eventually all group members know the content.

Divide students into groups and assign each group member a numbered section or a part of the material being studied. Have each student meet with the students from the other groups who have the same number. Next, have these new groups learn together, develop expertise on the material, and then plan how to teach the material to members of their original groups. Then, have students return to their original groups and teach their area of expertise to the other group members.

Corners: each student learns about a topic and shares that learning with the class, similar to jigsawing.

Assign small groups of students to different corners of the room to examine a particular topic. Have the students discuss various points of view concerning the topic. Have corner teams discuss conclusions, determine the best way to present their findings to the class, and practice their presentation.

Think, Pair, and Share: students develop their own ideas and build on the ideas of other learners.

Have students reflect on a topic and then pair up to discuss, review, and revise their ideas. Then have the students share their ideas with the class.

Debate: students participate in organized presentations of various viewpoints.

Have students form teams to research and develop their viewpoints on a particular topic or issue. Provide structure in which students will articulate their view points.

Brainstorming—to elicit ideas from a group.

Have students contribute ideas related to a topic. Accept all contributions without initial comment. After the list of ideas is finalized, have students categorize, prioritize, and defend selections.

Free Writing—to express ideas in writing.

Have students reflect on a topic, then have them respond in writing to a prompt, a quote, or a question. It is important that they keep writing whatever comes to mind. They should not self-edit as they write.

K–W–L (Know–Want to Know–Learned)—to structure recalling what is known about a topic, noting what is wanted to be known, and finally listing what has been learned and is yet to be learned.

Before engaging in an activity, list on the board under the heading "What We Know" all the information students know or think they know about a topic. Then list all the information the students want to know about a topic under, "What We Want to Know." As students work, ask them to keep in mind the information under the last list. After completing the activity, have students confirm the accuracy of what was listed and identify what they learned, contrasting it with what they wanted to know.

Learning Log—to follow-up K–W–L with structured writing.

During different stages of a learning process, have students respond in written form under three columns:

"What I Think"
"What I Learned"
"How My Thinking Has Changed"

Interviews—to gather information and report.

Have students prepare a set of questions in a format for an interview. After conducting the interview, have students present their findings to the class.

Dialogue Journals—to hold private conversations with the teacher or share ideas and receive feedback through writing; can be conducted by e-mail.

Have students write on topics on a regular basis, responding to their writings with advice, comments, and observations in written conversation. You may have students read a novel or biography and respond to the conflict and its resolution.

Continuums—to indicate the relationships among words or phrases.

Using a selected topic, have students place words or phrases on the continuum to indicate a relationship or degree.

Mini-Museums—to create a focal point.

Have students work in groups to create exhibits that represent, for example, a display of several electrical experiments that demonstrate concepts related to electricity.

Models—to represent a concept in simplified form; these may be concrete like a map of a character's travels and important places he or she visited, or may be an abstract model of the relationships between characters in a story.

Have students create a concrete product that represents an abstract idea or a simplified representation of an abstract idea.

Reflective Thinking—to reflect on what was learned after a lesson.

Have students write in a journal the concept they learned, comments on the learning process, questions or unclear areas, and interest in further exploration, or have students fill out a questionnaire addressing such questions as: Why did you study this? Can you relate to it in real life?

Problem Solving—to apply knowledge to solve problems.

Have students determine a problem, define the problem, and ask a question about the problem, then define the characteristics of possible solutions, which they research. Have them choose a promising solution that best fits the criteria stated in the definition of solutions, then test the solution. Finally, have students determine if the problem has been solved.

Predict, Observe, Explain—to predict what will happen in a given situation when a change is made.

Ask students to predict what will happen, given a situation, when some change is made. Have students observe what happens when the change is made and discuss the differences between their predictions and the results.

Literature, History, and Storytelling—to bring history to life through the eyes of a historian, storyteller, or author, revealing the social context of a particular period in history.

Have students locate books, brochures, and tapes relevant to science. Assign students to prepare reports on the "life and times" of scientists during specific periods of history. Ask students to write their own observations and insights afterwards.

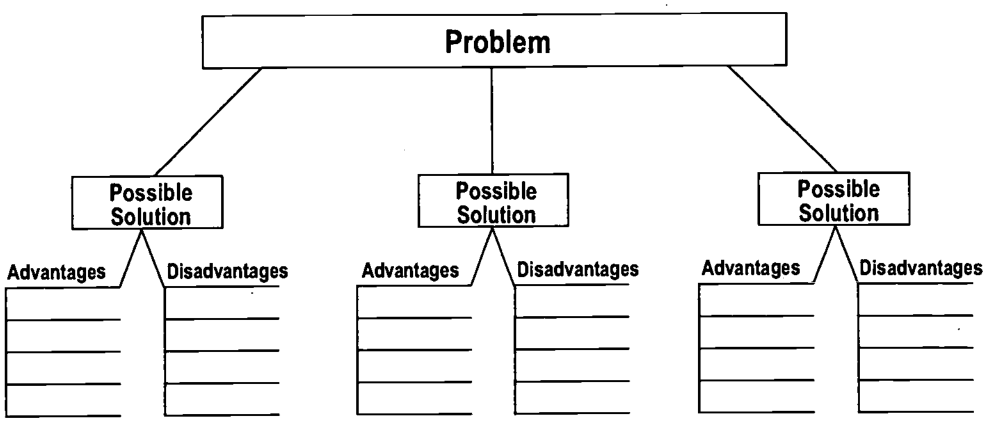
Laboratory Investigation—to involve students with their environment.

Have students propose a question, develop a hypothesis, explore methods of investigating the question, choose one of the methods, then conduct research and draw conclusions based on the information gathered. Ask students to report the results orally, in writing, or with a picture or diagram.

Graphic Organizers—to transfer abstract concepts and processes into visual representations.

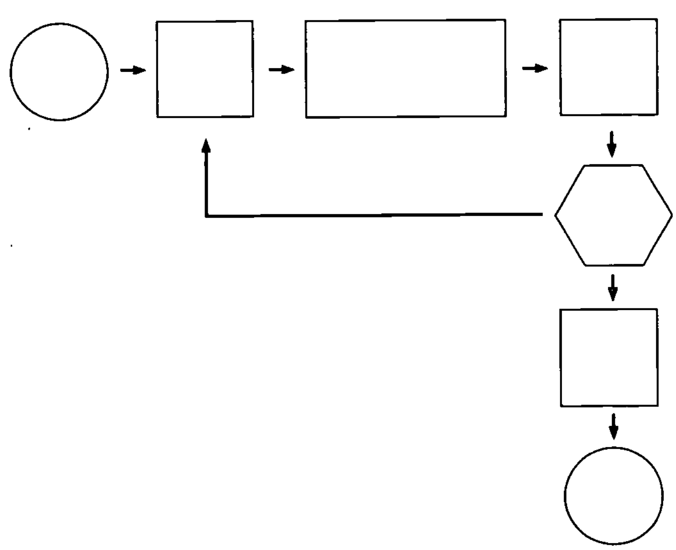
Consequence Diagram/Decision Trees: illustrates real or possible outcomes of different actions.

Have students visually depict outcomes for a given problem by charting various decisions and their possible consequences.



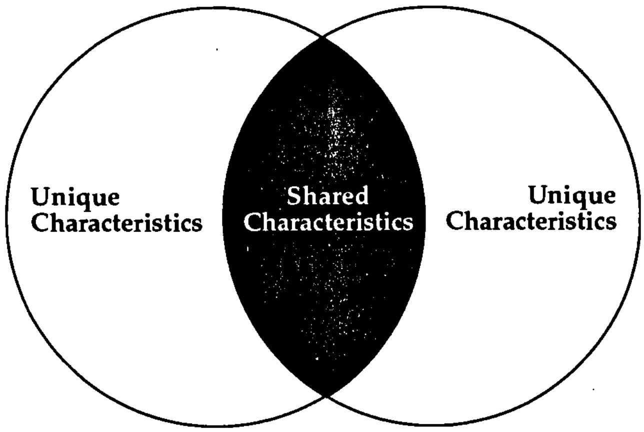
Flowchart: depicts a sequence of events, actions, roles, or decisions.

Have students structure a sequential flow of events, actions, roles, or decisions graphically on paper.



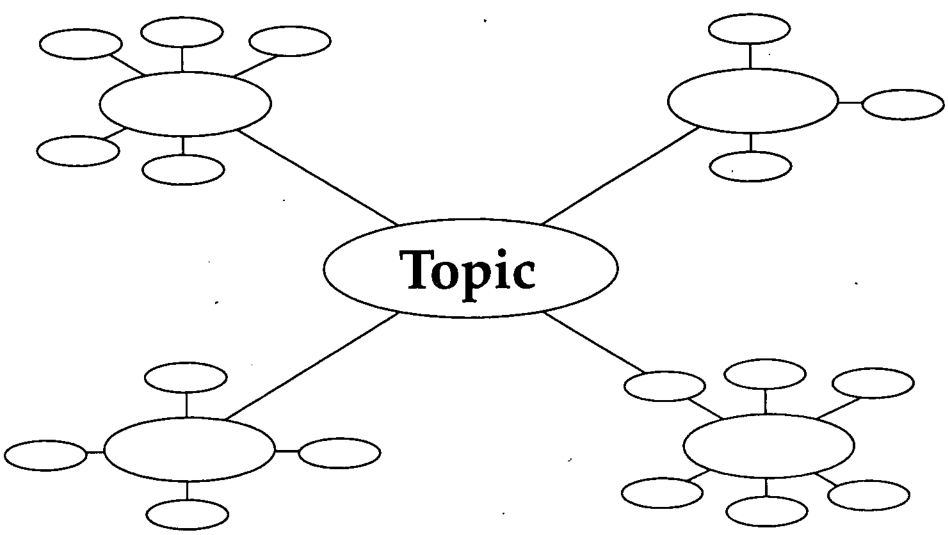
Venn Diagram: analyzes information representing the similarities and differences among, for example, concepts, objects, events, and people.

Have students use two overlapping circles to list unique characteristics of two items or concepts (one in the left part of the circle and one in the right); in the middle have them list shared characteristics.



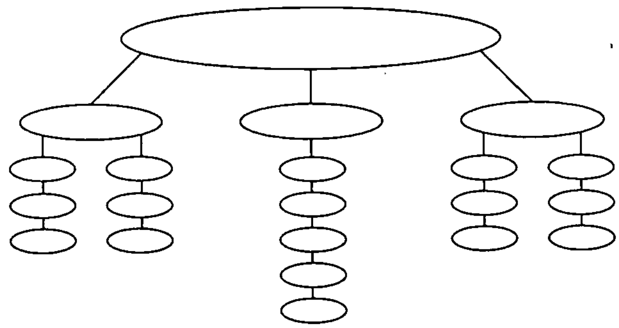
Webbing: pictures how words or phrases connect to a topic.

Have students list topics and build a weblike structure of words and phrases.



Concept Mapping: shows relationships among concepts.

Have students select a main idea and identify a set of concepts associated with the main idea. Next, have students rank the concepts in related groups from the most general to most specific. Then have students link related concepts with verbs or short phrases.



Portfolio—to capture students' learning within the context of the instruction.

Elements of a portfolio can be stored in a variety of ways; for example, they can be photographed, scanned into a computer, or videotaped. Possible elements of a portfolio could include the following selected student products:

Written Presentations
- expressive (diaries, journals, writing logs)
- transactional (letters, surveys, reports, essays)

Representations
- maps
- graphs
- dioramas
- models
- mock-ups
- displays
- bulletin boards
- charts
- replicas

Media Presentations
- films
- slides
- photo essays
- print media
- computer programs
- videotapes
- audiotapes

Visual and Graphic Arts
- storyboards
- drawings
- posters
- sculpture
- cartoons
- mobiles

Learning Cycle—to engage in exploratory investigations, construct meanings from findings, propose tentative explanations and solutions, and relate concepts to our lives.

Have students explore the concept, behavior, or skill with hands-on experience and then explain their exploration. Through discussion, have students expand the concept or behavior by applying it to other situations.

Field Experience—to observe, study, and participate in a setting off the school grounds, using the community as a laboratory.

Plan and structure the field experience with the students before the visit. Engage in follow-up activities after the trip.

Teaching Suggestions

The standards and benchmarks of the Sunshine State Standards are the heart of the curriculum frameworks and reflect the efforts to reform and enhance education. The following pages contain unit teaching suggestions of sample performance descriptions for students to demonstrate achievements of benchmarks.

The Nature of Matter

1. Have students interpret data from experiments to predict the mass ratio by which elements combine to form compounds.

2. Have students determine the density of common solids, liquids, and gases, compare their values, and report findings.

3. Have students design an experiment and collect data to determine if the average thermal energy of the particles in a solid is less that the average thermal energy of the particles in liquid or gaseous form and report findings.

4. With a team, have students demonstrate a mathematical relationship between solubility and temperature for a simple solid.

5. Have students grow crystals, observe them under a microscope, and work with others to create models of the crystalline structure.

6. In small groups, have students develop hypotheses, design simple experiments to explain variations in the acidity or alkalinity (pH) of local water samples, and report on findings and the processes used.

7. With other students in a small group, have students design and carry out an experiment to oxidize glucose to form elemental carbon and reports on findings in a balanced equation and on processes used.

8. Have students discuss the positive and negative effects of the use of radioactive isotopes.

9. Have students explain how life on Earth ultimately depends on the fusion reactions taking place on the sun.

10. Have students predict the chemical and physical properties of hydrogen, oxygen, nitrogen, and carbon atoms and compounds, using the periodic table to make generalizations about properties of certain elements.

11. Have students give examples of when matter acts as a wave, a particle, or something entirely different.

Energy

1. Have students design, conduct, and report on an experiment to determine the effect of several variables on home or school use of electricity.

2. Have students determine and report the potential and kinetic energy of a cart moving from the top to the bottom of an inclined plane.

3. Have students measure and report the energy required to operate an electrical device.

4. Have students measure and report the latent heat of fusion for an ice cube.

5. With others in a small group, have students build an electromagnetic generator, measure the energy generated when applied in a household tool, and report on the process and results.

6. Have students diagram a heat pump at work in heating and cooling and show areas of high-pressure vapor, low-pressure vapor, high-pressure liquid, and low-pressure liquid.

7. Have students demonstrate the conservation of energy and mass in a system.

8. Have students compare the interactions of energy and matter on Earth with models of these interactions in the galaxy.

9. With others in a small group, have students design and construct a solar collector, collect data on its effectiveness, and compare this model with others designed by classmates.

Force and Motion

1. Have students calculate and report the acceleration and motion of several different objects when released from the same position.

2. Have students measure, compare, and report the electrical forces between charged objects.

3. Have students observe, interpret, and explain the behavior of a compass needle near a permanent magnet.

4. Have students formulate a model of radioactive decay, explain why hospitals keep radioactive materials for 10 half-lives before disposing of these materials and calculate the fraction of the original activity left after 10 half-lives.

5. Have students describe how electric forces on neutral particles may be used to collect soot in smokestacks and paint cars uniformly.

6. Have students demonstrate that for every action there is a equal and opposite reaction by identifying the places on a roller-coaster ride where one feels heavier or lighter.

7. With other students in a small group, have students design and build a model car or vehicle that uses energy stored in a spring or the potential energy stored in a lifted weight to provide force to propel the vehicle. Next, have the students measure the distance traveled, the speed, and the acceleration of the vehicle, and report on the processes used and findings.

8. Have students give an example of an object moving in a circular path and find and compare its speed, period, frequency, acceleration, and centripetal force with other masses and report these findings.

9. Have students collect and graph data and explain that acceleration is a change in velocity or direction of travel.

Processes of Life

Have students describe biochemical reactions that are common to living things.

How Living Things Interact with Their Environment

Have students predict where the oxygen they inhaled last night may be in the morning.

The Nature of Science

1. Have students formulate a testable hypothesis supported by the knowledge and understanding generated by an experiment.

2. Have students engage in a debate on changes and continuity that are persistent features of science.

3. Have students compare closely aligned theories and identify ways to test the validity of these theories.

4. Have students review scientific publications on a topic, identify the conclusions of the researcher in the articles cited, and compare the findings of these different investigations.

5. Have students discuss the big new ideas in science today and trace their origins and developments.

6. Have students select and describe several scientific theories that were ridiculed as preposterous by some but are now supported with convincing evidence.

7. Have students review and edit the laboratory reports of peers.

8. Have students develop and record in a journal alternative interpretations based upon experimental evidence collected.

9. Have students describe scientists' efforts to predict the weather using computer modeling of weather conditions.

10. Have students use a computerized architectural design (CAD) program to determine the stress on bridge supports.

11. Have students compare the problems that had to be solved to make the first airplane flights with the problems that had to be solved to make airplanes fly faster than the speed of sound.

12. Have students review and discuss the efforts of scientists over the past three centuries to inform the public about environmental, political, and economic consequences of population growth.

13. Have students select one science topic that is actively being researched and determine the sources of funding for the research and who will benefit from new discoveries.

14. Have students compare the communication methods people use in cities of Bombay, Sao Paolo, and New York.

15. Have students identify practical problems solved with technology and describe the effect of the solutions on human values.

Accommodations/Modifications for Students

The following accommodations/modifications may be necessary for students with disabilities and diverse learning needs to be successful in school as well as any other placement. The specific strategies may be incorporated into the Individual Educational Plan (IEP) or 504 Plan as deemed appropriate.

Environmental Strategies

Provide preferential seating. Seat student near someone who will be helpful and understanding.
Assign a peer tutor to review information or explain again.
Build rapport with student; schedule regular times to talk.
Reduce classroom distractions.
Increase distance between desks.
Note that student may need frequent breaks for relaxation and small talk.
Accept and treat the student as a regular member of the class. Do not point out that the student is an ESE student.
Note that student may leave class to attend the ESE support lab.
Additional accommodations may be needed.

Organizational Strategies

Help student use an assignment sheet, notebook, or monthly calendar.
Allow student additional time to complete tasks and take tests.
Help student organize notebook or folder.
Help student set timelines for completion of long assignments.
Help student set time limits for assignment completion. Question student to help focus on important information.
Help highlight the main concepts in the book.
Ask student to repeat directions given.
Ask parents to structure study time. Give parents information about long-term assignments.
Provide information to ESE teachers and parents concerning assignments, due dates, and test dates.
Allow student to have an extra set of books at home and in the ESE classroom.
Additional accommodations may be needed.

Motivational Strategies

Encourage student to ask for assistance when needed.
Be aware of possible frustrating situations.
Reinforce appropriate participation in your class.
Use nonverbal communication to reinforce appropriate behavior.
Ignore nondisruptive, inappropriate behavior as much as possible.
Allow physical movement (distributing materials, running errands, etc.).
Develop and maintain a regular school-to-home communication system.
Encourage development and sharing of special interests.
Capitalize on student's strengths.
Provide opportunities for success in a supportive atmosphere.
Assign student to leadership roles in class or assignments.
Assign student a peer tutor or support person.
Assign student an adult volunteer or mentor.
Additional accommodations may be needed.

Presentation Strategies

Tell student the purpose of the lesson and what will be expected during the lesson (provide advance organizers).
Communicate orally and visually, and repeat as needed.
Provide copies of teacher's notes or student's notes (preferably before class starts).
Accept concrete answers; provide abstractions that student can handle.
Stress auditory, visual, and kinesthetic modes of presentation.
Recap or summarize the main points of the lecture.
Use verbal cues for important ideas and to help. ("The next important idea is....")
Stand near the student when presenting information.
Cue student regularly by asking questions, giving time to think, then calling student's name.
Minimize requiring the student to read aloud in class.
Use memory devices (mnemonic aids) to help students remember facts and concepts.
Allow student to tape the class.
Additional accommodations may be needed.

Curriculum Strategies

Help provide supplementary materials that student can read.
Provide Parallel Alternative Strategies for Students (PASS) materials.
Provide partial outlines of chapters, study guides, and testing outlines.
Provide opportunities for extra drill before tests.
Reduce quantity of material (reduce spelling and vocabulary lists, reduce number of math problems, etc.).
Provide alternative assignments that do not always require writing.
Supply student with samples of work expected.
Encourage a high quality of work (which involves proofreading and rewriting), not speed.
Use visually clear and adequately spaced work sheets. Student may not be able to copy accurately or fast enough from the board or book; make arrangements for student to get information.
Encourage the use of graph paper to align numbers.
Make specific comments to correct responses on written or verbal class work.
Allow student to have sample or practice test.
Provide all possible test items and student or teacher selects specific number. Give oral examinations and quizzes.
Provide extra assignment and test time.
Accept some homework papers dictated by the student and recorded by someone else.
Modify length of outside reading.
Provide study skills training and learning strategies.
Arrange to offer extra study time with student on specific days and times.
Allow study buddies to check spelling.
Allow use of technology to correct spelling.
Allow access to computers for in-class writing assignments.
Allow student to have someone edit papers.
Allow student to use fact sheets, tables, or charts.
Tell student in advance what questions will be asked.
Color code steps in a problem.
Provide list of steps that will help organize information and facilitate recall.
Assist in accessing taped texts.
Reduce the reading level of assignments.
Provide opportunity for student to restate assignment directions and due dates.
Additional accommodations may be needed.

Testing Modifications

Allow extended time for tests in the classroom and/or in the ESE support lab.
Provide adaptive tests in the classroom and/or in the ESE support lab (reduce amount to read, cut and paste a modified test, shorten, revise format, etc.).
Allow open book and open note tests in the classroom and/or ESE support and lab.
Allow student to take tests in the ESE support lab for help with reading and directions.
Allow student to take tests in the ESE support lab with allotted time to study.
Allow student to take tests in the ESE support lab using a word bank of answers or other aid as mutually agreed.
Allow student to take tests orally in the ESE support lab.
Allow the use of calculators, dictionaries, or spell checkers on tests in the ESE support lab.
Provide alternative to testing (oral reports, making bulletin board, poster, audiotape, demonstration, all notes on chapters, etc.).
Provide enlarged copies of the answer sheets.
Allow copy of tests to be written upon and later have someone transcribe the answers.
Allow and encourage the use of a blank piece of paper to keep pace and eliminate visual distractions on the page.
Allow use of technology to correct spelling.
Provide alternate test formats for spelling and vocabulary tests.
Highlight operation signs, directions, etc.
Allow students to tape-record answers to essay questions.
Use more objective items (fewer essay responses).
Give frequent short quizzes, not long exams.
Additional accommodations may be needed.

Evaluation Criteria Modifications

Student is on an individualized grading system.
Student is on a pass or fail system.
Student should be graded more on daily work and notebook than on tests (i.e., 60% daily, 25% notebook, 15% tests).
Student will have flexible time limits to extend completion of grading into next grading period.
Additional accommodations may be needed.

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

These requirements include, but are not limited to, the benchmarks from the Sunshine State Standards that are most relevant to this course. Benchmarks correlated with a specific course requirement may also be addressed by other course requirements as appropriate. Benchmarks from Science, Strand H, should not be taught and assessed in isolation, but should be combined with other benchmarks listed for this course.

1. Demonstrate understanding of the unifying concepts and processes of science.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.H.1.4.1	Know that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.	1	
SC.H.1.4.2.	Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge.	1	
SC.H.1.4.3	Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth.	6	
SC.H.1.4.4	Know that scientists in any one research group tend to see things alike and that therefore scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis.	21	
SC.H.1.4.5.	Understand that new ideas in science are limited by the context in which they are conceived, are often rejected by the scientific establishment, sometimes spring from unexpected findings, and usually grow slowly from many contributors.	18	
SC.H.1.4.6.	Understand that in the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism and that in the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.	6	
SC.H.1.4.7	Understand the importance of a sense of responsibility, a commitment to peer review, truthful reporting of the methods and outcomes of investigations, and making the public aware of the findings.	21	

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

continued

1. Demonstrate understanding of the unifying concepts and processes of science.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.H.2.4.1	Know that scientists assume that the universe is a vast system in which basic rules exist that may range from very simple to extremely complex but that scientists operate on the belief that the rules can be discovered by careful, systematic study.	6	
SC.H.2.4.2	Know that scientists control conditions in order to obtain evidence, but when that is not possible for practical or ethical reasons, they try to observe a wide range of natural occurrences to discern patterns.	1	
SC.H.3.4.1	Know that performance testing is often conducted using small-scale models, computer simulations, or analogous systems to reduce the chance of system failure.	1	

2. Demonstrate understanding of the structure of atoms.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.A.2.4.1	Know that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced.	5, 6, 10, 11	
SC.A.2.4.3	Know that a number of elements have heavier, unstable nuclei that decay, spontaneously giving off smaller particles and waves that result in a small loss of mass and release a large amount of energy.	18	
SC.A.2.4.4	Know that nuclear energy is released when small, light atoms are fused into heavier ones.	18	
SC.A.2.4.5	Know that elements are arranged into groups and families based on similarities in electron structure and that their physical and chemical properties can be predicted.	6	

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

3. Demonstrate understanding of the structure and properties of matter.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.A.1.4.2	Know that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together.	5, 10, 11	
SC.A.1.4.3	Know that a change from one phase of matter to another involves a gain or loss of energy.	3, 4, 5, 19	
SC.A.2.4.2	Know the difference between an element, a molecule, and a compound.	5, 7, 8, 9	
SC.A.2.4.6	Understand that matter may act as a wave, a particle, or something else entirely different with its own characteristic behavior.	20	

4. Demonstrate understanding of chemical reactions.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.A.1.4.1	Know that the electron configuration in atoms determines how a substance reacts and how much energy is involved in its reactions.	11	
SC.A.1.4.4	Experiment and determine that the rates of reaction among atoms and molecules depend on the concentration, pressure, and temperature of the reactants and the presence or absence of catalysts.	11	
SC.A.1.4.5	Know that connections (bonds) form between substances when outer-shell electrons are either transferred or shared between their atoms, changing the properties of substances.	5	
SC.F.1.4.1	Know that body processes involve specific biochemical reactions governed by biochemical principles.	11	
SC.G.1.4.3	Know that the chemical elements that make up the molecules of living things are combined and recombined in different ways.	11	

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

5. Demonstrate understanding of forces and motions.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.C.2.4.1	Know that acceleration due to gravitational force is proportional to mass and inversely proportional to the square of the distance between the objects.	14	
SC.C.2.4.2	Know that electrical forces exist between any two charged objects.	5, 16, 17	
SC.C.2.4.3	Describe how magnetic force and electrical force are two aspects of a single force.	13, 16, 17	
SC.C.2.4.4	Know that the forces that hold the nucleus of an atom together are much stronger than electromagnetic force and that this is the reason for the great amount of energy released from the nuclear reactions in the sun and other stars.	13, 18	
SC.C.2.4.5	Know that most observable forces can be traced to electric forces acting between atoms or molecules.	15, 17	
SC.C.2.4.6	Explain that all forces come in pairs commonly called action.and reaction.	14, 15	

6. Demonstrate understanding of conservation of energy and increase in disorder.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.B.1.4.1	Understand how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth).	12, 13	
SC.B.1.4.2	Understand that there is conservation of mass and energy when matter is transformed.	8, 13, 18	

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

7. Demonstrate understanding of interactions of energy and matter.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.A.2.4.4	Know that nuclear energy is released when small, light atoms are fused into heavier ones.	18	
SC.B.1.4.3	Know that temperature is a measure of the average translational kinetic energy of motion of the molecules in an object.	2, 13, 19	
SC.B.1.4.4	Know that as electrical charges oscillate, they create time-varying electric and magnetic fields that propagate away from the source as an electromagnetic wave.	17	
SC.B.1.4.6	Know that the first law of thermodynamics relates the transfer of energy to the work done and the heat transferred.	13, 19	
SC.B.1.4.7	Know that the total amount of usable energy always decreases, even though the total amount of energy is conserved in any transfer.	13, 19	
SC.B.2.4.1	Know that the structure of the universe is the result of interactions involving fundamental particles (matter) and basic forces (energy) and that evidence suggests that the universe contains all of the matter and energy that ever existed.	12, 13, 18	

Correlation to Sunshine State Standards

Course Requirements for Physical Science - Course Number 2003310

8. Demonstrate understanding of interactions between science and technology.

Benchmarks		Addressed in Unit(s)	Addressed in Class on Date(s)
SC.H.3.4.2	Know that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science.	21	
SC.H.3.4.3	Know that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events.	21	
SC.H.3.4.4	Know that funds for science research come from federal government agencies, industry, and private foundations and that this funding often influences the areas of discovery.	21	
SC.H.3.4.5	Know that the value of a technology may differ for different people and at different times.	21	
SC.H.3.4.6	Know that scientific knowledge is used by those who engage in design and technology to solve practical problems, taking human values and limitations into account.	21	

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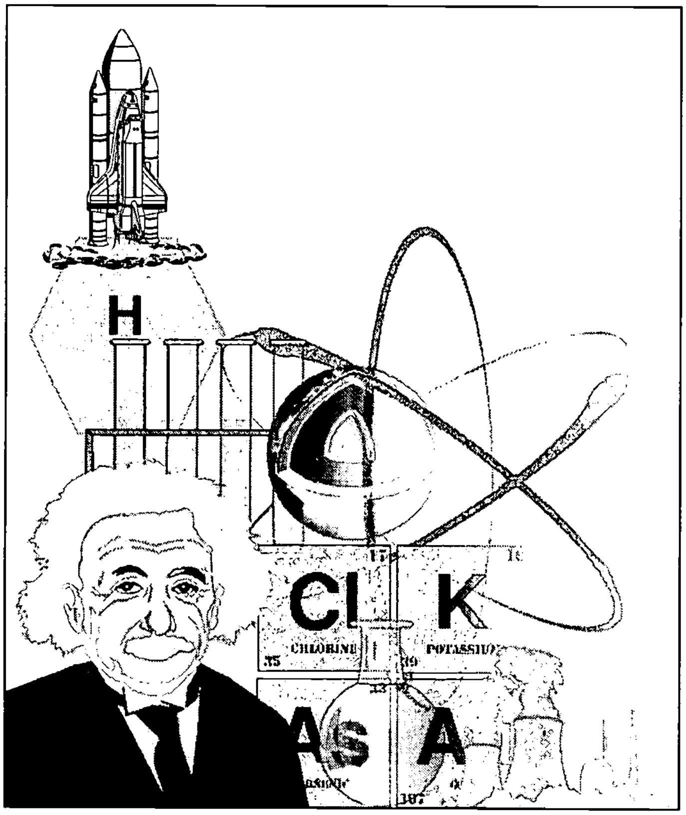

Bureau of Instructional Support and Community Services
Division of Public Schools and Community Education
Florida Department of Education
1999

Parallel Alternative Strategies for Students

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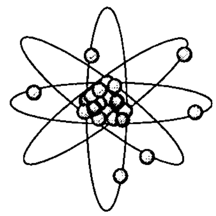

Physical Science

Course No. 2003310

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Curriculum Improvement Project
IDEA, Part B, Special Project

LEON COUNTY SCHOOLS

Exceptional Student Education

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Table of Contents

212

Acknowledgments

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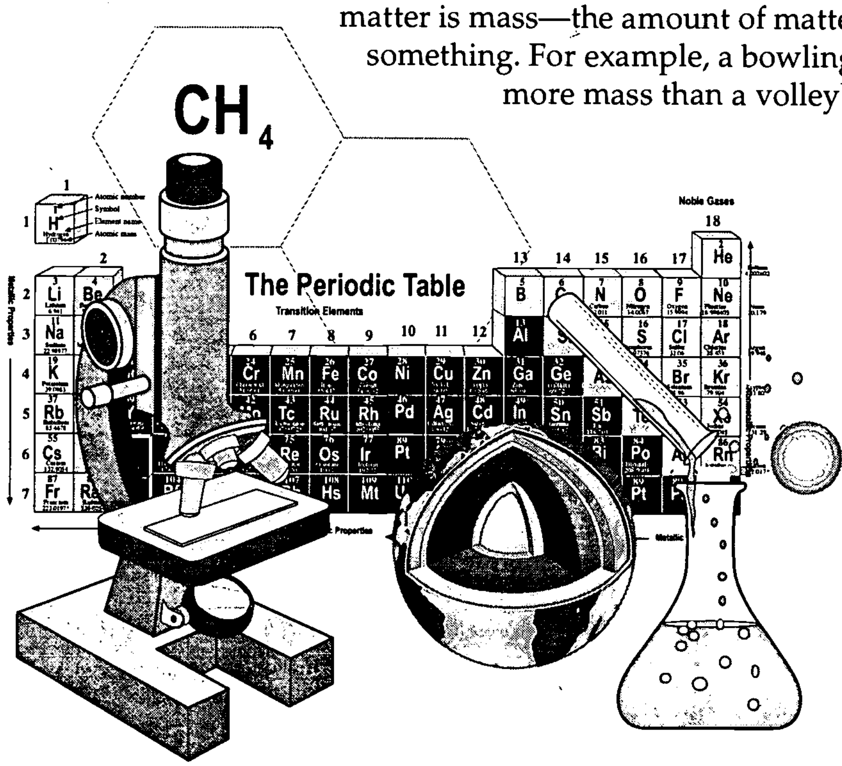
Introduction

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.

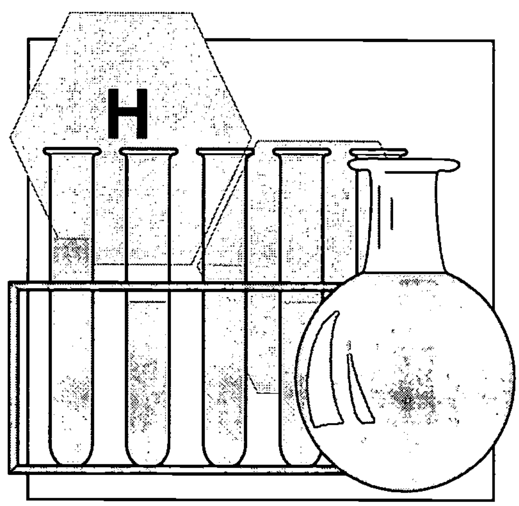
Physical science includes the study of how matter and energy are related. We use matter—all living and nonliving things—to work for us. In science, work means that a force (push or pull) causes something to move. Sir Isaac Newton investigated forces and motion. He asked questions about how gravity, mass,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

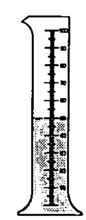
Bunsen burner .... an instrument that uses a mixture of air and natural gas to make a very hot, blue flame

evaporating dish .... a small ceramic dish used as a container to allow small amounts of liquid to evaporate

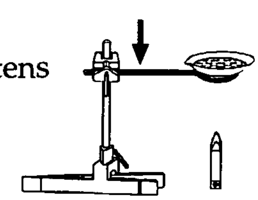
flask .... a narrow-necked, clear vessel used in laboratories

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

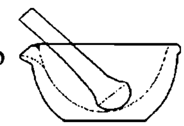
graduated cylinder .... clear tube with unit markings on the side and a flat base; used for measuring liquids



iron ring .... a ring-shaped clamp made of iron that fastens to the ring stand to support glass apparatus

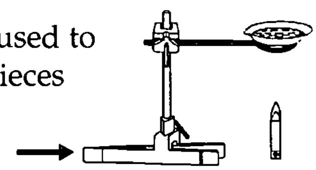


mortar and pestle .... a thick heavy bowl (mortar) and a tool shaped like a club (pestle) used for grinding, pounding, or mixing



pipet .... a glass tube used to transfer small amounts of liquid; usually marked to show units of volume

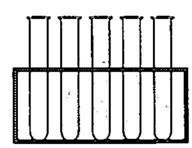
ring stand .... a holder or stand used to support various pieces of equipment



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

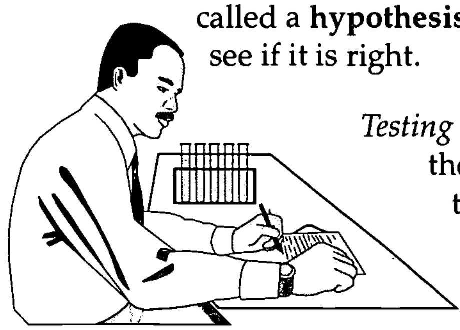
Do you ever wonder about things in nature? Do you wonder why or how? Science provides us with answers about how and why things happen the way they do. Scientists are people who conduct investigations in search of answers. Occasionally, something happens that appears to be totally new. Scientists try 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.

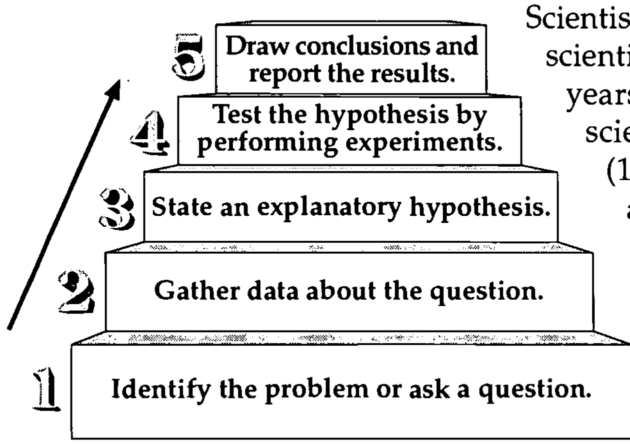
The second step of the scientific method is to *gather data about the question.* Information is collected about the question. **Observations** are made and recorded. This recorded information is called **data**. Another way to gather data is to read books, journals, or other publications that deal with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

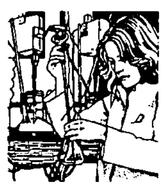


Scientists have been using the scientific method for about 400 years. It began with an Italian scientist named **Galileo Galilei** (1564–1642) who tested ideas about nature to explain the way things happen. Before Galileo, most people believed that heavier objects fell faster than lighter objects. No 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	**controlled**	**models**
behavior	**Galileo**	**predict**
computer simulations	**ideas**	**scientists**
conclusions	**investigate**	**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	**goggles**	**safety**
conclusion	**hypothesis**	**scientific method**
cotton	**laboratory**	**taste**
data		

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) ____________ .

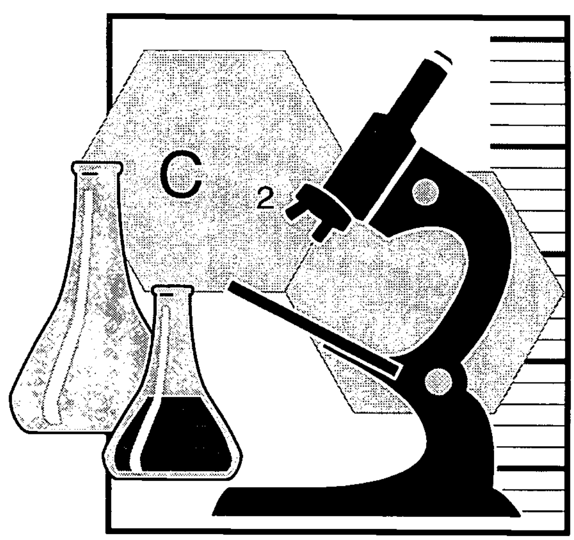
   a. iron ring
   b. mortar and pestle
   c. Bunsen burner
   d. ring stand

Practice

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

______ 1. equipment used in a scientific laboratory	A. apparatus
______ 2. a holder used to support various pieces of equipment	B. Bunsen burner
______ 3. a narrow-necked, clear vessel used in laboratories	C. flask
______ 4. an instrument that makes a hot, blue flame	D. funnel
______ 5. clear tube marked to measure liquid volume and has a flat base	E. graduated cylinder
______ 6. used to pour liquids without spilling into containers with small openings	F. mortar and pestle
______ 7. bowl and tool for grinding or mixing	G. ring stand
______ 8. small glass tube used in making chemical tests	H. test tube
______ 9. tool with two arms used to grasp apparatus	I. thermometer
______ 10. instrument used to measure temperature	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 1/100 of a gram

centiliter (cl or cL) .... a unit of volume in the metric system equal to 1/100 of a liter

centimeter (cm) .... a unit of measurement in the metric system equal to 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 1/10 of a gram

deciliter (dl or dL) .... a unit of volume in the metric system equal to 1/10 of a liter

decimeter (dm) .... a unit of distance in the metric system equal to 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 $\frac{1}{1000}$ of a gram

milliliter (ml or mL) .... a unit of volume in the metric system equal to $\frac{1}{1000}$ of a liter

millimeter (mm) .... a unit of distance in the metric system equal to $\frac{1}{1000}$ 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

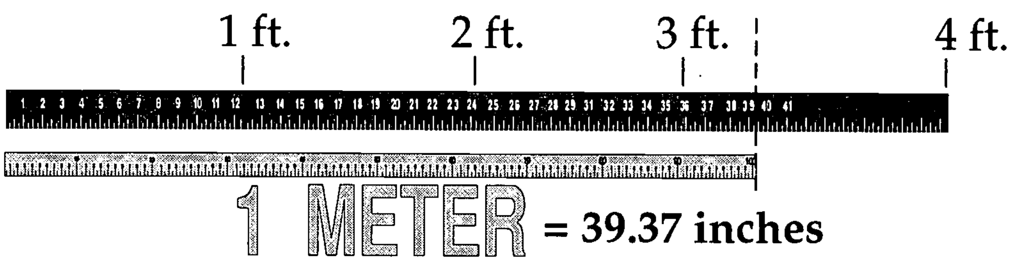
Introduction

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.

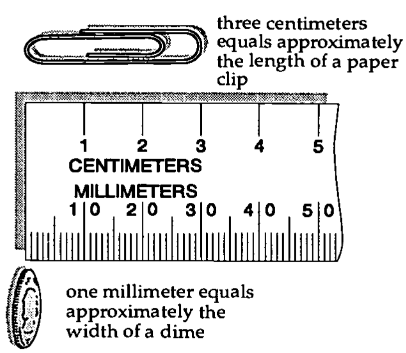
Length

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.



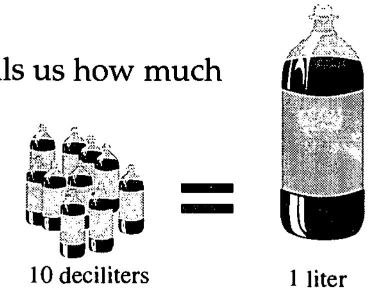
How do we measure small objects? Each meter is divided into 100 **centimeters (cm)**. One centimeter is equal to $\frac{1}{100}$ of a meter. Think of a dollar. Each penny is equal to $\frac{1}{100}$ of a dollar. Each centimeter can be divided into 10 parts. These smaller parts are called **millimeters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



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.

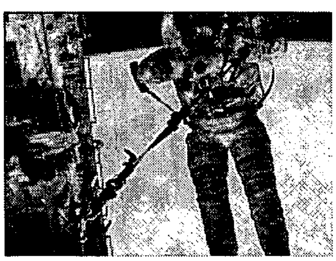
Volume



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 1/10 of a liter. In other words, it takes 10 deciliters to equal one liter. A **centiliter (cl or cL)** is 1/100 of a liter. It takes 100 centiliters to make a liter. A **milliliter (ml or mL)** is 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 1/10 of a gram, a centigram is 1/100 of a gram, and a milligram is 1/1000 of a gram. It takes 1,000 milligrams to equal a gram.

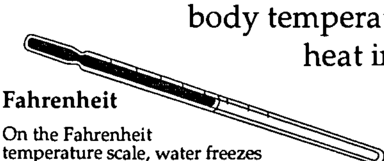
The mass of a gram of salt is about one milligram. Items which are sold in small amounts, such as medicine, are measured in milligrams.

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

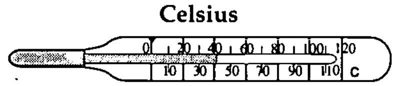
At times we must measure *temperature*. Temperature tells us how hot or cold something is at the moment. A **thermometer** measures temperature in **degrees**. The symbol for degrees is °. There are two common ways to measure temperature. On the **Fahrenheit** (F) temperature scale, water freezes at 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	A. centigram
______ 2.	how much gravity pulls on an object	B. decigram
______ 3.	$\frac{1}{10}$ of a gram	C. gram
______ 4.	the basic unit of mass in the metric system	D. milligram
______ 5.	$\frac{1}{1000}$ of a gram	E. weight

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

______ 6.	centiliter	F. L
______ 7.	deciliter	G. kL
______ 8.	kiloliter	H. mL
______ 9.	liter	I. dL
______ 10.	milliliter	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.

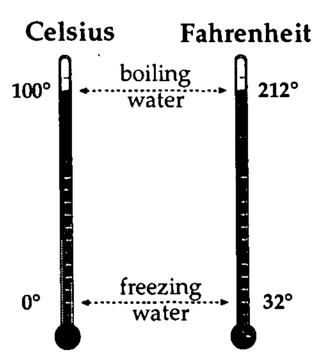
Investigate:

- 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	**1,000**	**liter**
32	**centimeter**	**meter**
100	**centimeters**	**millimeters**
212	**kilometers**	**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 ______________________ .

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

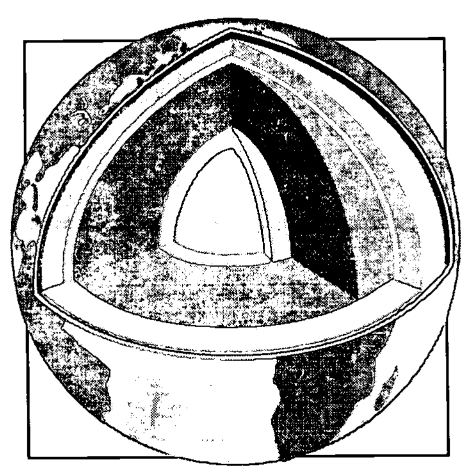
Match each definition with the correct term. Write the letter on the line provided.

______	1. the amount of space matter takes up	A. length
______	2. how long an object is from end to end	B. mass
______	3. the measure of the force of gravity pulling on an object	C. metric system
______	4. the system of measurement based on the decimal system	D. volume
______	5. the amount of material in an object	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	F. centi-
______	7. prefix meaning $\frac{1}{10}$	G. deci-
______	8. refix meaning $\frac{1}{100}$	H. gram
______	9. prefix meaning $\frac{1}{1000}$	I. kilo-
______	10. metric measurement of weight and mass	J. liter
______	11. prefix meaning 1,000	K. meter
______	12. basic metric measurement that is a little longer than one yard	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

263

Introduction

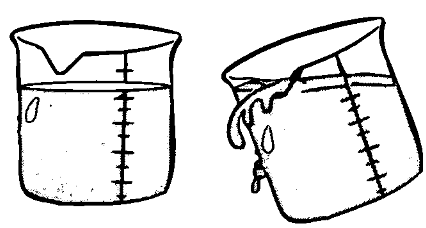
Look around you. Everything you see is **matter**. What is matter? Matter is anything that has **mass** and **volume** (takes up space). Mass is the amount of matter in an object. Remember that **weight** is the force of **gravity** pulling on the object. An object's weight depends on its mass and whether 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.



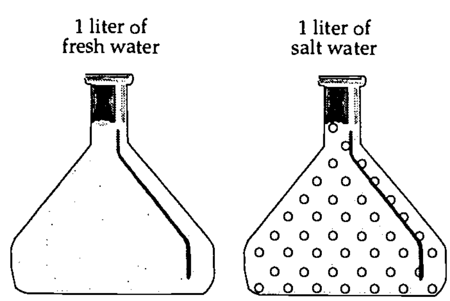
A cup of water takes up space in a beaker. Tilt the beaker. The water changes shape but it is still the same amount of water.

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

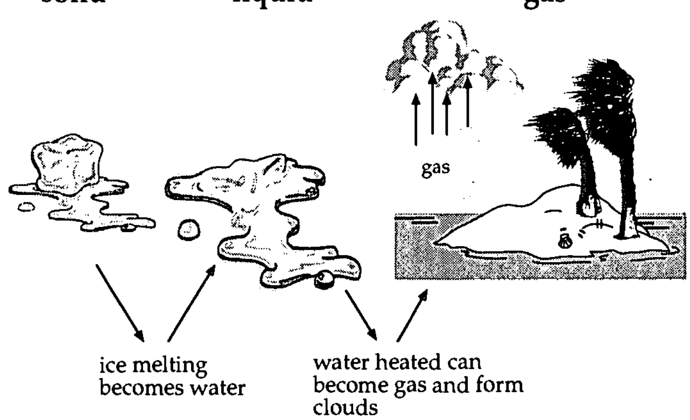
We learned that **chemistry** investigates how matter changes. **Chemical properties** of matter depend on how one substance **reacts** with other substances. Paper burns. That is because it reacts with oxygen in the air.

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.

solid **liquid** **gas**



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 ________________ .

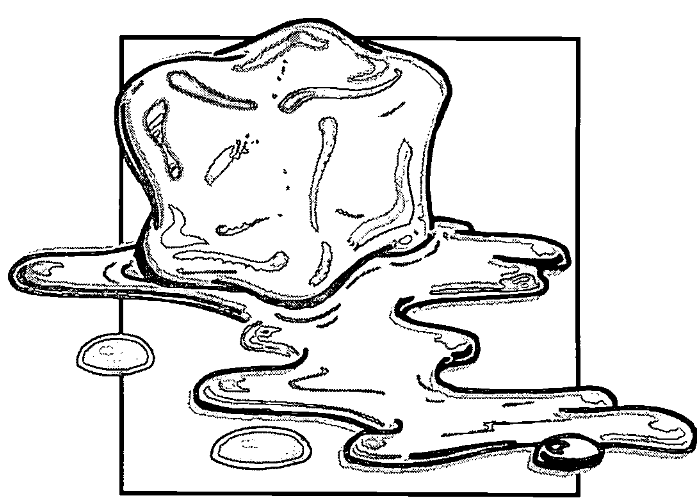
Practice

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.

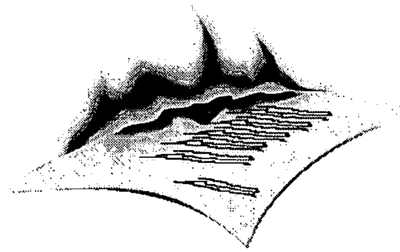
Physical Change

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	**chemical**	**physical**
changes	**phase**	

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.	1.
2.	2.

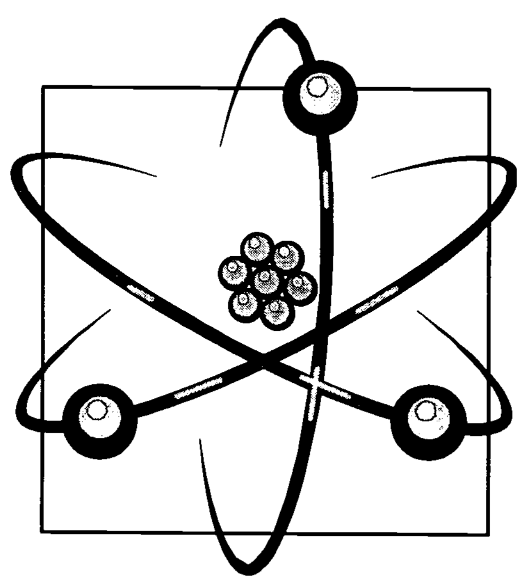
   f. You have just learned that by mixing vinegar and baking soda, you produced a __________________ change. Heat is often a product of a chemical change. One of the new substances you formed is carbon dioxide. Carbon dioxide is a gas. It is the same carbon dioxide as the substance formed when paper is 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	A. carbon dioxide
______	2. the makeup of a substance	B. chemical change
______	3. the force placed on an object	C. combustion
______	4. the process of burning a substance	D. composition
______	5. material or matter	E. physical change
______	6. any change in the form or state of matter	F. pressure
______	7. any change in which a new substance or substances are produced	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

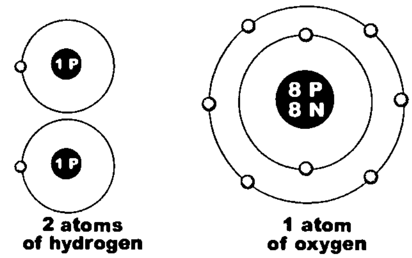
Did you ever wonder what is in air? Have you ever thought about how there are an incredible number of different things in the world? All that you see, touch, and feel is made from tiny units of matter. This unit will introduce you to these unseen building blocks of the universe.

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.

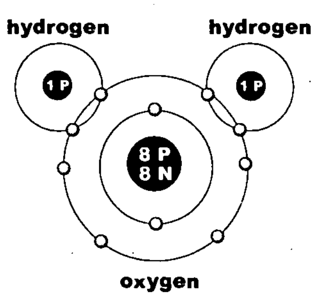


Water Molecule Broken Down into Its Elements

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**.

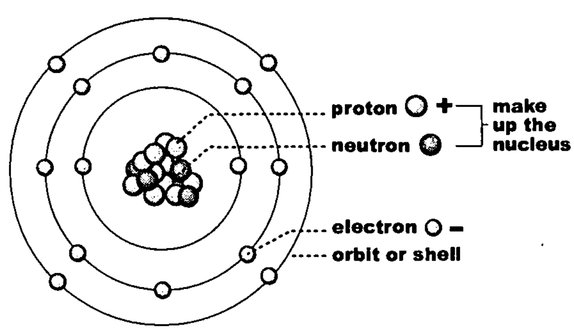
Compounds

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.

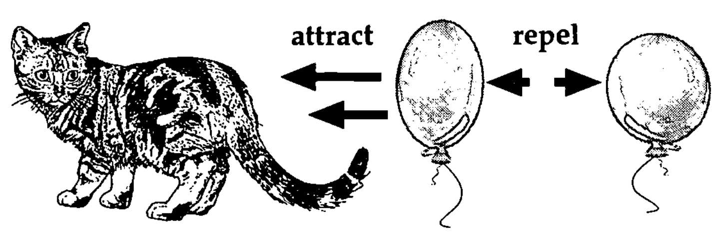


Parts of the Atom

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.

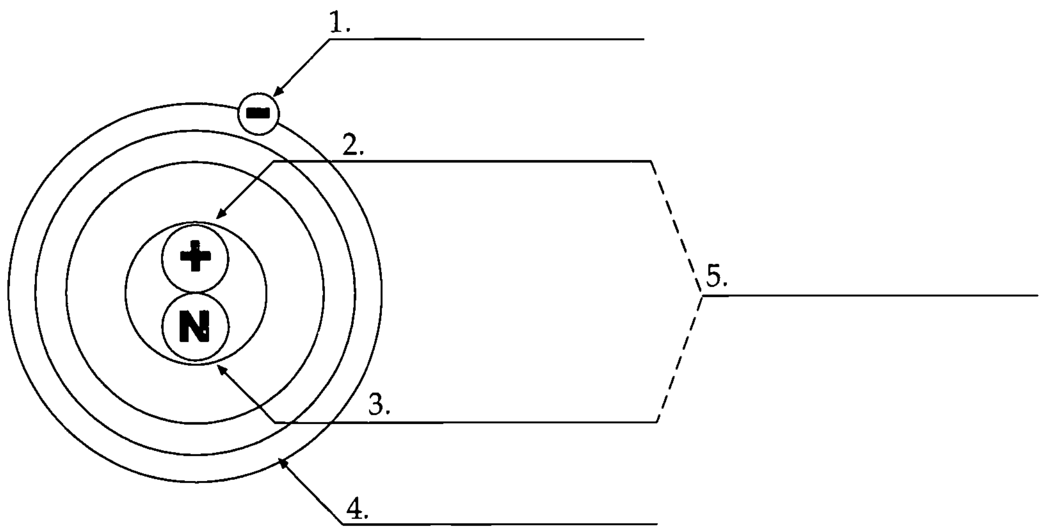
2. Draw a picture of your water molecule in the space below. Label the atoms with the correct symbols.

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	**electrons**	**nucleus**	**together**
atom	**forces**	**orbit**	
distance	**molecule**	**phase**	

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	**neutral**	**positive**	**toward**
away	**no**	**repel**	
negative	**one**	**shell**	

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

____________________ 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

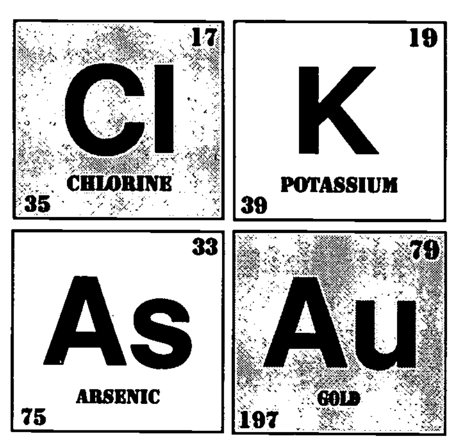
____________________ 11. the negatively charged particle of an atom

________________________ 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.

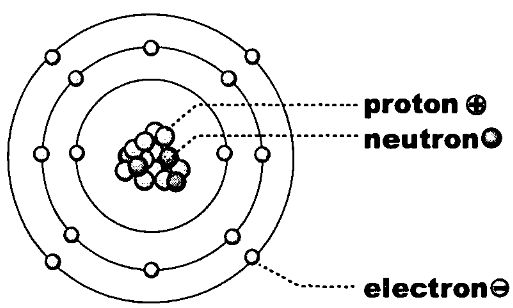
Now, scientists had quite a group of elements. They decided to make a chart or table based on the atomic number of each atom. Since hydrogen has an atomic number of one (1), it became the first element on the table. However, there were some problems with the table, because it had some missing spaces. 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.

Group 1
H
Li
Na
K
Rb
Cs
Fr

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

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.

2	Li	Be

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.

protons + neutrons = atomic mass

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.

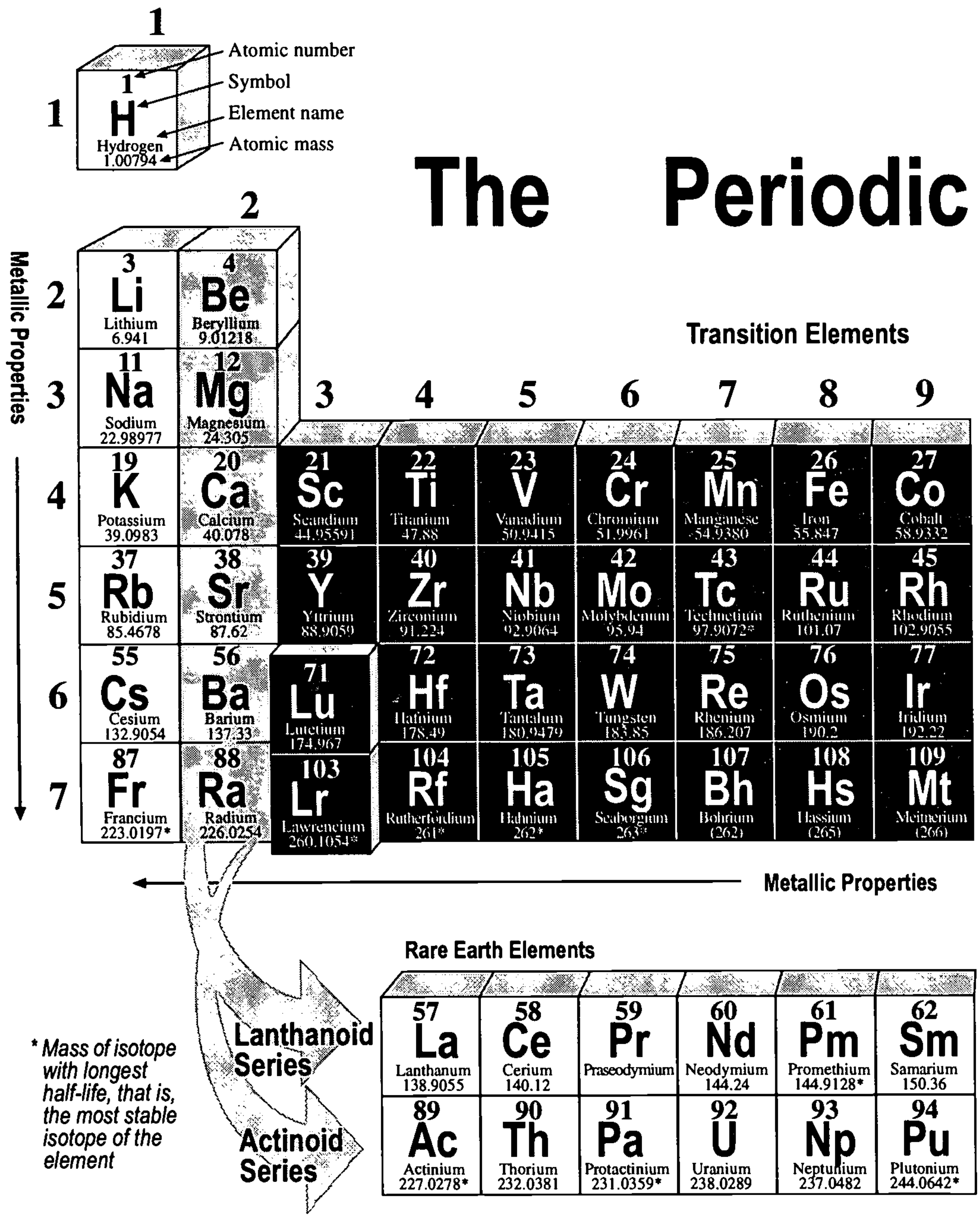
Elements and their symbols are listed in numerical order and grouped based on the atomic number.

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.



Table

Noble Gases

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§

Nonmetallic Propertiess

Metallic Properties

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	

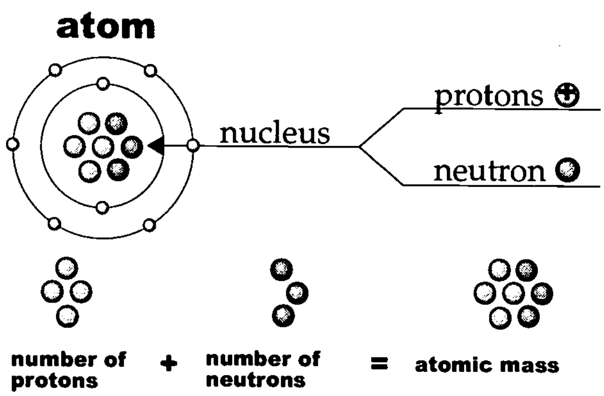
Practice

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 _______________________ .

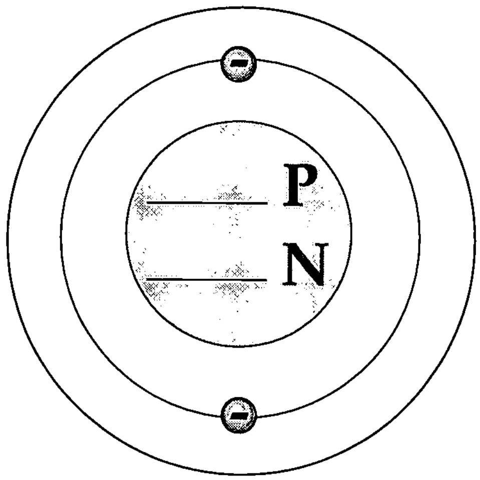
312

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

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

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.

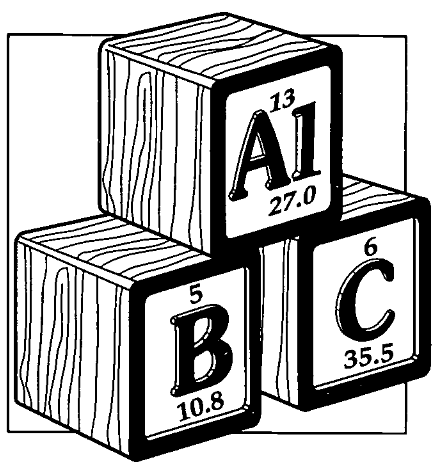
34. This process ____________________ our view of the universe.

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

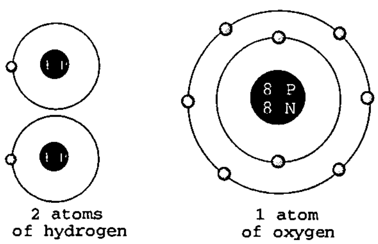
symbols .... the letters used by scientists to represent the names of the elements

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

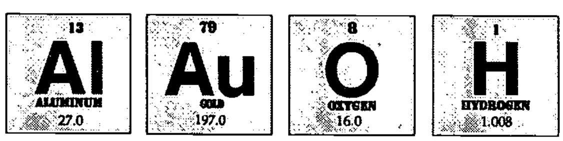
By now we know that matter has mass, volume, and density. We also know that matter can be a solid, liquid, or a gas. We have also learned some of the physical and chemical properties of matter. We experimented to show that chemical changes produce new substances. However, what makes up matter? Think 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.

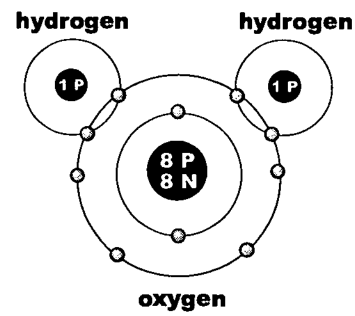
Scientists have a special way of writing the names of elements. They use letters instead of writing the whole word. The letters are called **symbols**. Here are some of the common ones.

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.

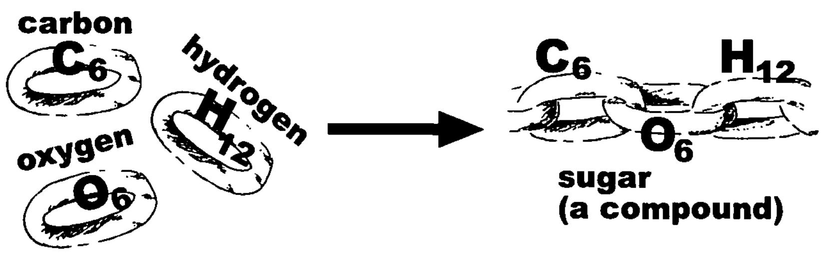
Compounds

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).



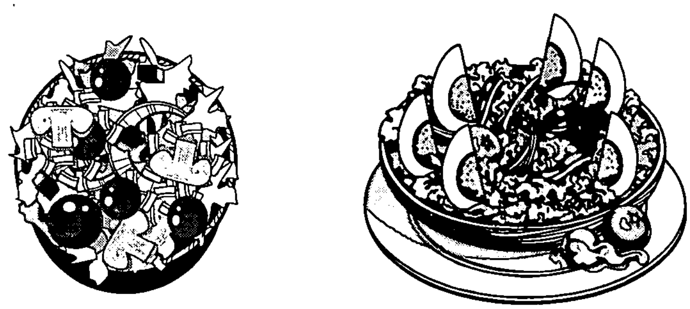
Sugar and water do not look like the elements that formed them. When compounds are formed, the elements always combine in the same proportions. A **formula** tells how elements combine to form compounds. The formula for water is H_2O. Compounds always have formulas.

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.

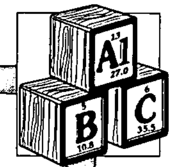
On the other hand, a mixture can be made in many different ways. Air is a mixture. The elements in the air are not always the same. Tossed salad is a mixture too; salads do not always have the same ingredients. Mixtures do not have formulas. They are not formed by chemical changes.



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 ____________________

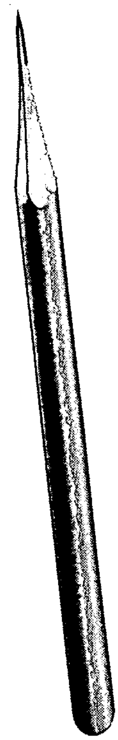
5. Cu ____________________

6. Fe ____________________

7. H ____________________

8. O ____________________

9. Al ____________________



324

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?

   ____

326

Practice

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

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

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.

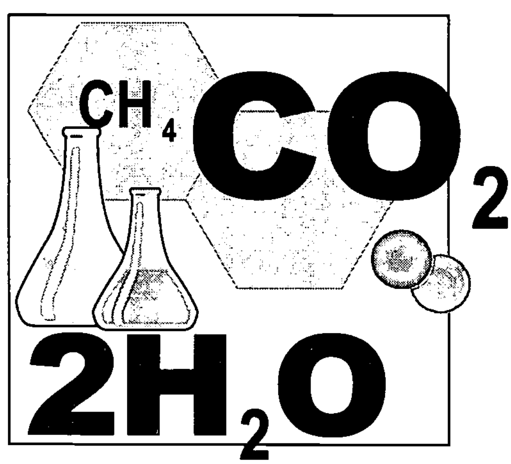
__________ 7. All mixtures have formulas.

__________ 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: **$NaOH + HCl \longrightarrow NaCl + H_2O$**

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: **$2\ H_2O$**

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: **H_2**

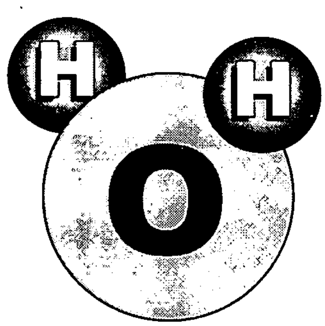
yields .... makes or produces

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:

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

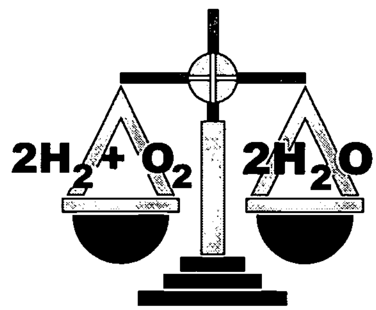
*The arrow stands for the word **makes** or **yields**.*

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.

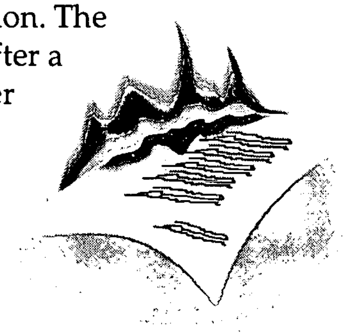
To determine the total number of atoms in a molecule, any **coefficient** is multiplied by the subscript for each element. For example, we could look at **2 H_2**. The coefficient of two means that two molecules of hydrogen are involved. To determine the number of hydrogen *atoms* in two *molecules* 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	$\longrightarrow$	$2H_2O$
(2 molecules of hydrogen)	+	(1 molecule of oxygen)	$\longrightarrow$	(2 molecules of water)
4 atoms	+	2 atoms	$\longrightarrow$	4 atoms of H + 2 atoms of O
		6 atoms	$\longrightarrow$	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 ____________________ . $2H_2 + O_2 \longrightarrow 2H_2O$

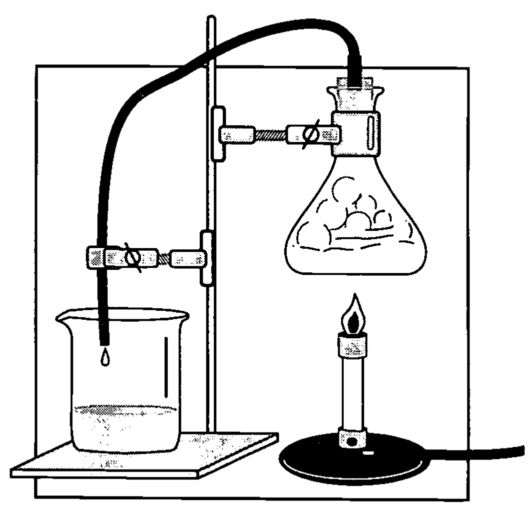
7. When the numbers of each type of atom on each side of the equation are equal, we say that the equation is ____________________ .

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.

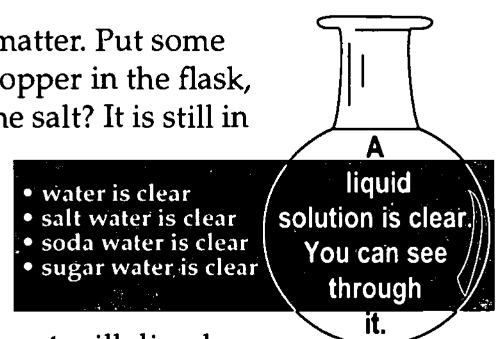
Reviewing Matter

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

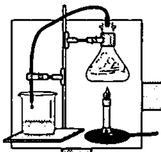
- Two or more elements combine chemically to form a compound.
- Compounds cannot be separated easily.
- A mixture of two or more substances does not combine chemically.
- Mixtures can be separated using physical means.

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.



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.

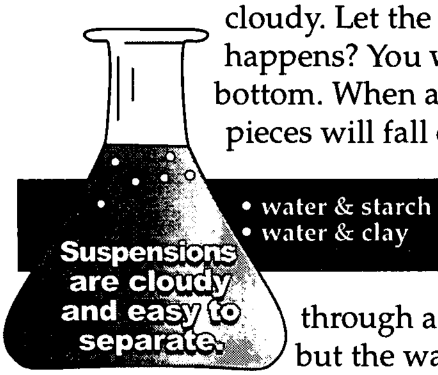


A liquid solution is clear. You can see through it. Salt water is clear. Soda water is a mixture of carbon dioxide and water. Soda water is clear also, and it is a liquid solution.

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	homogeneous	solution	universal
filtered	liquid	solvent	
heterogeneous	solute	suspension	

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.

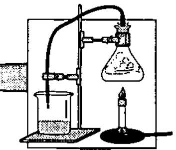
1. Using what you have learned, explain how you might clean a muddy pool.

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 ________ .

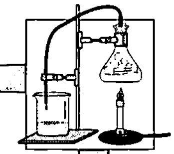
   a. filtering
   b. shaking

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.

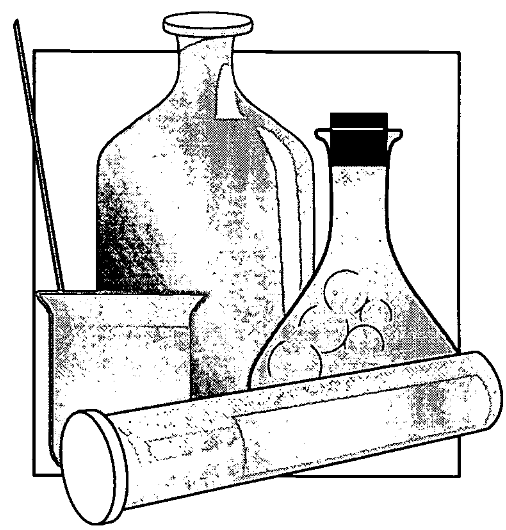
_________ 5. Salt water is heterogeneous.

_________ 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)

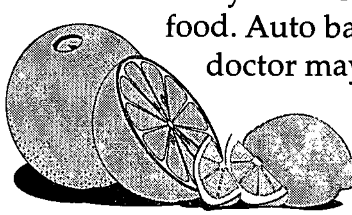
Introduction

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.

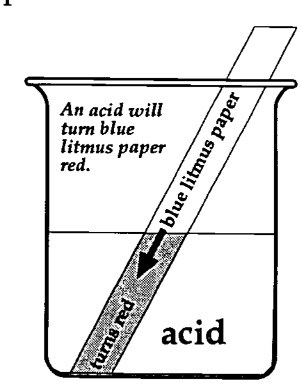
Acids are found in many parts of our daily life. Vinegar contains acetic acid (CH_3COOH). Citrus fruits (such as lemons and oranges) contain citric acid. The hydrochloric acid (HCl) in your stomach helps to digest food. Auto batteries contain sulfuric acid (H_2SO_4). Your doctor may tell you to use a 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.

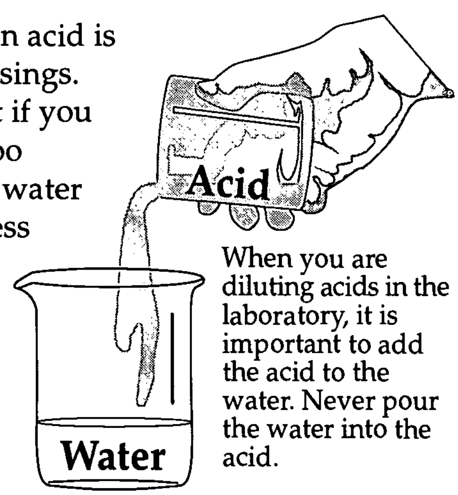
The litmus and the metal test are indicators for acids. They will only work on acids that are dissolved in water.

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.

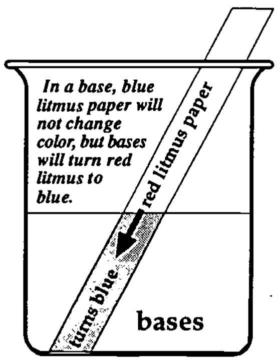
Sometimes, though, the concentration of an acid is too high or strong. Think about salad dressings. Many salad dressings include vinegar, but if you poured vinegar on a salad it might taste too strong. Instead, the vinegar is mixed with water and oil. The taste of the vinegar is made less strong. This 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.



When you are diluting acids in the laboratory, it is important to add the acid to the water. Never pour the water into the acid.

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):

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

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

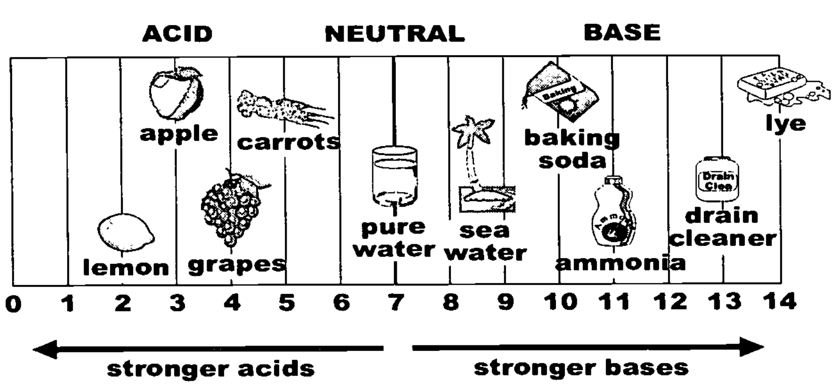
Salt water is a neutral solution that will not react with litmus paper. It is neither acidic nor basic. Although we can produce neutral solutions by the reaction of a base and an acid, some substances are naturally neutral.

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

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? ______________

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.

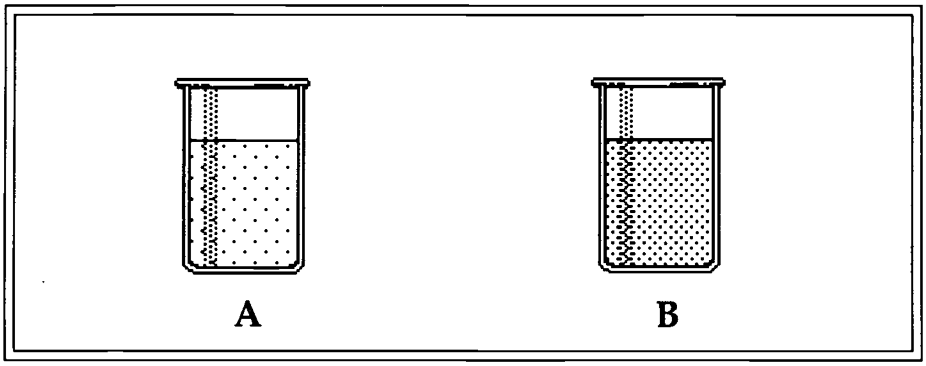
1. There are many types of substances in the air that cause air pollution. When rain water mixes with some of these substances, acid is formed. We call this "acid rain." Tell how acid rain might be harmful. (Think about what acids can do.)

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

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.

376

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

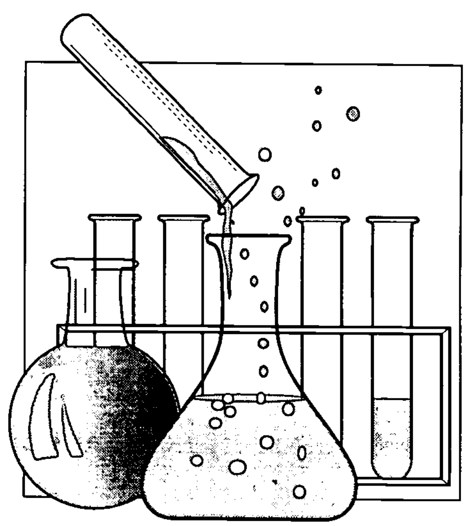
   ____________________ .

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

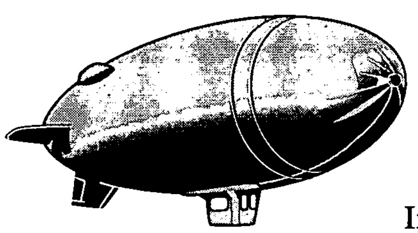
Chemical equations describe chemical reactions. The simplest type of reaction takes place when two or more elements combine to form a compound. There are other kinds of reactions that occur between elements and compounds. Chemical reactions are the results of the properties and arrangement of electrons. 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**

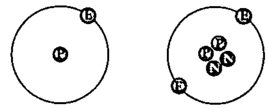


Hydrogen has one electron and one proton. Helium has two electrons and two protons. These are the two lightest elements. You might expect for there to be many similarities between the two elements. Both are gases and both are colorless and odorless. Additionally, both have been used to inflate balloons 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.

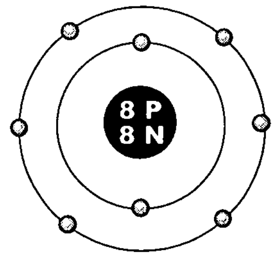
In the case of both hydrogen and helium, we can make some rules about electron configuration. One of the most important rules is a tendency to have two electrons in the valence shell. In some ways, you can almost think of the atoms as "wanting" two electrons. When they have the two electrons, the tendency 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



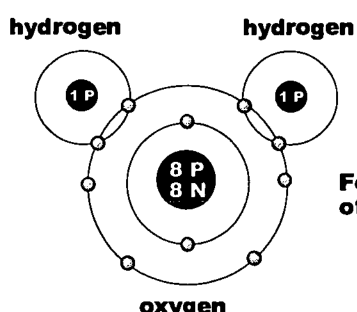
Electron Configuration of Oxygen

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.

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.



Formation of Water

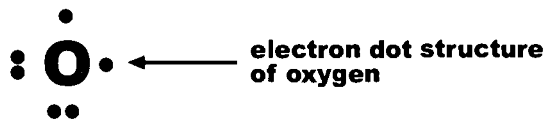
When water and hydrogen combine to form water, the oxygen shares electrons with hydrogen. The result is that each hydrogen shares one of the oxygen's electrons. This effectively gives each hydrogen two electrons in its outer shell. Because the electrons are being shared, oxygen shares the electrons of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

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

Electron Dot Structures

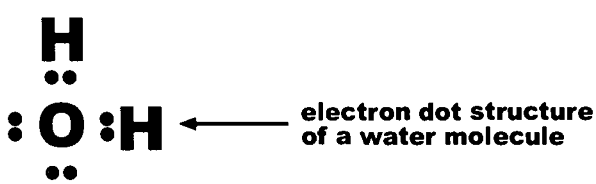
Electron dot structures model atoms. For instance, hydrogen has one electron. This is the dot structure of hydrogen:

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:

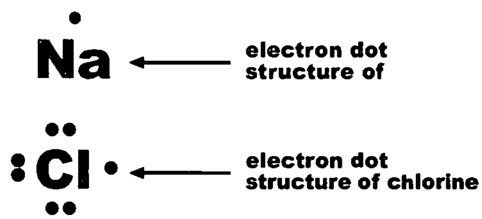


Take a pencil and draw a circle around the electrons that are on the edges of the oxygen molecule. Count the number of electrons. You should have counted eight electrons. Now, choose one of the hydrogen atoms. Circle the electrons that are around the hydrogen atom. Count them. You should have counted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

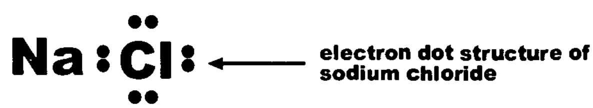
Other Bonds

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	He: helium		
2. sodium	Na· sodium		
3. calcium	·Ca· calcium		
4. argon	:Ar: argon		
5. krypton	:Kr: krypton		
6. carbon	·C· 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	eight	ionic bonds
carbon	electron dot configuration	recombine
catalyst	electrons	two
concentration	force	valence
covalent	increase	

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.

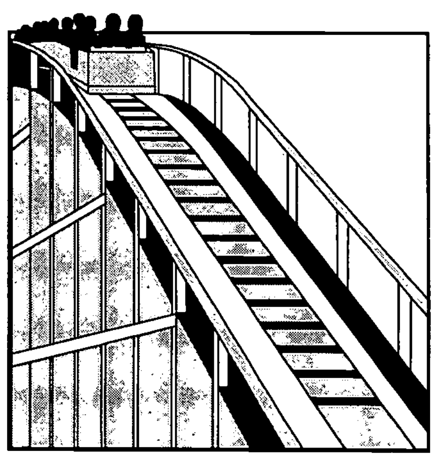
15. By lowering temperature, pressure, or concentration, the speed and completeness of reactions can be lowered. When food spoils, a chemical reaction has taken place. What common method of food storage helps prevent spoilage and why?

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

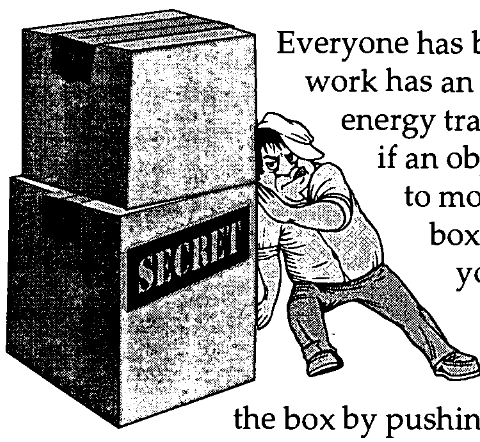
work .... the amount of change caused or energy transferred

Introduction

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

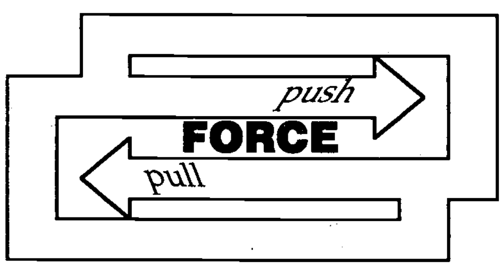
Energy, Work, Force, and Power

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.

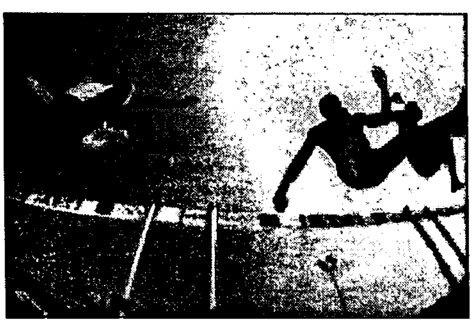
Potential and Kinetic Energy

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

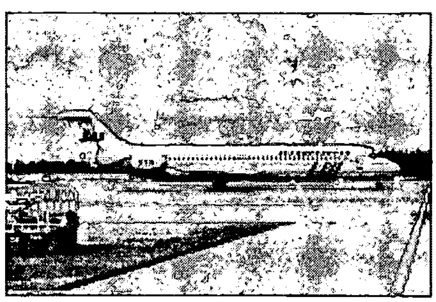
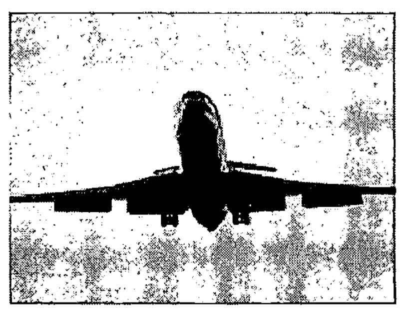


Figure B



2. A. ______________________ B. ______________________

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

____

401

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.

402

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

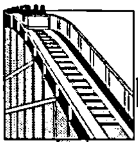
E. kinetic energy

F. potential energy

G. power

H. work

403



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	**potential**	**stored**
force	**power**	**work**
kinetic		

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?

____

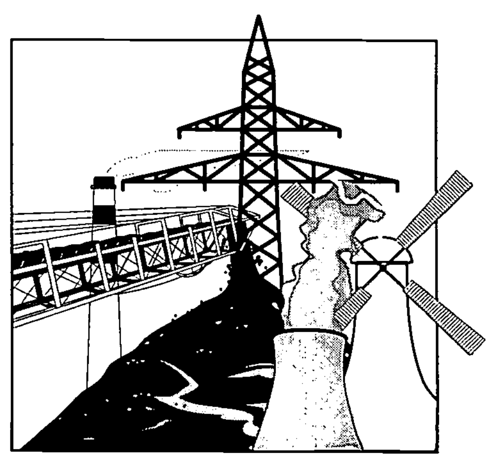
9. Which has more power? A train full of passengers that carries them across the state *or* the same train without any passengers as it makes the trip?

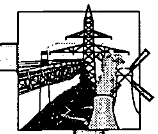
____

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

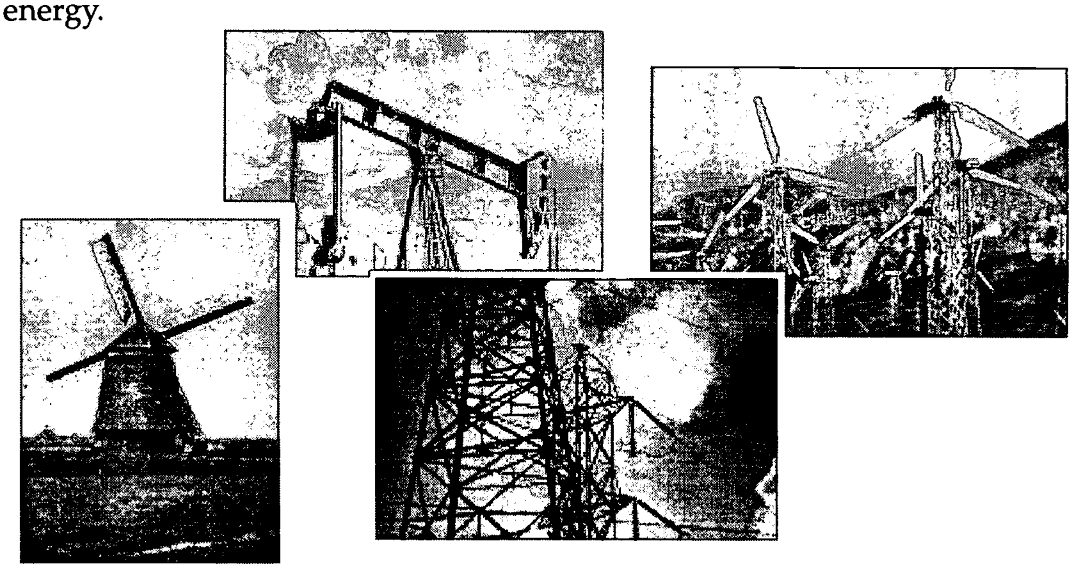
sound energy .... the energy of vibrating materials as detected by human ears

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.

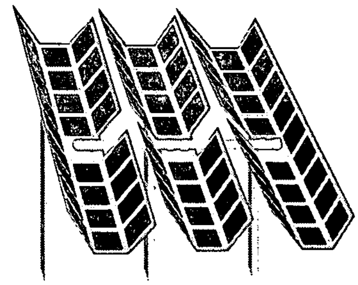


Electrical energy is caused by the flow of electric currents. Many of the appliances we use every day run on electrical energy—the energy of moving electrons. The energy in magnets is a result of the same force that causes electricity.

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.

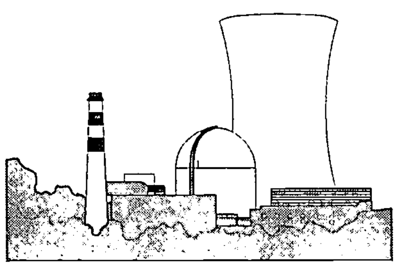
Heat energy is responsible for causing changes in temperature. The form of matter can be changed by heat energy. Remember that heat can change a solid to a liquid or a liquid to a gas. Almost all matter contains some heat energy.

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.


solar panels

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.

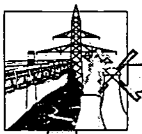
You have already learned that matter cannot be created or destroyed. What about energy? It can change form, but it is never destroyed. The **law of conservation of energy** states that energy is never created or destroyed—only changed from one form to another.

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	**electrical**	**mechanical**
change	**fundamental**	**nuclear**
chemical	**heat**	**sound**
converted	**light**	**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.

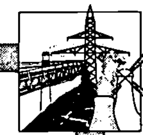
413

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	**heat energy**	**nuclear energy**
chemical energy	**light energy**	**sound energy**
electrical energy	**mechanical 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	**heat**	**nuclear**
chemical	**light**	**sound**
electrical	**mechanical**	

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

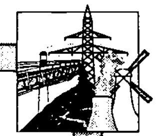
Complete the following statements with the correct answer.

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.

422

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.

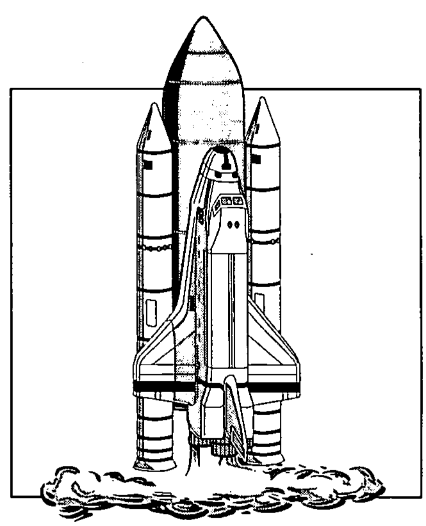
5. A stereo converts ____________________ energy into ____________________ energy.

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

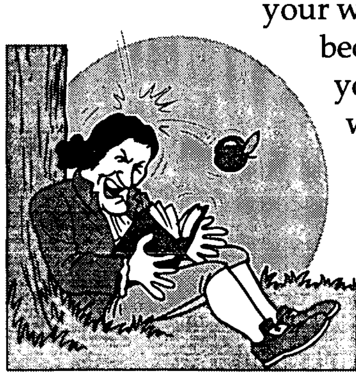
Introduction

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 **weigh**t 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.

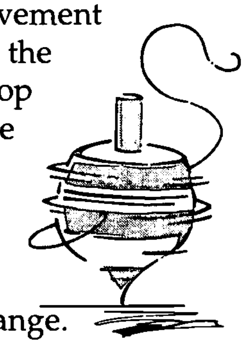


Sir Isaac Newton

427

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**.

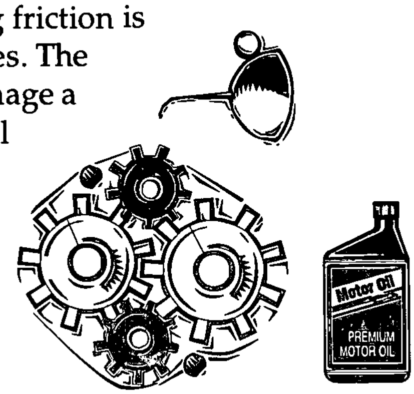


Friction

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.

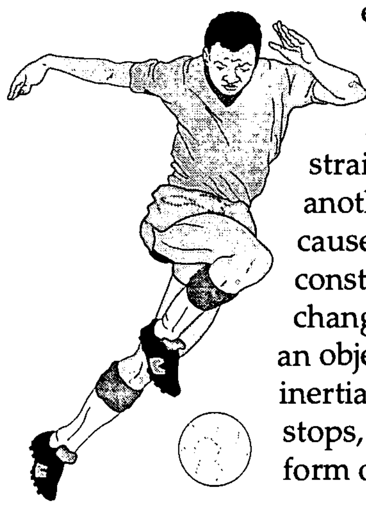


Oil is used as a lubrication to reduce friction on moving parts of machines.

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.

429

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	A.	1^{st} law of motion
______	9. a soccer ball at rest	B.	2^{nd} law of motion
______	10. a water skier rounding a curve	C.	3^{rd} law of motion

432

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	**friction**	**move**	**pull**	**unbalanced**
Earth	**gravity**	**movement**	**push**	**weight**
equal	**increases**	**N**	**resistance**	
far	**mass**	**newton (N)**	**Sir Isaac Newton**	

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 __________________ .

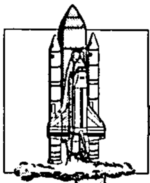
4. Unbalanced forces cause an object to __________________ .

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 __________________ .

433



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	**faster**	**lubrication**	**slow down**
action	**force**	**reaction**	**speed**
direction	**heat**	**rough**	**three**
do not	**inertia**	**size**	

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?

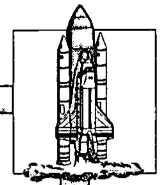
Law: ______

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.

Practice

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

______ 1. any push or pull on an object	A. balance force
______ 2. the laws that state the relationship between force and motion	B. force
______ 3. when forces are equal and do not cause movement	C. friction
______ 4. the idea that an object keeps its present state of motion	D. gravity
______ 5. the force of Earth's gravity pulling on an object	E. inertia
______ 6. when one force overpowers another force; the forces are not equal; causes movement	F. laws of motion
______ 7. the SI unit to measure force	G. lubrication
______ 8. the attraction between any two objects with mass	H. N
______ 9. abbreviation for newton	I. newton
______ 10. a type of resistance caused when one surface touches another surface	J. resistance
______ 11. any force that prevents or slows down motion	K. unbalanced force
______ 12. the greasing of surfaces that rub against each other in order to reduce friction	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?

    ____

441

12. How can the force of friction be reduced? ____________________

____

13. What are two substances used as lubricants? ____________________

____

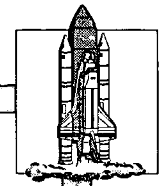
14. Who developed the three basic laws of motion? ______________

____

15. What is inertia? ______________________________________

____

____



Practice

Write the three **laws of motion**.

1. First law of motion: ______________________________

____

____

____

____

____

2. Second law of motion: ______________________________

____

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3. Third law of motion: ______________________________

____

____

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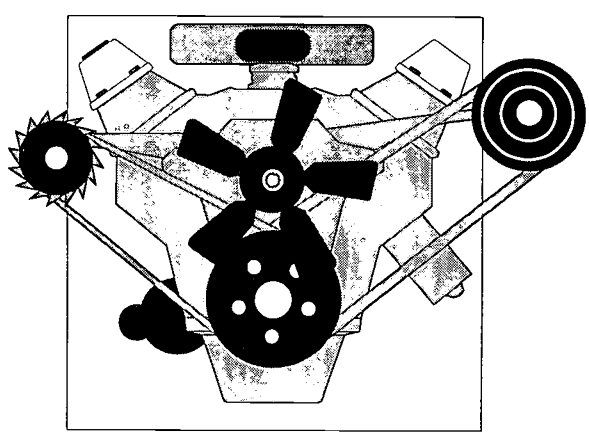
____

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

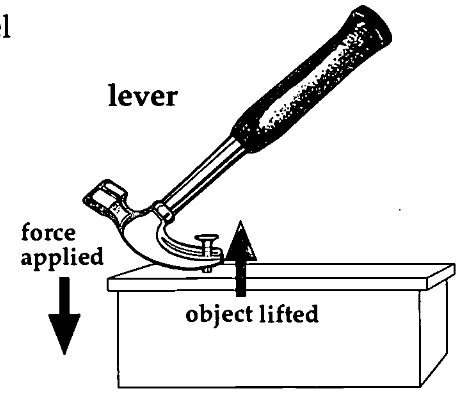
A *machine* is something that makes work easier and more efficient. A machine can change the size of a force, direction of a force, or the distance a force moves. Sometimes it may seem that a machine can create energy. This is not true. A machine cannot increase the amount of energy, it can only transfer 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:

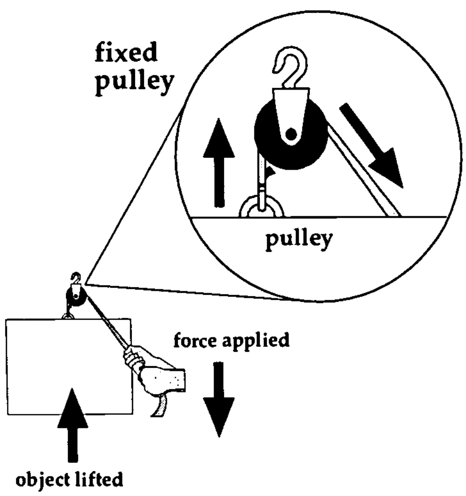
Six Kinds of Simple Machines
• lever • pulley • inclined planes • wedge • screw • wheel and axle

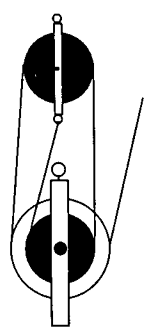
447

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.

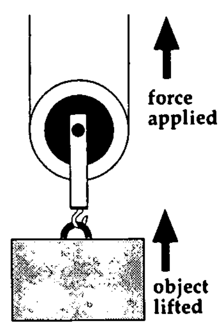


A **pulley** is a very common simple machine. It changes the direction of the force used. It also can increase the force. It is actually a kind of lever. A **fixed pulley** does not move. It does not multiply force. It only changes the direction of the force. When you pull down on a rope around a fixed pulley, the force will go up.





block and tackle

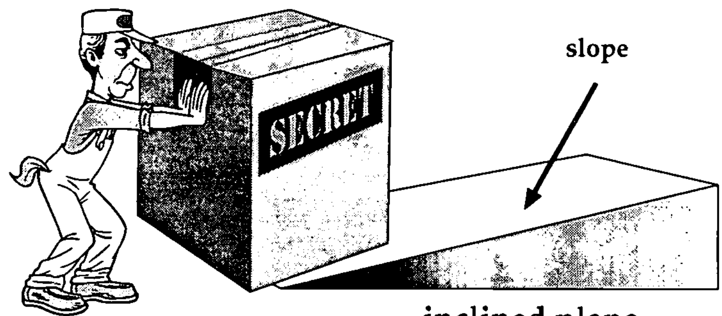


movable pulley

A **movable pulley** moves. It can increase force. When the rope is pulled, both sides of the rope apply force. The force is multiplied.

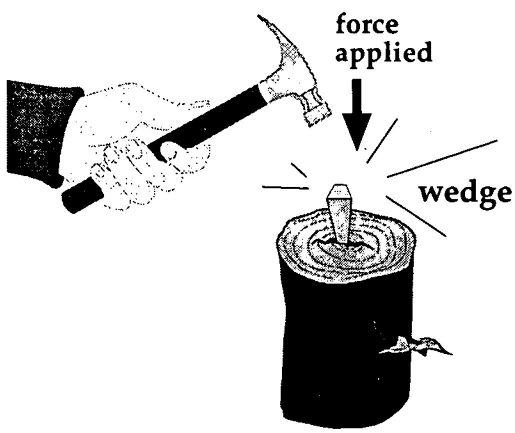
Fixed and movable pulleys can be used together. This type of arrangement is called a **block and tackle**. A block and tackle can be used to lift very heavy objects. A mechanic may use a block and tackle to lift an engine out of a car. A block and tackle can multiply force many times.

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.

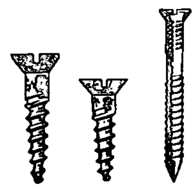
A **wedge** is a type of inclined plane. It has sloping sides. A wedge moves. It multiplies force. Suppose you want to split a log. Place a pointed wedge on the log. Hit the wedge with a hammer. The downward force of the hammer will hit against the wedge. The wedge will move downward, and the log's sides 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.

449

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.

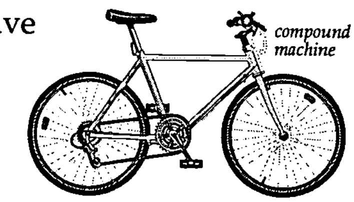
wheel and axle

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.

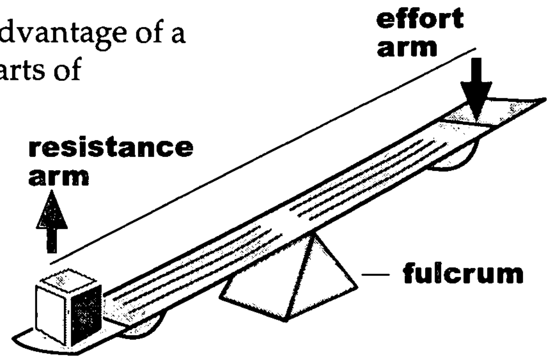
Mechanical Advantage

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.

$$MA = \frac{100\text{ n (R)}}{50\text{ n (E)}} = 2$$

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:

$$MA = \frac{\text{Length of Effort Arm}}{\text{Length of Resistance Arm}}$$

If an effort arm is 40 cm and the resistance arm is 80 cm, what is the MA?

$$MA = \frac{\text{Length of Effort Arm}}{\text{Length of Resistance Arm}} \qquad MA = \frac{40\text{ cm}}{80\text{ cm}} = \frac{1}{2}$$

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.

$$MA = \frac{120\text{ cm}}{60\text{ cm}} = 2$$

The longer the effort arm, the greater the mechanical advantage. The longer the resistance arm, the lower the mechanical advantage.

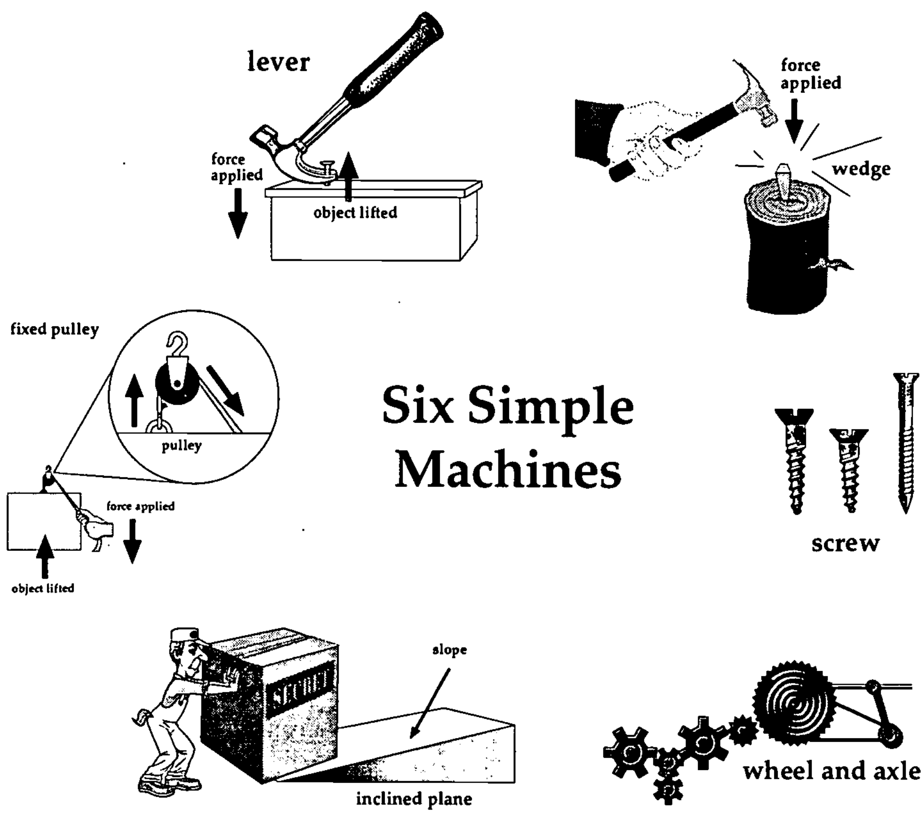
The mechanical advantage for all simple machines can be computed. Each simple machine has its own formula for finding mechanical advantage. However, you can find the mechanical advantage of any machine if you divide the force of the resistance by the effort it takes to move it. In essence,

$$MA = \frac{\text{Resistance}}{\text{Effort}}$$

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?

$$\textbf{MA} = \frac{150}{50} \qquad \textbf{MA} = 3$$

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?

____

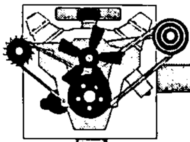
____

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?

____

____

455



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	**lever**	**resistance arm**
effort arm	**mechanical advantage**	
fulcrum	**resistance**	

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	lever	pulley
change direction	machines	screw
change speed	make a force stronger	transfer
fixed	movable	wedge
inclined plane	multiplies	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

463

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

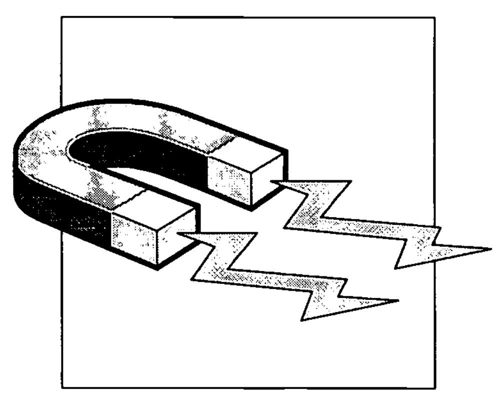
G. resistance

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)

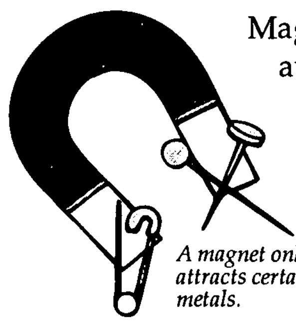
unlike poles .... the opposite poles; the poles of magnets that attract each other

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?

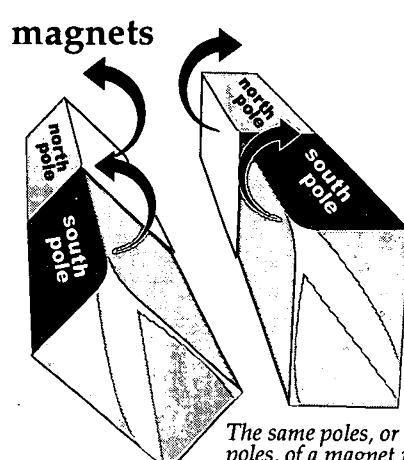
A **magnet** is a substance that **attracts** or pulls on other substances. Iron, cobalt, and nickel are **magnetic** metals because they are attracted to a magnet. Anything that is not attracted to a magnet is **nonmagnetic**. Tin, copper, paper, and wood are nonmagnetic.



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.

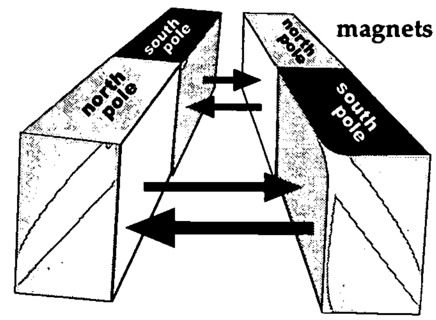
One pole, or end of a magnet, is called the **north pole**. The other end is called the **south pole**. All magnets have a north and south pole.



The same poles, or like poles, of a magnet will repel each other.

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 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.



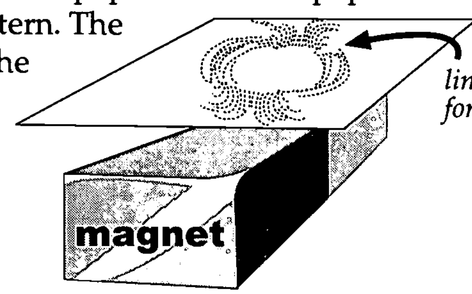
The opposite poles, or unlike poles, of magnets will attract each other.

Explaining Magnetism

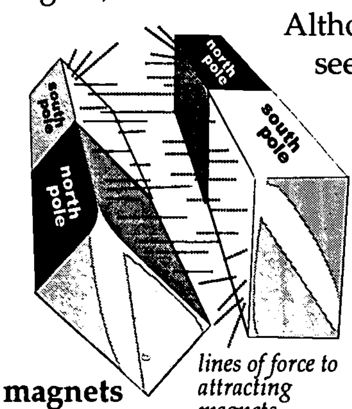
You know that atoms make up matter. Some atoms are like little magnets. In cobalt, iron, and nickel, the atoms may line up in a special way. When most of the atoms face the same way, the material will be magnetic. In nonmagnetic material, the poles cancel each other out. This is because they are not 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.



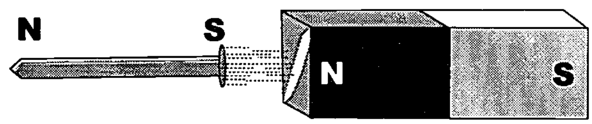
When you get too far away from a magnet, the force will not be noticeable Although magnetism seems like a strong force, we see that it quickly gets weak with distance.



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

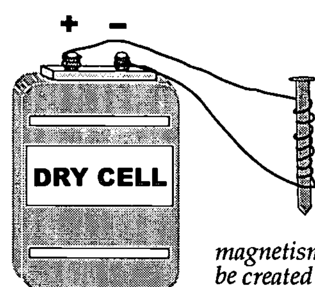
Magnetism can be **induced**, or created, in some materials. There are three ways to make a magnet. Place an iron nail against the north pole of a magnet. The force in the magnet will begin to pull at the atoms in the nail. They will line up in straight lines. This will make the nail temporarily magnetic. 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

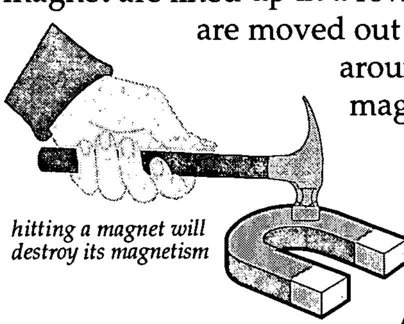
You saw that in the first two examples, a magnet was used to create a new magnet. In this last example, we did not use a magnet. Instead, we used electricity. Electricity is electrons that are flowing in a particular direction. Because these particles are charged, when they flow past the nail it causes 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

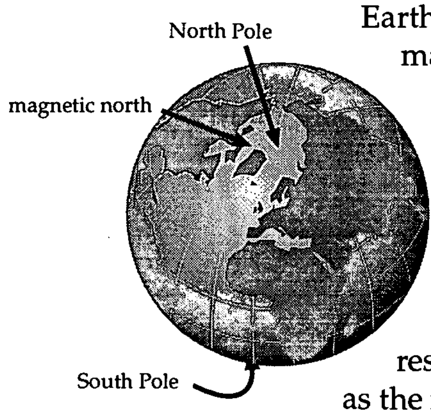
Hitting a magnet with a hammer will also destroy its magnetism. The force of the hammer will move the atoms out of line.

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	magnetism	repel
like	nonmagnetic	south pole
magnet	north pole	unlike
magnetic	poles	

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	**lines of force**	**magnetize**
demagnetize	**magnetic field**	**North Pole**
electromagnet	**magnetic north pole**	**South Pole**
induced		

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

_________________________ .

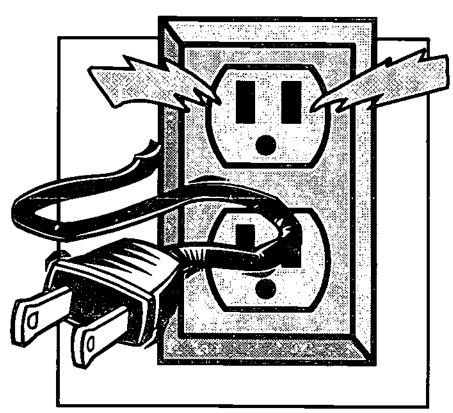
18. The southern end of Earth's axis is called the

_________________________ .

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

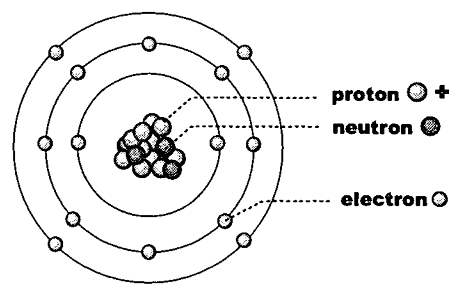
volt .... unit for measuring electromotive force

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.

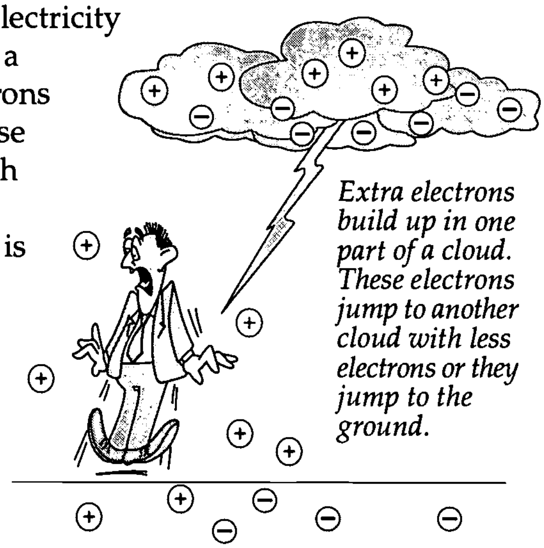
What Is Electricity?

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.



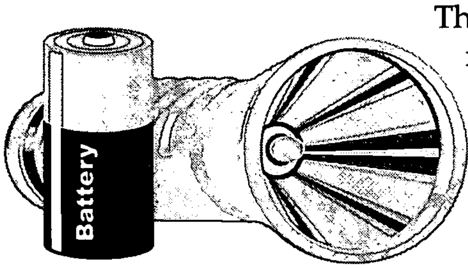
Extra electrons build up in one part of a cloud. These electrons jump to another cloud with less electrons or they jump to the ground.

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.

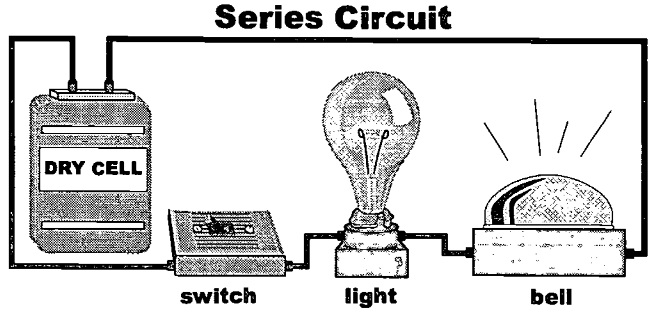
Circuits

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.

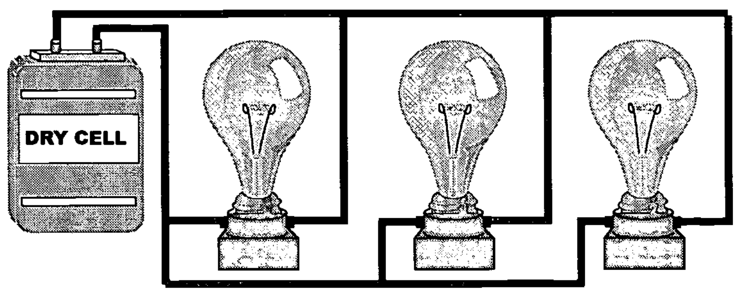
There are two basic kinds of circuits. Circuits may be either series or parallel. In a **series circuit**, electricity only has one path to follow. Connect a switch, a light, and a bell to a battery. Close the switch. The bell and the light will work. What happens if the light burns out? The circuit 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



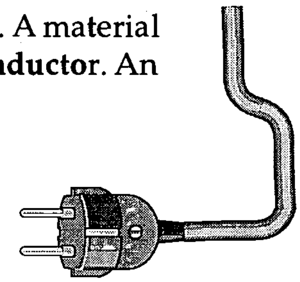
Currents

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.

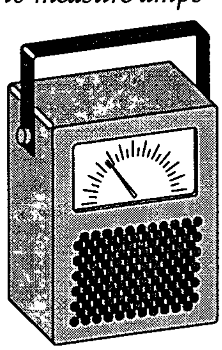
Electricity will travel through a conductor. Copper wire is a good conductor. Silver wire also conducts electricity very well, but is more costly to use than copper. Most metals will conduct electricity. Air and water will also conduct electricity.

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.

an ammeter is used to measure amps



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.

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?

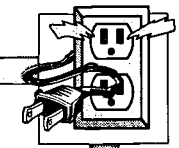
7. How does a dry cell produce electricity?

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?____________________

____

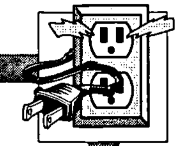
28. Describe how AC causes an electromagnetic wave to radiate.

____

____

____

____



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.

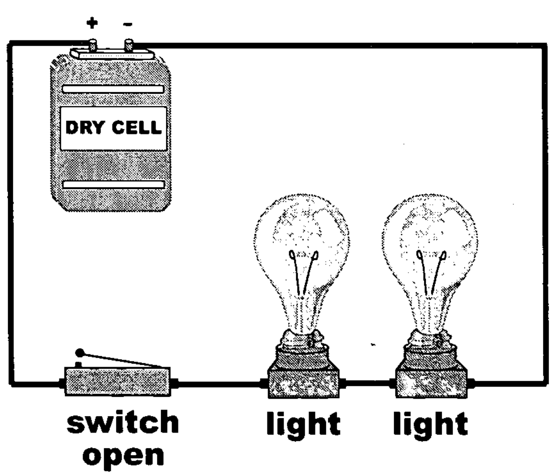
4. Optional Activity: Repeat the experiment using a comb or inflated balloon instead of the ruler.

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.

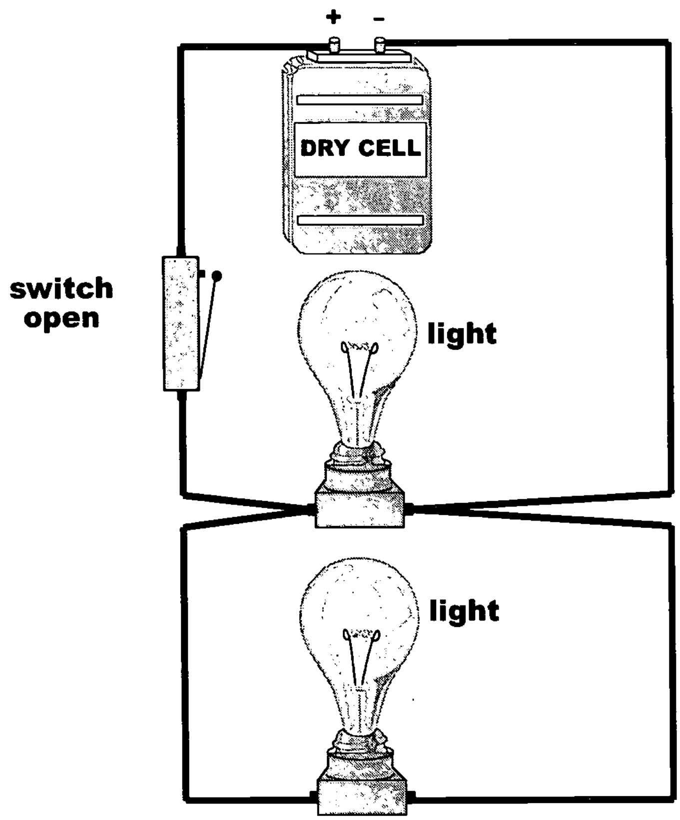
   b. Leave the switch connected.

   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	**direct**	**electrons**
armature	**dry cell**	**open**
cell	**electrical**	**parallel**
chemical	**electricity**	**series**
closed	**electromagnetic wave**	**static**
current		

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	**electromotive force (EMF)**	**plastic**
ammeter	**forces**	**resistance**
atoms	**glass**	**rubber**
conductor	**insulator**	**silver**
copper	**ohm**	**volt**
DC		

20. _______________ is the abbreviation for direct current.

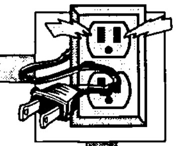
_______________ is the abbreviation for alternating current.

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

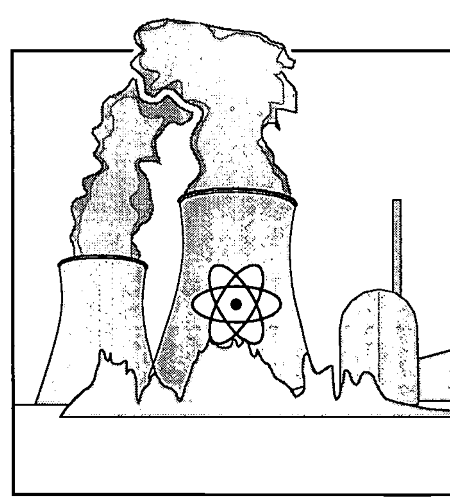
9. A(n) ____________ measures how much current is flowing.

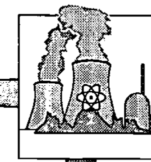
   a. ampere
   b. ohm
   c. resistance
   d. volt

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.)

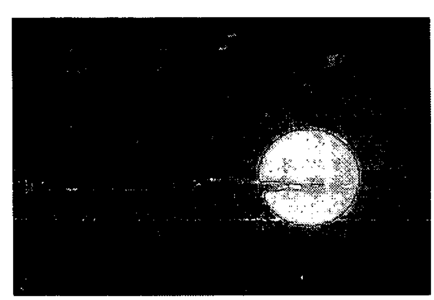
Introduction

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?

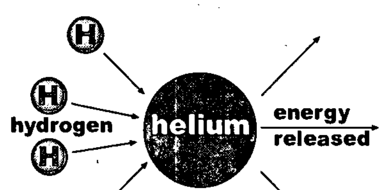


Most of the electromagnetic energy we know comes from the outer portions of atoms, the electrons. Within the center of the atom, however, is the nucleus. The energy that holds tightly together the nucleus of atoms is nuclear energy. Compared to the electromagnetic forces of the atom, the nuclear energy 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.

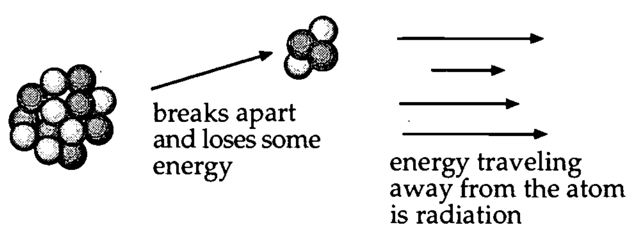
The process of taking these lighter elements and making a heavier element is called fusion. Fusion powers the sun and releases large amounts of energy. Because of the heat and pressure needed, however, scientists have not been able to control fusion. So far, the only use of fusion by humans has been 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

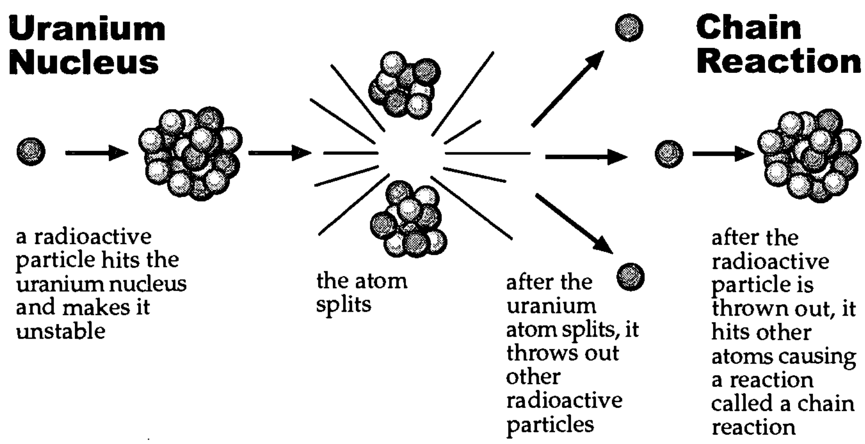


You may be wondering if there is a special name for atoms with a different number of neutrons. The name for these are **isotopes**. We discussed three isotopes of carbon. Most isotopes of atoms are harmless. Some are

513

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.

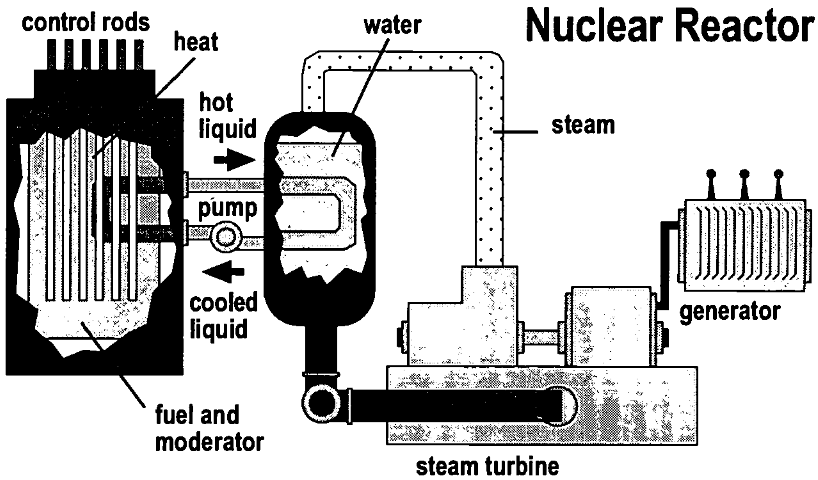


Controlling Nuclear Reactions

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.



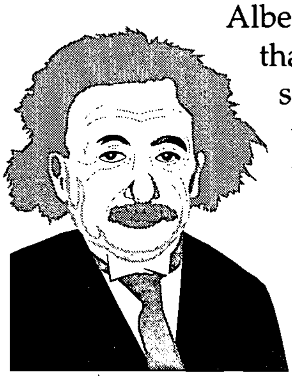
Radioactive Material

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

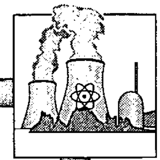
1. Stand 10 to 20 dominoes on one end, one behind the other. (Leave about ½ inch between each one.)
2. Push the first one down.
   a. What happens to the rest? ______________________________
   b. Was this reaction controlled or uncontrolled? _____________
3. Line the dominoes up again. Place a chalkboard 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?

____

518



Practice

Use the list below to complete the following statements.

chain reaction	**nuclear energy**	**nucleus**
fission	**nuclear reaction**	**theory of relativity**
fusion	**nuclear reactor**	

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.

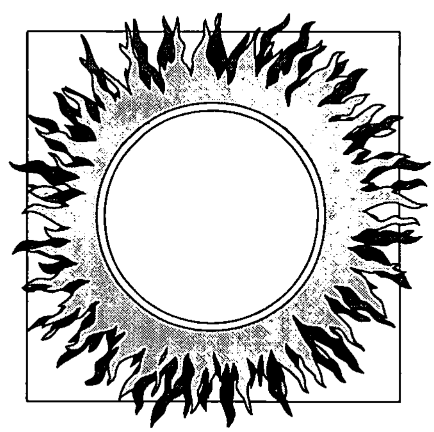
Practice

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

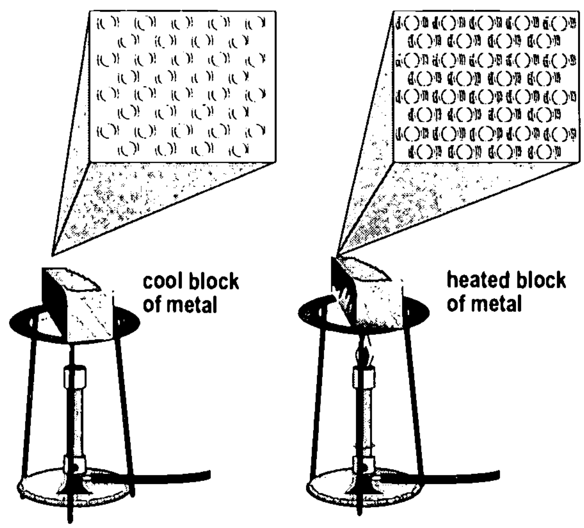
vibrate .... to move back and forth very quickly

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.

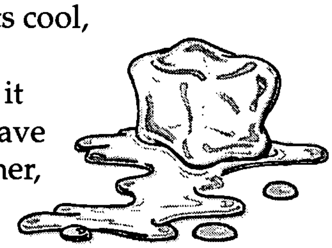
It is important to remember that every time energy is changed, some of it becomes heat. When we do work, we change forms of energy. These changes of energy are another source of heat. When heat energy enters matter, it causes the molecules or atoms to vibrate. The laws of thermodynamics describe interesting 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.

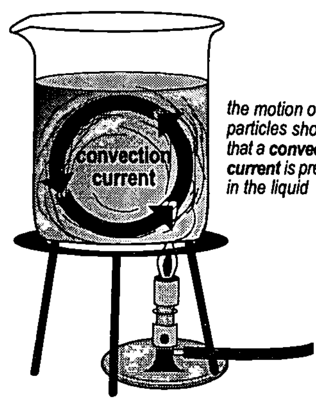
Ice seems like an exception to the idea that as objects cool, they contract. As water cools from around room temperature (25°C), it does contract. Finally, at 4°C, it finishes contracting. Because the water molecules have slowed, they begin to stick. As they stick to each other, they form ice. The ice 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.



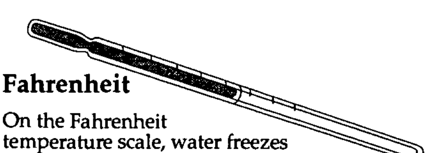
*the motion of particles shows that a **convection current** is present in the liquid*

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

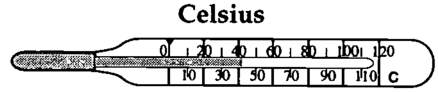
Temperature and heat are not the same. Temperature tells the amount of heat in matter. It is a measure of how fast the molecules are moving. Temperature is the average of how many molecules are moving and how fast they move. A **thermometer** measures temperature. Thermometers are filled with substances



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?

    ____

    ____

530

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?

____

534

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	**heat**	**phase**	**sun**
contract	**hot**	**size**	**vibrating**
expand	**oil**	**slow down**	

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	**convection**	**molecules**	**vibrate**
closest	**cooler**	**plastic**	**vibrating**
conduction	**insulators**	**Styrofoam**	**wood**
conductors			

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	**fast**	**rises**
Celsius	**kill**	**temperature**
convection current	**liquid**	**thermodynamics**
Fahrenheit	**radiation**	**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.

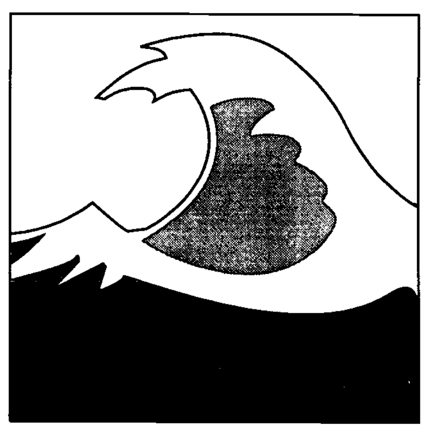
22. Two types of temperature scales are ____________________ and ____________________.

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

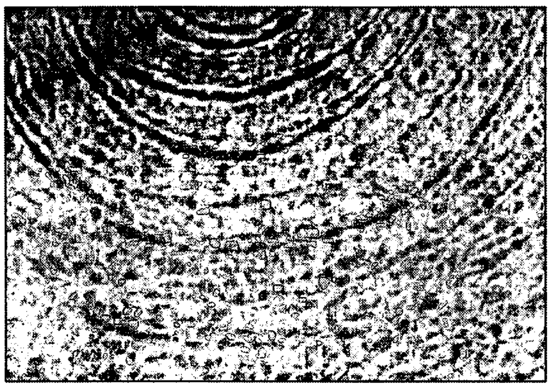
trough .... the low point of a wave

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.



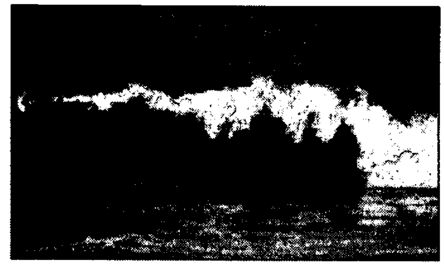
A circular pattern is formed when a rock is dropped into a calm lake.

Features of Waves

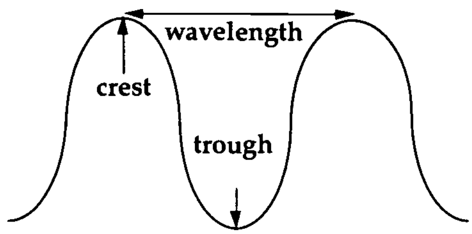
Waves are caused by energy. Waves carry energy from one place to another. You can see waves that travel across the surface of water. Some waves also move through gases, solids, and vacuums. Sound and light are types of waves. Sound can travel through gases, liquids, and solids. Light, however, can travel 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.

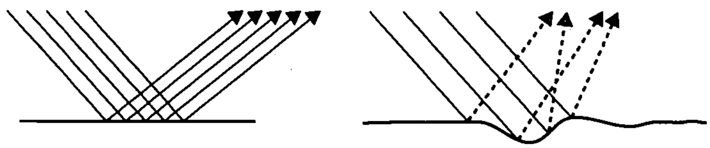
Because the waves have speed and wavelength, only a certain number can pass a point in a certain time. **Frequency** is the measure of the number of crests that pass a point in one second. The unit of measure for frequency is called **hertz** *(Hz)*. Frequency and wave length are related in an inverse way. A wave with a great wavelength has a low frequency. A wave with a small wavelength has a high frequency.

long wavelength *short wavelength*

low frequency **high frequency**

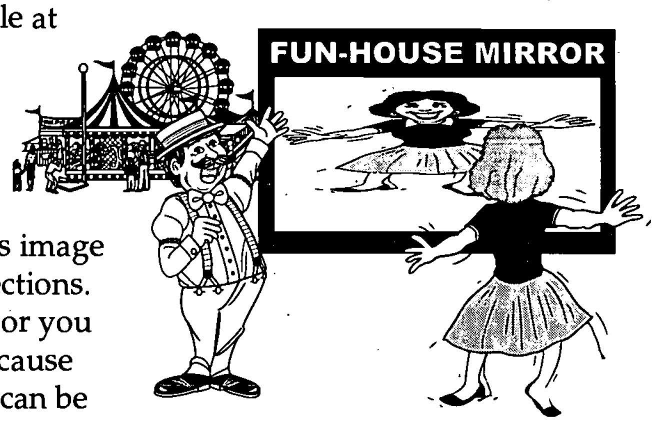
Wave Motion

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.

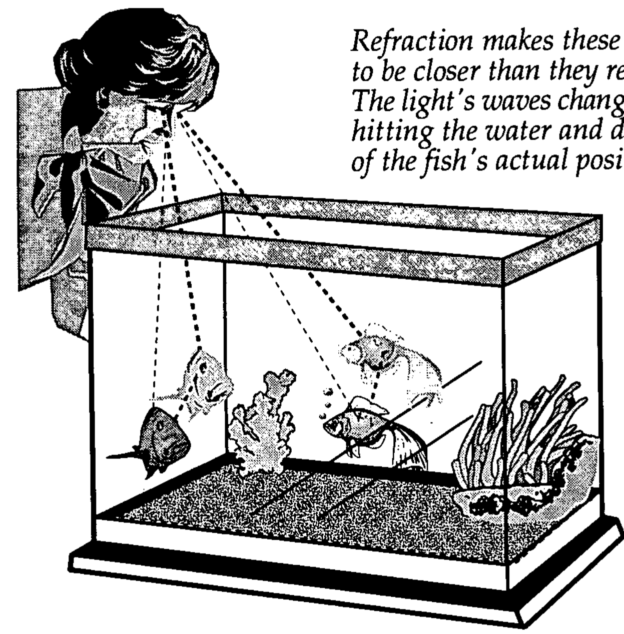


Waves are reflected at the same angle they are received, unless they are reflected off a rough surface.

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? __________________________________

549

Practice

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

amplitude	**hertz**	**speed**	**wavelength**
crest	**reflection**	**trough**	
frequency	**refraction**	**wave**	

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? ______________________

____

____

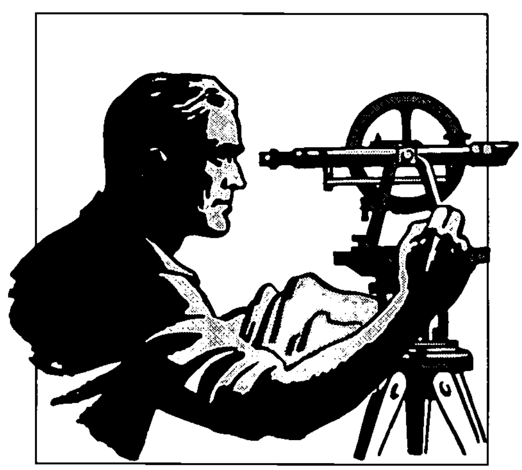
3. A wave with a long wavelength has what kind of frequency?

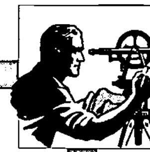
____

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

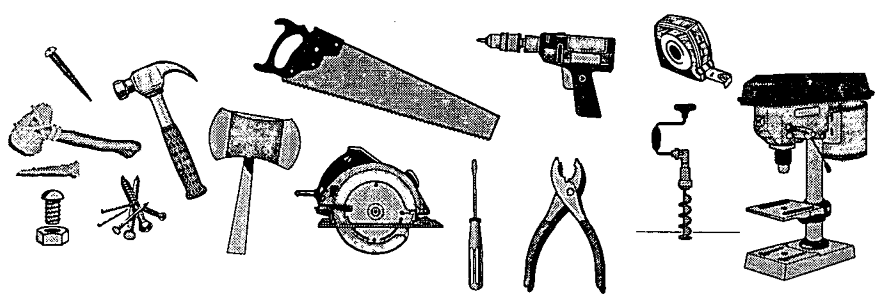
technology .... the knowledge, skill, and tools that allow people to perform tasks of increasing complexity

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.

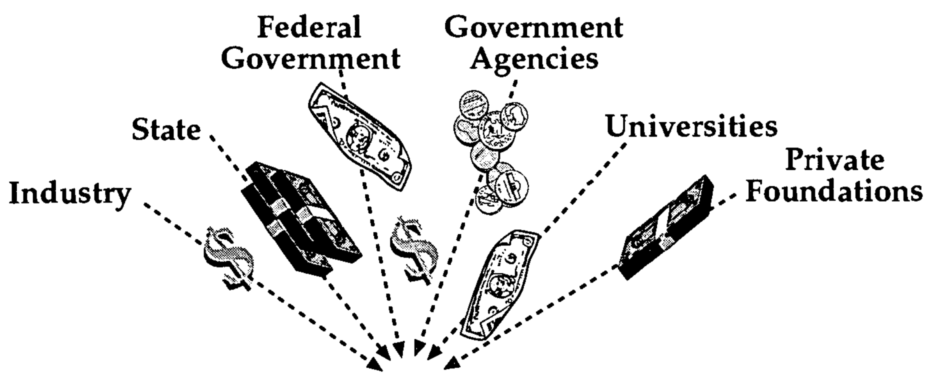


Each of these tools was created by humans and is a form of technology.

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.



Scientific Research

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.

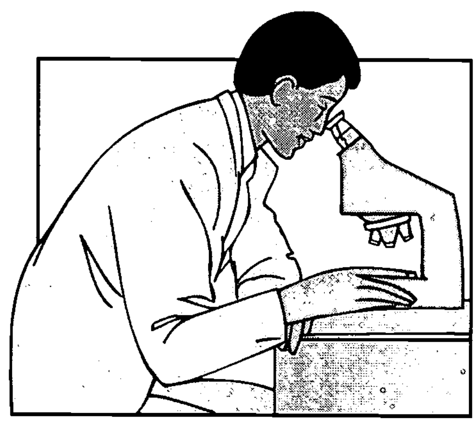
Technology is based on scientific knowledge. We now have a certain amount of knowledge about acid rain. Scientists and others who work with technology are using their knowledge. They are trying to solve this problem. One solution might be to stop burning the fuels that result in acid rain. Would this 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.

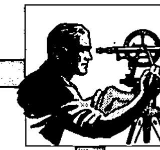
If you worked as an engineer for an electrical company, you might have a certain **bias**. That is, you would probably not like the idea of doing away with electricity. As a scientist, you would be expected to know your own bias. You would be expected to design your research and investigation to compensate 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.

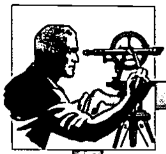
   a. people
   b. acid rain
   c. industry
   d. by-product

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 ____________ .

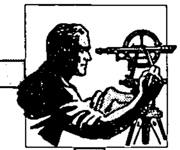
   a. acid rain
   b. by-product
   c. grant
   d. technology

9. A person's preference that can hinder impartial judgement is known as ____________ .

   a. peer
   b. technology
   c. bias
   d. economy

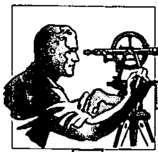
10. One of the foundations of scientific research is the commitment to review of findings by ____________ .

   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.

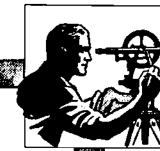
   ____

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?

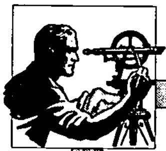
   ____



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?

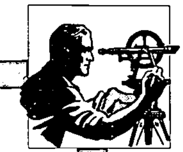
7. Describe how you could adapt your chalk-protecting technology to protect buildings from acid rain.



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	A. acid rain
______ 2. the knowledge, skill, and tools that allow people to perform tasks of increasing complexity	B. bias
______ 3. the way people live together, interact, and rely on one another	C. by-product
______ 4. the people and machines used to produce products	D. economy
______ 5. money that is awarded for a specific purpose	E. grant
______ 6. a tendency to see all things in a certain way	F. industry
______ 7. a person who is on the same level as another; people who have similar knowledge, background, and goals	G. peer
______ 8. rain that has a pH below that of seven because it carries dissolved acids	H. society
______ 9. the system by which money, ownership, and wealth are controlled	I. technology



Practice

Use the list below to complete the following statements.

abilities	peers	scientific
acid rain	predict	society
government agencies	preference	technology
grants	research	value
knowledge		

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

572

T

U

V

W

Y

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Production Software

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Adobe Photoshop 3.0. Mountain View, CA: Adobe Systems.

Macromedia Freehand 5.0. San Francisco: Macromedia.

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