Unit 3 Overview

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 7: Atoms and Molecules					
82	177–79	159–61	103		• Unit and chapter opener • Preview the unit and chapter content
83	180–83	162–65	104		• Parts of an atom • Atomic number • Models of atoms
84	184–87	166–69	105–6	Quiz 7-A	• Elements • Periodic Table of the Elements
85	188	170	107–8	Rubric	**Exploration: Wanted: U or Your Element** • Researching and writing about an element
86	189–91	171–73	109		• Compounds • Chemical formulas • Chemical reactions
87	192–93	174–75	109–10	Quiz 7-B	• Covalent bonds • Ionic bonds
88	194–95	176–77	111–12		**Activity: Hot or Cold** • Determining whether a chemical reaction has occurred
89	196–99	178–81	113–14	Quiz 7-C	• Properties of acids and bases • pH scale • Indicators • Neutralizing acids and bases
90	200–201	182–83	115–16	Rubric	**Activity: pH Indicator** • Identifying a solution as an acid or base
91	202–3	184–85	117–18	Rubric	**Activity: Which antacid is best?** • Testing the effectiveness of some antacids
92	204	186	119–20		**Chapter Review** • Apply knowledge to everyday situations
93	204			Test	**Chapter 7 Test**

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 8: Electricity and Magnetism					
94	205	187	121		• Chapter opener • Preview the chapter content
95	206–9	188–91	122		• Static electricity • Current electricity • Conductors, switches, insulators, resistors
96	210–11	192–93	123–24	Rubric	**Activity: An "Unbreakable" Circuit** • Experimenting to test hypothesis • Building an unbreakable circuit
97	212–15	194–97	125–28	Quiz 8-A	• Series and parallel circuits • Measuring electricity • Batteries
98	216–18	198–200	129	Quiz 8-B	• Magnetism • Electromagnets • Generators
99	219	201	130	Rubric	**Exploration: Famous Inventors** • Researching and making a speech about an inventor or discovery
100	220–21	202–3	131–32	Rubric	**Activity: Build an Electromagnet** • Predicting and identifying ways to strengthen an electromagnet
101	222–23	204–5	133		**Technology: Magnetic Levitation** • Recognizing another use for electromagnets • Identifying advantages of electromagnetic technology
102	224–27	206–9	134	Quiz 8-C	• Electronics • Integrated circuits • Computers
103	228	210	135–36		**Chapter Review** • Apply knowledge to everyday situations
104	228			Test	**Chapter 8 Test**

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 9: Motion and Machines					
105	229	211	137		• Chapter opener • Preview the chapter content
106	230–33	212–15	138		• Motion • Velocity and acceleration • Momentum
107	234–37	216–19	139–40	Quiz 9-A	• Newton's laws of motion
108	238–39	220–21	141–42	Rubric	**Activity: Mini Cars in Motion** • Demonstrating Newton's laws of motion
109	240	222	143–44	Rubric	**Exploration: Roller Coaster** • Designing and making a model rollercoaster
110	241–43	223–25	145–46		• Work • Simple machines (levers)
111	244–47	226–29	147–51	Quiz 9-B	• Pulleys • Wheel and axles • Inclined planes • Screws • Compound machines
112	248–49	230–31	152	Rubric	**Activity: How Much Force?** • Experimenting with inclined planes
113	250	232	153–56		**Chapter Review** • Apply knowledge to everyday situations
114	250			Test	**Chapter 9 Test**

Objectives
- Recognize the interrelationship of science concepts in the unit
- Recognize that man's inferences are sometimes inaccurate
- Preview the unit and chapter content

Unit Introduction
Someone once said that all science is physics. In Unit 3 students will learn about the most basic unit of matter and energy—the atom. Chapter 7 discusses the structure of the atom. Chapter 8 relates the atom to the flow of electrons that produce electricity.

Chapter 9 explains how chemical energy (Chapter 7) and electrical energy (Chapter 8) can be changed into mechanical energy.

Look through Unit 3. What are the topics of the chapters we will be studying in this unit? atoms, molecules, electricity, magnetism, motion, machines

Why do you think these chapters are organized into the same unit? Answers will vary, but elicit that they all have to do with matter and energy.

God's creation is not limited to what we can see. Forces such as gravity and magnetism, which cause objects to behave in certain ways, are also God's creation. This unit will help us better understand the wonderful way God holds our universe together.

TEACHER HELPS

Weblinks
The BJU Press website offers additional information and links you may find helpful throughout the year.

www.bjupress.com/resources

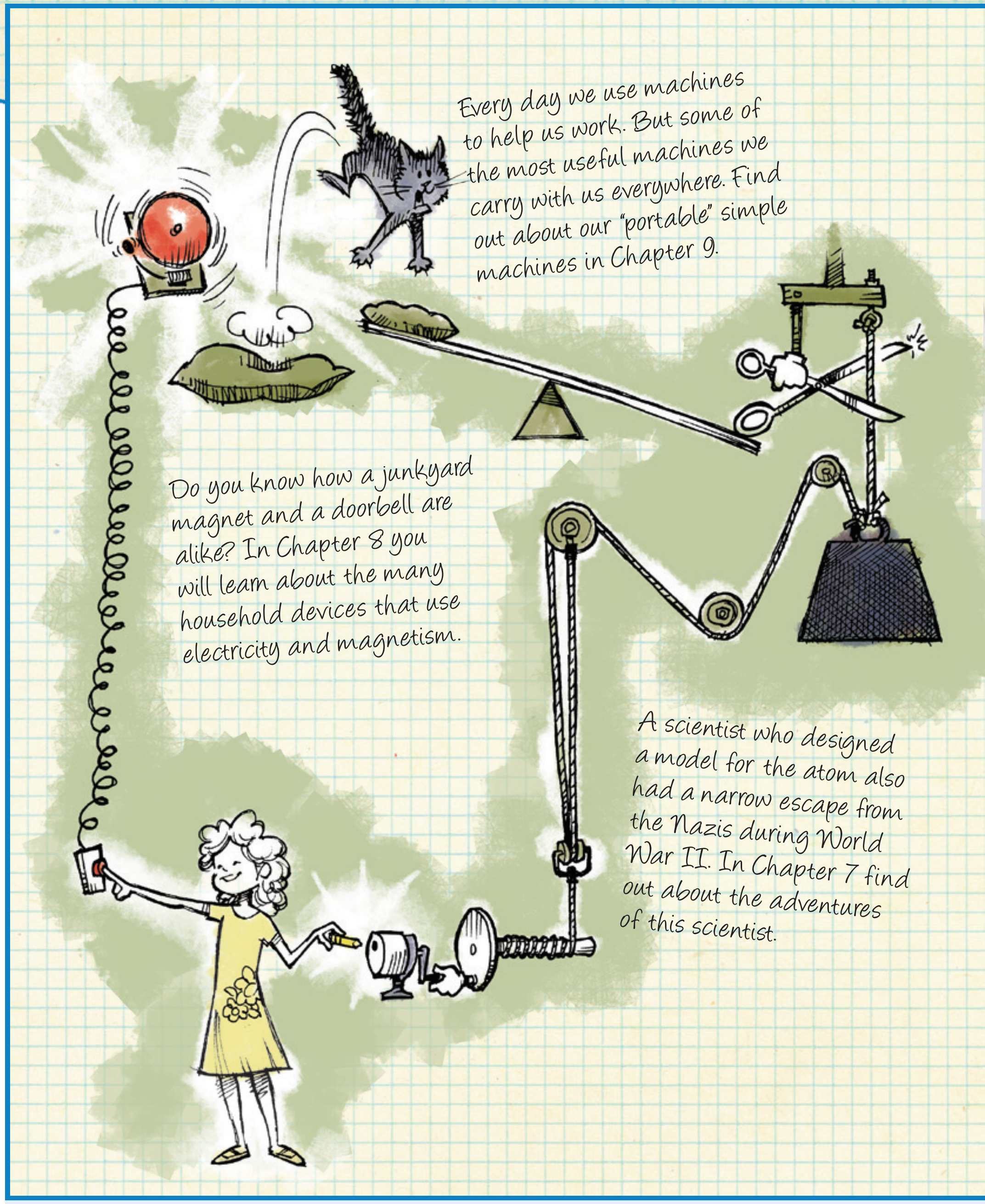
Unit photos
The photos on Student Text page 159 include a girl looking at a model of a molecule and a train and plane illustrating the use of motion and machines in Boston.

Project Idea

The project idea presented at the beginning of each unit is designed to incorporate elements of each chapter as well as information gathered from other resources. You may choose to use the project as a culminating activity at the end of the unit or as an ongoing activity while the chapters are taught.

Unit 3—Build a Better Mousetrap

Design a mousetrap that uses at least four simple machines. The mousetrap must also include either a chemical reaction or an electrical circuit as a force that causes parts of the mousetrap to move.



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Atoms and Molecules

Some ancient Greeks thought that there were only four basic elements: fire, air, water, and earth. They believed that everything was made from different combinations of these elements. These scientists also thought that the four elements could change from one form to another. For example, they noticed that water disappeared when it was boiled. Since they did not know that water changes into vapor, they thought the water had turned into air. Scientists now know that there are over one hundred basic elements that are made up of very tiny atoms. None of these elements are unknown to God because He created them. With each new discovery, God's glory is more fully revealed to man. As Colossians 1:16 says, "All things were created by him, and for him."

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Introduction

Man's understanding of science is always limited by what he can observe. Sometimes his observations are correct, but his conclusions are flawed.

Science is changeable because it is based on man's knowledge. However, God's knowledge is infinite. Nothing is new to God.

Teach for Understanding

Provide time for the student to complete Looking Ahead, Activity Manual page 103. For part B, encourage the student to think of things he would like to learn about atomic theory and chemical bonds. He should write his answers in question form, such as, "How many kinds of chemical bonds are there?"

Provide the answers for part A and allow the student to check his work. After the chapter is finished, you may choose to have him look back at this page and check his understanding of the items he missed.

As time allows, discuss student questions from part B about atomic theory and chemical bonds. You may choose to provide trade books or other resources to help answer questions that are beyond the scope of this chapter.

Allow the student to leaf through the chapter, looking at the headings, pictures, captions, charts, etc., and discuss the things he thinks he will be learning about.

What is the chapter title? Atoms and Molecules

What is pictured on this page? Possible answers: beakers, flasks, test tubes, a girl doing a chemistry experiment

Activity Manual

Preview, page 103

The Looking Ahead page is intended to assess the student's prior knowledge before beginning the chapter.

SCIENCE BACKGROUND

The four elements
Aristotle was a strong proponent of the four elements: fire, earth, air, and water. During his lifetime there was much debate as to which element was the main one. Greek philosophers argued for different elements based on their observations. Finally a philosopher named Empedocles convinced others that each element was equally important.

TEACHER HELPS

Chapter preview
Other preview and prereading activities may include using a K-W-L chart, a probe, or an anticipation guide.

Student Text diagrams
Diagrams from the Student Text are included on the Teacher's Toolkit CD.

Lesson 83

Student Text pages 162–65
Activity Manual page 104

Objectives
- Describe and label the size, charge, and location of each part of an atom
- Recognize that an element is made of only one kind of atom
- Differentiate between atomic mass and atomic number

Materials
- a piece of paper for each student

Vocabulary
chemistry	atomic mass
atom	electron
element	shell
nucleus	atomic number
proton	atomic theory
neutron	particle accelerator

Introduction
Give each student a piece of paper. Instruct him to fold the paper in half and then to tear it in half. Tell him to continue folding and tearing one section of the paper in half until it is too small to continue tearing.

Can you still see the smallest piece?

Is there a way you could continue tearing the very small piece in half?

Is the small piece still paper?

Today you will be studying things that are many times smaller than your tiny piece of paper.

Teach for Understanding
Purpose for reading
Which parts of an atom are found in the nucleus?

How is an atom's atomic number different from its atomic mass?

Discussion
What is chemistry? the study of matter—what it is made of, its usual characteristics, and how it reacts with other matter

What is the smallest piece of an element that still can be recognized as that element? an atom

What do we call substances that are made of only one kind of atom? elements

Can an element have more than one atom? Explain. Yes, but all the atoms are the same kind.

When you think of chemistry, perhaps you imagine a messy laboratory with lots of test tubes and billows of vapors rising from containers. A slightly unkempt person with a sinister smile and a white lab coat pours material from one test tube into another. Such images are more fiction than fact.

For centuries chemistry was considered somewhat of a mystical science. Some men, called *alchemists,* tried to find a way to turn common metals, such as iron or lead, into gold. Others looked for a potion that would help them live forever. However, not all alchemists were tricksters. Some studied and experimented to find out how one substance changed to another. Their careful investigation and accurate recording formed the basis of modern **chemistry**, the study of matter—what it is made of, what its usual characteristics are, and how it reacts with other matter.

Atoms
To understand matter—anything that takes up space and has mass—you must first start with the smallest part of it. Imagine that someone has just given you a kilogram of gold. Your job is to keep dividing the gold in half until you have the smallest piece possible. Once you divide the gold into the tiniest piece that you can see, are you finished? No! If you put the gold under a microscope, you could continue to divide it into smaller pieces. Eventually the gold would become so small that you could not see it even with a microscope. But the gold could still be divided more. Finally, you would get to a piece that could no longer be divided and still be gold. That tiny piece of gold would be called an atom. An **atom** is the smallest piece of an element, such as gold, that can be recognized as that element. Substances containing only one kind of atom are called **elements**. Some of the elements that you probably know about are gold, silver, iron, oxygen, and copper.

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SCIENCE BACKGROUND

Concept of atoms
Most people attribute the concept of the atom to the ancient Greeks, especially Leucippe and his disciple Democritus. There is evidence to suggest that at about the same time, philosophers in India were developing some of the same ideas.

Alchemy
One of alchemy's great benefits to scientific advancement was the use of scientific processes, such as observation, experimentation, measurement, and recording. These same skills are used today for scientific study.

Atomic mass
Atoms of the same element can differ in their atomic masses. This is possible because the number of neutrons can vary for most elements. The atomic mass that appears on the periodic table is a weighted average of the different masses of that element's atoms that are found in nature. Since the number of protons stays the same, they still have the same identity and the same atomic number. The different forms of an element that vary by the number of neutrons are called *isotopes* of that element.

SCIENCE MISCONCEPTIONS

Atomic models
Bohr's model of the atom is not the only model, and it is not the most accurate model. Electrons do not actually orbit in fixed paths the way they appear to in a Bohr model.

Parts of an Atom

All atoms have the same basic structure. They are made up of three main parts: protons, neutrons, and electrons. Two of these parts, the protons and the neutrons, make up the center section of the atom, called the **nucleus**.

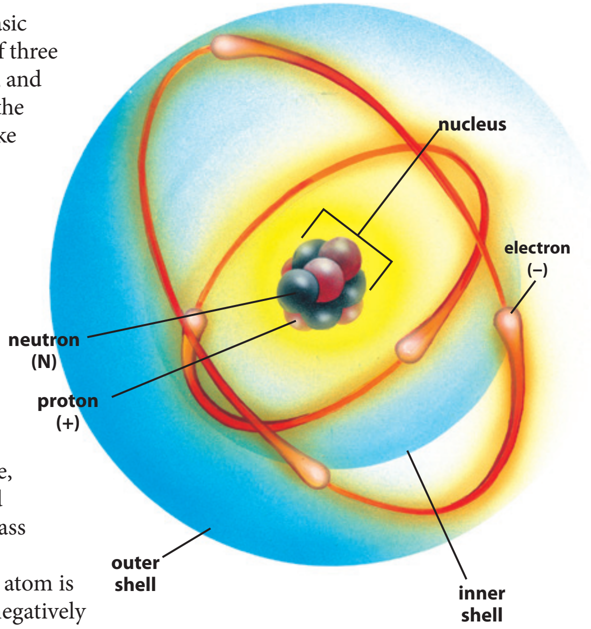
Protons have a positive charge (+) and **neutrons** have no charge (N). Protons and neutrons are by far the heaviest parts of an atom. Adding the number of protons and neutrons together results in the approximate **atomic mass** of an atom. For example, fluorine has nine protons and ten neutrons, so its atomic mass is approximately 19.

The third basic part of the atom is not part of the nucleus. The negatively charged **electrons** (–) travel around the nucleus. They are so light that they contribute almost nothing to the mass of an atom.

In a normal atom there are equal numbers of protons and electrons. Normal atoms have no overall electrical charge because the total negative charge of the electrons balances the total positive charge of the protons.

Though very small, electrons are very important to the atom. Scientists think that electrons constantly move and spin around the nucleus. The electrons move randomly in all directions, much like a swarm of bees around a hive. As they move, the electrons stay within a limited cloud-like space surrounding the nucleus. This space, called a **shell**, represents the average distance of the electrons from the nucleus. The first shell around the nucleus can hold a maximum of two electrons. The second shell can hold a maximum of eight electrons. Each shell farther away from the nucleus can hold more electrons. Because electrons move freely within their shells around the nucleus, they provide the means for atoms to combine with other types of atoms to form new substances.

Structure of an Atom



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Discussion

What are the three main parts of an atom? protons, neutrons, and electrons

What is the center section of an atom called? nucleus

Which parts of the atom are contained in the nucleus? protons and neutrons

Protons have a positive charge. What kind of charge do neutrons have? no charge

How do scientists calculate the approximate atomic mass of an atom? by adding together the number of protons and neutrons

Discuss *Structure of an Atom*.

Which symbols are used to represent a proton, a neutron, and an electron in the drawing? proton, +; neutron, N; electron, –

What does the negative sign tell us about electrons? They have a negative charge.

Are electrons stationary or moving? moving

Why do normal atoms usually not have an electrical charge? A normal atom has an equal number of protons and electrons.

Describe an electron shell. a cloudlike space around the nucleus; Each space has electrons that are the same average distance from the nucleus.

What is the maximum number of electrons any atom can have in its first shell? two

What is the maximum number of electrons any atom can have in its second shell? eight

Why is it important for electrons to move freely around the nucleus? This movement allows atoms to combine to form other substances.

LANGUAGE

Atom
The word *atom* comes from the Greek word *atomos*, which means "indivisible." The ancient Greeks considered the particles that make up all matter as being the smallest bits of matter possible.

Discussion

Which term refers to the number of protons in an atom's nucleus? atomic number

How is the atomic number different from the atomic mass? The atomic mass is calculated by adding together the number of protons and the number of neutrons. The atomic number is the number of protons only.

Do scientists use the atomic mass or the atomic number to classify each element? the atomic number

How many different elements have been identified? more than 100

Discuss the Niels Bohr box.

For what was Niels Bohr best known? his research on atomic structure

What news did Niels Bohr bring to the United States in 1939? Germany had successfully split the nucleus of an atom.

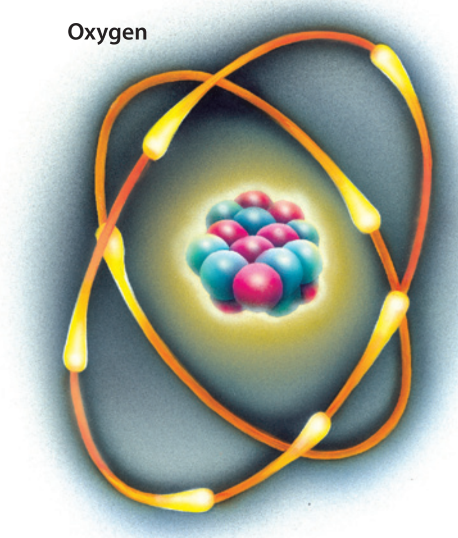
How did this news affect the United States? It motivated the United States to speed up its research on atomic energy.

Which war was happening during the time that Bohr had to escape to Sweden? World War II

What did Niels Bohr help the United States develop? the atomic bomb

Atomic Number

Scientists identify each element by the number of protons in its nucleus. This number is called the atom's **atomic number**. Each element has a different atomic number. Hydrogen has an atomic number of 1. Oxygen's atomic number is 8. Gold has an atomic number of 79. Since the atomic number equals the number of protons in an atom, we know that hydrogen has 1 proton, oxygen has 8 protons, and gold has 79 protons. Presently, scientists have identified and given atomic numbers to more than 100 elements. Some of these elements have been made in laboratories, but most of them occur naturally in the earth.



Niels Bohr

Niels Bohr (NEELS BOHR), a Danish scientist born in 1885, is considered to be one of the greatest scientists of the twentieth century. Although he is best known for his research on atomic structure, he also had a key role in developing the atomic bomb.

In 1939 Bohr visited the United States with news that Germany had successfully split the nucleus of an atom. This news motivated the United States to speed up its research on atomic energy. Bohr, however, returned to Denmark to provide a place for scientists escaping from the Nazis. In 1943 Bohr, who was half-Jewish, learned he was to be arrested by the Nazis. He was forced to escape on a fishing boat to Sweden.

Shortly afterwards Bohr returned to the United States. His knowledge aided the United States in the development of the atomic bomb. Bohr recognized the potential threat posed by atomic power and worked until his death in 1962 for international control of nuclear weapons.

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SCIENCE BACKGROUND

Tiny particles
Neutrinos, muons, gluons, and positrons are some of the other particles that make up an atom. Scientists think there are several hundred types of these tiny particles. Like Mendeleev (see Lesson 84), these scientists have identified the properties of some of these particles even though they have not actually discovered them yet. Most of these particles exist for such a short period of time (2 millionths of a second for a muon) that it is hard for scientists to track them down even with computers.

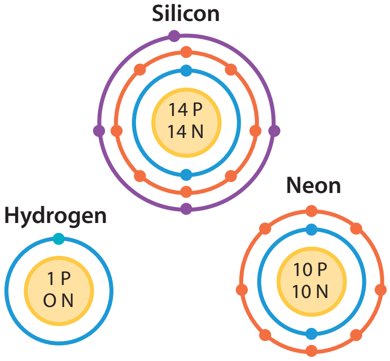
Models of the atom
John Dalton's model showed the atom as a solid sphere. Joseph (J. J.) Thomson's model, called the plum pudding model, has a positive sphere with electrons mixed in like "raisins in a cake." Ernest Rutherford's model was the first to show a nucleus with electrons moving around it like planets. Niels Bohr's model was similar to Rutherford's, but it limited the electrons to specific energy shells. Current models are more complex.

SCIENTIST **Niels Bohr**
In 1922, when he was 37 years old, Niels Bohr won the Nobel Prize for his work describing the atom. After escaping by boat from Denmark to Sweden, Bohr and one of his sons went to the United States and worked on the nuclear fission bombs. His wife and their other sons stayed behind in Sweden. After the war, Bohr and his family returned to Copenhagen, Denmark. Bohr died there in 1962. According to Bohr, "An expert is a man who has made all the mistakes which can be made in a very narrow field."

Models of Atoms

Because atoms are so small, no one has actually seen what they look like. We call what scientists think about atoms **atomic theory**. Atomic theory is based on repeated observations of how atoms act in experiments. The models have changed as scientists have discovered more about atoms.

Niels Bohr devised a model of an atom based on the idea that electrons move in shells. The Bohr model of the atom makes understanding the atom easier, but it is a very simplified model of what scientists think happens in an atom.



Even Smaller Parts

Once man discovered how to split the nucleus of an atom, it quickly became apparent that there were even smaller particles that were part of the nucleus. Today scientists have special machines called **particle accelerators** that smash atoms. When atoms break apart, these smaller particles can be measured but not seen.

Scientists have given some of these particles strange-sounding names such as quarks, leptons, mesons, pions, and gravitons. Perhaps you have heard these words used in science fiction stories.

As scientists continue to discover smaller and smaller particles, they come up with even more questions about the ultimate nature of matter. The Bible has an answer for us: "Through faith we understand that the worlds were framed by the word of God, so that things which are seen were not made of things which do appear" (Heb. 11:3). Even though we cannot observe the tiniest level of God's creation, we can rest completely in Him because we know that He is the God Who loves and cares for us.

QUICK CHECK

1. List and describe the three main parts of an atom.
2. What is an element?
3. How do scientists identify elements?

particle accelerator

Discussion

Do scientists know exactly what atoms look like? no **Why not?** because atoms are so small

Which term is used to describe what scientists think about atoms? atomic theory

What is atomic theory based on? repeated observations of how atoms act in experiments

Which scientist devised a model of an atom based on the idea that electrons move in shells? Niels Bohr

Is a Bohr model of an atom what the atom actually looks like? no **Explain.** The Bohr model is a simplified version.

Which of the atoms pictured on page 165 have the same number of protons and neutrons? silicon—14 protons and 14 neutrons; neon—10 protons and 10 neutrons

Hydrogen is the only atom that has no neutrons in its nucleus. How many protons does hydrogen have? 1

Which machines do scientists use to smash atoms? particle accelerators

What happens when a particle accelerator smashes an atom? The atom breaks apart and the smaller particles can be measured.

Name some of the subatomic particles. quarks, leptons, mesons, pions, and gravitons

According to Hebrews 11:3, what are all the things we see made of? things that do not appear, or things that we cannot see

Faith is a firm belief without having physical proof. It allows us to trust in God and accept things we cannot see. It is by faith that Christians believe that God is in control of all things. [Bible Promise: I. God as Master]

Answers

1. The nucleus of the atom contains the protons and neutrons. Protons have a positive charge and neutrons have no charge. Electrons travel around the nucleus in shells. Electrons have a negative electrical charge.
2. An element is a substance containing only one kind of atom.
3. Elements are identified by the atomic number, or the number of protons in the nuclei of their atoms.

Activity Manual

Reinforcement, page 104

TECHNOLOGY

Particle accelerators

A particle accelerator propels parts of the atom to exceedingly high speeds using a series of electromagnets.

Scientists use these accelerated atomic particles in experiments to smash the nucleus of the atoms. Other uses for particle accelerators include industrial x-ray machines that find small flaws in metal and special medical machines used to diagnose and treat cancer.

Some particle accelerators are long and straight, and others are circular. They are very large machines, varying in size from several hundred meters to over twenty kilometers.

DIRECT AN ACTIVITY

Drawing atoms

Write the word *argon* for display. List under it *18 protons* and *22 neutrons*.

Select several students to draw and label the nucleus and the first two shells of electrons for argon. The illustration should look similar to those shown on Student Text page 165.

Does this atom need a third shell? yes **How do you know?** Since it has 18 protons, it must have 18 electrons. So far only 10 electrons have been drawn.

Select another student to complete the third shell with 8 electrons.

Repeat with other elements as time permits.

Lesson 84

Student Text pages 166–69
Activity Manual pages 105–6

Objectives

- Recognize that the periodic table is a classification system
- Describe the process that Mendeleev used for arranging elements
- Identify the types of information provided for each element on the periodic table
- Identify the terms *period* and *group* as they relate to the periodic table
- Differentiate among categories on the periodic table

Vocabulary

chemical symbol
periodic table of the elements
period
group

Introduction

Write the following for display: FBI, NHL.

What do each of these symbols (letters) stand for? F-Federal, B-Bureau, I-Investigation; N-National, H-Hockey, L-League

Why do we use these symbols instead of words? Possible answers: They are easier and faster to write.

Scientists also use symbols to represent the elements because symbols are easier and faster to write.

Teach for Understanding

Purpose for reading

Why are the chemical symbols for some elements hard to recognize?

How was the periodic table of the elements first organized?

What are three ways that scientists classify elements in the periodic table?

Discussion

Why do scientists use chemical symbols? Symbols are quicker to use, and they make communication with other scientists around the world easier.

What is the basis for many of the chemical symbols? the element's English name

Elements

Classifying Elements

Scientists have devised a system of symbols to use when referring to elements. Symbols are quicker to write and easier to use than full names. And since scientists around the world use the same symbols, communication among themselves is much easier. These **chemical symbols** are abbreviations for the names of the elements.

Many of these abbreviations are based on an element's English name. The symbol for oxygen is O, and the symbol for carbon is C. Since some elements begin with the same letter, a second letter is often added. For example, the symbol for calcium is Ca. Notice that the first letter is capitalized and the second letter is lowercase. The second letter in the symbol is not always the second letter in the element's name. For example, the symbol for chlorine is Cl. Some abbreviations, such as the symbol for iron (Fe), are even more difficult to guess. These strange symbols make sense when you realize that the abbreviation is based on the Latin word for iron, which is *ferrum*. The Latin word for silver is *argentum,* so the symbol is Ag.

Unusual Chemical Symbols

Element	Symbol	Latin word
Tin	Sn	Stannum
Sodium	Na	Natrium
Potassium	K	Kalium
Iron	Fe	Ferrum
Silver	Ag	Argentum
Lead	Pb	Plumbum
Mercury	Hg	Hydrargyrum

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SCIENCE BACKGROUND

Natural and manmade elements
Most of the first 92 elements in the periodic table are found in nature. Most of the elements found after uranium on the table are manmade elements that do not occur naturally. The three-letter symbols used for elements at the end of the periodic table are temporary. They will be replaced with a two-letter symbol and final name when an official body of scientists confirms that the element actually exists. This is necessary because these new elements are created in a laboratory under extreme conditions and they do not exist for long before they break down.

Weight, mass, and isotopes
Atomic weight and atomic mass are sometimes used interchangeably, even though they are not quite the same. Atomic weight is the older term, referring to the average weight (protons + neutrons) of all the isotopes of a certain element. Isotopes are atoms of the same element that have different numbers of neutrons. Atomic mass refers to the mass (protons + neutrons) of one isotope. Usually the number given on the periodic table of the elements is the approximate atomic mass and is also the average of the element's isotopes' atomic masses.

Chemical symbols
The symbols used for the elements are also called *atomic symbols*.

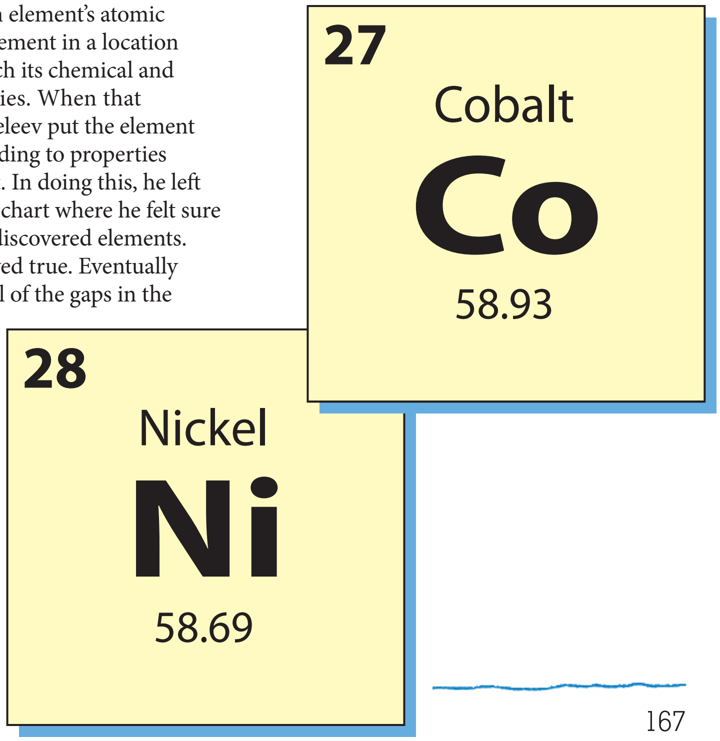
Periodic Table of the Elements

As scientists discovered more and more elements, they needed to find a system of classification. In 1869 a Russian chemist named Dmitri Mendeleev (duh-MEE-tree MEN-duh-LAY-uf) came up with a way to organize all of the elements known at that time. Mendeleev put the elements in order based on their atomic weights. Then he grouped the elements into rows and columns based on their chemical and physical properties. This classification system is called the **periodic table of the elements**.

Sometimes an element's atomic weight put the element in a location that did not match its chemical and physical properties. When that occurred, Mendeleev put the element where it fit according to properties instead of weight. In doing this, he left some gaps in his chart where he felt sure there existed undiscovered elements. His analysis proved true. Eventually elements filled all of the gaps in the chart.

Scientists later realized that organizing by atomic weight was not the best way to arrange the chart. Instead, arrangement by atomic number (the number of protons) gives a more accurate picture of the common characteristics that elements share. The current table also changes as new elements are discovered or formed in laboratories.

Each square in the periodic table describes one element. Within the square you will find the name of the element, its chemical symbol, its atomic number, and sometimes other information, such as atomic mass. For example, you can look for the atomic number 50 and find out that its name is tin and its chemical symbol is Sn. Or you can look up the name potassium to find its symbol, K, and its atomic number, 19.



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Dmitri Mendeleev

SCIENTIST

Dmitri Mendeleev was born in Tobolsk, Siberia, in 1834. In addition to the periodic table, Mendeleev also wrote a chemistry textbook. He was well known for wanting to educate people about chemistry. Whenever he traveled by train, he would sit in the third-class section with the Russian peasants and talk to them about his findings.

Mendeleev believed there must be a pattern to the sixty-three known elements of his time. He wrote notes on cards about each element's melting point, density, color, atomic mass, and bonding power. Then he began the process of arranging the cards in various ways. He noticed certain patterns began to appear when he arranged the elements by atomic weight. Next, he placed elements with similar properties underneath one another. After arranging his elements, he found three blank spaces in his table. Mendeleev predicted that these blank spaces would be filled by elements that had not yet been discovered. He even predicted the properties of these missing elements. Within sixteen years, the missing elements scandium, gallium, and germanium were found.

Discussion

Why is a second letter sometimes included in the chemical symbol for an element? Some elements begin with the same letter.

If an element's symbol has two letters, how is the symbol written? The first letter is capitalized and the second letter is lowercase.

What is another basis for some of the chemical symbols? the element's Latin name

Discuss some of the Latin names for elements as time allows.

Who came up with a method for classifying the elements? Dmitri Mendeleev

How did Mendeleev organize his table? He put the elements in order based on atomic weight. The rows and columns are organized based on the chemical and physical properties of the elements.

What do we call this classification system? the periodic table of the elements

Why did Mendeleev's periodic table have gaps? Sometimes an element's atomic weight put the element in a location that did not match its chemical and physical properties. Mendeleev put those elements where they fit according to properties instead of weight. He thought that undiscovered elements would fill in the gaps.

How do scientists arrange the periodic table now? by atomic number instead of atomic weight

What does each square in the periodic table represent? one element

What kinds of information can be found within each square on the periodic table? Possible answers: the name of the element; its chemical symbol; its atomic number; sometimes its atomic mass

If you know the atomic number of an element, what else do you know besides the number of protons? the number of electrons that element has

Look at the squares from the periodic table on page 167. Which element would come first in the periodic table—nickel or cobalt? cobalt

If you arranged these two elements by atomic mass only, which element would come first? nickel

Discussion

Refer to *The Periodic Table of the Elements* as each part is discussed.

What are the horizontal rows of the periodic table called? periods

What do elements in the same period have in common? They all have the same number of shells.

What is the highest number of shells for atoms whose elements are listed in the periodic table? 7

What do we call the columns of elements in the periodic table? groups

What do all the elements in a group have in common? They all have the same number of electrons in their outer shells.

What is another name for groups? families

How do you know that sulfur and oxygen have similar physical and chemical properties? They are in the same group.

What is another way scientists classify elements in the periodic table? by placing them into categories based on similar chemical properties and how they react with other elements

How can you tell which category on the periodic table an element belongs to? The categories are color coded.

Based on this periodic table, what are some of the families that scientists use to classify elements? metals, nonmetals, and metalloids

What are some characteristics of metals? usually solid at room temperature; require high temperatures to melt; good conductors of heat and electricity; easily combined with other elements

What are some characteristics of nonmetals? often gases at room temperature; not good conductors of heat and electricity

What are metalloids? elements that have properties of both metals and nonmetals

Why do you think metalloids are also called semimetals? The prefix *semi* means "part." An element that is a metalloid is part metal and part nonmetal.

The horizontal rows of the periodic table are called **periods**. Elements in the same row, or period, have something in common. They all have the same number of shells. Both elements in the first row have one shell for their electrons. All the elements in the second row have two shells for their electrons. The table continues all the way to seven shells.

The vertical columns of the table are called **groups**, or families. All the elements in a group have the same number of electrons in their outer shells. Every element in the first column, or group, has one electron in its outer shell. Every element in the second group has two electrons in its outer shell. All the elements in a group also share similar physical and chemical properties. If you want to find the elements that are similar to neon, just look at the elements located in the same column as neon.

Another way scientists classify elements in the periodic table is by placing them into categories. Categories of elements possess similar

	1A	2A	3B	4B	5B	6B	7B	8B	8B
1	1 Hydrogen **H**								
2	3 Lithium **Li**	4 Beryllium **Be**							
3	11 Sodium **Na**	12 Magnesium **Mg**							
4	19 Potassium **K**	20 Calcium **Ca**	21 Scandium **Sc**	22 Titanium **Ti**	23 Vanadium **V**	24 Chromium **Cr**	25 Manganese **Mn**	26 Iron **Fe**	27 Colbalt **Co**
5	37 Rubibium **Rb**	38 Stronium **Sr**	39 Yttrium **Y**	40 Zirconium **Zr**	41 Nioblum **Nb**	42 Molybdenum **Mo**	43 Technetium **Tc**	44 Ruthenium **Ru**	45 Rhodium **Rh**
6	55 Cesium **Cs**	56 Barium **Ba**	57 Lanthanum **La**	72 Hafnium **Hf**	73 Tantalum **Ta**	74 Tungsten **W**	75 Rhenium **Re**	76 Osmium **Os**	77 Iridium **Ir**
7	87 Francium **Fr**	88 Radium **Ra**	89 Actinium **Ac**	104 Rutherfordium **Rf**	105 Dubnium **Db**	106 Seaborgium **Sg**	107 Bohrium **Bh**	108 Hassium **Hs**	109 Meitnerium **Mt**

58 Cesium **Ce**	59 Praseodymium **Pr**	60 Neodymium **Nd**	61 Promethium **Pm**	62 Samarium **Sm**
90 Thorium **Th**	91 Protactinium **Pa**	92 Uranium **U**	93 Neptunium **Np**	94 Plutonium **Pu**

Metals

Nonmetals

Metalloids (semi-metals)

168

SCIENCE BACKGROUND

Periodic table
Not all periodic tables look the same. Scientists do not always agree on how the elements should be classified and labeled. The table is modified as research methods improve and new elements are discovered.

The periodic table shown on Student Text pages 168–69 has been simplified for student use. The categories are general groupings that may be further divided on other copies of the periodic table.

Hydrogen
Hydrogen is set apart from group 1A because it has many unique properties and does not clearly belong to one group. It can combine with all elements except those in Group 8A. Since it is a gas (or a liquid, when pressurized), it has more physical properties of a nonmetal than a metal. However, it does sometimes react chemically as a metal.

Groups
Elements in groups 1A–8A have the same number of electrons in the outer shells of their atoms. However, this is not true for the B groups.

LANGUAGE

Periodic
The term *periodic* refers to a repeating pattern, a cycle, or a reoccurring event.

Why do you think "periodic" is used for the table of elements? Possible answer: The table is set up to show the repeating or recurring number of shells (periods), number of electrons in the outer shell (groups), and physical and chemical properties.

chemical properties and react similarly with other elements. They are often color-coded in the periodic table. The columns to the left are *metals.* Elements can also be classified as *nonmetals*, and *metalloids*, or semi-metals. A stairstep line separates these categories from one another. Metals are usually solids at room temperature and melt at high temperatures. They are good conductors of heat and electricity and are easily combined with other elements. Nonmetals are often gases at room temperature and are not good conductors of heat and electricity. Metalloids are elements that have properties of both metals and nonmetals.

QUICK CHECK

1. What are chemical symbols and why do scientists use them?
2. What is the periodic table of the elements?
3. What do elements in a group in the periodic table of the elements have in common?

	1B	2B	3A	4A	5A	6A	7A	8A
								2 Helium **He**
			5 Boron **B**	6 Carbon **C**	7 Nitrogen **N**	8 Oxygen **O**	9 Fluorine **F**	10 Neon **Ne**
			13 Aluminum **Al**	14 Silicon **Si**	15 Phosphorus **P**	16 Sulfur **S**	17 Chlorine **Cl**	18 Argon **Ar**
28 Nickel **Ni**	29 Copper **Cu**	30 Zinc **Zn**	31 Gallium **Ga**	32 Germanium **Ge**	33 Arsenic **As**	34 Selenium **Se**	35 Bromine **Br**	36 Krypton **Kr**
46 Palladium **Pd**	47 Silver **Ag**	48 Cadmium **Cd**	49 Indium **In**	50 Tin **Sn**	51 Antimony **Sb**	52 Tellurium **Te**	53 Iodine **I**	54 Xenon **Xe**
78 Platinum **Pt**	79 Gold **Au**	80 Mercury **Hg**	81 Thallium **Ti**	82 Lead **Pb**	83 Bismuth **Bi**	84 Polonium **Po**	85 Astatine **At**	86 Radon **Rn**
110 Darmstadtium **Ds**	111 Roentgenium **Rg**	112 Copernicium **Cn**	113 Ununtrium **Uut**	114 Ununquadium **Uuq**	115 Ununpentium **Uup**	116 Ununhexium **Uuh**	117 Ununseptium **Uus**	118 Ununoctium **Uuo**

63 Europium **Eu**	64 Gadolinium **Gd**	65 Terbium **Tb**	66 Dysprosium **Dy**	67 Holmium **Ho**	68 Erbium **Er**	69 Thulium **Tm**	70 Ytterbium **Yb**	71 Lutetium **Lu**
95 Americium **Am**	96 Curium **Cm**	97 Berkelium **Bk**	98 Californium **Cf**	99 Einsteinium **Es**	100 Fermium **Fm**	101 Mendelevium **Md**	102 Nobelium **No**	103 Lawrencium **Lr**

DIRECT AN ACTIVITY

Identifying elements

Many of the elements are named after people, places, or planets.

Ask the student to find the element on the periodic table named after the following.

People: Pierre and Marie Curie (curium), Albert Einstein (einsteinium), Enrico Fermi (fermium), Dmitri Mendeleev (mendelevium), Niels Bohr (bohrium), Alfred Nobel (nobelium), Ernest Rutherford (rutherfordium), Glenn Seaborg (seaborgium)

Places: America (americium), Europe (europium), France (francium), Poland (polonium), Scandinavia (scandium), Germany (germanium), California (californium), Berkley, CA (berkelium)

Planets: Mercury (mercury), Neptune (neptunium), Pluto (plutonium), Uranus (uranium)

ART

Models

Make models of elements 2–36 using foam balls to represent protons and neutrons and smaller foam balls to represent electrons. The balls can be painted to identify the parts they represent. Direct the student to devise a way to show the shells with the appropriate number of electrons. Display the finished elements from the ceiling.

Discussion

Discuss *The Periodic Table of the Elements* with questions such as the following.

What is the name of element 13? aluminum

Which element has K as its chemical symbol? potassium

What is the atomic number for neon? 10

How many protons does an atom of gold have? 79

What is the chemical symbol for silicon? Si

In what category does silicon belong? metalloids or semi-metals

Sodium and calcium have similar properties. In what category are they placed? metals

Look at element 57. What is the atomic number of element 57? 57 **What is the atomic number of the element to its right?** 72

It appears that some elements are missing. Can you find them on the chart? Yes; they are the elements in the two rows at the bottom.

Why do you think these elements are not in the regular chart? Accept reasonable answers, but conclude that they have properties similar to lanthanum. They are actually called the Lanthanide series.

Do you think it was an accident that elements can fit so well into an organized system? Answers may vary, but emphasize that God's creation is a reflection of the fact that God does everything "decently and in order." (1 Cor. 14:40)

Answers

1. Chemical symbols are abbreviations for the names of the elements and are quicker to use than the elements' full names. The abbreviations make communication with scientists around the world easier.
2. a classification system for the elements developed by Dmitri Mendeleev
3. All the elements in a group have the same number of electrons in their outer shells.

Activity Manual

Review, pages 105–6

These pages review Lessons 83 and 84.

Assessment

Quiz 7-A

The quiz may be given any time after completion of this lesson.

Objectives
- Write about an element based on research
- Construct a visual aid

Materials
- poster board
- file folder (optional)
- additional materials to make the poster

Introduction

Have you ever heard a news reporter give a profile on a criminal that the police are looking for?

The criminal may have escaped from police custody, or the police might have a case file on him because he has committed other crimes.

What kind of information is usually included in a case file or on a wanted poster? Possible answers: the crime committed; what the criminal looks like; disguises; aliases; last known location of the criminal; how the crime was committed

For this exploration you will be preparing a case file for a given element.

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the exploration.

What to do
Build enthusiasm for creating the case file. Give each student an element to research. Choose from the elements with atomic numbers 2–36. Explain your specific requirements for the way the student should prepare and present his information.

Refer the student to the poster pictured on Student Text page 170.

How does the picture show what hydrogen looks like? It shows one large proton and a smaller electron.

Activity Manual
Exploration, pages 107–8

Assessment
Rubrics
Select the prepared rubric, or design a rubric to include your chosen criteria.

EXPLORATION

Wanted: U or Your Element

There are over ninety naturally occurring elements and over a dozen elements that have been artificially produced in laboratories. Elements have been named for people, places, colors, and a variety of other things. There are even some elements that have no official names because there is disagreement as to who first produced these elements in the laboratory. Some elements have been known since ancient times, and others have been identified only recently (within the last fifty years).

Elements hide in lots of places. Your body, the sun, and even your food contain many unexpected elements. You would probably be amazed to know all the elements contained in a box of cereal.

You will be given the name of a "wanted" element. Your assignment is to prepare a case file on that "wanted" element. You need to give the element's structure, position on the periodic table, history, and uses. Of course, you also need to provide a poster to help apprehend your element.

What to do
1. After you are given an element to investigate, use the periodic table on pages 168–69 of your text and other resources to complete the case file in your Activity Manual.
2. Prepare a "wanted" poster for your element. Attach the case file to your poster.

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TEACHER HELPS

Grouping
This exploration may be done by individual students or in groups.

Periodic table variations
There are variations between different periodic tables. Decide if you want other periodic tables used or only the one in the Student Text.

Additional information may include where the element is found in its natural state, its flammability, its color, and its other chemical properties. Chemical properties are the properties and characteristics specific to that element.

Project size variation
Instead of making one large wanted poster, the wanted poster could be prepared on a size of paper that can be placed with the case file in a notebook or file folder for future reference. An expandable file folder could be used to hold the case files of different elements.

Compounds

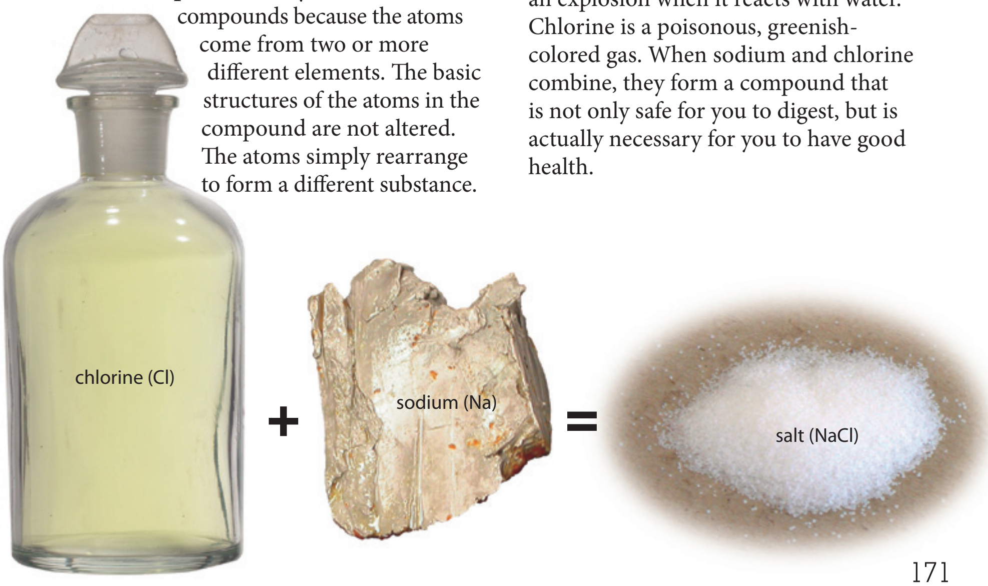
If single atoms were always by themselves, we would never see them because they are so tiny. However, atoms rarely exist alone. Sometimes identical atoms group together to form elements such as gold, silver, copper, and mercury. Atoms may join with other atoms to form units that are called **molecules**. A few atoms chemically join with identical atoms to form units called diatomic molecules. For example, two oxygen atoms may join with one another to form a molecule of oxygen.

However, most atoms join with different types of atoms in a process called a **chemical change**, or **chemical reaction**. Usually the chemical change produces molecules known as **compounds**. They are called compounds because the atoms come from two or more different elements. The basic structures of the atoms in the compound are not altered. The atoms simply rearrange to form a different substance.

Common Compounds

When elements combine through a chemical change, a new substance forms. The properties of this substance are usually very different from those of the original elements. A combination of hydrogen and oxygen forms the most common compound on Earth. Hydrogen is an extremely flammable gas, and oxygen is also a gas that permits things to burn. But when the two combine in a chemical change, they make the compound we call water (H_2O). We use this compound to put out many types of fire. The properties of water are very different from the properties of its original elements.

Another example of a compound that differs greatly from its individual elements is sodium chloride, or table salt. Sodium is a metal that may cause an explosion when it reacts with water. Chlorine is a poisonous, greenish-colored gas. When sodium and chlorine combine, they form a compound that is not only safe for you to digest, but is actually necessary for you to have good health.



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Student Text pages 171–73
Activity Manual page 109

Lesson 86

Objectives

- Explain that a chemical change occurs when atoms of different elements combine
- Demonstrate how to read and write a chemical formula
- Differentiate between synthesis and decomposition reactions

Materials

- trail mix or snack cracker mix
- 500 mL bottle with 125 mL vinegar inside
- balloon with 15 mL baking soda inside

Vocabulary

molecule	compound
chemical change	chemical formula
chemical reaction	

Introduction

Give the student a small amount of trail mix.

Identify the types of food in the trail mix. Possible answers: peanuts, raisins, candy

Each of the foods in the trail mix has kept its original identity. This is called a mixture because the parts do not change when they are combined.

Carefully attach the balloon to the top of the bottle. Lift the balloon quickly, so that the baking soda falls into the vinegar.

What happened? The balloon inflated. **Why?** Elicit that when the baking soda and vinegar combined, a change took place, and a gas was given off, filling the balloon.

This type of combination is a chemical reaction. The gas that filled the balloon is a new product different from the liquid and solid that were mixed.

Teach for Understanding

Purpose for reading

What is a compound?

What happens in a synthesis reaction?

Discussion

What is a group of atoms joined together called? a molecule

Do molecules form from the same kind of atoms joining together or by different kinds of atoms joining together? Both. Molecules form whenever atoms join together whether the atoms are the same or different.

What kind of molecule is formed when identical atoms join together? a diatomic molecule

What occurs when different types of atoms are joined together? a chemical change, or chemical reaction

What kind of molecule is produced as a result of a chemical change? a compound

Describe a compound. a molecule with atoms from two or more different elements

The properties of the elements that make up a compound are different from the properties of the compound they form.

What is the most common compound on Earth? water

Which two elements make up water? hydrogen and oxygen

What are the properties of hydrogen and oxygen? Hydrogen is a flammable gas. Oxygen is a gas that helps things burn.

What are some properties of water? It is a liquid. It is safe to drink. It puts out many types of fire.

If you ate chlorine and sodium individually, what would happen to you? You would be poisoned.

When chlorine and sodium combine, what compound is formed? salt

Discussion

What is a chemical formula? the chemical symbols and numbers that show the elements that make up a compound

Remind the student of the introduction of the previous lesson where letters represented words.

Although the individual letters in FBI and NHL stand for words, the symbols together also stand for something. When we hear FBI we do not usually think of the words. Instead we think of our national crime-fighting organization. Scientists also combine the chemical symbols to form chemical formulas that represent molecules.

What do the small subscript numbers in a formula tell us? how many atoms of that element are in a molecule

How many atoms of oxygen are in carbon dioxide? 2

Compounds can be made of two or more elements. How many elements are in carbonic acid? 3 **What are they?** hydrogen, carbon, oxygen

How many atoms of hydrogen are in carbonic acid? 2 **Atoms of carbon?** 1 **Atoms of oxygen?** 3

Discuss the formulas for cane sugar, baking soda, and aspirin. The student may use the periodic table on Student Text pages 168–69 to help him identify the elements.

Which elements make up cane sugar? carbon, hydrogen, and oxygen

Which element in cane sugar has the most atoms? hydrogen

Which four elements combine to form baking soda? sodium, hydrogen, carbon, and oxygen

How many atoms of carbon are in aspirin? 9

Look at the formula for carbonic acid in the paragraph and the formulas for cane sugar and aspirin in the chart. What do those formulas have in common? They are all combinations of the same elements—carbon, hydrogen, oxygen.

How are those formulas different? Each compound has different amounts of each element.

Use the Direct an Activity to allow the student to practice reading and writing chemical formulas.

Chemical Formulas

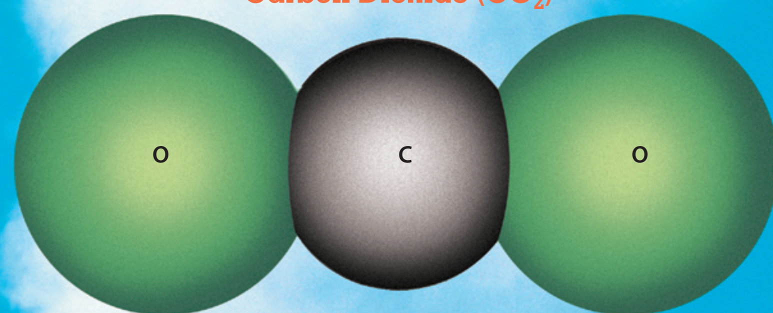
When scientists want to show the elements that make up a compound, they use a chemical formula. A **chemical formula** uses chemical symbols and numbers to abbreviate the name of a compound. Using a chemical formula is similar to using the letters USA for the United States of America. Often that abbreviation is used for the country's full name.

A chemical formula gives a scientist information about a compound. For instance, the formula for carbon dioxide is CO_2. The subscript $_2$ tells us that this molecule has two atoms of oxygen. Those two atoms of oxygen are combined chemically with one atom of carbon to form one molecule of carbon dioxide.

Compounds are not always made up of just two elements. Sometimes the atoms of several elements combine to form a compound. For example, the carbonic acid that can cause chemical weathering has more than two elements. The chemical formula for carbonic acid is H_2CO_3. The formula tells us that a molecule of carbonic acid has two atoms of hydrogen, one atom of carbon, and three atoms of oxygen.

Cane sugar	Baking soda	Aspirin
$C_{12}H_{22}O_{11}$	$NaHCO_3$	$C_9H_8O_4$

Carbon Dioxide (CO_2)



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DIRECT AN ACTIVITY

Reading and writing formulas

Direct the student to use the periodic table to identify the elements in the formula and the number of atoms of each element. Allow the student to research to find and interpret formulas for other compounds.

N_2O (Laughing gas): 2 nitrogen + 1 oxygen

NaOH (Lye): 1 sodium + 1 oxygen + 1 hydrogen

SiO_2 (Sand): 1 silicon + 2 oxygen

Write the formula for each compound.

1 calcium + 1 carbon + 3 oxygen (Chalk): $CaCO_3$

2 hydrogen + 2 oxygen (Hydrogen peroxide): H_2O_2

2 iron + 3 oxygen (Rust): Fe_2O_3

SCIENCE BACKGROUND

Introduction activity

The chemical reaction observed is actually two chemical reactions. The baking soda and vinegar combine to form a weak acid called carbonic acid. Carbonic acid is not stable and rapidly undergoes a decomposition reaction, breaking down into carbon dioxide and a water solution. This chemical reaction was used in the volcano eruption in Lessons 8–9.

Synthesis reactions

A synthesis reaction is often the reverse of a decomposition reaction. In a synthesis reaction, two reactants come together to make a new compound. The two reactants could be an element, a diatomic molecule, or a compound.

TRY IT YOURSELF

You can demonstrate a chemical reaction. Pour 60 mL of vinegar into a clear plastic cup. Stir 10 mL of salt into the vinegar until the salt is completely dissolved. Place two ¾ in. copper couplings (pipe joints) into the solution. Add to the solution several iron nails or screws that have not been coated or galvanized. Leave for several hours. What do you observe? The copper from the pipe replaces the iron on the surface of the nails or screws.

Chemical Reactions

Some chemical reactions occur when molecules combine to form new substances. This kind of chemical reaction is called a *synthesis reaction*. Let's again use carbonic acid as an example. Carbonic acid forms when carbon dioxide (CO_2) reacts with the water (H_2O) that is in the air. When these molecules combine, they form the new compound H_2CO_3.

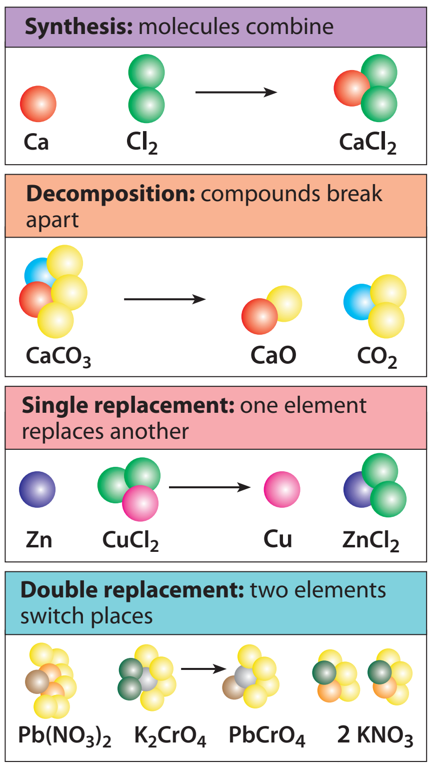
Not all chemical reactions result in more complex compounds. Some chemical reactions break down a complex compound into two or more simpler compounds. This kind of chemical reaction is called a *decomposition reaction*. When our bodies digest complex molecules, such as sugars, the sugar is broken down into much simpler molecules, such as water and carbon dioxide.

In other reactions, one element replaces another element in a compound. There are even some chemical reactions that cause compounds to trade elements with each other.

QUICK CHECK

1. What is a chemical reaction?
2. What is a compound?
3. What does the symbol CO_2 show about the molecule?
4. What happens in a synthesis chemical reaction?

Types of Chemical Reactions



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DIRECT A DEMONSTRATION

Demonstrate a chemical change

Materials: 60 mL water, 30 g Borax, 60 mL white glue, zip-close plastic bag

Describe the appearance and properties of the water, Borax, and glue. Possible answers: Water is a colorless and tasteless liquid. Borax is a white powder. Glue is a thick white liquid that pours slowly.

Borax is made from the element boron. Look at the periodic table of the elements. What is the atomic number for boron? 5

What do you think Borax is used for? It works with laundry detergent to brighten clothing.

What do you think will happen when we mix these items together? Answers will vary.

In the plastic bag, combine the water and Borax. Add the glue and squeeze (knead) to mix well. Direct the student to observe and record any changes in the appearance of the substance. Remove the substance from the bag. Allow the student to touch the mixture and describe how it feels.

Describe the properties of this new substance. Possible answers: smooth, slippery, shiny, stretchy, malleable

Hold the substance. Could you pick up the water, Borax, or glue in this way? no

Think of a name and uses for your substance.

This substance is similar to Silly Putty.

Discussion

What is a chemical reaction? the process through which different types of atoms join together

Which compounds join to make carbonic acid? carbon dioxide and water **What atoms make up those compounds?** carbon, oxygen, and hydrogen

Is carbonic acid a different substance than carbon dioxide and water? yes

What is this type of chemical reaction called? synthesis reaction

What happens during a synthesis reaction? molecules combine to form new substances

Look back at the chemical formula for cane sugar. Our bodies cannot use this sugar as it is. It must be broken down into simpler molecules that our bodies can use. What kind of chemical reaction happens when a compound is broken down into simpler compounds? a decomposition reaction

Which type of chemical reaction occurs as the acids in your digestive system break down the food you eat? decomposition reaction

What happens during other kinds of chemical reactions? Sometimes one element replaces another element or some compounds trade elements.

Discuss *Types of Chemical Reactions.*

What are four types of chemical reactions? synthesis, decomposition, single replacement, and double replacement

How are synthesis and decomposition reactions different? In a synthesis reaction, molecules combine to make a new compound. In a decomposition reaction, a compound breaks apart into simpler compounds.

How many elements switch places in a double replacement reaction? two

Answers

1. the process through which different types of atoms join together
2. molecules formed as a result of a chemical reaction of two or more different elements
3. The compound consists of one atom of carbon and two atoms of oxygen.
4. Molecules combine to form new substances.

Activity Manual

Reinforcement, page 109

This page is used for both Lesson 86 and 87. Questions 1–8 are for Lesson 86 and questions 9–10 are for Lesson 87.

Student Text pages 174–75
Activity Manual pages 109–110

Objectives

- Compare and contrast ionic and covalent bonding
- Describe what causes an ion

Vocabulary

stable
covalent bond
ion
ionic bond

Introduction

What do you do when you see that a friend needs to use something that you have? Possible answers: share, lend, or give it to the friend

Atoms also share electrons.

Today we will talk about how atoms share electrons.

Teach for Understanding

Purpose for reading

How are covalent bonds and ionic bonds different?

Discussion

What factor determines how atoms tend to form compounds? the number of electrons in the outer shells of the atoms

When is a shell of an atom closed? when it is completely filled with electrons

If the last shell of an atom is completely filled with electrons, is the atom considered stable or unstable? stable

What does stable mean? the atom is not likely to form compounds with other atoms

What kind of gases are made up of stable atoms? noble gases

Look back at the periodic table on pages 168–69. Noble gases include neon, argon, and krypton. Which group are they? 8A

What do all the elements in a group have in common? the number of electrons in their outer shells

How many electrons do noble gases have in their outer shells? 8

Why do most atoms bond with other atoms? Since the outer shells of most atoms are not filled, bonding allows each atom to complete its outer shell of electrons.

Atomic Bonds

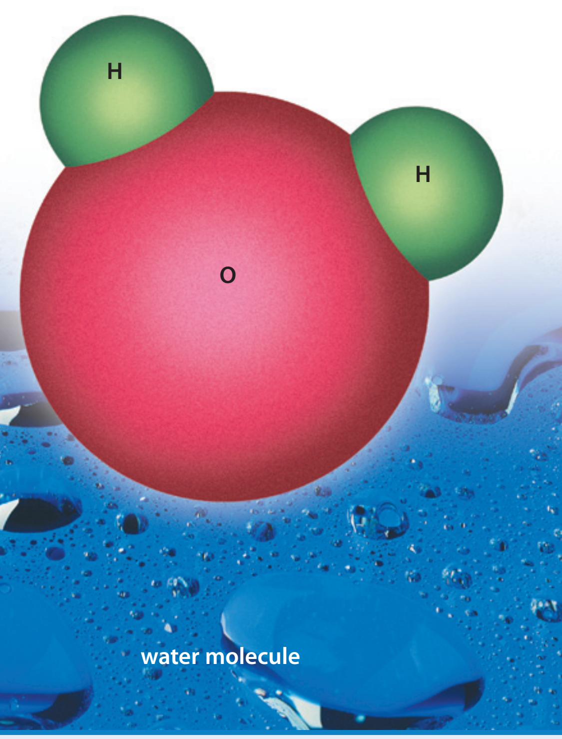
Atoms tend to form molecules of a compound based on the number of electrons in each atom's outermost shell. Electron shells can hold only a certain number of electrons. If the atom's outermost shell is completely filled, that shell is *closed*, and the atom is considered **stable**. Stable atoms are not likely to form compounds with other atoms. Noble gases are made up of stable atoms; thus, they rarely undergo chemical reactions. Noble gases include elements such as neon, argon, and krypton.

Most atoms have electron shells that are not completely filled. Some atoms' outer shells have electrons that can be either given up or shared to form bonds, or unions. These atoms bond with other atoms so that each atom completes its outer shell.

Atoms bond with each other in several ways. Each kind of bond affects the characteristics of the compound formed by the atoms.

Covalent bonds

Some bonds occur when atoms share pairs of electrons. This kind of bond is called a **covalent** (koh VAY lunt) **bond**. By such sharing, the electrons fill in more of the outer shells of both atoms. Gases and liquids are most likely to contain covalent bonds, or bonds formed by sharing electrons. Oxygen in the air (O_2) is actually a molecule of two oxygen atoms that have joined by sharing a pair of electrons. Water (H_2O) is a liquid compound formed by atoms sharing electrons. In water, two hydrogen atoms combine with one oxygen atom to form a water molecule.



water molecule

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SCIENCE BACKGROUND

Metallic bonds
Another type of bonding can occur between identical metal atoms. In metallic bonding, each atom releases the electrons from its outer shell and they flow freely around the positive ion cores. This arrangement allows the metal to conduct heat and electricity well because the electrons move easily.

Noble gases
Noble gases are the elements listed in group 8A on the periodic table.

Water molecule
Oxygen has an atomic number of 8. There are 2 electrons in the first shell and 6 in the outer shell. It needs two more electrons to be complete. When it combines with two hydrogen atoms to form water, each hydrogen atom shares one electron, bringing oxygen to eight. One pair of electrons is shared at each bond. Since hydrogen has only the first energy level (shell), it only needs two electrons to be full.

Bond type
Typically, covalent bonds occur between nonmetals. Ionic bonds form between a metal and nonmetal.

SCIENCE MISCONCEPTIONS

Stable molecules
Covalent bonds do not necessarily mean that the atoms are now stable. For example, oxygen (O_2) has only 7 electrons per atom after bonding. That molecule can still react and combine with other molecules.

Ionic bonds

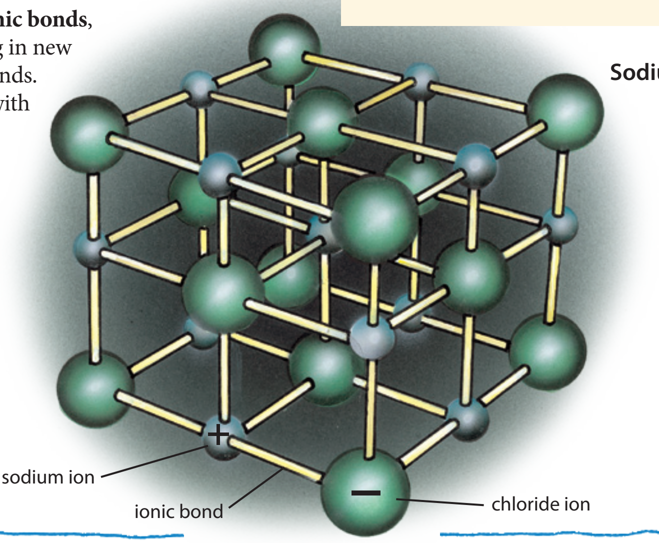
An atom that has gained or lost electrons is called an **ion**. Ions occur when the number of electrons in an atom does not equal the number of protons. The atom is positively charged when the number of protons is greater than the number of electrons. A positive charge means that the atom has given away electrons from its outer shell. The atom is then called a *positive ion*. If the number of electrons is greater than the number of protons, the atom is negatively charged. It is then called a *negative ion* because it has gained electrons to fill its outer shell.

Perhaps you remember that the opposite ends—the north and south poles—of magnets attract. The same principle applies to ions. Positively and negatively charged ions attract each other to form **ionic bonds**, resulting in new compounds. Atoms with ionic bonds are held together by their opposite charges.

The compound sodium chloride, or table salt, contains ionic bonds. Sodium and chlorine atoms transfer electrons to form this compound. Chlorine atoms receive from sodium one electron apiece in order to fill their outer shells. Chlorine is then a negative ion. Each sodium atom gives up one electron to the chlorine and becomes a positive ion. However, you would not find just one molecule made up of these oppositely charged ions. Many of these ions attract each other and bond together. They fit in such a way that they form beautiful geometric shapes called crystals. All ionic compounds form crystals.

QUICK CHECK

1. What are two ways that atoms bond?
2. What is an ion?



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DIRECT AN ACTIVITY

Model atomic bonds

Materials: tokens to represent electrons such as checkers or paper circles

Randomly distribute up to 10 electrons per student, but avoid giving a student 8 electrons. Each student represents an atom, and the tokens represent the electrons found in the atom's outer shell. For this activity, the outer shell is considered full when it has 8 electrons.

Students should find other atoms with which they can bond. Each atom should have no more than 8 electrons. A student may share electrons with another atom (covalent bonding). Students may also give or receive electrons. Oppositely charged ions attract each other (ionic bonding).

Direct students to identify each type of bond formed.

Discussion

Which type of bond is formed when atoms share electrons? a covalent bond

Which states of matter are most likely to contain covalent bonds? gases and liquids

What are two examples of molecules that have covalent bonds? oxygen in the air and water

What do we call an atom that has gained or lost electrons? an ion

What do we call an atom with less electrons than normal? a positive ion

Why does an atom that has lost an electron have a positive charge? because it has more protons than electrons and protons have a positive charge

What do we call an atom with more electrons than normal? a negative ion

What is needed for a molecule to form with an ionic bond? positive and negative ions

Why do positive and negative ions join to form bonds? They are attracted to each other and exchange electrons.

What holds ionic bonds together? the opposite charges of their atoms

What shape do all ionic compounds form? crystals

Name an example of a molecule that forms from an ionic bond. Possible answer: sodium chloride (table salt)

Discuss the diagrams of the water molecule and sodium chloride crystal.

Why do you think atoms such as oxygen and chloride are pictured larger than the hydrogen and sodium atoms? Possible answers: Oxygen and chloride are actually larger than the other atoms pictured. They have larger atomic numbers.

Answers

1. Atoms share electrons in covalent bonds. Atoms give or receive electrons in ionic bonds.
2. An ion is an atom that has a negative or positive charge due to gaining or losing electrons.

Activity Manual

Reinforcement, page 109

This page is used for both Lesson 86 and 87. Questions 9–10 are for Lesson 87.

Review, page 110

This page reviews Lessons 86 and 87.

Assessment

Quiz 7-B

The quiz may be given any time after completion of this lesson.

Student Text pages 176–77
Activity Manual pages 111–12

Objectives
- Evaluate whether a chemical reaction has occured
- Collect data to identify a reaction as endothermic or exothermic

Material
- See Student Text page

Vocabulary
endothermic reaction
exothermic reaction

Introduction

Have you ever seen or used sparklers for holidays, such as the Fourth of July? Answers will vary.

A sparkler burns longer than a firecracker and produces a shower of sparks. It consists of a rigid stick or wire that has been coated with chemicals. When the sparkler is lighted, some of the chemicals decompose to produce oxygen, and other chemicals react with the oxygen.

What do these chemical reactions produce? Possible answers: heat, smoke, sparks

In today's activity, you will use physical characteristics to determine whether or not a chemical reaction has occurred as different substances are combined.

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

Discussion
What are some indications that a chemical change has occurred? Possible answers: solid substance appears; change of color; heat produced or absorbed

ACTIVITY

Hot or Cold

Process Skills
- Predicting
- Measuring
- Experimenting
- Observing
- Recording data

Chemical reactions often show visible signs that something has taken place. Sometimes a solid substance appears in a solution. A color change might also indicate a chemical reaction.

Another sign of a chemical reaction is whether heat is produced or absorbed. An *endothermic* (EN doh THUR mik) *reaction* uses thermal (heat) energy, so the temperature of a solution experiencing an endothermic reaction decreases. An *exothermic* (EK soh THUR mik) *reaction* produces heat. The reaction raises the temperature of the solution in which an exothermic reaction is occurring.

In this activity, you will combine substances to determine whether the reaction occurring is endothermic, exothermic, or even a chemical reaction at all.

Problem
How can I use temperature to determine whether a chemical reaction has occurred?

Materials
goggles
3 plastic cups
metric measuring spoons
30 mL 3% hydrogen peroxide
thermometer
5 mL yeast
3 stirring sticks
stopwatch
30 mL water
5 mL salt
30 mL vinegar
5 mL baking soda
green, red, and blue colored pencils
Activity Manual

Procedure
1. You will need at least three people for this activity—one person to time, one person to read the temperature, and one person to record the information. Be sure everyone is ready before combining the substances.
2. Look at the chart in the Activity Manual. Predict which pairs of substances will cause a chemical reaction. Record your predictions.
3. Pour 30 mL of hydrogen peroxide into a cup.
4. Measure and record the starting temperature of the hydrogen peroxide. Keep the thermometer in the cup.
5. Measure 5 mL of yeast and set it aside until each person is ready.

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TEACHER ★ HELPS ★

Stirring sticks
These could be coffee stirrers, craft sticks, or plastic spoons. Choose anything that can easily fit inside the cup with the thermometer.

Thermometers
Provide extra water for students to rinse the thermometers between tests or provide extra thermometers.

Visible evidences of chemical change
Observable evidences that a chemical change has taken place include the following:
- change in temperature
- change to a solid
- change in mass or weight
- change in color
- produces gas (bubbles)
- produces light, sound, heat, or an odor

6. Add the yeast to the hydrogen peroxide and stir.
7. Immediately begin timing 10-second intervals. As one person calls the time every 10 seconds, the second person reads the thermometer, and the third person records the temperature.
8. Using a green colored pencil, graph the recorded information.
9. Repeat the procedure using 30 mL of water and 5 mL of salt. Using a red colored pencil, graph the information.
10. Repeat another time using 30 mL of vinegar and 5 mL of baking soda. Using a blue colored pencil, graph the information.

Conclusions

- Which of the experiments demonstrated a chemical reaction? How could you tell?
- Which reaction demonstrated an exothermic reaction?
- Why was it important to have several people working together on this activity?

Follow-up

- Try changing the amounts of substances used to see if there is a difference in the amount of heat consumed or absorbed.

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What are you trying to determine in this activity? whether the reaction is endothermic, exothermic, or even a chemical reaction

Procedure

What kind of reaction uses thermal energy? endothermic reaction

What will happen to the temperature of a solution that experiences an endothermic reaction? Possible answers: It will decrease, or get colder.

What kind of reaction produces heat? exothermic reaction

What will happen to the temperature of a solution that experiences an exothermic reaction? Possible answers: It will increase, or get warmer.

Provide time for each student to record his predictions. If desired, help him formulate a hypothesis about each of his predictions or just one of them. The hypotheses can be written under the prediction chart. A possible hypothesis could be "Combining vinegar and baking soda will result in an endothermic chemical reaction."

Remind the student to measure the starting temperature of each liquid (hydrogen peroxide, water, and vinegar) before combining the ingredients. Ingredients should not be combined until each partner is ready to do his assigned task.

Provide water for the students to rinse the thermometer between each test.

Allow time for the students to copy the chart information from their group's recorder. Each student should complete his own observation chart and graphs.

Conclusions

Provide time for the student to evaluate his predictions and answer the questions.

Which solutions produced a chemical reaction? hydrogen peroxide and yeast; vinegar and baking soda

How do you know that a chemical reaction occurred? The temperature of the solutions changed.

Which reaction was endothermic? the vinegar and baking soda

Which reaction was exothermic? the hydrogen peroxide and yeast

Use the questions in the Science Process Skills to discuss collecting and recording data.

Activity Manual

Activity, pages 111–12

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

LANGUAGE

Prefix clues

Exothermic means "giving off or producing heat." The prefix *exo* means "outside," "external," or "beyond." *Thermic* is an adjective relating to or associated with heat. *Endothermic* means "using or absorbing heat." The prefix *endo* means "inside" or "within." Students can remember the difference by thinking about the clues given by the prefixes. An exothermic reaction produces heat that can be given off outside or beyond the reaction, causing the temperature to rise. An endothermic reaction uses heat inside or within the reaction, causing the temperature to drop.

SCIENCE PROCESS SKILLS

Collecting and recording data

What kinds of data were collected in this experiment? temperature and time

Could you collect only the data about the temperature and still have a valid experiment? Answers will vary, but point out that longer time intervals might have caused the solution to return to room temperature before you could determine whether a chemical reaction had occurred or not.

What ways did you record data? on the chart and then by graphing

How helpful is the graph in showing what took place? Answers will vary, but elicit that being able to compare the three on one graph shows the contrast better.

Objectives

- Compare and contrast characteristics of acids and bases
- Describe the purpose of an indicator
- Identify products that are acids, bases, or salts
- Summarize how a salt forms

Materials

- box of baking soda
- container
- water

Vocabulary

acid	neutral
base	indicator
alkali	salt
pH scale	

Introduction

Display the box of baking soda.

Have you ever used baking soda for a purpose other than baking? Answers will vary.

Read the variety of uses listed on the box of baking soda or those listed in Teacher Helps. Discuss the variety of uses and why the student thinks baking soda works these ways.

Allow a student to examine some dry baking soda.

What are some characteristics, or properties, of baking soda? Possible answers: white, powdery, smooth, odorless

Allow another student to add a little water to the baking soda and feel it.

How would you describe the baking soda paste? Possible answers: slippery, slimy

The compound we call baking soda is classified as a base. Today we will look at acids and bases to see how these chemicals are useful in our daily lives.

Teach for Understanding

Purpose for reading

How are acids and bases different?

How are salts formed?

Discussion

What is an acid? a compound that forms hydrogen ions when dissolved in water

What determines the strength of an acid? the number of hydrogen ions it forms

Acids and Bases

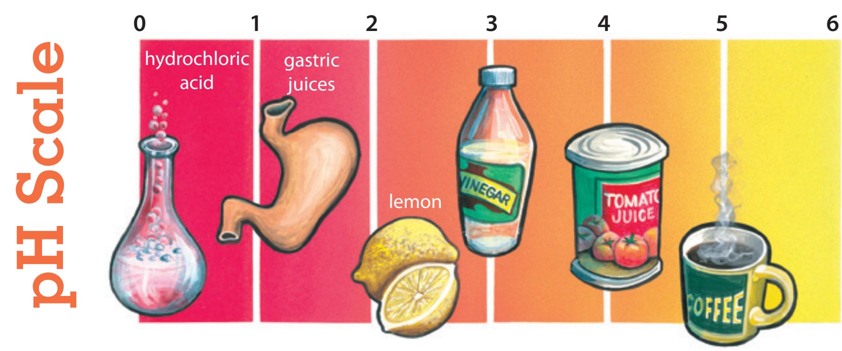
Properties

Acids and bases are compounds with properties that make them useful to people in a variety of ways. **Acids** form hydrogen ions (H^+) when they are dissolved in water. The strength of an acid depends on the number of hydrogen ions it forms. Acids have a sour taste. Some weak acids, such as lemon juice and vinegar, can make us pucker when we taste them.

Many stronger acids are dangerous to taste and can burn your skin. Strong acids, such as sulfuric acid, are corrosive. *Corrosive* acids can even dissolve metals. Strangely enough, your stomach produces one of the strongest acids, *hydrochloric* (HY druh KLOR ik) *acid,* to help digest food. However, God has designed our stomach with a special coating. This coating protects the stomach from its corrosive acid.

Bases form hydroxide (hy DRAHK SIDE) ions (OH^-) when they are dissolved in water. Similar to acids, the strength of a base depends on the number of hydroxide ions it forms. Bases taste bitter and feel slippery. You have probably experienced this property when you have tried to pick up a piece of soap.

Like acids, some bases are weak and some are strong. Baking soda and antacid tablets are two common weak bases. Just as strong acids can be dangerous, so can strong bases. The base sodium hydroxide is used to make lye and drain cleaners. Bases that dissolve in water are referred to as **alkalis** (AL kuh LYES).



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TEACHER HELPS

Baking soda uses
Baking soda may be used for baking and as a cleanser, deodorizer, toothpaste, laundry booster, and an antacid.

SCIENCE BACKGROUND

Definition of an acid
Most definitions of acids are actually lists of properties. The properties of acids include the following: taste sour, cause blue litmus paper to turn red, neutralize bases, react with metals, produce hydrogen ions when dissolved in water, accept electrons, conduct electricity, and have a pH range of 0–6.9.

Definition of a base
Most definitions of bases are actually lists of properties. The properties of bases include the following: taste bitter, feel slippery, turn red litmus paper blue, neutralize acids, produce hydroxide ions when dissolved in water, donate electrons, conduct electricity, and have a pH range of 7.1–14.

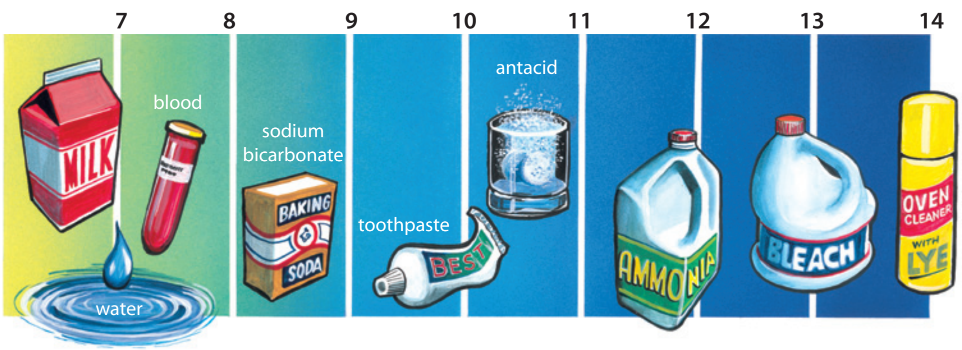
Bases feel soapy
Bases react with and dissolve natural fatty acids and oils found on skin. This reaction results in the slippery soapiness felt as the friction is reduced. Bases are used to make soap. The high base content of early homemade soaps often irritated the skin. Most modern soaps have a pH value between 9.5 and 10.0.

pH Scale

Scientists use a special scale to determine the concentration, or amount, of an acid or a base in a solution. The term *pH* comes from French words meaning "the power of hydrogen." The **pH scale** is numbered from 0 to 14. Acids measure from 0 to 6.9 on the scale, with 0 being highly acidic and 6 being slightly acidic. Bases measure from 7.1 to 14 on the scale, with 14 being highly basic and 8 being slightly basic. Solutions with a pH of 7.0 are **neutral**, meaning they are neither basic nor acidic. Pure water has a pH of 7.0.

Soil pH affects how well plants absorb nutrients from the soil. Most plants grow best if the soil pH is around 6.0–7.0. People can buy pH test kits at most lawn and garden stores. Once a gardener knows the pH of his soil, he can raise or lower the pH by adding substances to the soil. To increase the pH, most gardeners add a base called lime to the soil. To lower the soil pH, many gardeners add peat moss or compost. These items usually have some type of acid in them.


testing the pH of pool water



Bases

LANGUAGE

The term *alkali* refers to a soluble base or a solution of a base. Items that have a pH value above 7 are considered to be basic, or alkaline. The adjective *alkaline* is often used as a synonym for *base*, especially for soluble bases. Bases with a higher pH are considered to have a higher alkalinity.

Discussion

How do acids taste? sour

What are some common weak acids? Possible answers: lemon juice and vinegar

What is an example of a corrosive acid that can be found in your body? Possible answers: hydrochloric acid found in the stomach

What is a base? a compound that forms hydroxide ions when dissolved in water

What determines the strength of a base? the number of hydroxide ions it forms

What are some characteristics of bases? They taste bitter and feel slippery.

What are some common weak bases? Possible answers: baking soda and antacids

How do you dilute an acid or a base? add more water to the solution

Describe an alkali. It is a base that dissolves in water.

What is the name of the scale that is used to show the strength of an acid or a base in a solution? pH scale

How is the pH scale numbered? 0–14

Why is pure water considered a neutral compound? It has a pH of 7, which is neither an acid nor a base.

What numbers on the scale indicate that a compound is an acid? 0–6.9

Do lower or higher numbers indicate a strong acid? lower numbers

What numbers on the scale indicate that a compound is a base? 7.1–14

Do lower or higher numbers indicate a strong base? higher numbers

How do gardeners increase the soil pH? They add lime or another base.

How do gardeners decrease the soil pH? They add compost, peat moss, or some other substance containing an acid.

Why do gardeners sometimes change the pH of their soil? Possible answer: Plants need different types of soil.

Look at the photo. What is another way the pH scale is used? to test pool water

Discuss the pH scale. Compare and contrast acid and base characteristics that the student may know about the items pictured.

Discussion

What important property do indicator substances have? They change color when in contact with an acid or a base solution.

Explain how litmus paper works. Red litmus paper turns blue in a basic solution. Blue litmus paper turns red in an acidic solution.

Where does the substance used in litmus paper come from? lichens

Indicator paper is also used to determine whether a solution is an acid or a base. What else can it show? the pH value of a solution

What are some other natural substances that are indicators? Possible answers: beets, pears, red cabbage

Discuss *Creation Corner*.

What is a unique feature of some hydrangeas? The color of their blossoms depends on the pH of the soil.

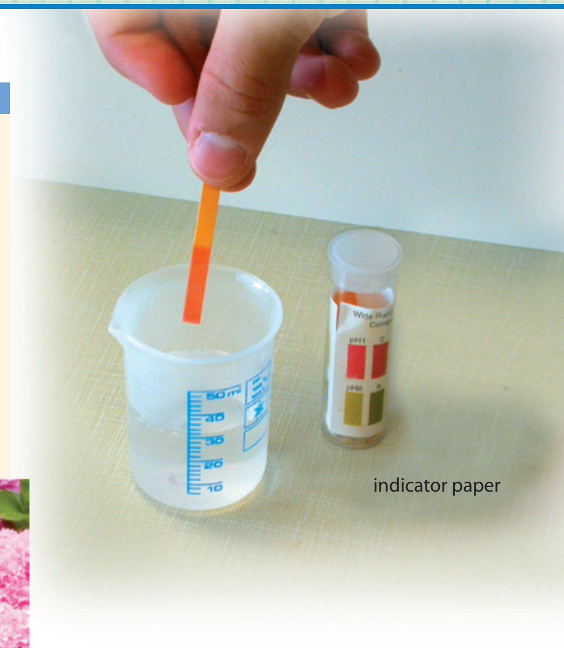
How is the hydrangea like litmus paper? An acidic soil will produce pink flowers just as litmus paper turns red in an acid. A basic soil will turn the blossoms blue just as litmus paper turns blue in a base.

Why do you think some bushes might have both pink and blue blossoms? Answers will vary, but suggest that the soil may be different where different parts of the root system are. As different parts of the root system supply different parts of the bush, the colors may vary.

God's design includes many things that are for man's enjoyment.

CREATION CORNER

Flowering bushes usually produce flowers of the same color year after year. But the blossoms on some hydrangeas will be different depending on the soil pH. Acidic soil produces pink blossoms, while basic soil produces blue blossoms. You can even change the color of the flowers in the middle of a blooming season by adding acid or base substances to change the pH of the soil. What an amazing plant God has created for our enjoyment!



indicator paper

Indicators

Acids and bases are usually found in water solutions. Certain substances called **indicators** change color when exposed to acid or base solutions. Litmus paper is a paper that has been treated with an indicator substance made from lichens. If you dip blue litmus paper into an acid solution, the paper turns red. If you dip red litmus paper into a base solution, the paper turns blue. Litmus paper is a helpful tool for determining whether or not a solution is basic or acidic. Another helpful tool is indicator paper. Indicator paper will change colors depending on whether the solution is acidic or basic. It also shows by its color the pH value of the solution.

Many other natural substances, such as beets, pears, and red cabbage, can also indicate by changing their color whether a solution is an acid or a base. Their color changes can even indicate the pH range of the substance.

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SCIENCE BACKGROUND

Antacids

Whether antacids are liquids to drink, tablets to chew, or tablets to be dissolved in water, all antacids are bases. Often they contain a type of flavoring such as mint or fruit to cover the bitter taste of the base. Two common bases found in antacids are sodium bicarbonate ($NaHCO_3$) and magnesium hydroxide ($Mg(OH)_2$). Baking soda, a product with many household uses, is sodium bicarbonate. Magnesium hydroxide is sold as Milk of Magnesia. When combined with the hydrochloric acid in your stomach, either of these bases reacts chemically, producing water and a harmless salt.

DIRECT AN ACTIVITY

Using litmus paper

Materials: 10 mL of ammonia in a glass container, 10 mL of vinegar in a glass container, red and blue litmus paper, medicine dropper, goggles

Label the two containers.

Which of these is an acid and which is a base? (The student may look at the pH scale.) Ammonia is a base and vinegar is an acid.

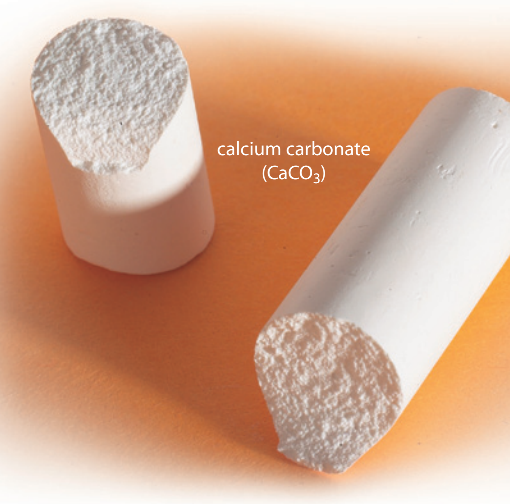
What is one way we can be sure which is an acid and which is a base? Test with litmus paper.

Direct the student to use red and blue litmus paper to test the ammonia. Then use fresh red and blue litmus paper to test the vinegar.

Neutralizing Acids and Bases

Perhaps you have heard someone complain of heartburn, the release of too much acid in the stomach. Sometimes people take antacid tablets to make them feel better. Antacid tablets contain a base material that stops or lessens the effect of the stomach acid.

As we learned earlier, the properties of new substances formed during a chemical reaction are often very different from the original substances. When an acid and a base come in contact with each other, they neutralize each other. The properties of each substance change. The chemical reaction between an acid and a base produces water and a salt. A **salt** is an ionic compound formed from a reaction between an acid and a base. It contains positive ions from a base and negative ions from an acid.



calcium carbonate ($CaCO_3$)

Most salts are composed of a metal and a nonmetal. Different combinations of bases and acids form different types of salts. You may be familiar with salts such as table salt (NaCl—sodium chloride), salt substitute (KCl—potassium chloride), and chalk ($CaCO_3$—calcium carbonate).

QUICK CHECK

1. What are the properties of bases?
2. What are the properties of acids?
3. What are some everyday products that contain acids or bases?
4. How is a salt formed?

salt crystals

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Continued from page 198.

What are the results of the tests? The ammonia turns the red litmus paper blue, and the blue litmus paper stays blue. The vinegar turns the blue litmus paper red, and the red litmus paper stays red.

Fill a medicine dropper with ammonia and add five drops to the vinegar. Have another student stir the mixture and check it with blue litmus paper.

Continue adding ammonia one drop at a time and checking with litmus paper until the litmus paper no longer reacts.

What change did you observe in the litmus paper? At first the blue litmus paper turned red, but after adding ammonia the paper stayed blue.

Is this liquid still an acid? no **What is it?** It is neutral.

How many drops of ammonia were needed before the solution became neutral? Answers will vary.

What formed when you neutralized the acid and base? water and a salt

How do we know the solution is neutral? Litmus paper does not change color when a solution is neutral.

Discussion

- **Explain what it means to neutralize an acid or a base.** Possible answer: When an acid and a base come in contact with each other, the reaction causes the pH to become closer to 7, or neutral.
- **Explain how an antacid can help your stomach feel better.** An upset stomach can be caused by too much gastric acid. The antacid contains a base. When the acid and base are combined, they neutralize each other.

What substances form as a result of the reaction between an acid and a base? water and a salt

Describe a salt. an ionic compound formed from a reaction between an acid and a base that contains positive ions from the base and negative ions from the acid

What are most salts composed of? a metal and a nonmetal

Are all salts the same? no

What makes salts different from one another? the different combinations of bases and acids which form different types of salt

Name some common salts. Possible answers: sodium chloride—table salt; potassium chloride—salt substitute; calcium carbonate—chalk

Answers

1. Bases form hydroxide ions in water, taste bitter, and feel slippery.
2. Acids form hydrogen ions in water and taste sour.
3. Possible answers: Acids include lemons, vinegar, tomato juice, and coffee. Bases include baking soda, toothpaste, antacid, and ammonia.
4. Salts form as a result of the neutralizing of an acid and a base by a chemical reaction.

Activity Manual

Review, page 113

This page reviews Lesson 89.

Expansion, page 114

This page looks at the life of Robert Boyle, who was both a scientist and a Christian.

Assessment

Quiz 7-C

The quiz may be given any time after completion of this lesson.

Student Text pages 182–83
Activity Manual pages 115–16

Objectives
- Identify a solution as an acid or a base by using a pH indicator solution
- Observe the effects of an acid or a base on an indicator
- Estimate the strength of an acid or a base solution by interpreting a table

Materials
- See Student Text page
- pH meter (optional)

Introduction

What is an indicator? a substance that changes color when exposed to acid or base solutions

Today you will test several different substances with an indicator solution to determine whether each is an acid, a base, or if it is neutral.

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

Discussion
What are some reasons people check pH values? Gardeners check the pH of soil to determine which plants will grow best in their gardens. Aquarium owners and swimming pool operators monitor the pH of water. Doctors may check the pH level in a person's esophagus when treating acid reflux.

What does litmus paper indicate? only whether something is an acid or a base

What do you need to use to know the pH value of a substance? Possible answers: a pH meter, red cabbage juice

What is another tool you could use? indicator paper

Today we will use red cabbage juice to test pH values.

Procedure
Direct the student's attention to the Table of Colors on Activity Manual page 115. Remind him to refer to that chart as he records his predictions and observations on the Observation Chart.

What color is the cabbage juice when it is neutral? purple

ACTIVITY

pH Indicator

Process Skills
- Predicting
- Measuring
- Observing
- Recording data

Gardeners want to know the pH of the soil so they can determine which plants will grow best in their gardens. Aquarium owners and swimming pool operators monitor the pH of the water. Doctors sometimes need to check the pH level in a person's esophagus to help treat acid reflux disease. These are just some of the reasons why pH levels are checked.

There are many ways to identify the pH value of a substance. Litmus paper shows whether something is an acid or a base. Scientists can also use a tool called a pH meter to measure the pH value of a substance. However, a less expensive way to test pH values is to use red cabbage juice. Red cabbage juice contains a pigment, or coloring, called flavin (FLAY vin). This coloring reacts with acids and bases and makes the cabbage juice change color. In this activity you will use red cabbage juice as an indicator to test whether solutions are acids or bases.

Materials
- 250 mL prepared red cabbage juice
- goggles
- 5 cups labeled with numbers 1–5
- metric measuring spoons
- metric measuring cups
- The following chemicals labeled as indicated:
  - 15 mL lemon juice (Solution 1)
  - 15 mL household ammonia (Solution 2)
  - 15 mL baking soda solution (Solution 3)
  - 15 mL distilled water (Solution 4)
  - 15 mL white vinegar (Solution 5)
- Activity Manual

Problem
How will acid and base solutions change the color of red cabbage juice?

Procedure
Caution: Acids and bases can be dangerous. Wear goggles or glasses when handling the solutions. Never try to taste a solution. Avoid spilling the solutions on your skin. If a solution spills on your skin, wash immediately with soap and water.

1. Write the names of the solutions in the *Observation Chart* in your Activity Manual.
2. Use the *Table of Colors* in the Activity Manual to predict whether each solution is an acid or a base and what its approximate pH value is. Record your predictions in the *Observation Chart.*
3. Pour 50 mL of red cabbage juice into each of cups 1–5.
4. Add 15 mL of lemon juice (Solution 1) to the cabbage juice in cup 1.

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TEACHER HELPS

Red cabbage juice preparation
- Chop one head of red or purple cabbage.
- Place cabbage pieces in a stainless steel pan and cover with one liter of water.
- Boil until the water turns a dark color.
- Strain the cabbage, reserving the water.
- Refrigerate the cabbage juice until ready for use.

Note: Beets, pears, blackberries, or red onion can be used as a substitute for red cabbage. Also, some science supply companies sell red cabbage extract that can be prepared according to package directions. Check www.bjupress.com/resources for possible weblinks to science supply companies.

Containers
Choose containers that are sturdy and large enough to hold the liquid without spilling and allow the student to easily observe the color changes. Clear containers, such as baby food jars, are a good option.

Baking soda solution preparation
Prepare the baking soda solution by mixing 15 mL of distilled water with enough baking soda to saturate the water.

5. Observe and record the color of the cabbage juice in cup 1.
6. Use the *Table of Colors* to determine whether Solution 1 is an acid or a base and what its approximate pH value is. Record your findings.
7. Repeat steps 4–7 with solutions 2–5. Rinse the measuring spoon or measuring container with water before measuring each different solution.
8. Compare your results and decide where each solution would be placed on the pH scale. Use the pH scale on pages 178–79 of your textbook to help you.

Conclusions

- Which solution was the strongest acid?
- Which solution was the weakest base?

Follow-up

- Use another natural indicator, such as red beets, to test the solutions.
- Test the solutions with a pH meter and compare your results.

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Activity extension
Test other items such as Milk of Magnesia (prepare a solution similar to the baking soda solution), colorless soft drinks, shampoo, clear liquid soap, or tap water. You will need additional red cabbage juice if testing other items. Allow the students to make predictions and then test the other items as described in the activity procedures.

pH meter
If you have access to a pH meter, use that to check the solutions as well. Compare its readings to the results obtained from the cabbage juice.

SCIENCE PROCESS SKILLS

Observing

Observing is not always an exact skill. Do you think that your idea of reddish purple might be different from someone else's? possibly

Would your difference of opinion cause your observation to be flawed? possibly

How could you make your observations more reliable? Possible answers: redo the activity and see if the colors were consistent; come to a group decision about what to call the color; observe other groups

How might a scientist in a laboratory make sure his observations were accurate? Possible answers: redo his experiment; come to a group decision about the observations; use more advanced instruments to determine the pH of a solution

Guide the student in measuring the cabbage juice and solutions to be added. Remind him to test only one solution at a time. Provide water for rinsing the measuring tools after each use. As needed, use questions such as the following to guide the student in determining the color and approximate pH for each solution.

After adding lemon juice solution to the cabbage juice in cup 1:

What is the color of the cabbage juice now? bright red/pink

Is this solution an acid or a base? an acid

What is its pH range? 0–2

After all solutions have been tested, provide time for the student to compare his results and decide where each would be placed on the pH scale.

Conclusions

Provide time for the student to evaluate his predictions and answer the questions.

Which solution was the most acidic? lemon juice

Which solution was the most basic? ammonia

Is there a way that we could get one of the solutions that has turned green to turn purple again? If it turned green, it is a base. Add some of one of the acid solutions to change the color back to a red/purple color.

Did the color of the cabbage juice change when distilled water was added? no **Why not?** Distilled water is neutral.

Discuss how the student ranked the solutions he tested and where he placed them on the pH scale. Refer to the discussion in the Science Process Skills if students ranked solutions differently.

Use the questions in the Science Process Skills to discuss observing.

Activity Manual

Activity, pages 115–16

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Objectives
- Hypothesize about the effectiveness of several antacids
- Make and use a model of "upset stomach" acid
- Infer information from the model

Materials
- See Student Text page

Introduction
When you have an upset stomach, what kind of medicine do you take? Answers will vary.

Do you prefer one type of medicine over another? Why? Answers will vary.

Do you know whether your preferred medicine works better than other medicines? How do you know? Answers will vary.

Today you will have the opportunity to test which antacids work best for neutralizing an acid.

Teach for Understanding
Purpose for reading
The student should read all the pages before beginning the activity.

Procedure
Prepare the antacid tablets ahead of time by crushing them. You could place them in separate plastic bags, cover them with paper, and hit them with a hammer.

Guide the student in writing his hypothesis. Use the procedure in the Science Process Skills to discuss hypothesizing.

Direct the student to make his upset stomach mixture. If needed, demonstrate how to use the indicator paper. Remind him to check and record the pH level of the upset stomach before testing antacids.

Explain to the student that the activity requires one dosage of various antacids. Show the student where to look on the package to determine the appropriate dosage. He should record the name of the antacid tested in each cup and the pH level of the upset stomach after the antacid has been added.

ACTIVITY

Which Antacid Is Best?

Process Skills
- Hypothesizing
- Experimenting
- Observing
- Inferring
- Recording data

The stomach uses acid to digest food, but the stomach should not be too acidic or too basic. Many antacids can help an upset stomach caused by the presence of too much acid. Some antacids are sold as medications. Other antacids may be food or cooking ingredients found around your house. In this activity you will test the effectiveness of several different antacids on experimental "upset stomachs."

Problem
Which antacid works best to neutralize an acid?

Procedure
1. Write a hypothesis in your Activity Manual explaining which antacid you think will work best to neutralize an acid.
2. Combine 80 mL of water and 40 mL of vinegar in the container to make an *upset stomach mixture.*
3. Place a pH indicator strip into the *upset stomach mixture* for 30 seconds. Immediately compare the color of the strip to the pH chart. Record the pH level in your Activity Manual.
4. Pour 20 mL of the *upset stomach mixture* into each plastic cup. These are your "upset stomachs." Label the cups 1–6.
5. Place one dose of each antacid into cups 1–4 and mix well. (Tablets should first be crushed.)

Materials
goggles
metric measuring cups
metric measuring spoons
80 mL water
40 mL vinegar
200 mL or larger container
pH indicator paper (range of 1–14)
6 clear plastic cups
6 spoons or stirring sticks
5 mL baking soda
80 mL milk
One dose each of four different commercial antacids (or their generic equivalents) such as:
Alka-Seltzer
Maalox
Pepto Bismol
Rolaids
Tums
Milk of Magnesia
Activity Manual

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TEACHER HELPS

Variety of antacids
Choose antacids that are made of different ingredients. Two antacids with the same ingredients will likely have a similar pH reading.

Indicator papers
The pH indicator paper is different from litmus paper.

Using red cabbage juice
Red cabbage juice may be used in place of the pH paper, but this will give a less accurate reading. The colors of the cabbage juice and their coordinating pH levels are as follows:

pH 2–red
pH 4–purple
pH 6–violet
pH 8–blue
pH 10–blue-green
pH 12–greenish yellow

SCIENCE BACKGROUND

Modeling stomach acid
A normal stomach is actually acidic with a pH level of 1.6–2.4. The general principles used in this activity are valid; however, the pH numbers used do not approach the true physiologic pH values in the stomach. An upset stomach may be caused by too much acid in the stomach rather than a lower pH level of acid in the stomach.

Not all antacids work the same way. Since this activity does not involve a real stomach, an antacid that acts as a buffer will show better results in this activity than an antacid that is an acid reducer. Antacids that reduce the amount of acid in the stomach will appear to be less effective, although they may actually be more effective in a stomach with more acid.

6. Check the effectiveness of each antacid by placing a fresh piece of pH indicator paper into each solution for 30 seconds. Immediately compare the color of the strip to the pH chart. Record the pH level in your Activity Manual.
7. Compare the pH level with the original pH of the "upset stomach."
8. Test the effectiveness of baking soda and milk as antacids. Add 5 mL of baking soda to cup 5. Add 80 mL of milk to cup 6. Mix and check with pH paper. Record your results.

Conclusions

- Which antacid would you want to use if you had an upset stomach?
- Do you think this is a valid test of an antacid's effectiveness? Why or why not?

Follow-up

- Try some other medicines that are advertised to relieve an upset stomach.
- Prepare an advertising campaign based on your findings.

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Creating an advertisement
WRITING
Instruct the student to make an advertisement for the product he found to work best for neutralizing an acid. The student can choose to write a radio advertisement, a TV commercial, an advertisement for a newspaper, or a billboard advertisement. The advertisements can be presented to the rest of the class.

SCIENCE PROCESS SKILLS

Hypothesizing
Remind the student that a hypothesis is a testable statement that tells what he thinks will happen. Although at this level it is not necessary for all conditions to be defined in a hypothesis, a student's hypothesis should be as specific as possible.

Allow several students to read their hypotheses. Discuss whether the hypotheses are testable and suggest improvements as needed.

The hypothesis for this activity should be straightforward. For example, "Maalox will neutralize the acid the best."

Conclusions

Provide time for the student to evaluate his hypothesis and answer the questions.

Which antacid worked best to neutralize the acid?
Answers will vary.

How is this model like or unlike a human stomach?
Elicit the idea that a human stomach would not have exactly the same pH levels as the upset stomach mixture model and that upset stomachs can be caused by things other than acid.

Discuss student answers to question 4 in the Activity Manual. You may choose to share the information discussed in the Science Background.

Activity Manual

Activity, pages 117–18

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Student Text page 186
Activity Manual pages 119–20

Objectives
- Recall concepts and terms from Chapter 7
- Apply knowledge to everyday situations

Introduction
Material for the Chapter 7 Test will be taken from Student Text page 186 and Activity Manual pages 105–6, 110, 113, and 119–20. You may review any or all of the material during the lesson. Questions similar to Solve the Problem or the ones in Thinking It Through, Activity Manual pages 119–20, may appear on the test.

You may choose to review Chapter 7 by playing "Atomic Construction" or a game from the Game Bank on the Teacher's Toolkit CD.

Teach for Understanding
Diving Deep into Science
Information on this page reflects the vocabulary and concepts the student should know for the test.

Solve the Problem
In order to solve the problem, the student must apply material he has learned. The student should attempt the problem independently. The answer for this Solve the Problem is based on the material on Student Text page 181. Answers will vary and may be discussed.

Activity Manual
Review, pages 119–20

These pages require written responses to application questions.

Lesson 93

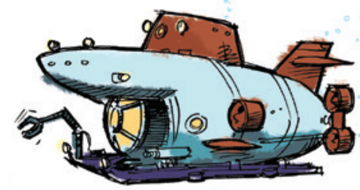
Objective
- Demonstrate knowledge of concepts taught in Chapter 7

Assessment
Tests, Chapter 7

DIVING DEEP INTO SCIENCE

Words to Know
chemistry
atom
element
atomic mass
atomic number
atomic theory
particle accelerator
chemical symbols
period
group
molecule
chemical change
chemical reaction
compound
stable
ion
alkalis
pH scale
neutral
indicator

Key Ideas
Parts of an atom and their charges
Ways elements are classified
Parts of the periodic table of the elements
Contributions of Niels Bohr and Dmitri Mendeleev
Writing chemical formulas
Kinds of atomic bonds
Types of chemical reactions
Properties of acids, bases, and salts



Solve the Problem
A fire ant has just bitten your friend. You remember that a fire ant's bite is painful because of the acid that it contains. Can you think of something from your kitchen or bathroom that would help relieve the pain? Why would it work?

Accept any answer that recognizes that a base neutralizes an acid. Possible products include using a paste made of baking soda and water, a dab of toothpaste, or some Milk of Magnesia.

Review Game
Atomic Construction

Prepare two sets of the following: twenty small circles each of blue (protons), green (neutrons), and red (electrons) paper.

Divide the class into two teams. Each time a team answers a review question correctly, it may choose an atomic particle to complete a sodium (Na) atom (11 protons, 12 neutrons, 11 electrons). The first team to complete its atom wins.

Additional elements you may use include oxygen (8 protons, 8 neutrons, 8 electrons), chlorine (17 protons, 18 neutrons, 17 electrons), and fluorine (9 protons, 10 neutrons, 9 electrons).