POWER BASICS®

Chemistry

Robert Taggart

WALCH PUBLISHING

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UNIT 2

Properties of Matter

LESSON 5: The Structure of Matter

GOAL: To learn about the internal structure of atoms

WORDS TO KNOW

atomic mass	**coulombs**	**molecular mass**
atomic mass unit	**electrons**	**neutrons**
atomic number	**isotopes**	**protons**
cathode-ray tube	**mass number**	

Dalton's Atomic Theory

The ancient Greek philosopher Leucippus and his follower, Democritus, proposed more than 2000 years ago that matter is made up of extremely small particles that cannot be divided further. Democritus called these bits of matter *atomos*. *Atomos* means "indivisible" and is the source of our word *atoms* today.

Many contemporaries of Leucippus and Democritus, including Plato and Aristotle, did not accept the idea that matter was made up of particles that have distinct properties of their own. Instead, they believed that all matter was uniform in composition, no matter how small the piece of matter.

These two opposing ideas were not tested until the 1700s. That is when scientists began doing careful experiments on the changes that matter undergoes. In 1808, an English schoolteacher named John Dalton proposed his own atomic view of matter. It has since become known as Dalton's atomic theory.

Dalton's atomic theory can be summarized as follows:

1. All matter is composed of tiny particles called atoms.
2. All atoms of a given element are identical. They all have the same mass, size, and chemical properties.

3. All atoms of a given element are distinct from all atoms of any other element. The mass, size, and chemical properties of the atoms of one element are different from the mass, size, and chemical properties of the atoms of any other element.

4. Chemical compounds form when atoms combine in whole-number ratios. A pure compound has the same combination of atoms, no matter how it was prepared. For example, pure water always contains two hydrogen atoms chemically joined to one oxygen atom. If some compound contains a different combination of hydrogen and oxygen atoms, then it is not water. It is a different compound altogether.

5. Atoms cannot be created from nothing or destroyed in a chemical reaction. Instead, atoms retain their identities but change the way they are combined or arranged.

PRACTICE 20: Dalton's Atomic Theory

Decide if each statement that follows is true (**T**) or false (**F**). Write the correct letter on each line.

_____ **1.** The Greek word *atomos* means "indivisible" and is the source of the word *atoms* today.

_____ **2.** Dalton's atomic theory is named for the ancient Greek philosopher Leucippus and his follower, Democritus.

_____ **3.** According to Dalton's atomic theory, all atoms of a given element are identical.

_____ **4.** According to Dalton's atomic theory, a pure compound has a different combination of atoms depending on how it was prepared.

_____ **5.** According to Dalton's atomic theory, atoms cannot be created from nothing or destroyed in a chemical reaction.

_____ **6.** According to Dalton's atomic theory, the mass, size, and chemical properties of the atoms of one element are different from the mass, size, and chemical properties of the atoms of any other element.

_____ **7.** According to Dalton's atomic theory, atoms CAN be created or destroyed in a chemical reaction.

_____ **8.** According to Dalton's atomic theory, chemical compounds form when atoms combine in whole-number ratios.

Electrons, Protons, and Neutrons

Although matter is composed of atoms, atoms are not as indivisible as Democritus or Dalton suggested. Thanks to the careful experiments of physicists such as J. J. Thomson, Robert Millikan, Hans Geiger, Ernest Marsden, Ernest Rutherford, and James Chadwick, it is now known that atoms are made up of electrons, protons, and neutrons.

Electrons are negatively charged particles that have very little mass but take up most of the volume of an atom. **Protons** are positively charged particles that have more than 1800 times the mass of an electron, but take up very little of the volume of an atom. The charge on a proton is equal and opposite to the charge on an electron. **Neutrons** have no charge and have a mass that is only slightly greater than the mass of a proton. Electrons, protons, and neutrons are called subatomic particles because they are the building blocks of atoms. The mass of a subatomic particle is measured in kilograms. The charge of a subatomic particle is measured in units called **coulombs.**

Name	Symbol	Charge	Mass
Electron	e	-1.6022×10^{-19} coulomb	9.1094×10^{-31} kg
Proton	p	$+1.6022 \times 10^{-19}$ coulomb	1.6726×10^{-27} kg
Neutron	n	0	1.6749×10^{-27} kg

J. J. Thomson's experiments in 1897 measured the ratio of the electron's mass to the electron's charge. Thomson was unable to determine the exact mass of an electron, but he estimated it to be less than $\frac{1}{1000}$ as much as hydrogen, the lightest element known. Thomson's experiments showed that atoms were divisible into smaller particles, after all.

Robert Millikan's experiments in 1909 determined the exact charge on an electron. From his value for the charge, and Thomson's value for the electron's mass-to-charge ratio, Millikan was able to determine the mass of an electron:

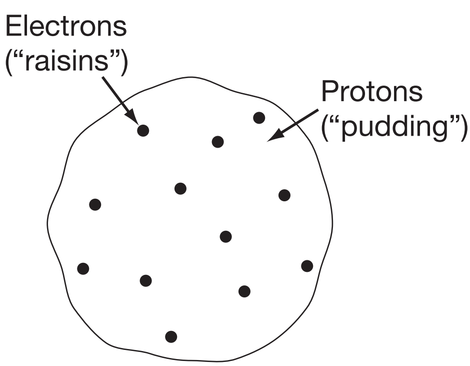
$$\text{Mass of electron} = \frac{\text{mass}}{\text{charge}} \times \text{charge}$$

$$= \left(5.686 \times \frac{10^{-12}\,\text{kg}}{\text{coulomb}}\right)(1.602 \times 10^{-19}\ \text{coulomb})$$

$$= 9.109 \times 10^{-31}\ \text{kg}$$

At this point, scientists knew two things about atoms. First, they knew that atoms are electrically neutral overall. Second, they knew that atoms contain negatively charged electrons. In order to be electrically neutral overall, atoms must also contain some positively charged particles (protons) to balance the negative charge of the electrons. Thomson proposed that atoms could be thought of as positively charged spheres of matter in which electrons are embedded like raisins in plum pudding.

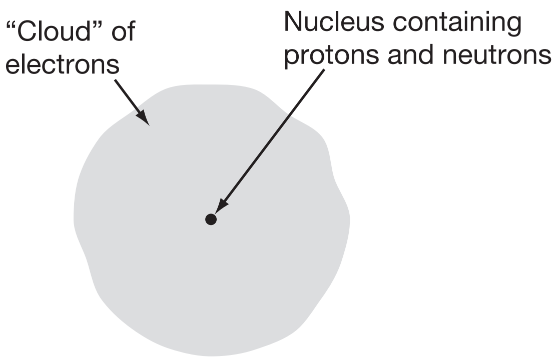
Another way to think of Thomson's "plum pudding" model of the atom is to imagine a chocolate-chip cookie. The chocolate chips are the electrons, and the cookie is the "positively charged sphere of matter." Together, the cookie and the chips make up an atom.



Thomson's "Plum Pudding" Model

The experiments of Hans Geiger and Ernest Marsden in Ernest Rutherford's lab in 1911 suggested, however, that the protons are concentrated in the core of the atom, not spread throughout the atom. Rutherford proposed that an atom consists of a positively charged nucleus surrounded by a cloud of electrons. The nucleus is the central core of the atom where most of the mass is. Thus, the protons of an atom are in the nucleus. Rutherford's theory is often called the nuclear model of the atom.

In the nuclear model of the atom, the volume of the cloud of electrons is huge compared to the volume of the nucleus. In fact, if a golf ball were the nucleus of an atom, the electron cloud would measure 3 miles across. The mass of an electron is so small compared to the mass of a proton that the electron cloud is mostly empty space.



Rutherford's Nuclear Model

Finally, in 1932, James Chadwick conducted experiments that led to the discovery of the neutron. Because the mass of a neutron is slightly greater than the mass of a proton, neutrons must be located in the nucleus, too.

PRACTICE 21: Electrons, Protons, and Neutrons

Decide if each statement that follows is true (**T**) or false (**F**). Write the correct letter on each line.

_____ **1.** The nucleus of an atom is where the electrons are.

_____ **2.** The nucleus of an atom is where the protons and neutrons are.

_____ **3.** The mass of a neutron is slightly greater than the mass of a proton, and the mass of a proton is more than 1800 times greater than the mass of an electron.

_____ **4.** J. J. Thomson's experiments measured the ratio of the electron's mass to the electron's charge.

_____ **5.** Hans Geiger proposed the "plum pudding" model of the atom.

_____ **6.** James Chadwick discovered the electron.

_____ **7.** In Rutherford's nuclear model of the atom, protons have most of the mass, but electrons have most of the volume of an atom.

_____ **8.** Robert Millikan's experiments determined the exact charge on an electron.

POWER BASICS®

Chemistry

Teacher's Guide

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To the Teacher

Overview

Power Basics® is a complete textbook program designed to meet the needs of students who are daunted by the length and complexity of traditional textbooks. The goal of all textbook programs is to provide students with important new information. However, in traditional textbook programs, this goal is often overshadowed by other considerations. Many textbooks are written for the above-average reader and cover a wide range of content. They are filled with photographs, illustrations, and other visual elements. For some students, the amount of material is overpowering, the visual elements are distracting, and the rapid pace is unnerving. In *Power Basics®*, we revisited the basic goal, developing a streamlined textbook program that presents the essential content students need to succeed.

Program Components

As with traditional textbook programs, *Power Basics®* includes a core textbook and ancillary products designed to round out the program. The student text provides coverage of the essential content in each subject area. A consumable workbook provides a variety of activities for each lesson, including practice activities, extension activities, and activities designed for different learning styles.

Teacher support materials include a teacher's guide and test pack for each student text. The teacher's guide includes the following: an overview of each unit in the student text; suggestions for extension activities; the student text glossary and appendixes; a complete answer key to all practice activities and unit reviews in the student text; classroom record-keeping forms; and graphic organizers for student use.

For more detailed assessments, the test pack offers a pretest, unit tests for each unit in the student text, a posttest, scoring keys, and test-taking strategies for students.

Student Text Organization

The student text is divided into units. Each unit contains a series of lessons on related topics, with one lesson for each topic. Each lesson begins with a clear, student-centered goal and a list of key words that are introduced in the lesson. The definitions for these words are included in the teacher material for each lesson.

Next comes a brief introduction to the topic of the lesson, followed by instructional text that presents essential information in short, easy-to-understand sections. Each section of instructional text is followed by a practice activity that lets students apply what they have just learned. A unit review is provided at the end of each unit to assess students' progress. The review is followed by an application activity that encourages students to extend and apply what they have learned.

The student text also includes several special features. "Think About It" sections ask students to use critical-thinking skills. "Tip" sections give students useful hints to help them remember specific pieces of information in the student text. "In Real Life" sections show students how the material they are learning connects to their own lives, answering the perennial question, "When am I ever going to use this?"

The reference section at the back of the student text includes a summary of rules and other important information presented in the text, a glossary (with pronunciation guide) that includes all vocabulary in the Words to Know sections, and an index to help students locate information in the text.

Record-Keeping Forms

To make record-keeping easier, we have provided reproducible class charts that you can use to track students' progress. Fill in your students' names, and make copies of the chart for each unit in the student text. Add lesson numbers, lesson titles, and practice numbers as needed. We have also provided a generic grading rubric for the application activities in the student text so that these activities may be assigned for credit, if you wish. You may customize the rubric by adding more grading criteria or adapting the criteria on the sheet to fit your needs.

We're pleased that you have chosen to Power Up your Basic Skills Curriculum with *Power Basics®*!

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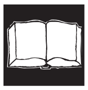
To the Teacher, *continued*

Guide to Icons

Teacher's Guide



Teaching Tip

Practical suggestions help you to engage students in the learning process.

Thinking Skills

Helpful suggestions increase students' ability to think critically.

Fascinating Facts

These tidbits of information are guaranteed to pique your students' interest.

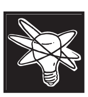
Differentiation

Different approaches to the content gives all learners the opportunity to connect to the material.

Student Text

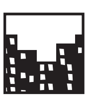
Tip

Tips give helpful hints to boost understanding and retention.



Think About It

These sections develop critical-thinking.



In Real Life

These features connect learning concepts to students' lives, answering the perennial question, "When am I ever going to use this?"

Workbook

Reinforcement

Reinforcement activities give students additional opportunities to practice what they have learned.

Multiple Intelligences

Different approaches capitalize on different learning styles and interests to help all students connect to the material.

Extension

Deepen and broaden learning with critical-thinking activities, real-life applications, and more.

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Classroom Management

Student Name	Lesson No.: ______ Title: ________________________								
	Practice # ___	Practice # ___	Practice # ___	Practice # ___	Practice # ___	Practice # ___	Practice # ___	Practice # ___	Unit Review Score
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
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22.									
23.									
24.									
25.									
26.									
27.									
28.									
29.									
30.									

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Application Activity Rubric

Name ______________________________ Date ______________

Unit ________ Activity ______________________________________

POINTS	4 all of the time	3 most of the time	2 some of the time	1 almost none of the time
followed directions				
organized material well				
used appropriate resources				
completed the entire activity				
showed an understanding of the content				
produced error-free materials				
drew logical conclusions				
where appropriate, listed sources used				

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Use Chart

POWER BASICS WORKBOOK	STUDENT TEXT PRACTICE
Unit 1: Matter and Measurement	
Activity 1: What Is Chemistry?	Practice 1: What Is Chemistry?
Activity 2: Antoine Lavoisier	Practice 1: What Is Chemistry?
Activity 3: The Scientific Method	Practice 2: The Scientific Method
Activity 4: Substances and Mixtures	Practice 3: Substances and Mixtures
Activity 5: Homogeneous and Heterogeneous Mixtures	Practice 4: Homogeneous and Heterogeneous Mixtures
Activity 6: Elements and Compounds	Practice 5: Elements and Compounds
Activity 7: Elements and Their Symbols	Practice 6: Elements and Their Symbols
Activity 8: Elements and Their Symbols II	Practice 6: Elements and Their Symbols
Activity 9: Molecules	Practice 7: Molecules
Activity 10: Chemical Formulas	Practice 8: Chemical Formulas
Activity 11: Writing Binary Formulas	Practice 8: Chemical Formulas
Activity 12: Solids, Liquids, and Gases	Practice 9: Solids, Liquids, and Gases
Activity 13: Physical Changes and Chemical Changes	Practice 10: Physical Changes Versus Chemical Changes
Activity 14: Changes of State	Practice 11: Changes of State
Activity 15: Units of Measurement	Practice 12: Units of Measure
Activity 16: Converting Between Different Units	Practice 13: Converting Between Different Units
Activity 17: Sir Isaac Newton	Practice 13: Converting Between Different Units
Activity 18: Series of Unit Conversions	Practice 14: Series of Unit Conversions
Activity 19: Mass and Weight	Practice 15: Mass and Weight
Activity 20: Volume and Density	Practice 16: Volume and Density
Activity 21: Temperature and Heat	Practice 17: Temperature and Heat
Activity 22: Temperature Scales—Celsius to Fahrenheit to Kelvin	Practice 18: Temperature Scales
Activity 23: Scientific Notation	Practice 19: Scientific Notation
Unit 2: Properties of Matter	
Activity 24: Dalton's Atomic Theory	Practice 20: Dalton's Atomic Theory
Activity 25: John Dalton	Practice 20: Dalton's Atomic Theory
Activity 26: Joseph Proust	Practice 20: Dalton's Atomic Theory
Activity 27: Electrons, Protons, and Neutrons	Practice 21: Electrons, Protons, and Neutrons
Activity 28: Crookes, Thomson, and Rutherford	Practice 21: Electrons, Protons, and Neutrons
Activity 29: Light	Practice 21: Electrons, Protons, and Neutrons
Activity 30: Max Planck and James Clerk Maxwell	Practice 21: Electrons, Protons, and Neutrons
Activity 31: Atomic Number and Mass Number	Practice 22: Atomic Number and Mass Number
Activity 32: Henry Moseley	Practice 22: Atomic Number and Mass Number
Activity 33: Isotopes and Average Atomic Mass	Practice 23: Isotopes
Activity 34: Atomic Mass and Molecular Mass	Practice 24: Atomic Mass and Molecular Mass
Activity 35: Periodic Trends	Practice 25: What Is the Periodic Table?
Activity 36: Mendeleev	Practice 25: What Is the Periodic Table?

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Use Chart, *continued*

POWER BASICS WORKBOOK	STUDENT TEXT PRACTICE
Activity 37: Categories of the Elements	Practice 26: Categories of the Elements
Activity 38: Metals, Nonmetals, and Metalloids	Practice 27: Metals, Nonmetals, and Metalloids
Activity 39: Alkali Metals and Alkaline Earth Metals	Practice 28: Alkali Metals and Alkaline Earth Metals
Activity 40: The Halogens and Noble Gases	Practice 29: The Halogens and the Noble Gases
Activity 41: Anions and Cations	Practice 30: Anions and Cations
Activity 42: Drawing Dot Diagrams	Practice 30: Anions and Cations
Activity 43: Naming Ionic Compounds	Practice 31: Ionic Compounds
Activity 44: Writing Ionic Formulas	Practice 32: Molecular Formulas and Empirical Formulas
Activity 45: Naming Ionic Compounds with Polyatomic Ions	Practice 32: Molecular Formulas and Empirical Formulas
Activity 46: Writing Ionic Formulas with Polyatomic Ions	Practice 32: Molecular Formulas and Empirical Formulas
Activity 47: Structural Formulas and Chemical Bonds	Practice 33: Structural Formulas and Chemical Bonds
Activity 48: The Mole and Avogadro's Number	Practice 34: The Mole and Avogadro's Number
Activity 49: Amedeo Avogadro	Practice 34: The Mole and Avogadro's Number
Activity 50: Molar Mass	Practice 35: Molar Mass
Activity 51: Atomic and Ionic Radii	Practice 38: Atomic and Ionic Radii

Unit 3: Transformations of Matter

Activity 52: Writing Skeleton Equations	Practice 39: Writing Chemical Equations
Activity 53: Reading Equations	Practice 39: Writing Chemical Equations
Activity 54: Balanced Versus Unbalanced Chemical Equations	Practice 40: Balanced Versus Unbalanced Chemical Equations
Activity 55: Balancing Chemical Equations	Practice 41: Balancing Chemical Equations
Activity 56: Balancing Complete Equations	Practice 41: Balancing Chemical Equations
Activity 57: Molar Ratios	Practice 42: Molar Ratios
Activity 58: Mole–Mole Conversions	Practice 43: Mole–Mole Conversions
Activity 59: Mass–Mole Conversions	Practice 44: Mass–Mole Conversions
Activity 60: Mass–Mass Conversions	Practice 45: Mass–Mass Conversions
Activity 61: Mass–Mole–Particle Conversions	Practice 46: Mass–Mole–Number Conversions
Activity 62: Mass–Volume Conversions	Practice 46: Mass–Mole–Number Conversions
Activity 63: Limiting Reactants	Practice 47: Limiting Reactants
Activity 64: Reaction Yields	Practice 48: Reaction Yields
Activity 65: Ionic Bonding	Practice 49: Ionic Bonding
Activity 66: Properties of Ionic Compounds	Practice 50: Properties of Ionic Compounds
Activity 67: Covalent Bonding	Practice 51: Covalent Bonding
Activity 68: Electronegativity	Practice 52: Electronegativity
Activity 69: Properties of Covalent Compounds	Practice 53: Properties of Covalent Compounds
Activity 70: Properties of Metals	Practice 55: Properties of Metals
Activity 71: The Arrangement of Metal Atoms	Practice 55: Properties of Metals

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Use Chart, *continued*

POWER BASICS WORKBOOK	STUDENT TEXT PRACTICE
Unit 4: Topics in Chemistry	
Activity 72: Dipole Moments	Practice 58: Dipole Moments
Activity 73: Hydrogen Bonding	Practice 60: Hydrogen Bonding
Activity 74: Types of Solids	Practice 62: Types of Solids
Activity 75: Johannes van der Waals	Practice 63: Properties of Liquids
Activity 76: Properties of Liquids	Practice 63: Properties of Liquids
Activity 77: Boyle's Law Problems	Practice 64: Behavior of Gases
Activity 78: Charles's Law Problems	Practice 64: Behavior of Gases
Activity 79: Combined Gas Law Problems	Practice 64: Behavior of Gases
Activity 80: Ideal Gas Law Problems	Practice 64: Behavior of Gases
Activity 81: Boyle and Charles	Practice 64: Behavior of Gases
Activity 82: What Is a Solution?	Practice 65: What Is a Solution?
Activity 83: Solubility of Solids in Water	Practice 67: Solubility of Solids
Activity 84: Solubility of Gases in Water	Practice 68: Solubility of Gases
Activity 85: Solubility of Liquids, Solids, and Gases	Practices 66, 67, and 68: Solubility of Liquids, Solids, and Gases
Activity 86: The Effect of Temperature and Pressure on Solubility	Practices 69: The Effect of Temperature and Pressure on Solubility
Activity 87: Colligative Properties	Practice 70: Colligative Properties
Activity 88: What Are Acids and Bases?	Practice 71: What Are Acids and Bases?
Activity 89: Svante Arrhenius	Practice 71: What Are Acids and Bases?
Activity 90: Measuring Acidity—pH	Practice 73: Measuring Acidity: pH and Indicators

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gas	melting point	solid
liquid	physical change	sublimation
melting	physical properties	

Lesson 4—Measuring Matter

Goal: To learn how scientists measure things

WORDS TO KNOW

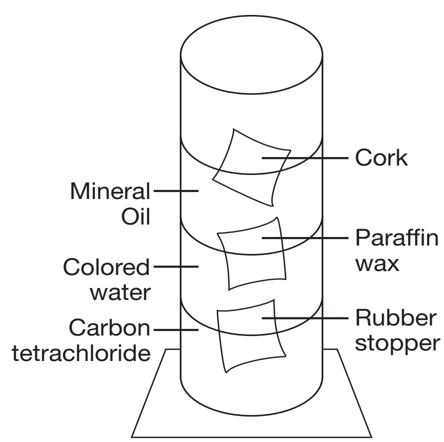
absolute zero	Fahrenheit scale	scientific notation
Celsius scale	heat	temperature
conversion factor	Kelvin scale	volume
density	mass	weight

Notes on Application Activities in Student Text

Activity	Skills Applied	Product
Metric Calculation Versus English Calculation	measuring, calculating areas, comparing units	measurement comparison
Freshwater and Saltwater Boiling Points	observing, measuring, drawing conclusions	graph
Rubber Versus Mylar ®	observing, reasoning	chart

Additional Activity Suggestion

- Demonstrate density differences for learners. Using a 250 ml graduated cylinder, place each of the following in order (about 25 to 30 ml of each liquid will be enough): carbon tetrachloride; rubber stopper; colored water; piece of paraffin wax (or a small piece of candle); mineral oil; cork. Ask learners why the liquids remain in layers and why the solid objects have the positions shown in the diagram at the right.



Teaching Tip

- Learners often have difficulty setting up a graph. Explain the differences between independent and dependent variables. Explain how to determine which is which and that dependent variables always lie on the *y*-axis, while independent variables always lie on the *x*-axis.

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Unit 2: Properties of Matter

This unit introduces basic information about atoms and molecules. In Lesson 5, students will explore the internal structure of atoms. Lesson 6 presents the periodic table of elements and shows students how chemical information is organized. In Lesson 7, students will learn about ions, chemical formulas, and how chemists count using the mole. Lesson 8 discusses how the properties of atoms vary across the periodic table.

Lesson 5—The Structure of Matter

Goal: To learn about the internal structure of atoms

WORDS TO KNOW

atomic mass
atomic mass unit
atomic number
cathode-ray tube
coulombs
electrons
isotopes
mass number
molecular mass
neutrons
protons

Lesson 6—The Periodic Table

Goal: To learn what the periodic table of the elements is and how it organizes chemical information

WORDS TO KNOW

actinides
alkali metals
alkaline earth metals
ductile
families
graphite
groups
halogens
heteronuclear diatomic molecule
homonuclear diatomic molecule
inner transition elements
lanthanides
luster
malleable
metalloids
metals
noble gases
nonmetals
periodic table
periods
transition metals

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Lesson 7—Atoms, Molecules, Ions, and the Mole

Goal: To learn about ions, different chemical formulas, and how chemists count using the mole

WORDS TO KNOW

anions
Avogadro's number
bonds
cations
double bond
empirical formula
ionic compound
ions
molar mass
mole
molecular formula
single bonds
structural formula
triple bond

Lesson 8—Periodic Trends

Goal: To learn how the properties of atoms vary across the periodic table

WORDS TO KNOW

atomic radius
effective nuclear charge, *Zeff*
ionic radius
shielding
valence electrons

Notes on Application Activities in Student Text

Activity	Skills Applied	Products
Finding the Density of an Irregular Solid	measuring mass, measuring volume, calculating density	density of sand
Comparing Atomic Radii	graphing data, accounting for trends (making inferences)	two graphs

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Additional Activity Suggestion

- The hazards of asbestos are well documented. Have learners research asbestos and what elements (ions) are in its molecular formula. Ask them to research the damage that asbestos can do to the human body. You might direct learners to an Internet site such as the one run by the American Lung Association (http://www.lungusa.org/air/envasbestos.html). Lead a discussion about the major health problems associated with asbestos. Topics to consider could be the following: Can people exposed to asbestos in the workplace sue their employers for diseases they may have contracted? Are employers obligated to tell workers that there is asbestos in their work environment? What costs are associated with this problem?

Differentiation

- Pique learner interest in chemical activity with this simple demonstration. In photography, the film is usually coated with a gelatin emulsion containing tiny grains of some silver salt, usually Ag^+Br^- (an ionic compound). Put enough AgBr in a petri dish to cover the bottom of the dish. Place a colored paper clip in the center of the dish on top of the AgBr. (Use a colored paper clip instead of a silver clip for dramatic effect.) Place the dish in direct sunlight for about 30 minutes. The AgBr will change color from white to dark gray. Lift off the paper clip and a "photo" of it will appear in white against the gray AgBr. Explain that the light causes the Br^- to transfer electrons to Ag^+, forming elemental Ag. Because the paper clip blocks the light, the electron exchange will not occur as quickly as it will to the AgBr exposed to light. This leaves an image of the paper clip that resembles a photo.

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POWER BASICS PLUS

Chemistry

Workbook

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UNIT 2 • ACTIVITY 24
Dalton's Atomic Theory

John Dalton was an English schoolteacher who was serious about his search for an atomic theory. The following is a brief summary of his atomic theory:

1. All matter is composed of tiny particles called atoms, which are indivisible.
2. All atoms of a given element are identical; in particular, they have the same mass.
3. All atoms of a given element are distinct from all atoms of any other element; in particular, they have different masses.
4. Chemical compounds form when atoms combine in whole-number ratios.
5. Atoms cannot be created or destroyed in a chemical reaction.

Although Dalton's theory was quite an advance for its time, it has flaws that were corrected when new information became available.

Research the three major differences between Dalton's atomic theory and modern atomic theory. Describe those differences in a brief essay on another sheet of paper. In the space below, write research notes, brainstorm ideas, or organize information.

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UNIT 2 • ACTIVITY 25
John Dalton

John Dalton was an English chemist, physicist, schoolteacher, meteorologist, and college professor who lived from 1766 to 1844. Dalton made an impressive number of contributions to fields such as chemistry, optics, and meteorology. The following are some of Dalton's contributions:

- constructed his atomic theory in chemistry
- discovered color blindness, which is still called Daltonism
- stated what is now known as Gay-Lussac's gas law before Gay-Lussac himself did
- stated his law of partial pressures
- created his own table of atomic weights
- stated the law of multiple proportions, which contradicted a popular theory that had existed for at least 2200 years
- explained the law of definite proportions
- discovered that when some kinds of salts were added to water, the volume of the solution did not increase

Write two analogies that describe the law of definite proportions and the law of multiple proportions.

Example: The law of definite proportions is similar to when you take apart the ingredients in a bottle of cola. There will always be a fixed amount of sugar, a fixed amount of water, and a fixed amount of caffeine. The ratios are always the same.

1. ____

____

____

____

2. ____

____

____

____

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UNIT 2 • ACTIVITY 26
Joseph Proust

Joseph Proust was a French chemist who lived from 1754 to 1826. Like many academics of the time, he worked in many fields. He was a hot-air balloon flight instructor and a chemistry teacher at an artillery school, for example.

Proust's claim to fame in chemistry was his formulation of the law of definite proportions. This law states that the proportion by mass of the elements in a given compound is always the same. Using this law, he was able to show that there were actually three different kinds of sugars in some vegetables and thereby discovered glucose, fructose, and sucrose. Proust spent a fair amount of time defending his law against a well-known scientist of the day named C. L. Berthollet, who believed that elements could combine in any combination given the correct conditions. (In the time of Proust and Berthollet, the equipment needed to make the incredibly small measurements did not exist. Much of the equipment was constructed by chemists who were often inventing the laboratory equipment they needed as they went along.)

On another sheet of paper, write a brief essay describing how the law of definite proportions makes it easier to determine the products formed by a chemical reaction. In the space below, brainstorm ideas, organize information, or write a first draft.

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UNIT 2 • ACTIVITY 27
Electrons, Protons, and Neutrons

The particles that make up most atoms include protons, neutrons, and electrons. These particles are quite small and have tiny amounts of electric charge associated with them. In the case of the neutron, the charge is zero. Below is a chart that summarizes the properties of these particles.

Particle	Symbol	Charge	Mass
electron	*e*	-1.6022×10^{-19} C	9.1094×10^{-31} kg
proton	*p*	$+1.6022 \times 10^{-19}$ C	1.6726×10^{-27} kg
neutron	*n*	0	1.6749×10^{-27} kg

Using the chart above and the periodic table, answer the following questions.

1. How many protons are there in a carbon-12 atom? ________________
2. How many electrons are in a carbon-12 atom? ________________
3. How many neutrons are in a carbon-12 atom? ________________
4. How many particles make up a carbon-12 atom? ________________
5. What is the mass of the protons in an oxygen-16 atom? ________________
6. What is the mass of the neutrons in an oxygen-16 atom? ________________
7. What is the mass of the electrons in an oxygen-16 atom? ________________
8. What is the total mass of one oxygen-16 atom? ________________
9. What is the charge on the electrons in a calcium atom? ________________
10. What is the charge of the protons in a calcium atom? ________________
11. What is the charge of the neutrons in a calcium atom? ________________
12. What is the total charge on a calcium atom? ________________

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POWER BASICS PLUS

Chemistry

Test Pack

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CHEMISTRY • PRETEST

Circle the correct answer to each of the following questions.

1. Which of the following is NOT an example of matter?
   a. air
   b. asteroids
   c. gravity
   d. water

2. Which of the following is a substance?
   a. air
   b. brass
   c. gold
   d. tap water

3. What is a homogeneous mixture?
   a. a mixture in which one substance makes up more than 90 percent of the mixture
   b. a mixture in which substances are unevenly divided
   c. a mixture with visible boundaries between substances
   d. a solution

4. Which of the following is least likely to go into solution in pure water?
   a. corn starch
   b. salt
   c. sugar
   d. baking soda

5. Which of the following has a fixed volume, but not a fixed shape?
   a. a gas
   b. a liquid
   c. a solid
   d. a vapor

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UNIT 2 TEST • PROPERTIES OF MATTER

Circle the correct answer to each of the following questions.

1. The atomic number of an atom of lithium is 3, and its mass number is 7. How many neutrons does this atom contain?
   a. three
   b. four
   c. seven
   d. ten

2. Which of the following is NOT a subatomic particle?
   a. an electron
   b. an ion
   c. a neutron
   d. a proton

3. In what way do the various isotopes of the same element differ?
   a. They have different atomic numbers.
   b. They have different mass numbers.
   c. They have different numbers of electrons.
   d. They have different numbers of protons.

4. Under what circumstances do the elements of Group 2 of the periodic table form stable ionic compounds?
   a. when they appear as anions with a –1 charge
   b. when they appear as anions with a –2 charge
   c. when they appear as cations with a +1 charge
   d. when they appear as cations with a +2 charge

5. What does it mean to say that the natural abundance of ^{48}Ti is 5.5 percent?
   a. In a naturally occurring sample of titanium, ^{48}Ti will account for 5.5 percent of the sample.
   b. In a naturally occurring sample of titanium, ^{48}Ti will account for 48 percent of the sample 5.5 percent of the time.
   c. In nature, ^{48}Ti is only 5.5 percent pure.
   d. In nature, ^{48}Ti is 5.5 percent heavier than the other isotopes of titanium.

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6. Z = 1 for hydrogen; Z = 2 for helium; Z = 3 for lithium. What is Z?
   - **a.** the atomic number
   - **b.** the mass number
   - **c.** the number of neutrons in each
   - **d.** the relative abundance of the elements in nature

7. How is the modern periodic table of the elements organized?
   - **a.** by atomic number
   - **b.** by mass number
   - **c.** by melting point
   - **d.** by physical state at room temperature (20°C)

8. Which parts of the periodic table are called periods?
   - **a.** the horizontal rows
   - **b.** the lanthanides
   - **c.** the transition elements
   - **d.** the vertical columns

9. Which group of the periodic table is known for being highly unreactive?
   - **a.** group 1
   - **b.** group 6
   - **c.** group 9
   - **d.** group 18

10. Which of the following elements is the least reactive?
    - **a.** lithium
    - **b.** magnesium
    - **c.** neon
    - **d.** sodium

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11. Which of the following is NOT a metalloid?

a. arsenic (As)

b. boron (B)

c. silicon (Si)

d. sodium (Na)

---

12. In the formula MOH, what does M stand for?

a. any alkali metal

b. any alkaline earth metal

c. any halogen

d. any noble gas

---

13. What happens when an element becomes a cation?

a. Electrons are held tighter and closer to the nucleus.

b. It gains an electron.

c. Its atomic mass increases.

d. Its atomic radius increases.

---

14. Which is true of a cation?

a. It is attracted to an anode during electrolysis.

b. It is a free radical.

c. It is a positively charged ion.

d. It is a negatively charged ion.

---

15. Which is true of an anion?

a. It is a negatively charged ion.

b. It is attracted to a cathode.

c. It is held tightly by the nucleus of an atom.

d. It is unreactive.

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16. Which of the following may be highly stable?

a. a large collection of anions

b. a large collection of cations

c. a large collection of both anions and cations

d. Anions and cations are never stable, under any conditions.

---

17. Which of the following is a diatomic homonuclear molecule?

a. Br_2

b. CO_2

c. HCl

d. HF

---

18. The molecular formula for caffeine is $C_8H_{10}N_4O_2$. What is its empirical formula?

a. CHNO

b. $C_4H_5N_2O$

c. $C_6H_8N_2O$

d. $C_8H_{10}N_4O_2$

---

19. When there is a double bond between two atoms, how many electrons do they share?

a. two

b. four

c. six

d. eight

---

20. The atomic mass of boron is 10.81 amu. What will be the mass of 1 mole of boron atoms?

a. 1.081 grams

b. 10.81 grams

c. 108.1 grams

d. 1.081 kilograms

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21. Which of the following is NOT the result of a reaction between a Group 1 element and a halogen?

a. CsCl

b. CsF

c. LiCl

d. Li_2O

---

22. What happens when the outer shell of an element is completely filled with electrons?

a. The element is highly reactive.

b. The element is moderately reactive.

c. The element is slightly reactive.

d. The element is highly unreactive.

---

23. Lithium has three protons and one valence electron. What is the effective nuclear charge on this electron?

a. +1

b. +2

c. +3

d. +4

---

24. How big is the radius of a cation compared to the corresponding neutral atom?

a. The radius of the cation is smaller.

b. The radius of the cation is unchanged.

c. The radius of the cation is somewhat larger.

d. The radius of the cation is much larger.

---

25. When sodium reacts with chlorine to form table salt (NaCl), how big is the radius of the sodium ion compared to the radius of the sodium atom?

a. smaller

b. the same

c. somewhat larger

d. much larger

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CHEMISTRY • POSTTEST

Circle the correct answer to each of the following questions.

1. Which of the following is the first step in the scientific method?
   a. conducting an experiment
   b. defining a problem
   c. developing a theory
   d. gathering information

2. Which of the following is a mixture?
   a. air
   b. gold
   c. oxygen
   d. pure water

3. You brew a pot of coffee. Chemically, what have you made?
   a. a solution
   b. a suspension
   c. a chemical reaction
   d. a solute

4. You have washed your kitchen floor with a liquid cleaner. Chemically, what is the cleaner?
   a. a solution
   b. a suspension
   c. a solvent
   d. a solute

5. Which of the following is a compound?
   a. copper
   b. helium
   c. nitrogen
   d. table salt

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