

# Chapter 1

## Section 1 Chemistry Is a Physical Science

### Objectives ▼

- **Define** *chemistry*. ▼
- **List** examples of the branches of chemistry. ▼
- **Compare and contrast** basic research, applied research, and technological development.



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# Chapter 1

## Section 1 Chemistry Is a Physical Science

**Chemistry** is the study of the composition, structure, and properties of matter, the processes that matter undergoes, and the energy changes that accompany these processes.



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### Branches of Chemistry ▼

1. **Organic chemistry**—the study of most carbon-containing compounds ▼
2. **Inorganic chemistry**—the study of non-organic substances, many of which have organic fragments bonded to metals (organometallics) ▼
3. **Physical chemistry**—the study of the properties and changes of matter and their relation to energy



### Branches of Chemistry ▾

4. **Analytical chemistry**—the identification of the components and composition of materials
5. **Biochemistry**—the study of substances and processes occurring in living things
6. **Theoretical chemistry**—the use of mathematics and computers to understand the principles behind observed chemical behavior and to design and predict the properties of new compounds



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## Section 1 Chemistry Is a Physical Science

### Branches of Chemistry ▼

- A **chemical** is any substance that has a definite composition. ▼
  - sucrose ▼
  - water ▼
  - carbon dioxide



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### Branches of Chemistry ▼

- **Basic Research** is carried out for the sake of increasing knowledge. ▼
  - how and why a specific reaction occurs ▼
  - what the properties of a substance are ▼
  - the discovery of Teflon™ ▼
- **Applied Research** is generally carried out to solve a problem. ▼
  - development of new refrigerants



### Branches of Chemistry ▼

- **Technological Development** typically involves the production and use of products that improve our quality of life. ▼
  - computers ▼
  - catalytic converters in cars ▼
  - biodegradable materials ▼
- Basic research, applied research, and technological development often overlap



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## Section 1 Chemistry Is a Physical Science

### Top Eight Chemicals Made in the United States

Rank	Name	Formula	Uses
1	sulfuric acid	$\text{H}_2\text{SO}_4$	production of fertilizer; metal processing; petroleum refining
2	ethene	$\text{C}_2\text{H}_4$	production of plastics; ripening of fruits
3	propylene	$\text{C}_3\text{H}_6$	production of plastics
4	ammonia	$\text{NH}_3$	production of fertilizer; refrigeration
5	chlorine	$\text{Cl}_2$	bleaching fabrics; purifying water; disinfectant
6	phosphoric acid (anhydrous)	$\text{P}_2\text{O}_5$	production of fertilizer; flavoring agent; rustproofing metals
7	sodium hydroxide	$\text{NaOH}$	petroleum refining; production of plastics
8	1,2-dichloroethene	$\text{C}_2\text{H}_2\text{Cl}_2$	solvent, particularly for rubber

Source: *Chemical and Engineering News*.

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### Objectives ▼

- **Distinguish** between the physical properties and chemical properties of matter. ▼
- **Classify** changes of matter as physical or chemical. ▼
- **Explain** the gas, liquid, and solid states in terms of particles.



### Objectives, *continued* ▼

- **Explain** how the law of conservation of energy applies to changes of matter. ▼
- **Distinguish** between a mixture and a pure substance.



### Matter ▼

- **Volume** is the amount of three dimensional space an object occupies. ▼
- **Mass** is a measure of the amount of matter. ▼
- **Matter** is anything that has mass and takes up space.



### Basic Building Blocks of Matter ▼

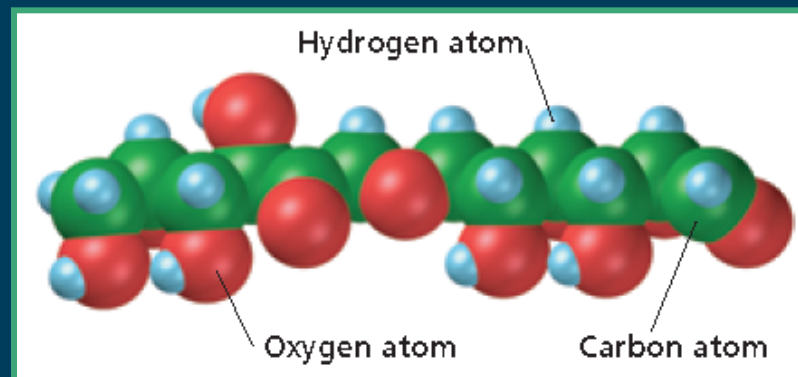
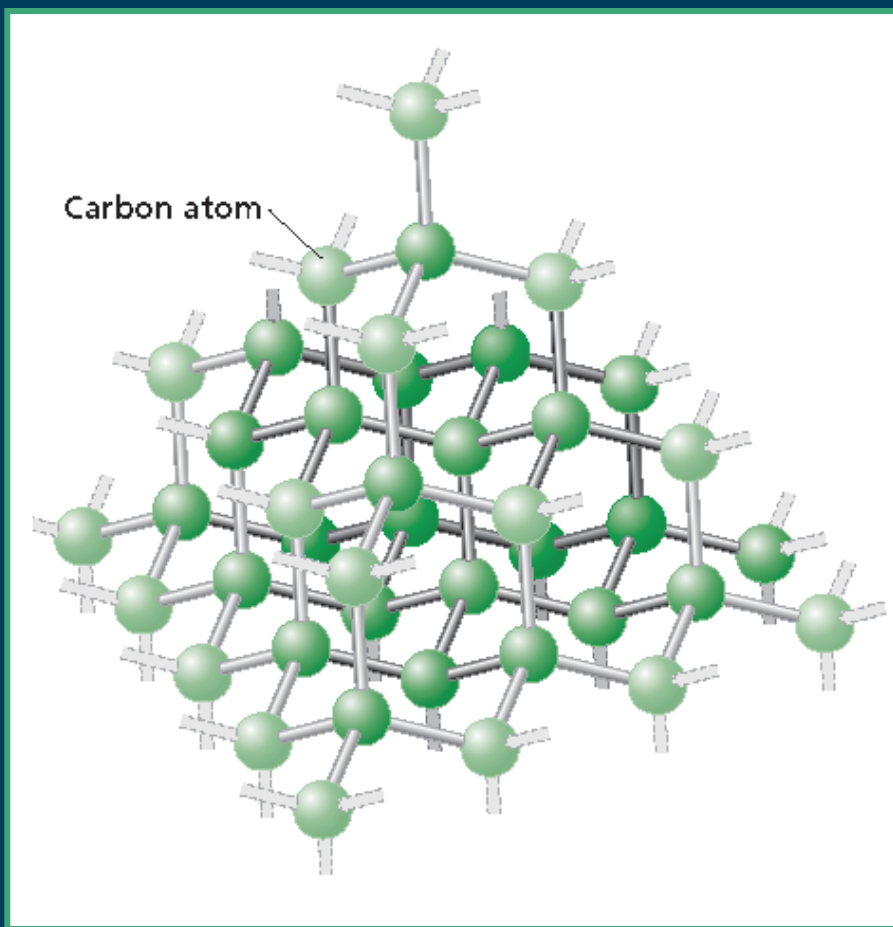
- An **atom** is the smallest unit of an element that maintains the chemical identity of that element. ▼
- An **element** is a pure substance that cannot be broken down into simpler, stable substances and is made of one type of atom. ▼
- A **compound** is a substance that can be broken down into simple stable substances. Each compound is made from the atoms of two or more elements that are chemically bonded.



# Chapter 1

## Section 2 Matter and Its Properties

### Basic Building Blocks of Matter, *continued*



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### Properties and Changes in Matter ▼

- **Extensive properties** depend on the amount of matter that is present.▼
  - volume ▼
  - mass ▼
  - the amount of energy in a substance.



### Properties and Changes in Matter ▼

- **Intensive properties** do not depend on the amount of matter present. ▼
  - melting point ▼
  - boiling point ▼
  - density ▼
  - ability to conduct electricity ▼
  - ability to transfer energy as heat



### Properties of Matter

Property	Description	Example
<b>Electrical conductivity</b>	ability to carry electricity	Copper is a good electrical conductor, so it is used in wiring.
<b>Heat conductivity</b>	ability to transfer energy as heat	Aluminum is a good heat conductor, so it is used to make pots and pans.
<b>Density</b>	mass-to-volume ratio of a substance; measure of how tightly matter is “packed”	Lead is a very dense material, so it is used to make sinkers for fishing line.
<b>Melting point</b>	temperature at which a solid changes state to become a liquid	Ice melts to liquid water at the melting point of water.
<b>Boiling point</b>	temperature at which a liquid boils and changes state to become a gas at a given pressure	Liquid water becomes water vapor at the boiling point of water.
<b>Index of refraction</b>	extent to which a given material bends light passing through it	The index of refraction of water tells you how much light slows and bends as it passes through water.
<b>Malleability</b>	ability to be hammered or beaten into thin sheets	Silver is quite malleable, so it is used to make jewelry.
<b>Ductility</b>	ability to be drawn into a thin wire	Tantalum is a ductile metal, so it is used to make fine dental tools.



### Physical Properties and Physical Changes ▼

- A **physical property** is a characteristic that can be observed or measured without changing the identity of the substance. ▼
  - melting point and boiling point ▼
- A **physical change** is a change in a substance that does not involve a change in the identity of the substance. ▼
  - grinding, cutting, melting, and boiling



### Physical Properties and Physical Changes, *continued* ▼

- A **change of state** is a physical change of a substance from one state to another. ▼
- **states of matter**—solid state, liquid state, gas state, plasma ▼
- In the **solid state**, matter has definite volume and definite shape. ▼
- In the **liquid state**, matter has a definite volume but an indefinite shape.

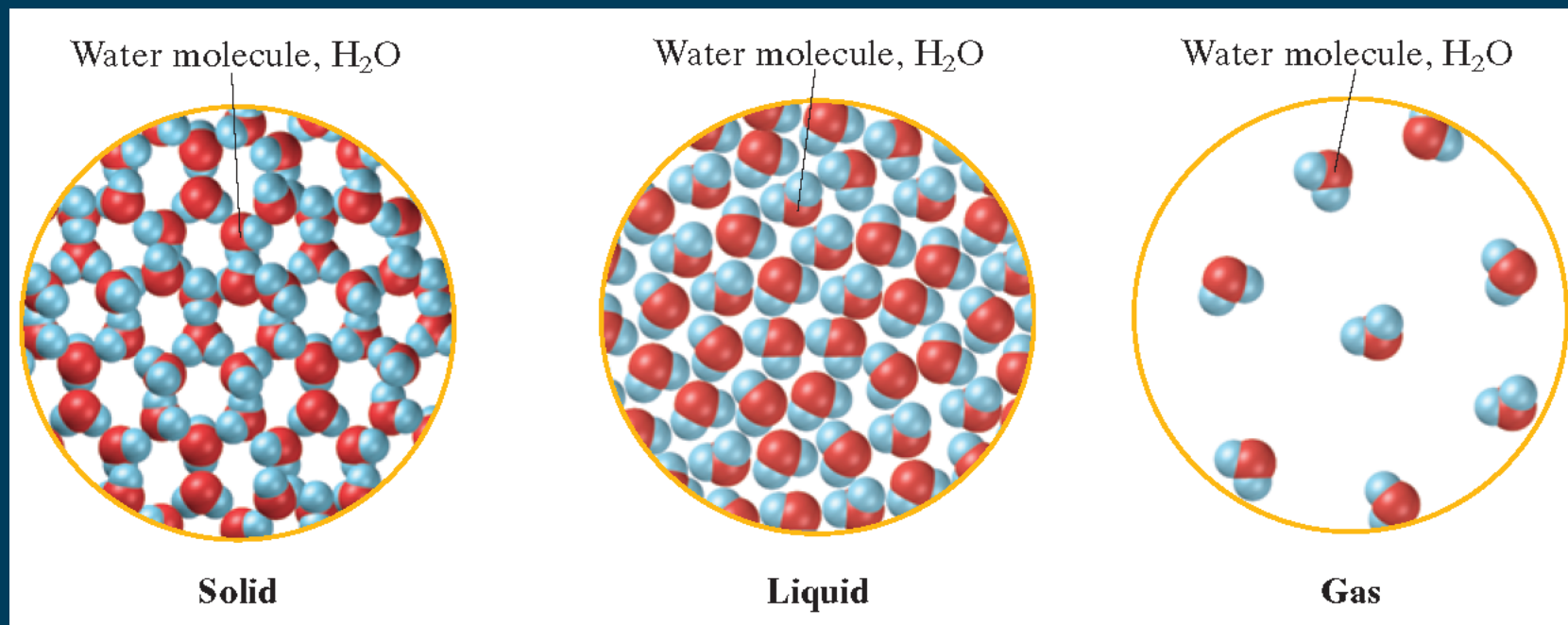


### Physical Properties and Physical Changes, *continued* ▼

- In the **gas state**, matter has neither definite volume nor definite shape. ▼
- **Plasma** is a high-temperature physical state of matter in which atoms lose most of their electrons, particles that make up atoms.



### Water in Three States



### Chemical Properties and Chemical Changes ▼

- A **chemical property** relates to a substance's ability to undergo changes that transform it into different substances ▼
- A change in which one or more substances are converted into different substances is called a **chemical change** or **chemical reaction**.



### Chemical Properties and Chemical Changes, *continued* ▼

- The **reactants** are the substances that react in a chemical change. ▼
- The **products** are the substances that are formed by the chemical change. ▼

*reactants*

*product* ▼

Carbon plus oxygen yields (or forms) carbon dioxide. ▼

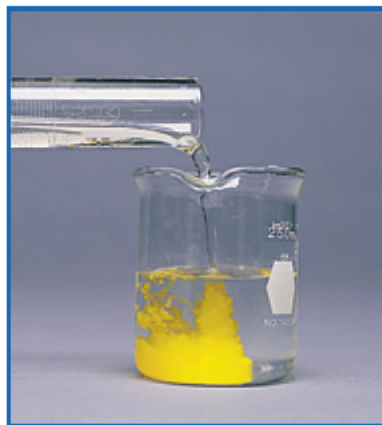
carbon + oxygen ▼  $\longrightarrow$  carbon dioxide



### Evidence of a Chemical Change



**a** When acetic acid, in vinegar, and sodium hydrogen carbonate, or baking soda, are mixed, the solution bubbles as carbon dioxide forms.



**b** When solutions of sodium sulfide and cadmium nitrate are mixed, cadmium sulfide, a solid precipitate, forms.



**c** When aluminum reacts with iron(III) oxide in the clay pot, energy is released as heat and light.

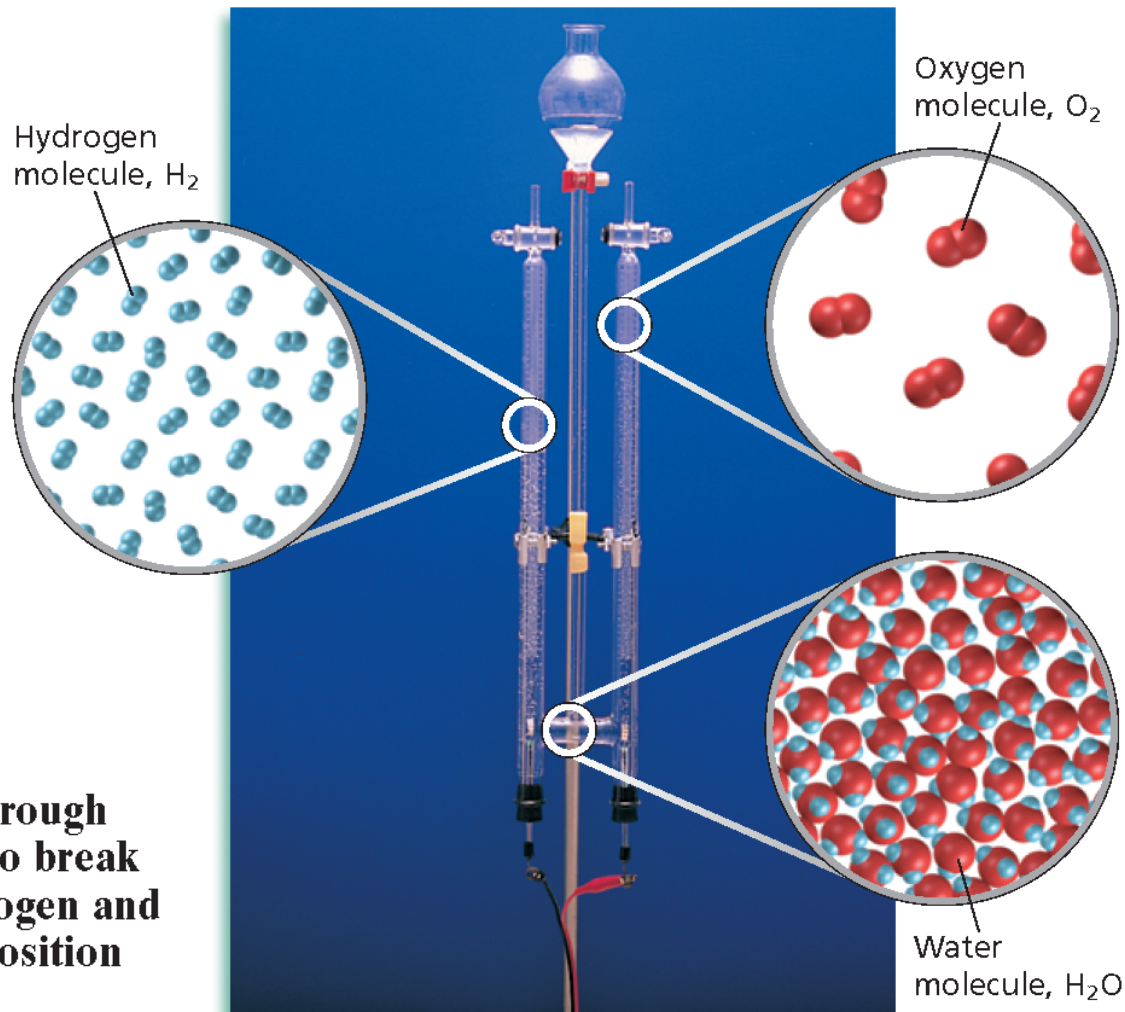


**d** When phenolphthalein is added to ammonia dissolved in water, a color change from colorless to pink occurs.



### Electrolysis of Water

Passing an electric current through water causes the compound to break down into the elements hydrogen and oxygen, which differ in composition from water.





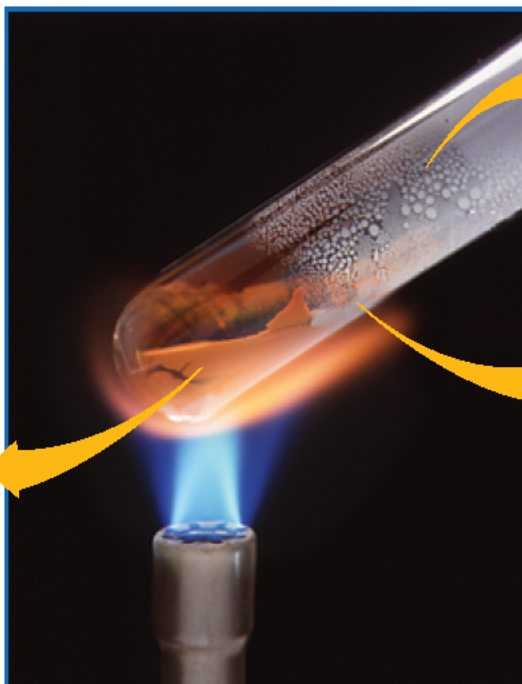
### Comparison of Physical and Chemical Properties

#### MERCURY(II) OXIDE

**Physical properties:** Bright red or orange-red, odorless crystalline solid; almost insoluble in water

**Chemical properties:**

Decomposes when exposed to light or at 500°C to form mercury and oxygen gas



#### OXYGEN

**Physical properties:** Colorless, odorless gas; soluble in water

**Chemical properties:** Supports combustion; reacts with many metals

#### MERCURY

**Physical properties:** Silver-white, liquid metal; in the solid state, mercury is ductile and malleable and can be cut with a knife

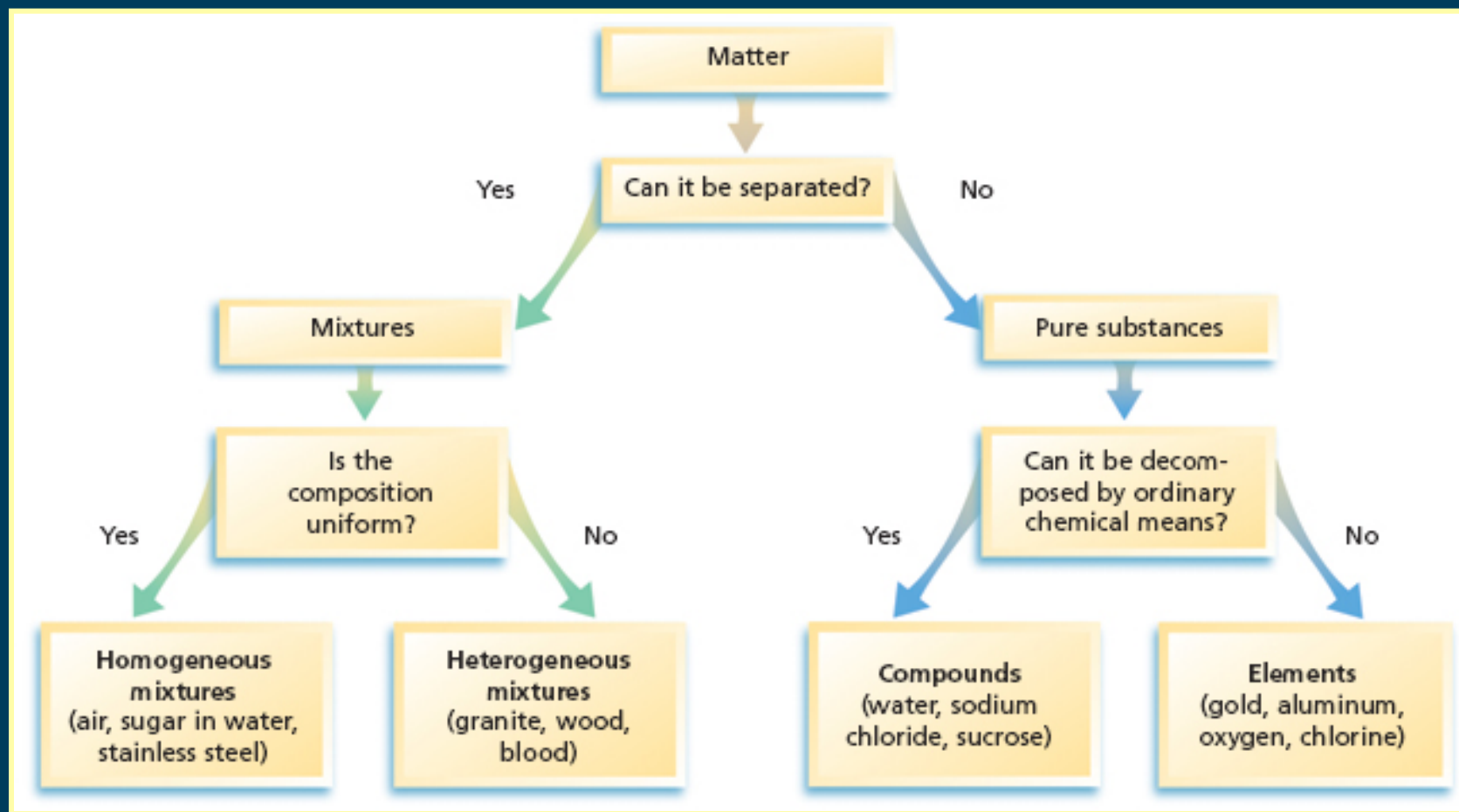
**Chemical properties:** Forms alloys with most metals except iron; combines readily with sulfur at normal temperatures; reacts with nitric acid and hot sulfuric acid; oxidizes to form mercury(II) oxide upon heating

### Energy and Changes in Matter ▼

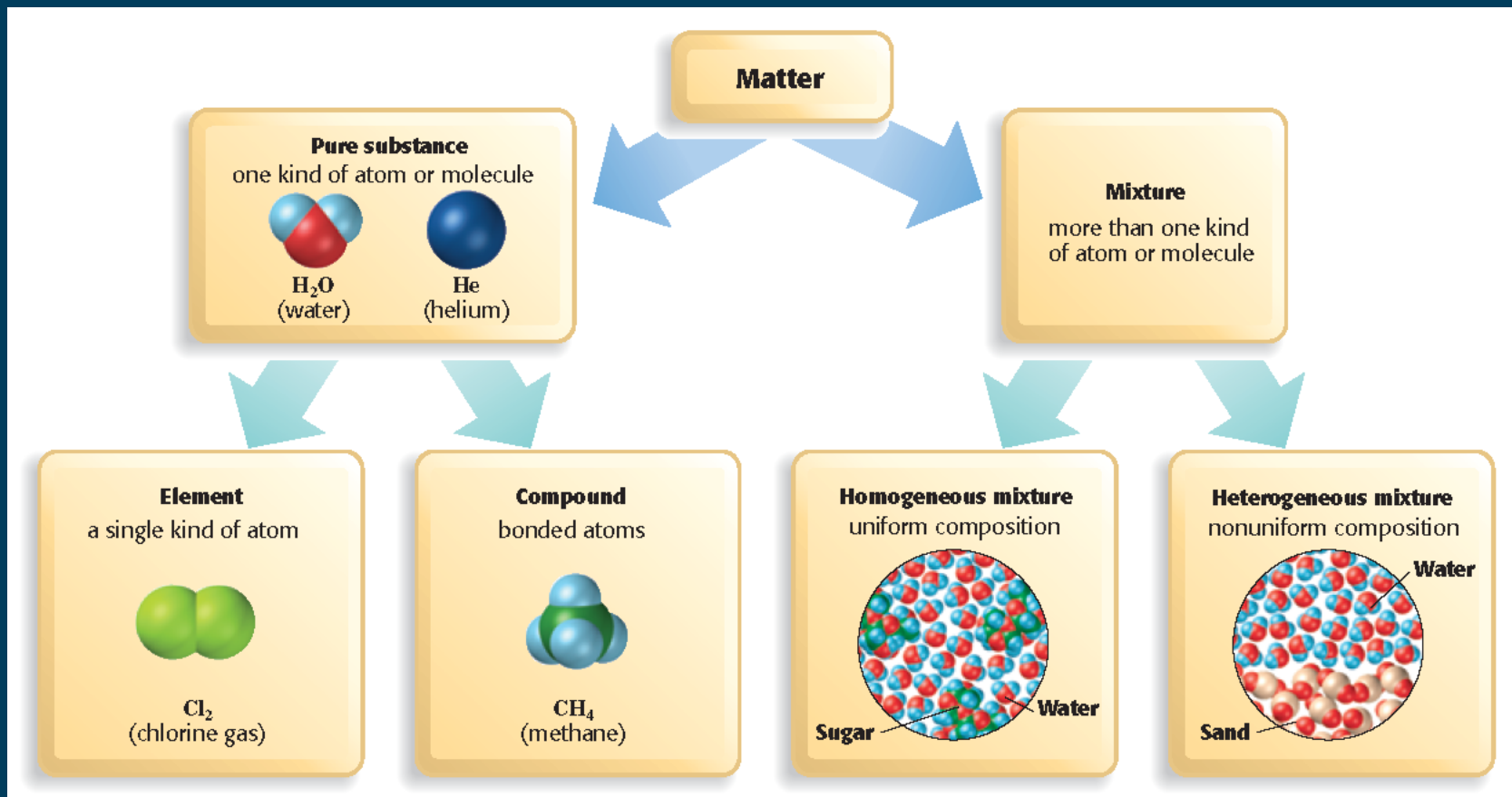
- Energy is always involved when physical or chemical changes occur. ▼
- Energy can be in various forms. ▼
  - heat ▼
  - light ▼
- Energy can be absorbed or released in a change, it is **not** destroyed or created. ▼
  - law of conservation of energy



### Classification of Matter



### Classifying Matter



### Classification of Matter ▼

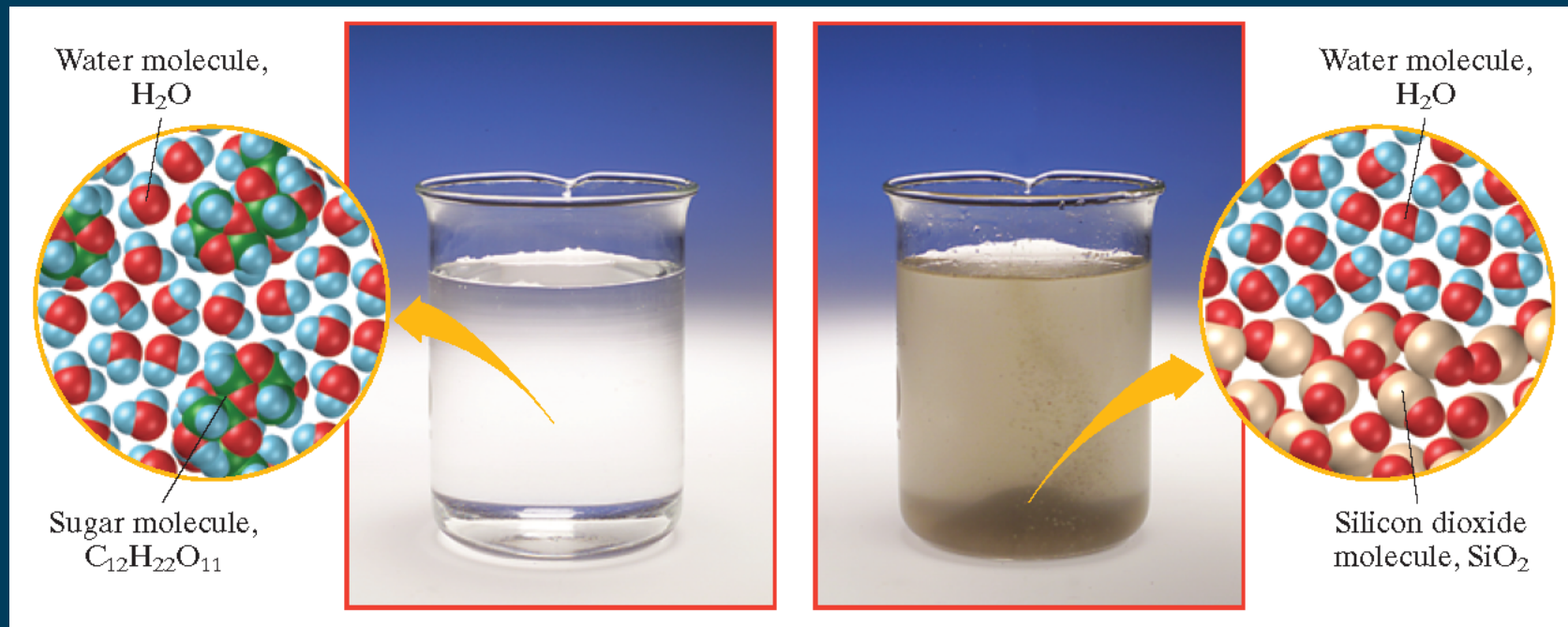
- A **mixture** is a blend of two or more kinds of matter, each of which retains its own identity and properties. ▼
  - mixed together physically ▼
  - can usually be separated ▼
- **Homogeneous** mixtures are called **solutions** ▼
  - uniform in composition (salt-water solution) ▼
- **Heterogeneous** mixtures ▼
  - not uniform throughout (clay-water mixture)



# Chapter 1

## Section 2 Matter and Its Properties

### Types of Mixtures



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### Pure Substances ▼

- A **pure substance** has a fixed composition. ▼
- Pure substances are either compounds or elements. ▼
- A pure substance differs from a mixture in the following ways: ▼
  - Every sample of a given pure substance has exactly the same characteristic properties. ▼
  - Every sample of a given pure substance has exactly the same composition. ▼
  - Water is always 11.2% hydrogen and 88.8% oxygen by mass.



### Laboratory Chemicals and Purity

**TABLE 1** Some Grades of Chemical Purity

Increasing purity ↑	Primary standard reagents
	ACS (American Chemical Society–specified reagents)
	USP (United States Pharmacopoeia standards)
	CP (chemically pure; purer than technical grade)
	NF (National Formulary specifications)
	FCC (Food Chemical Code specifications)
	Technical (industrial chemicals)



$Zn(NO_3)_2 \cdot 6H_2O$  F.W. 297.47

**Certificate of Actual Lot Analysis**

Acidity (as $HNO_3$ )	0.008%
Alkalies and Earths	0.02%
Chloride (Cl)	0.005%
Insoluble Matter	0.001%
Iron (Fe)	0.0002%
Lead (Pb)	0.001%
Phosphate ( $PO_4$ )	0.0002%
Sulfate ( $SO_4$ )	0.002%

Store separately from and avoid contact with combustible materials. Keep container closed and in a cool, dry place. Avoid contact with skin, eyes and clothing.

**LOT NO. 917356**

FL-02-0588

CAS 10196-18-6



### Examples of Mixtures

#### Homogeneous

Iced tea—uniform distribution of components; components cannot be filtered out and will not settle out upon standing

Stainless steel—uniform distribution of components

Maple syrup—uniform distribution of components; components cannot be filtered out and will not settle out upon standing

#### Heterogeneous

Orange juice or tomato juice—uneven distribution of components; settles out upon standing

Chocolate chip pecan cookie—uneven distribution of components

Granite—uneven distribution of components

Salad—uneven distribution of components; can be easily separated by physical means

### Objectives ▼

- **Use** a periodic table to name elements, given their symbols. ▼
- **Use** a periodic table to write the symbols of elements, given their names. ▼
- **Describe** the arrangement of the periodic table. ▼
- **List** the characteristics that distinguish metals, nonmetals, and metalloids.



### Introduction to the Periodic Table

Modern name	Symbol	Older name
Antimony	Sb	stibium
Copper	Cu	cuprum
Gold	Au	aurum
Iron	Fe	ferrum
Lead	Pb	plumbum
Mercury	Hg	hydrargyrum
Potassium	K	kalium
Silver	Ag	argentum
Sodium	Na	natrium
Tin	Sn	stannum
Tungsten	W	wolfram

# Chapter 1

## Section 3 Elements

### Regions of the Periodic Table

Legend:

- Metals (Red)
- Nonmetals (Green)
- Metalloids (Orange)
- Noble Gases (Purple)

Group 1 1 H																	Group 18 2 He	
Group 2 3 Li	4 Be											Group 13 5 B	Group 14 6 C	Group 15 7 N	Group 16 8 O	Group 17 9 F	10 Ne	
11 Na	12 Mg	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds									
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

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### Introduction to the Periodic Table ▼

- The vertical columns of the periodic table are called **groups**, or **families**. ▼
  - Each group contains elements with similar chemical properties. ▼
- The horizontal rows of elements in the periodic table are called **periods**. ▼
  - Physical and chemical properties change somewhat regularly across a period.



### Types of Elements

#### Metals ▼

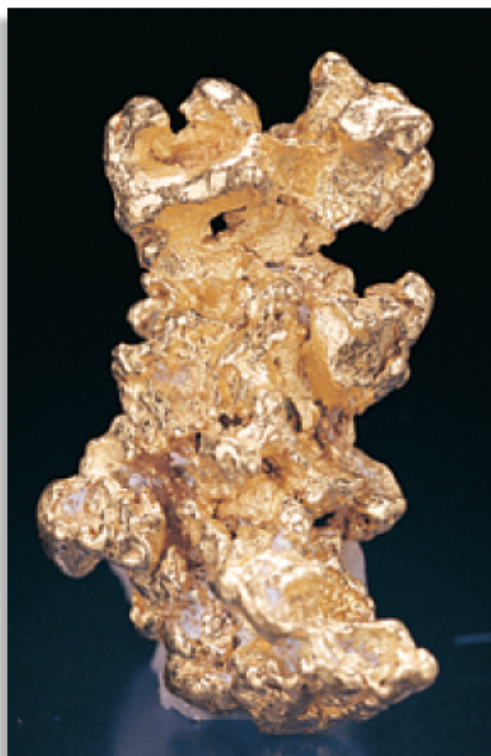
- A **metal** is an element that is a good electrical conductor and a good heat conductor. ▼
  - Properties of metals ▼
    - most are **solids** at room temperature ▼
    - **malleable** - they can be hammered or rolled into thin sheets ▼
    - **ductile** - they can be drawn into a fine wire ▼
    - **conduct** electricity and heat well



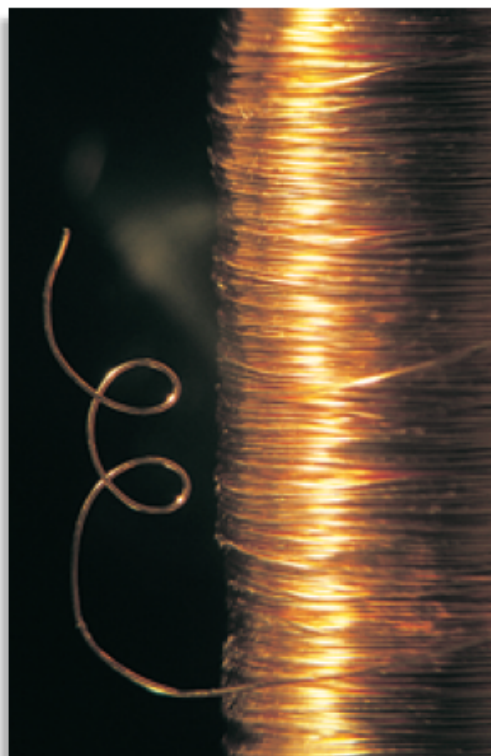


### Types of Elements

- Gold, copper, and aluminum are metals



(a)



(b)



(c)

### Types of Elements

#### Nonmetals ▼

- A **nonmetal** is an element that is a poor conductor of heat and electricity. ▼
  - Properties of nonmetals ▼
    - many are **gases** ▼
    - solids are **brittle** ▼
    - **poor conductors** of heat and electricity





### Types of Elements ▾

- **Various nonmetal elements**

(a) carbon, (b) sulfur, (c) phosphorus, and (d) iodine



### Types of Elements

#### Metalloids ▼

- A **metalloid** is an element that has some characteristics of metals and some characteristics of nonmetals. ▼
  - Properties of metalloids ▼
    - all metalloids are **solids** at room temperature ▼
    - **semiconductors** of electricity



### Types of Elements ▼

#### Noble Gases

- elements in Group 18 of the periodic table ▼
- generally unreactive ▼
- gases at room temperature

