1.1 SOME FUNDAMENTAL DEFINITIONS

The science of chemistry deals with the makeup of the entire physical universe. A good place to begin our discussion is with the definition of a few central ideas, some of which may already be familiar to you. **Chemistry** is *the study of matter and its properties, the changes that matter undergoes, and the energy associated with those changes.*

The Properties of Matter

Matter is the "stuff" of the universe: air, glass, planets, students—*anything that has mass and volume.* (In Section 1.5, we discuss the meanings of mass and volume in terms of how they are measured.) Chemists are particularly interested in the **composition** of matter, *the types and amounts of simpler substances that make it up.* A *substance* is a type of matter that has a defined, fixed composition.

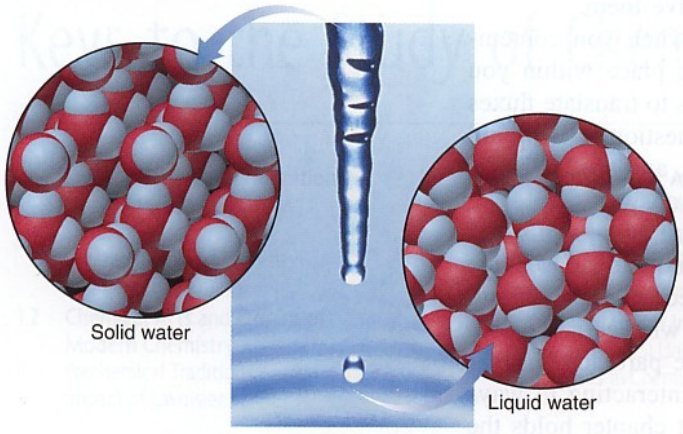
We learn about matter by observing its **properties,** *the characteristics that give each substance its unique identity.* To identify a person, we observe such properties as height, weight, eye color, race, fingerprints, and, now, even DNA fingerprint, until we arrive at a unique identification. To identify a substance, chemists observe two types of properties, physical and chemical, which are closely related to two types of change that matter undergoes. **Physical properties** are those that a substance shows *by itself, without changing into or interacting with another substance.* Some physical properties are color, melting point, electrical conductivity, and density.

A **physical change** occurs when a substance *alters its physical form,* ***not*** *its composition.* Thus, a physical change results in different physical properties. For example, when ice melts, several physical properties have changed, such as hardness, density, and ability to flow. But the sample has *not* changed its composition: it is still water. The photo in Figure 1.1A shows this change the way you

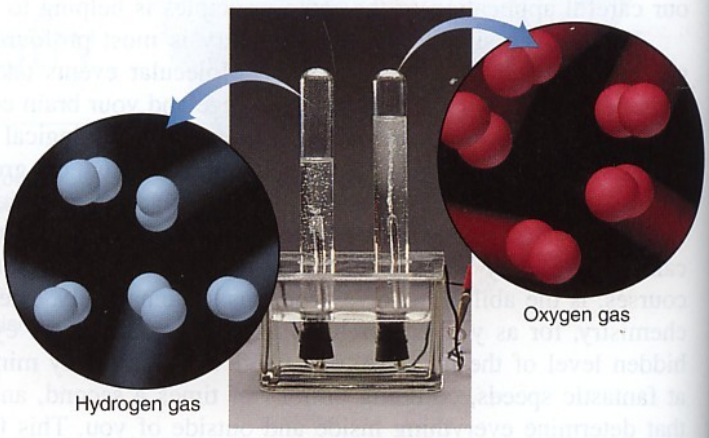
Animation: The Three States of Matter
Online Learning Center
Animations Center, Chapter 1,
The Three States of Matter

Transparency/DCM, Photo Library

Figure 1.1 The distinction between physical and chemical change.



A Physical change:
Solid form of water becomes liquid form; composition does not change because particles are the same.



B Chemical change:
Electric current decomposes water into different substances (hydrogen and oxygen); composition does change because particles are different.

would see it in everyday life. In your imagination, try to see the magnified view that appears in the "blow-up" circles. Here we see the particles that make up the sample; note that the same particles appear in solid and liquid water.

Physical change (same substance before and after):

$$\text{Water (solid form)} \longrightarrow \text{water (liquid form)}$$

On the other hand, **chemical properties** are those that a substance shows *as it changes into or interacts with another substance (or substances).* Some examples of chemical properties are flammability, corrosiveness, and reactivity with acids. A **chemical change,** also called a **chemical reaction,** occurs when *a substance (or substances) is converted into a different substance (or substances).*

Figure 1.1B shows the chemical change (reaction) that occurs when you pass an electric current through water: the water decomposes (breaks down) into two other substances, hydrogen and oxygen, each with physical and chemical properties different from each other *and* from water. The sample *has* changed its composition: it is no longer water, as you can see from the different particles in the magnified view.

Chemical change (different substances before and after):

$$\text{Water} \xrightarrow{\text{electric current}} \text{hydrogen gas} + \text{oxygen gas}$$

A substance is identified by its own set of physical and chemical properties. Some properties of copper appear in Table 1.1.

Table 1.1 Some Characteristic Properties of Copper

Physical Properties	Chemical Properties
Reddish brown, metallic luster	 Slowly forms a basic, blue-green sulfate in moist air
 Easily shaped into sheets (malleable) and wires (ductile)	 Reacts with nitric acid (photo) and sulfuric acid
Good conductor of heat and electricity	 Slowly forms a deep-blue solution in aqueous ammonia
 Can be melted and mixed with zinc to form brass	
Density = 8.95 g/cm^3	
Melting point = 1083°C	
Boiling point = 2570°C	