CHEM 101

First Semester 1444

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Reference

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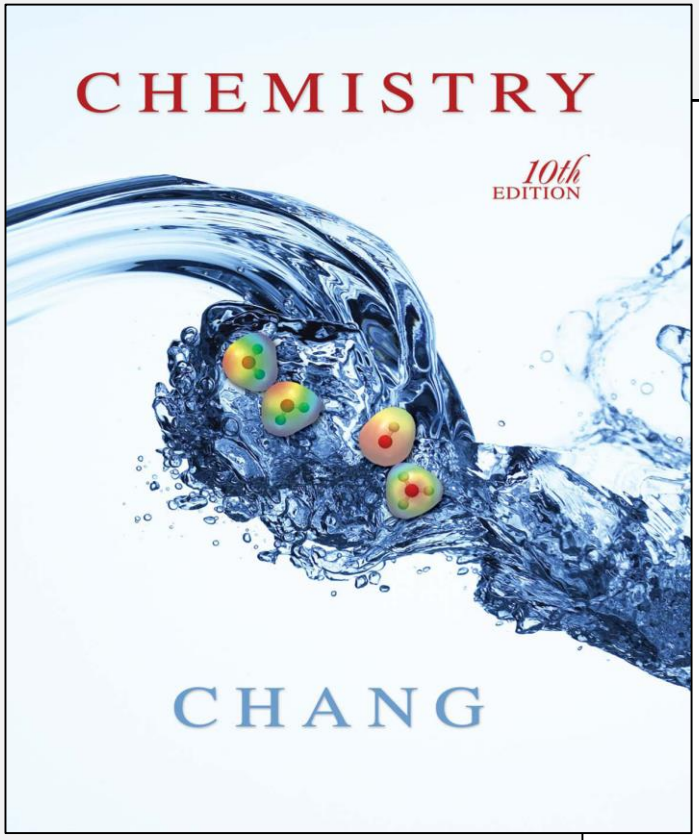

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الإختبار النهائي سيكون في جميع مواضيع المقرر

Chemistry:
The Study of Change

Chapter 1

Chemistry is the study of matter and the changes it undergoes

Matter is anything that occupies space and has mass.

A ***substance*** is a form of matter that has a definite composition and distinct properties.

liquid nitrogen

gold ingots

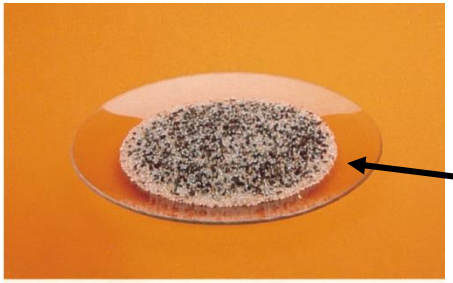
silicon crystals

A ***mixture*** is a combination of two or more substances in which the substances retain their distinct identities.

1. ***Homogenous mixture*** – composition of the mixture is the same throughout.

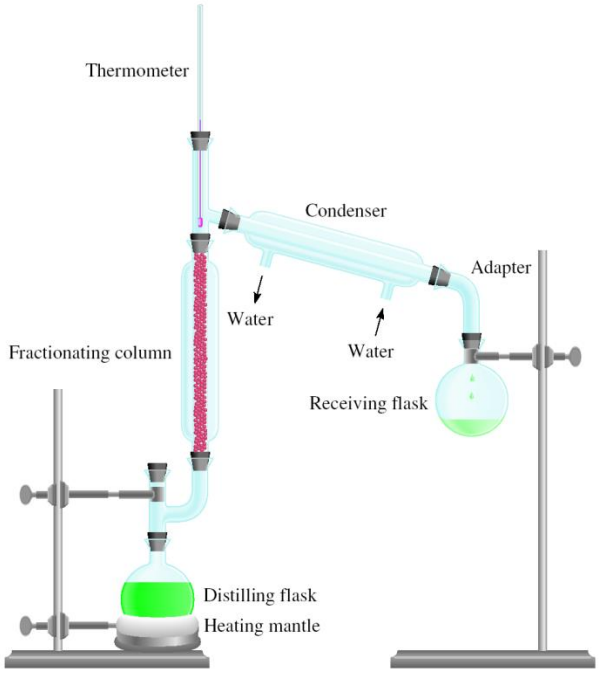
soft drink, milk, solder

2. ***Heterogeneous mixture*** – composition is not uniform throughout.



cement,
iron filings in sand

Physical means can be used to separate a mixture into its pure components.



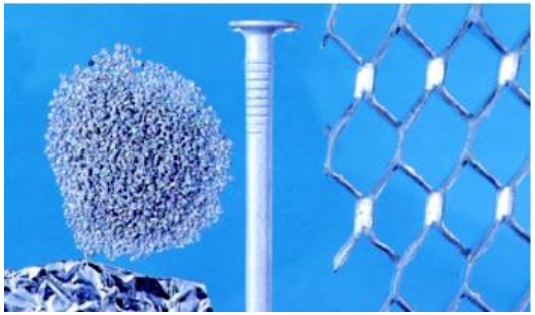
distillation

magnet

An ***element*** is a substance that cannot be separated into simpler substances by ***chemical means***.

- 118 elements have been identified
  - 82 elements occur naturally on Earth

    gold, aluminum, lead, oxygen, carbon, sulfur



  - 36 elements have been created by scientists

    technetium, americium, seaborgium

TABLE 1.1 Some Common Elements and Their Symbols

Name	Symbol	Name	Symbol	Name	Symbol
Aluminum	Al	Fluorine	F	Oxygen	O
Arsenic	As	Gold	Au	Phosphorus	P
Barium	Ba	Hydrogen	H	Platinum	Pt
Bismuth	Bi	Iodine	I	Potassium	K
Bromine	Br	Iron	Fe	Silicon	Si
Calcium	Ca	Lead	Pb	Silver	Ag
Carbon	C	Magnesium	Mg	Sodium	Na
Chlorine	Cl	Manganese	Mn	Sulfur	S
Chromium	Cr	Mercury	Hg	Tin	Sn
Cobalt	Co	Nickel	Ni	Tungsten	W
Copper	Cu	Nitrogen	N	Zinc	Zn

A ***compound*** is a substance composed of atoms of two or more elements chemically united in fixed proportions.

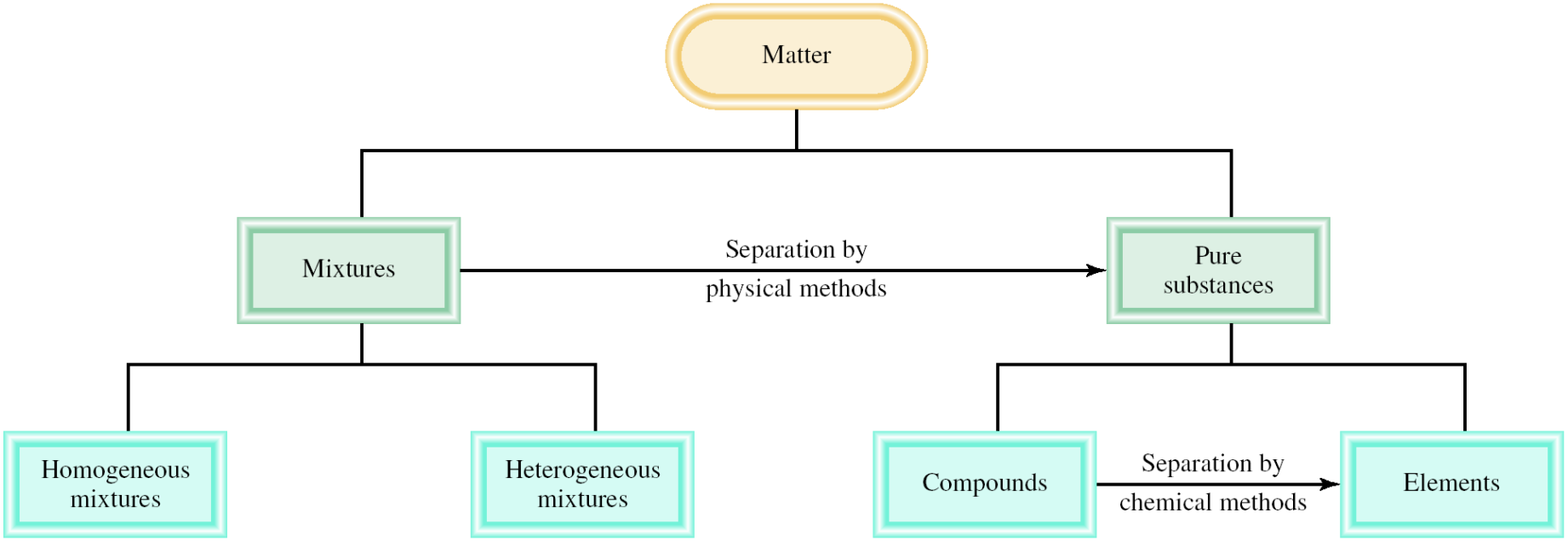
Compounds can only be separated into their pure components (elements) by ***chemical*** means.

lithium fluoride

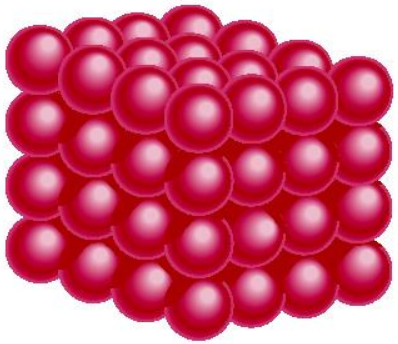
quartz

dry ice – carbon dioxide

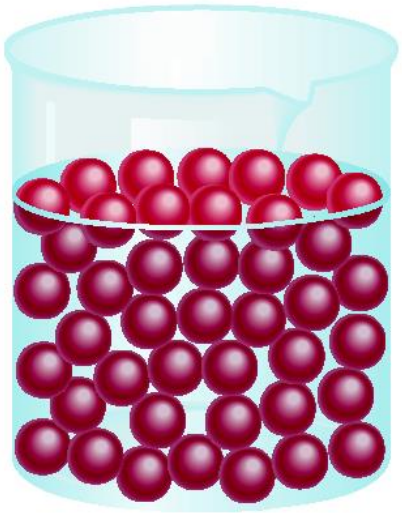
Classifications of Matter



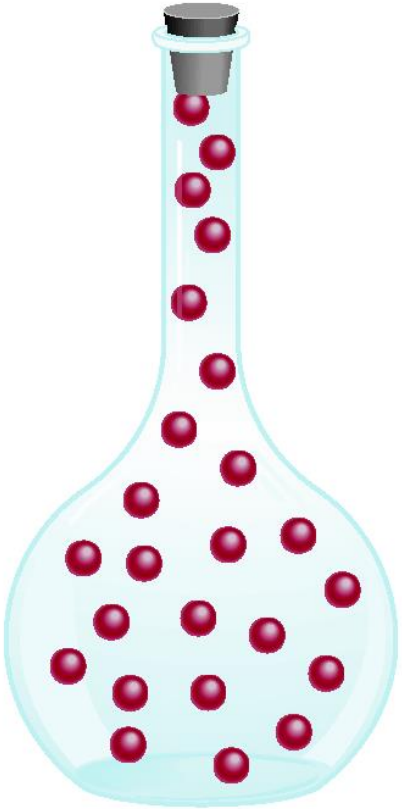
A Comparison: The Three States of Matter



Solid

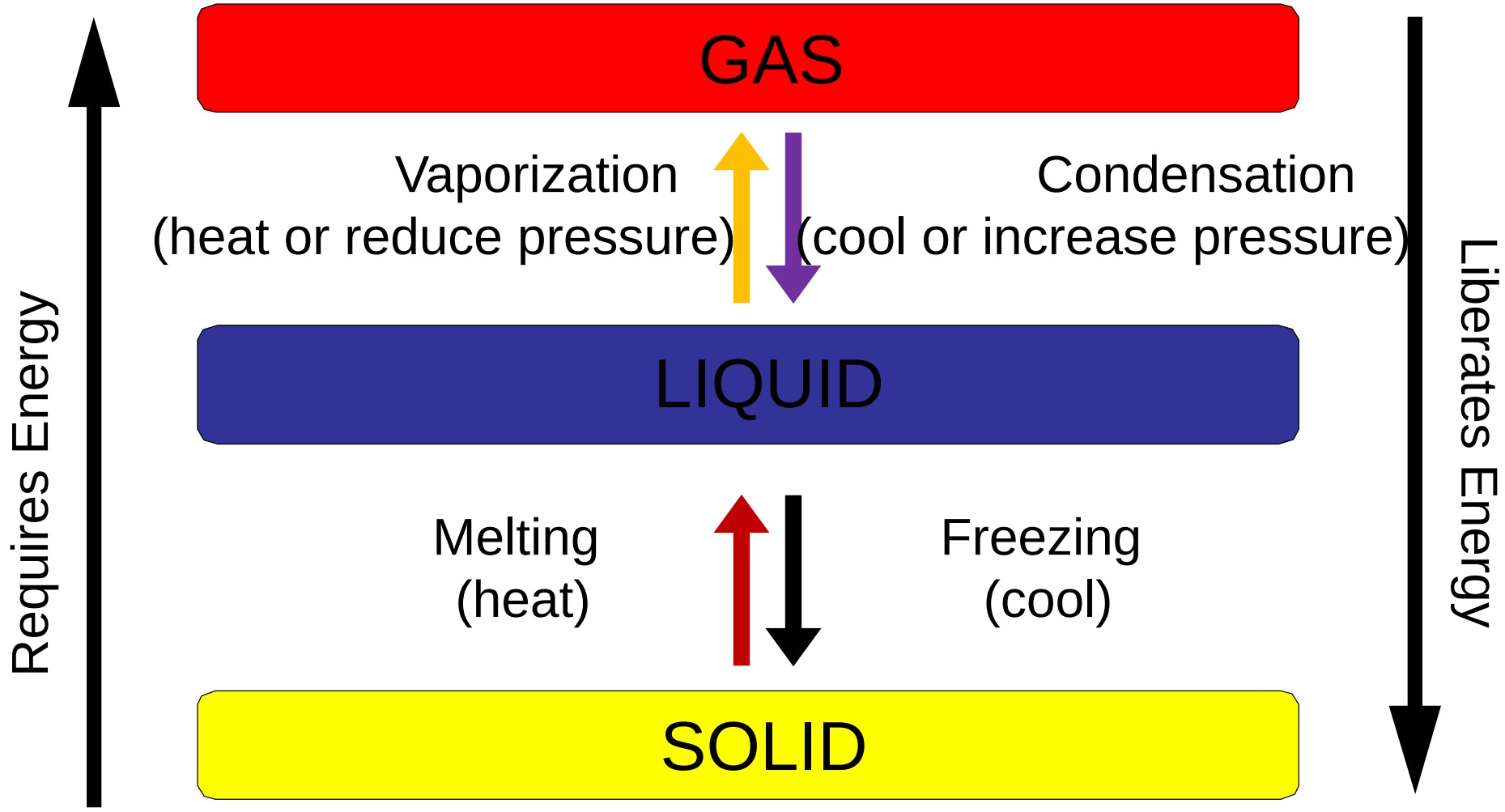


Liquid



Gas

The Three States of Matter: Effect of a Hot Poker on a Block of Ice



Types of Changes

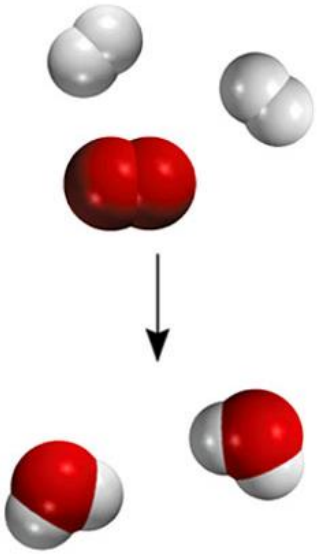
A ***physical change*** does not alter the composition or identity of a substance.

ice melting

sugar dissolving in water

A ***chemical change*** alters the composition or identity of the substance(s) involved.

hydrogen burns in air to form water



PROBLEM: Decide whether each of the following process is primarily a physical or a chemical change, and explain briefly.

(a) Frost forms as the temperature drops on a humid winter night.

(b) Dynamite explodes to form a mixture of gases.

(c) Dissolving sugar in water.

(d) A silver fork tarnishes in air.

Criteria: "Does the substance change composition or just change form?"

SOLUTION:

(a) physical change

(b) chemical change

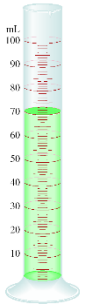
(c) physical change

(d) chemical change

Extensive and Intensive Properties

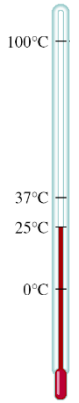
An ***extensive property*** of a material depends upon how much matter is being considered.

- mass
- length
- volume



An ***intensive property*** of a material does not depend upon how much matter is being considered.

- density
- temperature
- color



International System of Units (SI)

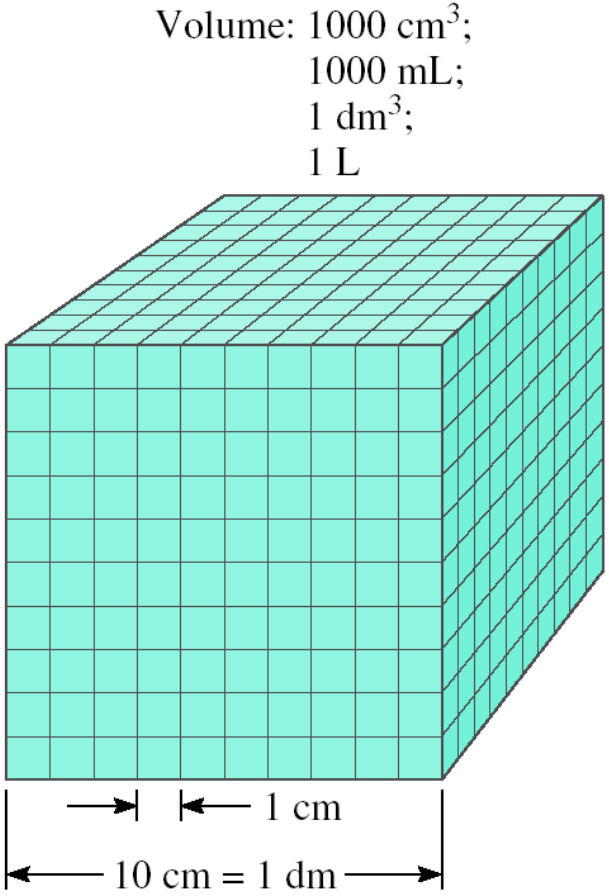
TABLE 1.2 SI Base Units

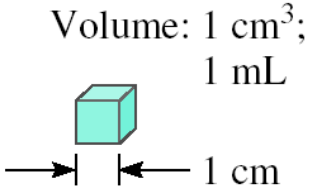
Base Quantity	Name of Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electrical current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

TABLE 1.3 Prefixes Used with SI Units

Prefix	Symbol	Meaning	Example
tera-	T	1,000,000,000,000, or 10^{12}	1 terameter (Tm) = 1×10^{12} m
giga-	G	1,000,000,000, or 10^{9}	1 gigameter (Gm) = 1×10^{9} m
mega-	M	1,000,000, or 10^{6}	1 megameter (Mm) = 1×10^{6} m
kilo-	k	1,000, or 10^{3}	1 kilometer (km) = 1×10^{3} m
deci-	d	1/10, or 10^{-1}	1 decimeter (dm) = 0.1 m
centi-	c	1/100, or 10^{-2}	1 centimeter (cm) = 0.01 m
milli-	m	1/1,000, or 10^{-3}	1 millimeter (mm) = 0.001 m
micro-	μ	1/1,000,000, or 10^{-6}	1 micrometer (μm) = 1×10^{-6} m
nano-	n	1/1,000,000,000, or 10^{-9}	1 nanometer (nm) = 1×10^{-9} m
pico-	p	1/1,000,000,000,000, or 10^{-12}	1 picometer (pm) = 1×10^{-12} m

Volume – SI derived unit for volume is cubic meter (m^3)





$1\ cm^3 = (1 \times 10^{-2}\ m)^3 = 1 \times 10^{-6}\ m^3$

$1\ dm^3 = (1 \times 10^{-1}\ m)^3 = 1 \times 10^{-3}\ m^3$

$1\ L = 1000\ mL = 1000\ cm^3 = 1\ dm^3$

$1\ mL = 1\ cm^3$

Density

The **density** a substance is its mass per unit volume (the volumetric mass).

SI derived unit for density is kg/m^3

$1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{V}$$

TABLE 1.4

Densities of Some Substances at 25°C

Substance	Density (g/cm^3)
Air*	0.001
Ethanol	0.79
Water	1.00
Mercury	13.6
Table salt	2.2
Iron	7.9
Gold	19.3
Osmium†	22.6

*Measured at 1 atmosphere.
†Osmium (Os) is the densest element known.

A piece of platinum metal with a density of 21.5 g/cm^3 has a volume of 4.49 cm^3. What is its mass?

$$d = \frac{m}{V}$$

$$m = d \times V = 21.5 \text{ g/cm}^3 \times 4.49 \text{ cm}^3 = 96.5 \text{ g}$$

EXAMPLE 1.1

Gold is a precious metal that is chemically unreactive. It is used mainly in jewelry, dentistry, and electronic devices. A piece of gold ingot with a mass of 301 g has a volume of 15.6 cm^3. Calculate the density of gold.

Solution We are given the mass and volume and asked to calculate the density. Therefore, from Equation (1.1), we write

$$d = \frac{m}{V}$$

$$= \frac{301\ \text{g}}{15.6\ \text{cm}^3}$$

$$= 19.3\ \text{g/cm}^3$$

Practice Exercise A piece of platinum metal with a density of 21.5 g/cm^3 has a volume of 4.49 cm^3. What is its mass?

EXAMPLE 1.2

The density of mercury, the only metal that is a liquid at room temperature, is 13.6 g/mL. Calculate the mass of 5.50 mL of the liquid.

Solution We are given the density and volume of a liquid and asked to calculate the mass of the liquid. We rearrange Equation (1.1) to give

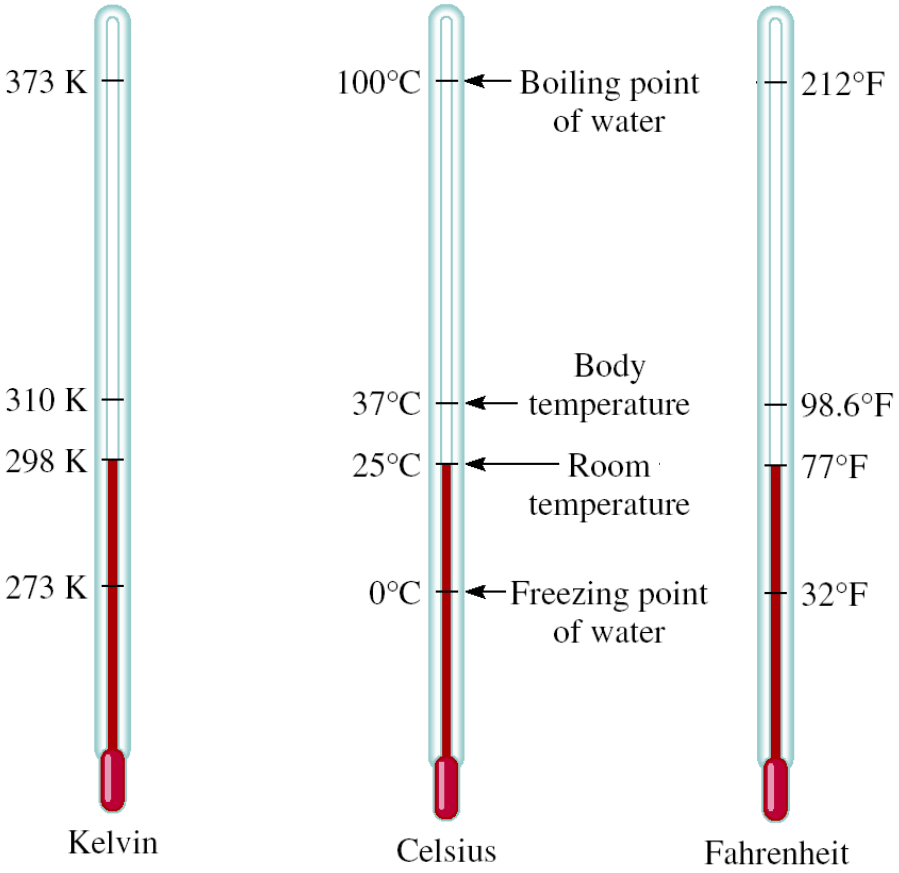
$$m = d \times V$$

$$= 13.6 \frac{\text{g}}{\cancel{\text{mL}}} \times 5.50 \cancel{\text{mL}}$$

$$= 74.8 \text{ g}$$

Practice Exercise The density of sulfuric acid in a certain car battery is 1.41 g/mL. Calculate the mass of 242 mL of the liquid.

A Comparison of Temperature Scales



$$K = {}^0C + 273.15$$

$$273\ K = 0\ {}^0C$$

$$373\ K = 100\ {}^0C$$

$${}^0F = \frac{9}{5} \times {}^0C + 32$$

$$32\ {}^0F = 0\ {}^0C$$

$$212\ {}^0F = 100\ {}^0C$$

Convert 172.9 ^{0}F to degrees Celsius.

$$^0F = \frac{9}{5} \times {}^0C + 32$$

$$^0F - 32 = \frac{9}{5} \times {}^0C$$

$$\frac{5}{9} \times (^0F - 32) = {}^0C$$

$$^0C = \frac{5}{9} \times (^0F - 32)$$

$$^0C = \frac{5}{9} \times (172.9 - 32) = 78.3$$

EXAMPLE 1.3

(a) Solder is an alloy made of tin and lead that is used in electronic circuits. A certain solder has a melting point of 224°C. What is its melting point in degrees Fahrenheit? (b) Helium has the lowest boiling point of all the elements at −452°F. Convert this temperature to degrees Celsius. (c) Mercury, the only metal that exists as a liquid at room temperature, melts at −38.9°C. Convert its melting point to kelvins.

Solution These three parts require that we carry out temperature conversions, so we need Equations (1.2), (1.3), and (1.4). Keep in mind that the lowest temperature on the Kelvin scale is zero (0 K); therefore, it can never be negative.

(a) This conversion is carried out by writing

$$\frac{9°F}{5°C} \times (224°C) + 32°F = 435°F$$

(Continued)