Chapter 2

Measurements In Chemistry

Measurements are not exact

→

Measurements can never be exact; there is always some uncertainty.

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Metric System

Metric system units are becoming increasingly evident on highway signs.

Metric Prefixes

	Prefix[a]	Symbol	Mathematical Meaning[b]
Multiples	giga-	G	1,000,000,000 (10^9, billion)
	mega-	M	1,000,000 (10^6, million)
	kilo-	k	1000 (10^3, thousand)
Fractional parts	deci-	d	0.1 (10^{-1}, one-tenth)
	centi-	c	0.01 (10^{-2}, one-hundredth)
	milli-	m	0.001 (10^{-3}, one-thousandth)
	micro-	μ (Greek mu)	0.000001 (10^{-6}, one-millionth)
	nano-	n	0.000000001 (10^{-9}, one-billionth)
	pico-	p	0.000000000001 (10^{-12}, one-trillionth)

[a]Other prefixes also are available but are less commonly used.
[b]The power-of-10 notation for denoting numbers is considered in Section 2.6.

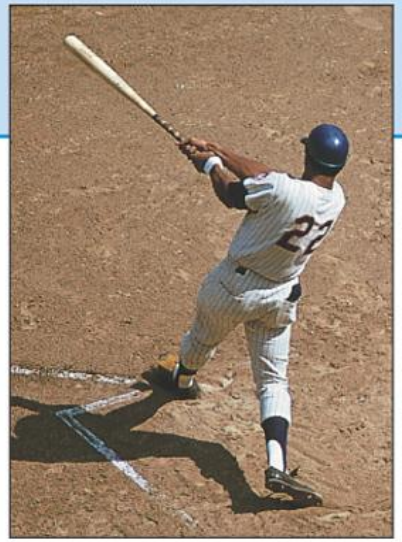
← **Table 2.1**

Metric System Base Units

→ **Fig. 2.2**

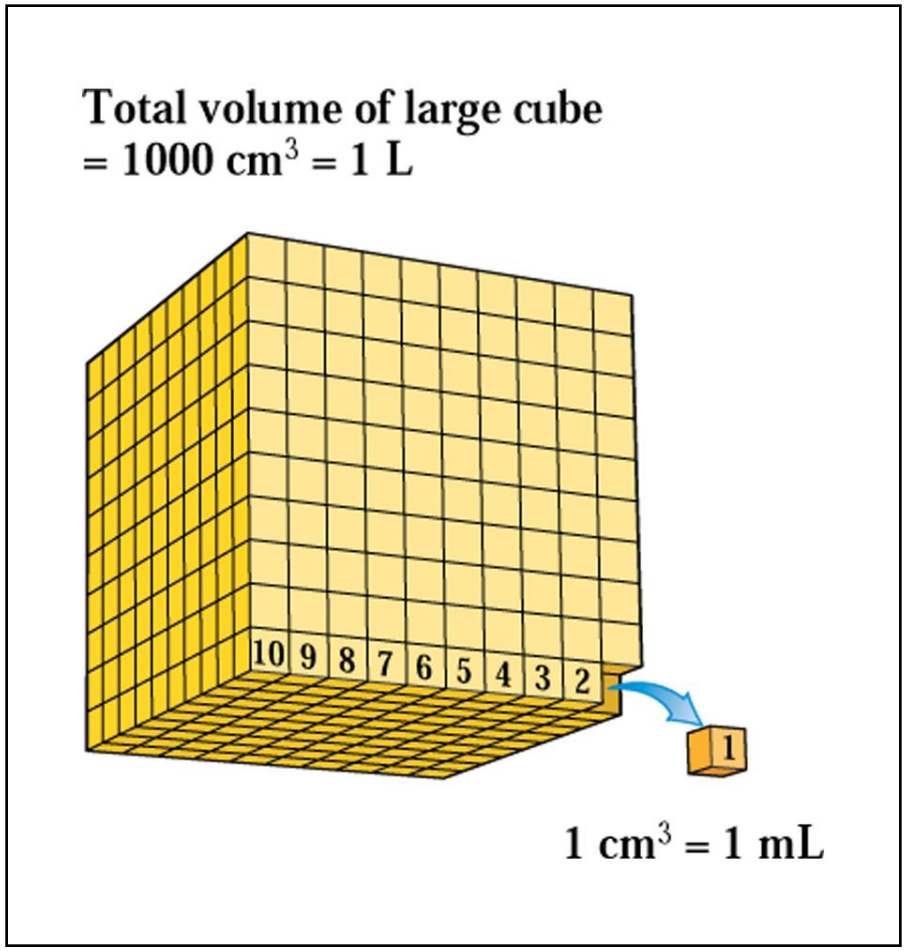
Comparisons of the base metric system units of length, mass, and volume with common objects.

(a) Length	(b) Mass	(c) Volume
A meter is slightly larger than a yard. 1 meter = 1.09 yards. A baseball bat is about 1 meter long.	A gram is a small unit compared to a pound. 1 gram = 1/454 pound. Two pennies, five paper-clips, and a marble have masses of about 5, 2, and 5 grams, respectively.	A liter is slightly larger than a quart. 1 liter = 1.06 quarts. Most beverages are now sold by the liter rather than by the quart.



E.R. Degginger

Volume Unites (cm^3, L and mL)



← **Fig. 2.3**

A cube 10 cm on a side is equal to 1 L; a cube 1 cm on a side is equal to 1 mL.

Solution Concentration Units

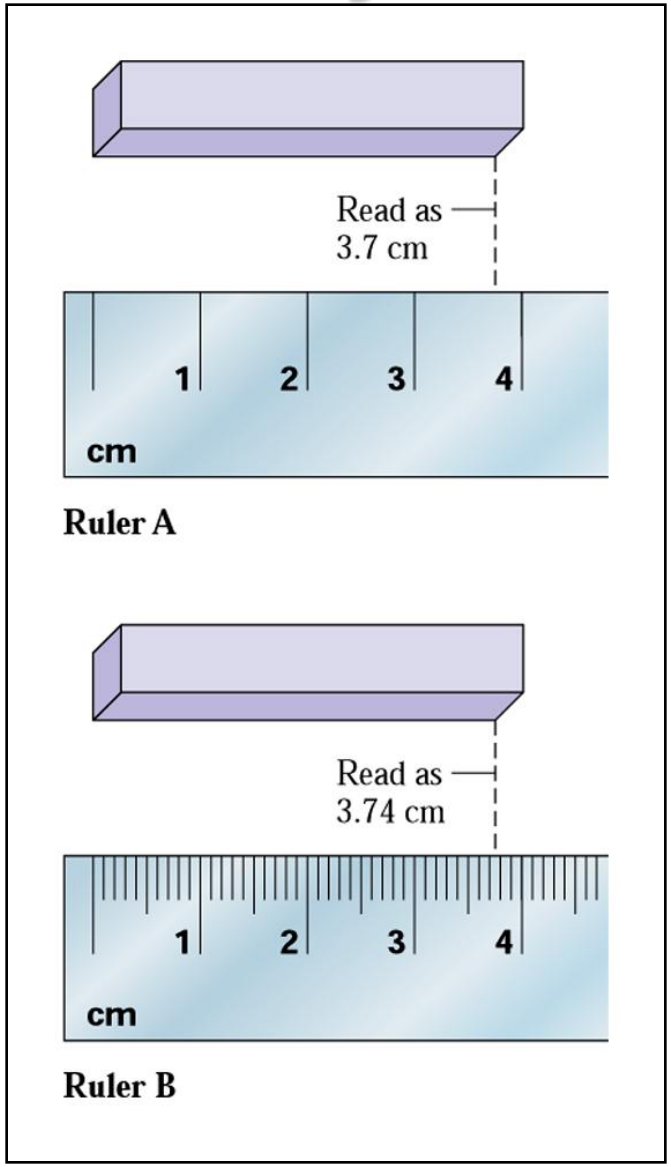
The use of the concentration unit milligrams per deciliteris common in clinical laboratory reports dealing with the composition of human body fluids.

Healthy, I.M.	3/12/03	3/12/03	3/13/03
M	37		05169
000-00-000	Your Doctor Anywhere, U.S.A.		032136

Test Name	Result	Units	Normal Reference Range
CHEM-SCREEN PROFILE			
CALCIUM	9.70	mg/dL	9.00-10.40
PHOSPHATE (as PHOSPHORUS)	3.00	mg/dL	2.20-4.30
BUN	16.00	mg/dL	9.00-23.0
CREATININE	1.30	mg/dL	0.80-1.30
BUN/CREAT RATIO	12.31		12-20
URIC ACID	7.50	mg/dL	3.60-8.30
GLUCOSE	114.00	mg/dL	65.0-130
TOTAL PROTEIN	7.90	g/dL	6.50-8.00
ALBUMIN	5.10	g/dL	3.90-4.90
GLOBULIN	2.80	g/dL	2.10-3.50
ALB/GLOB RATIO	1.82		1.20-2.20
TOTAL BILIRUBIN	0.55	mg/dL	0.30-1.40
DIRECT BILIRUBIN	0.18	mg/dL	0.04-0.20
CHOLESTEROL	203.00	mg/dL	140-233
CHOLESTEROL PERCENTILE	50	PERCENTILE	1-74
HDL CHOLESTEROL	71	mg/dL	
CHOL./HDL CHOLESTEROL	*(01)-2.77		
TRIGLYCERIDES	148.00	mg/dL	50.0-200

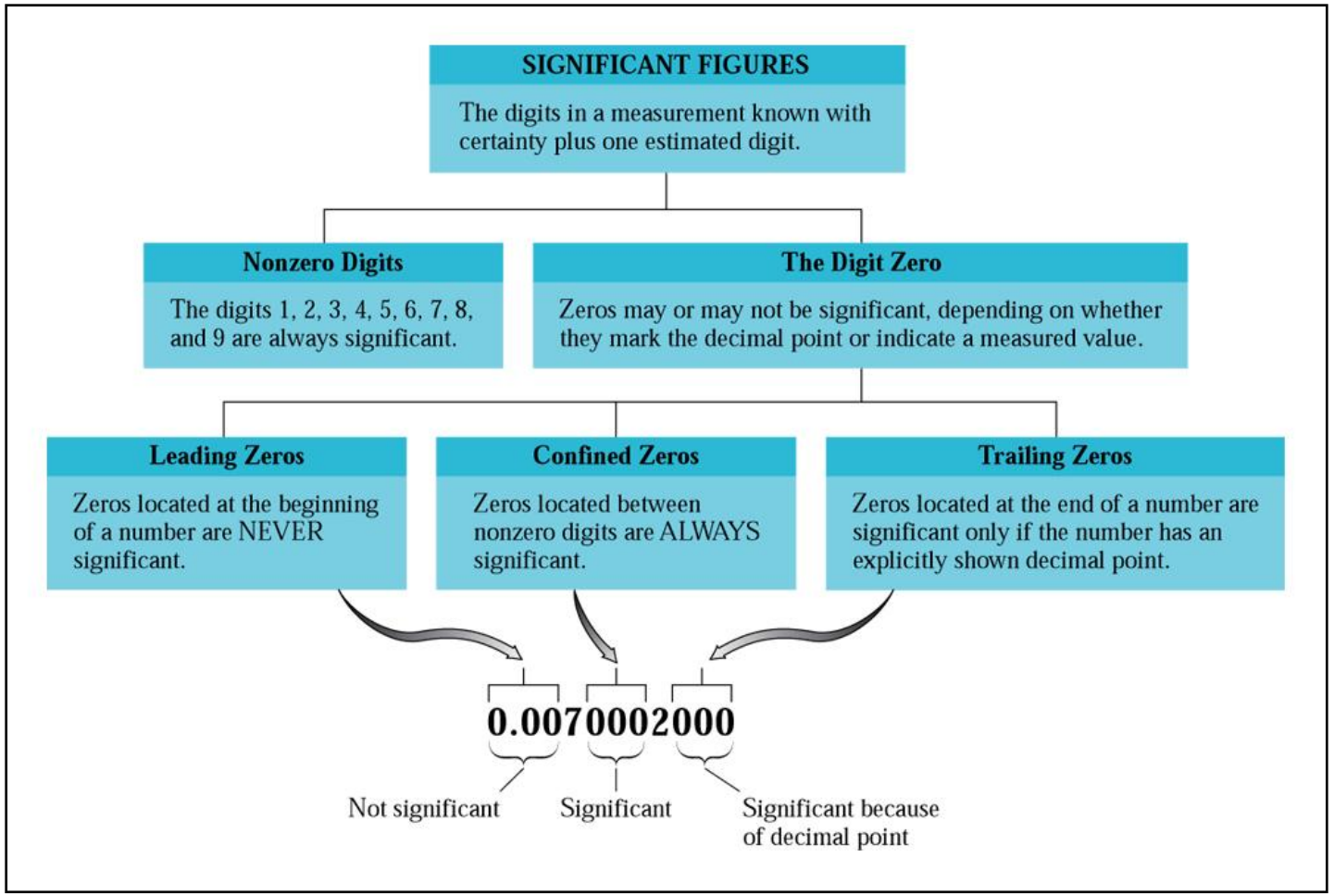
(01) THE RESULT OBTAINED FOR THE CHOLESTEROL/HDL CHOLESTEROL RATIO FOR THIS PATIENT'S SAMPLE IS ASSOCIATED WITH THE LOWEST CORONARY HEART DISEASE (CHD) RISK.

Uncertainty of Measurements



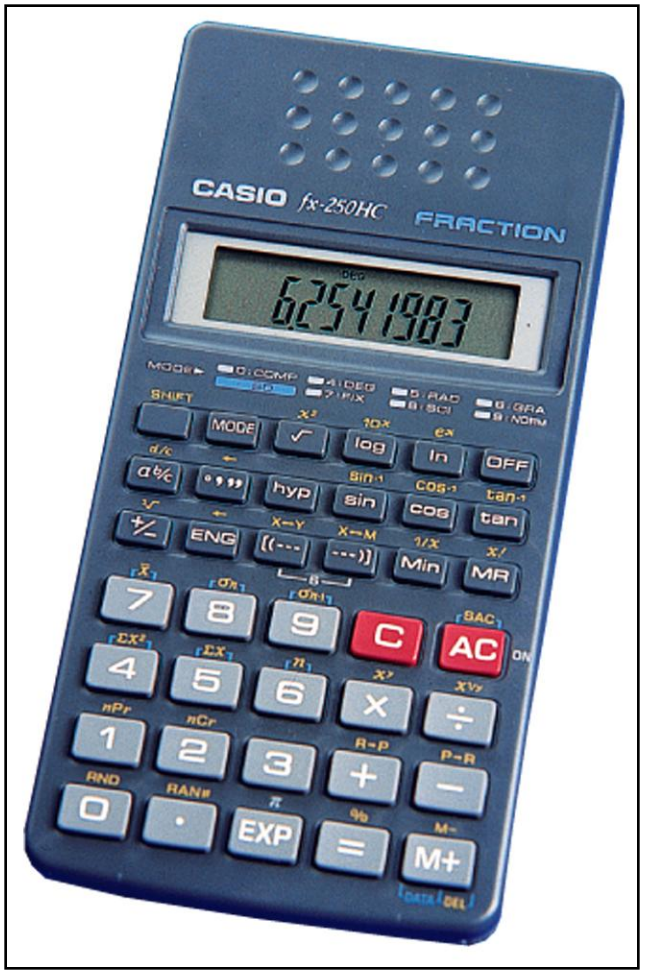
The scale on a measuring device determines the magnitude of the uncertainty for the recorded measurement.

Significant Figures in Measurements

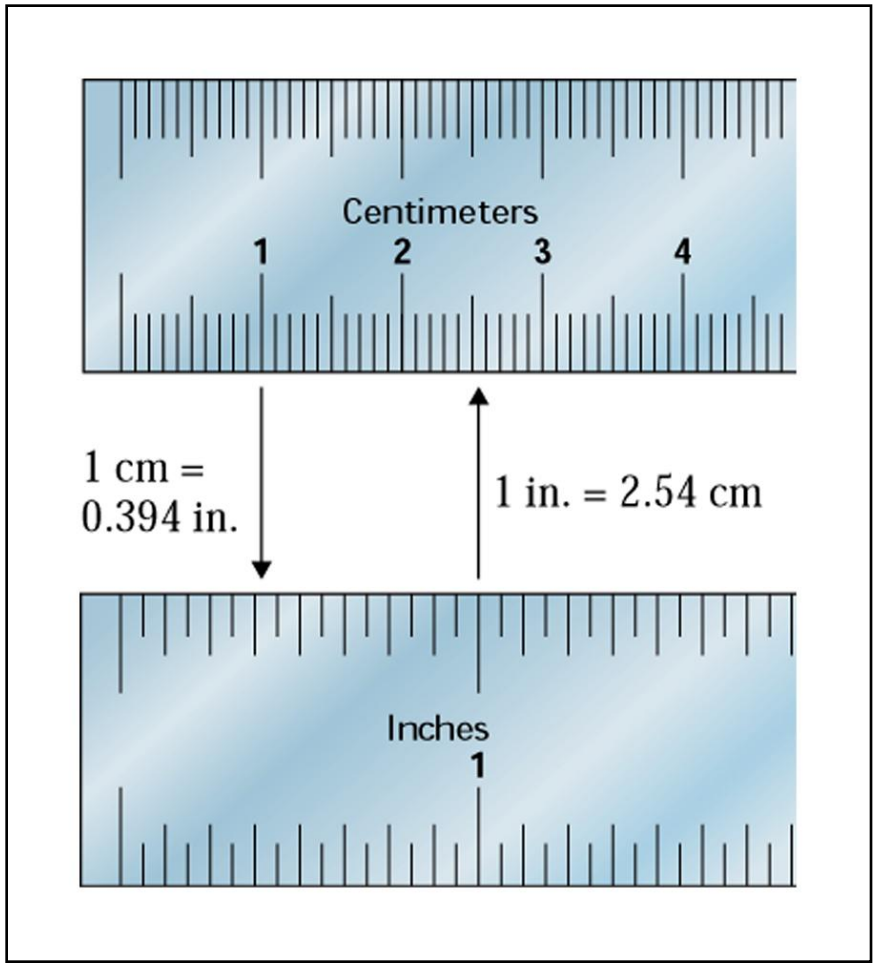


Rounding off from Calculator Answer

The digital readout on an electronic calculator usually shows more digits than are needed.



Unit Conversions



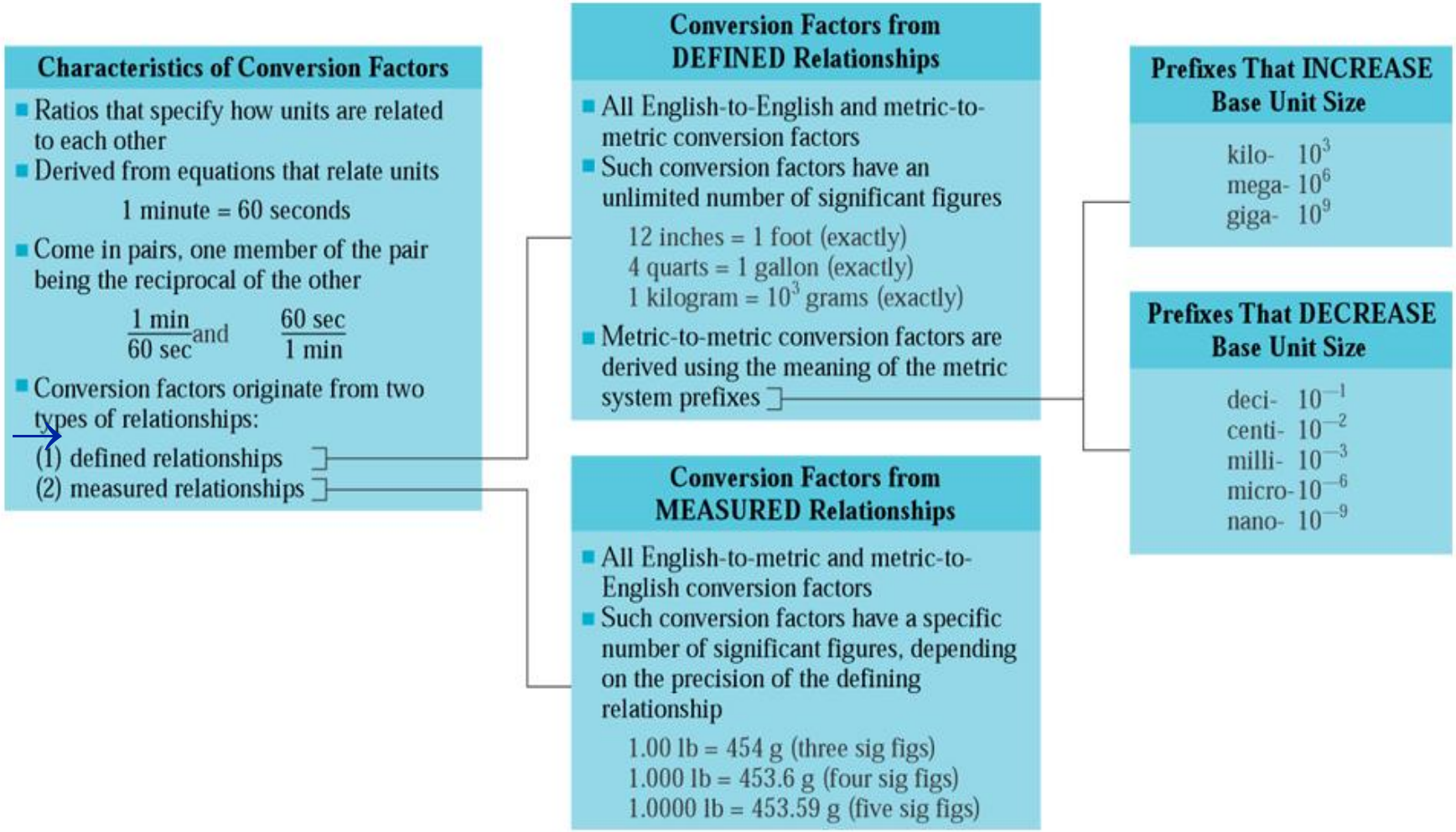
It is experimentally determined that 1 inch equals 2.54 cm, or 1 cm equals 0.394 inch

Unit Conversion Factors

	Metric to English	English to Metric
Length		
1.00 inch = 2.54 centimeters	$\frac{1.00\ \text{in.}}{2.54\ \text{cm}}$	$\frac{2.54\ \text{cm}}{1.00\ \text{in.}}$
1.00 meter = 39.4 inches	$\frac{39.4\ \text{in.}}{1.00\ \text{m}}$	$\frac{1.00\ \text{m}}{39.4\ \text{in.}}$
1.00 kilometer = 0.621 mile	$\frac{0.621\ \text{mi}}{1.00\ \text{km}}$	$\frac{1.00\ \text{km}}{0.621\ \text{mi}}$
Mass		
1.00 pound = 454 grams	$\frac{1.00\ \text{lb}}{454\ \text{g}}$	$\frac{454\ \text{g}}{1.00\ \text{lb}}$
1.00 kilogram = 2.20 pounds	$\frac{2.20\ \text{lb}}{1.00\ \text{kg}}$	$\frac{1.00\ \text{kg}}{2.20\ \text{lb}}$
1.00 ounce = 28.3 grams	$\frac{1.00\ \text{oz}}{28.3\ \text{g}}$	$\frac{28.3\ \text{g}}{1.00\ \text{oz}}$
Volume		
1.00 quart = 0.946 liter	$\frac{1.00\ \text{qt}}{0.946\ \text{L}}$	$\frac{0.946\ \text{L}}{1.00\ \text{qt}}$
1.00 liter = 0.265 gallon	$\frac{0.265\ \text{gal}}{1.00\ \text{L}}$	$\frac{1.00\ \text{L}}{0.265\ \text{gal}}$
1.00 milliliter = 0.034 fluid ounce	$\frac{0.034\ \text{fl oz}}{1.00\ \text{mL}}$	$\frac{1.00\ \text{mL}}{0.034\ \text{fl oz}}$

← *Table 2.2*

Common Conversion Factors



Densities and Masses

Both of these items have a mass of 23 grams, but they have very different volumes; therefore, their densities are different as well.

Properties of Gases, Liquids and Solids

→ **Table 2.3**

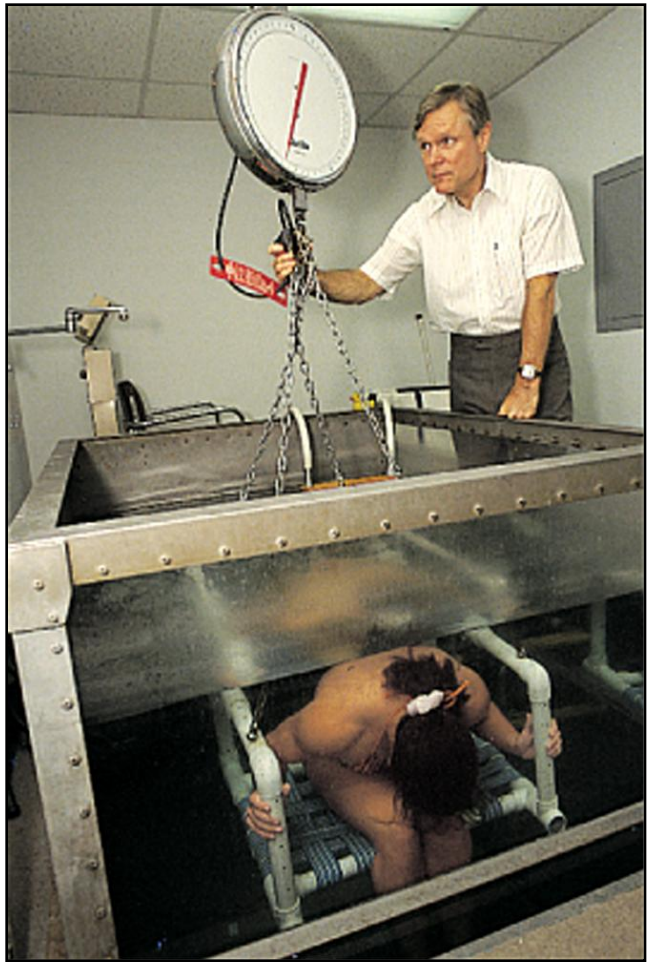
Solids (25°C)			
gold	19.3 g/cm^3	table salt	2.16 g/cm^3
lead	11.3 g/cm^3	bone	1.7–2.0 g/cm^3
copper	8.93 g/cm^3	table sugar	1.59 g/cm^3
aluminum	2.70 g/cm^3	wood (pine)	0.30–0.50 g/cm^3
Liquids (25°C)			
mercury	13.55 g/mL	water	0.997 g/mL
milk	1.028–1.035 g/mL	olive oil	0.92 g/mL
blood plasma	1.027 g/mL	ethyl alcohol	0.79 g/mL
urine	1.003–1.030 g/mL	gasoline	0.56 g/mL
Gases (25°C and 1 atmosphere pressure)			
chlorine	3.17 g/L	nitrogen	1.25 g/L
carbon dioxide	1.96 g/L	methane	0.66 g/L
oxygen	1.42 g/L	hydrogen	0.08 g/L
air (dry)	1.29 g/L		

Why the Coin floats on Mercury?

← **Fig. 2.9**

The penny is less dense than the mercury it floats on.

Measurements of Body Density



Specific Heat of Substances

→ **Table 2.4**

Substance	Specific Heat (cal/ g · °C)[a]
water, liquid	1.00
ethyl alcohol	0.58
olive oil	0.47
wood	0.42
aluminum	0.21
glass	0.12
silver	0.057
gold	0.031

[a]The unit notation cal/g · °C means calories per gram per degree Celsius.

Temperature Scales

Fig 2.10

The relationships among the Celsius, Kelvin, and Fahrenheit temperature scales are determined by the degree sizes and the reference point values.