CHEMISTRY AND MEASUREMENTS

Chapter 2

JOBS IN CHEMISTRY

- In addition to assisting physicians, **registered nurses** work to promote patient health and prevent and treat disease.

CHAPTER 2

- 2.1 – Units of Measurement
- 2.2 – Measured Numbers and Significant Figures
- 2.3 – Significant Figures and Calculations
- 2.4 – Prefixes and Equalities
- 2.5 – Writing Conversion Factors
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

2.1 – Units of Measurement

Write the names and abbreviations for the metric or SI units for: **length, volume, mass, temperature, and time.**

UNITS OF MEASUREMENT

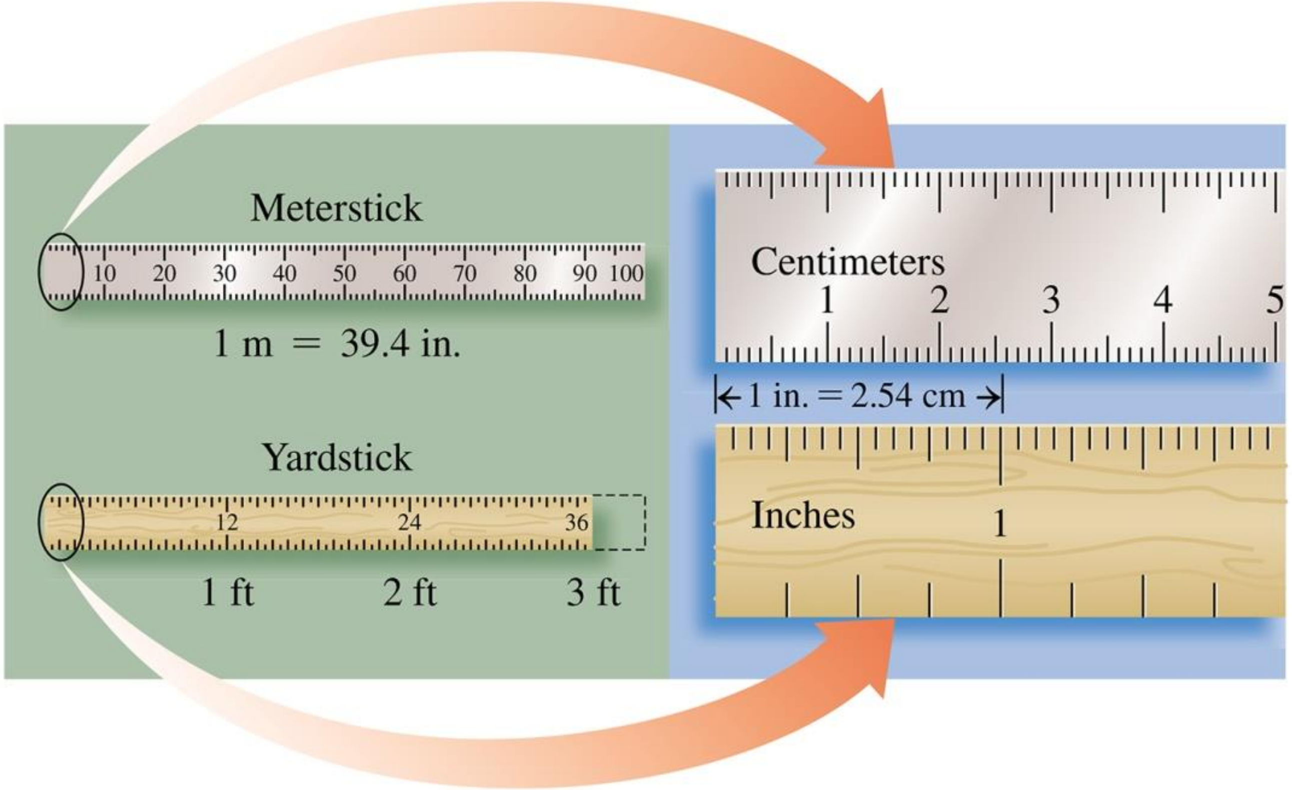
- Scientists use the **metric system** of measurement and a modified version called **Le Systeme International d'Unites** **(SI units)** as an official system used throughout the world for units of length, volume, mass, temperature, and time.

TABLE 2.1 Units of Measurement and Their Abbreviations

Measurement	Metric	SI
Length	meter (m)	meter (m)
Volume	liter (L)	cubic meter (m^3)
Mass	gram (g)	kilogram (kg)
Temperature	degree Celsius (°C)	kelvin (K)
Time	second (s)	second (s)

LENGTH: METER (m), CENTIMETER (cm)

- Length in the metric and SI systems is based on the meter, which is slightly longer than a yard.



1 m = 100 cm
1 m = 39.4 in

1 m = 1.09 yd
2.54 cm = 1 in

VOLUME: LITER (L) MILLILITER (mL)

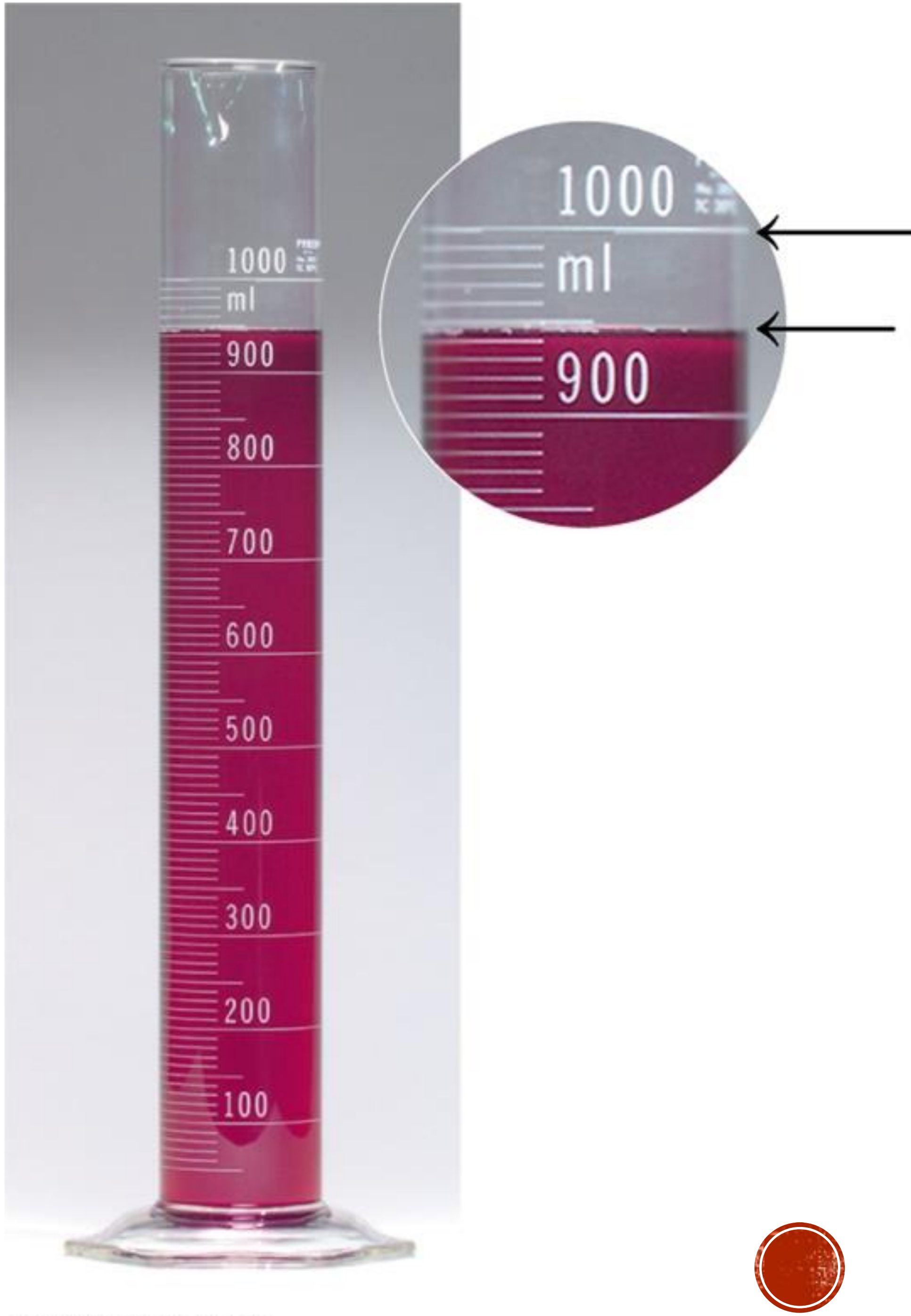
- Volume is the space occupied by a substance.

  Metric unit: m^3
  SI unit: liter

1 L = 1000 mL

1 L = 1.06 qt

946 mL = 1 qt



MASS: GRAM (g) KILOGRAM (kg)

- The mass of an object is a measure of the quantity of material it contains.

1 kg = 1000 g

1 kg = 2.20 lb

454 g = 1 lb

Metric unit: grams (g)
SI unit: kilograms (kg)

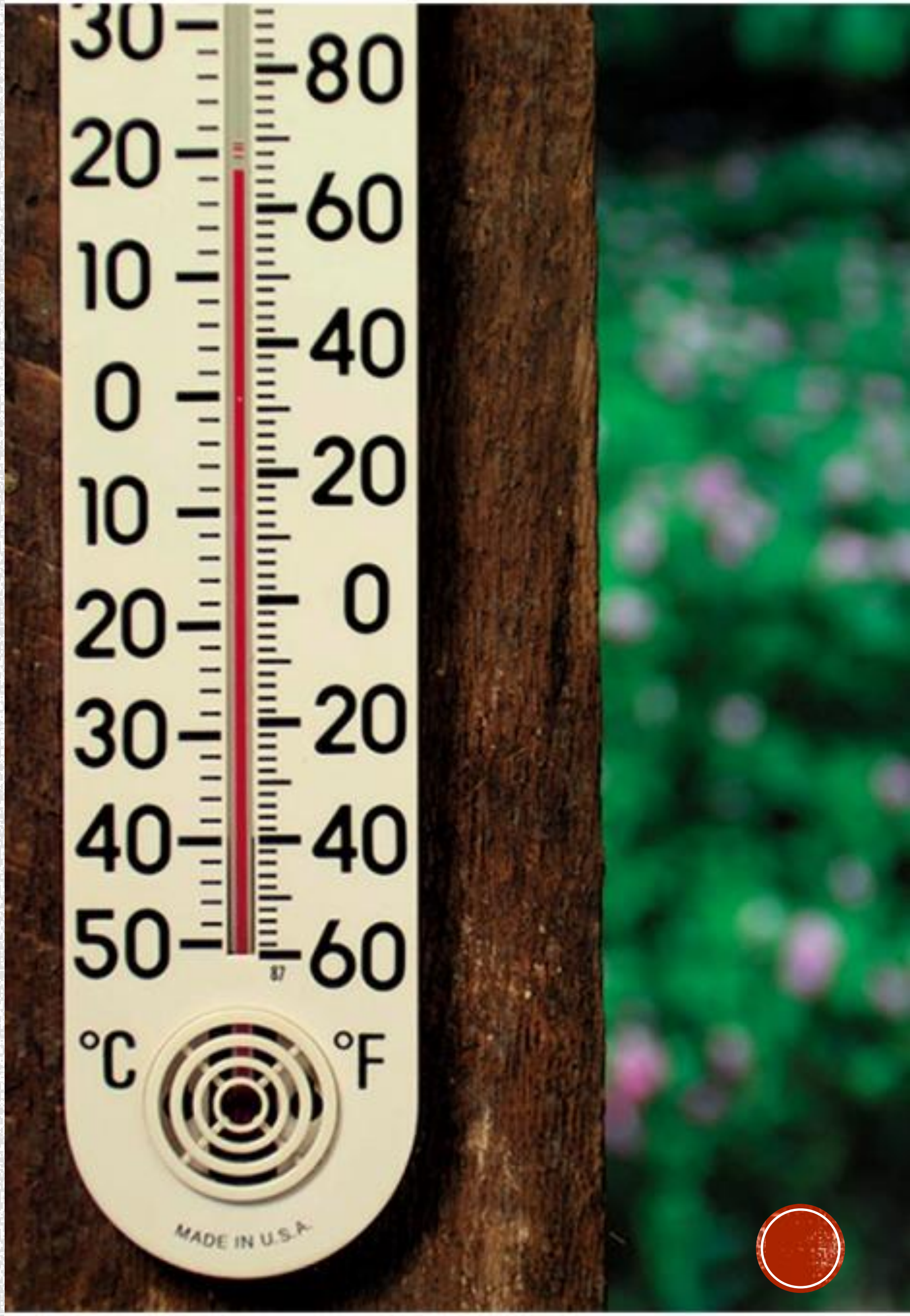
On an electronic balance, the digital readout gives the mass of a nickel, which is 5.01 g.

TEMPERATURE:
CELSIUS (°C) KELVIN (K)

- Temperature tells us how hot or cold something is.

Metric system: Celsius (°C)
SI system: Kelvin (K)

- Water freezes at 32°F, or 0°C, or 273.15K
- The Kelvin scale for temperature begins at the lowest possible temperature, 0K



TIME: SECONDS (s)

- Time is measured in units such as:
  - Years (yr)
  - Days
  - Hours (h)
  - Minutes (min)
  - Seconds (s)

- The SI and metric unit for time is the second (s).

STUDY CHECK

What are the SI units for the following?

A. Volume
B. Mass
C. Length
D. Temperature

CHAPTER 2

- ~~2.1 – Units of Measurement~~
- 2.2 – Measured Numbers and Significant Figures
- 2.3 – Significant Figures and Calculations
- 2.4 – Prefixes and Equalities
- 2.5 – Writing Conversion Factors
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

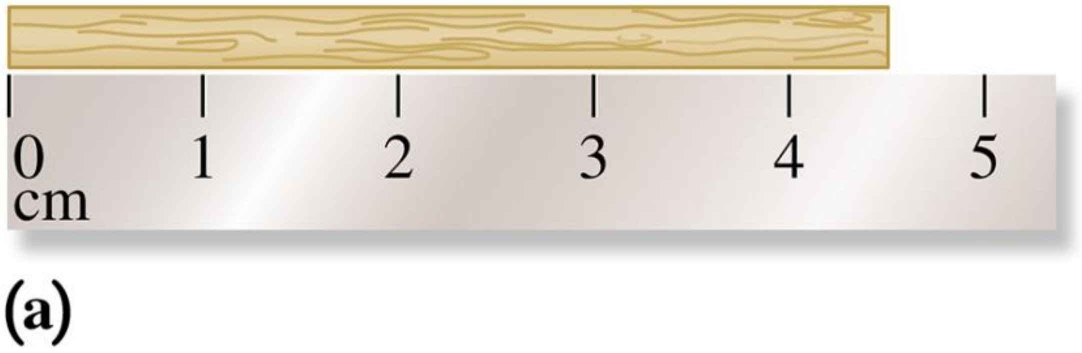
2.2 – MEASURED NUMBERS AND SIGNIFICANT FIGURES

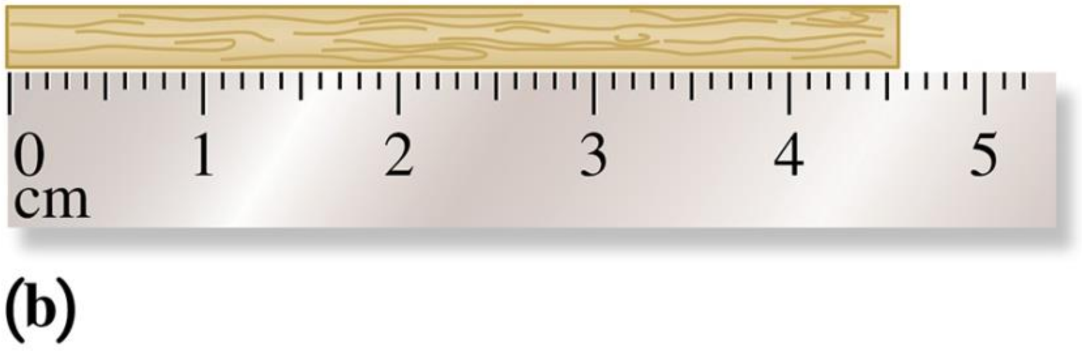
- Identify a number as measured or exact
- Determine the number of significant figures in a measured numbers

MEASURED NUMBERS

- **Measured numbers**: are the numbers obtained when you measure a quantity such as your height, weight, or temperature.

MEASURED NUMBERS FOR LENGTH

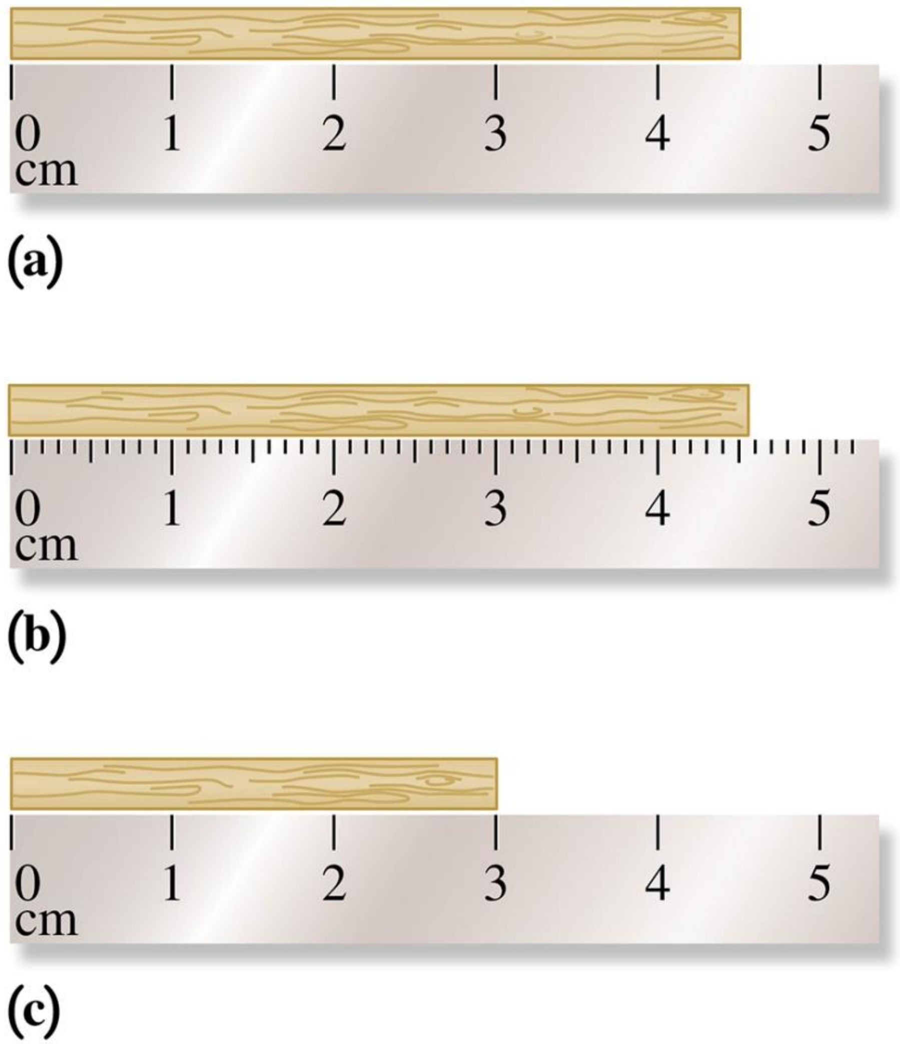




Taking a measurement:

- Notice the numbers and marks at the end of the object.
- *Estimate* the final digit between the marked lines.

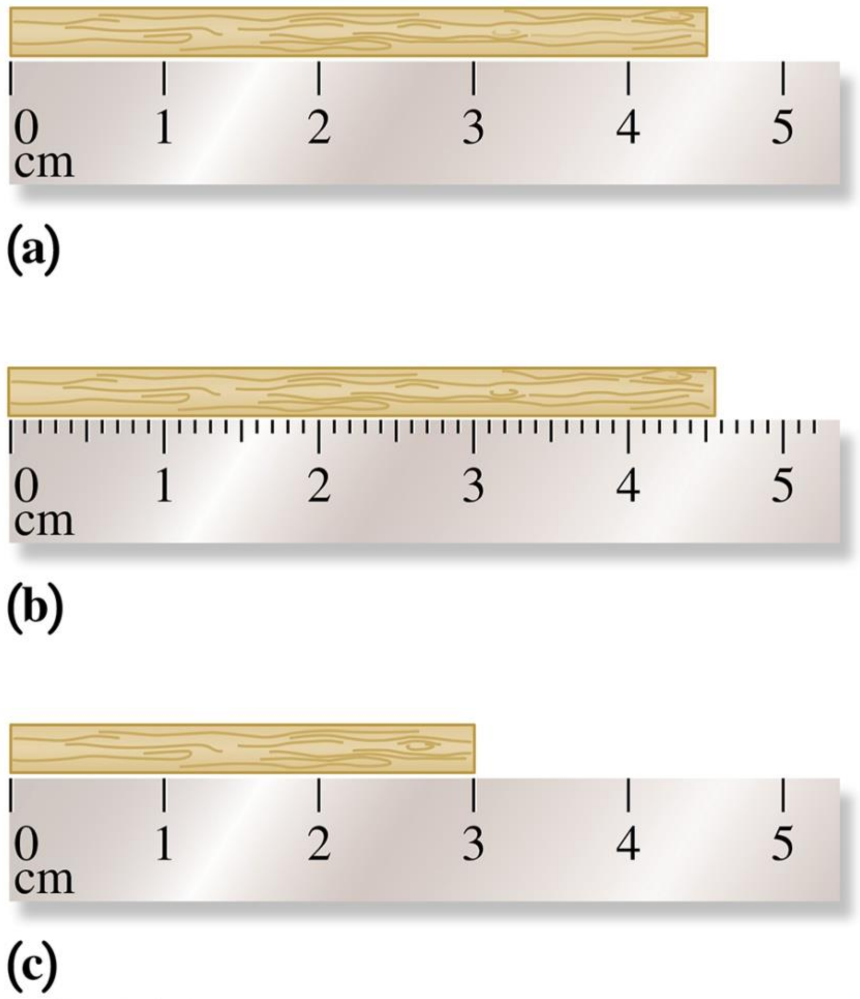
MEASURED NUMBERS FOR LENGTH



Taking a measurement:

- Notice the numbers and marks at the end of the object.
- *Estimate* the final digit between the marked lines.

SIGNIFICANT FIGURES



- **Significant figures:** the number of digits in a measured number including the estimated digit.

TABLE 2.2 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. a zero between nonzero digits	205 m 5.008 kg	3 4
c. a zero at the end of a decimal number	50. L 25.0 °C 16.00 g	2 3 4
d. in the coefficient of a number written in scientific notation	4.8×10^5 m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 cm	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

HOW MANY SIGNIFICANT FIGURES?

- 43.026 g
- 0.002650 m
- 1044000 L

TABLE 2.2 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. a zero between nonzero digits	205 m 5.008 kg	3 4
c. a zero at the end of a decimal number	50. L 25.0 °C 16.00 g	2 3 4
d. in the coefficient of a number written in scientific notation	4.8×10^5 m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 cm	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

HOW MANY SIGNIFICANT FIGURES?

- 1044000 L

- When one or more zeros at the end of a large number are significant, use scientific notation.
  - In our book, there may be a decimal at the end of a number if the zeros are significant.

HOW MANY SIGNIFICANT FIGURES?

- 0.0004 s

- Zeros at the beginning of a decimal number are used as placeholders and are **not** significant.

TABLE 2.2 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. a zero between nonzero digits	205 m 5.008 kg	3 4
c. a zero at the end of a decimal number	50. L 25.0 °C 16.00 g	2 3 4
d. in the coefficient of a number written in scientific notation	4.8×10^5 m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 cm	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

HOW MANY SIGNIFICANT FIGURES?

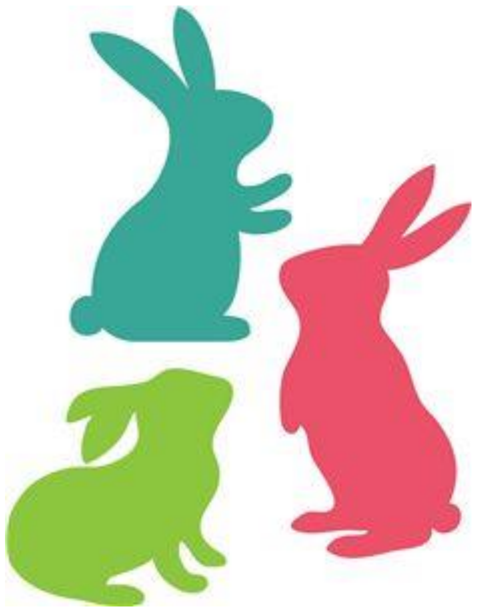
7.90×10^{-7}

009045.700

TABLE 2.2 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. a zero between nonzero digits	205 m 5.008 kg	3 4
c. a zero at the end of a decimal number	50. L 25.0 °C 16.00 g	2 3 4
d. in the coefficient of a number written in scientific notation	4.8×10^5 m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 cm	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

EXACT NUMBERS

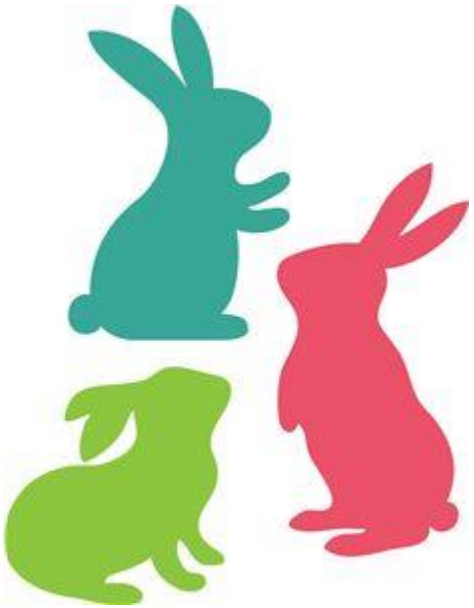


- **Exact numbers:**
  - Numbers obtained by counting items
    - 3 bunnies
    - $14.22
    - 7 coins
  - Numbers obtained by using a definition that compares two units in the same measuring system.
    - 1 L = 1000 mL
    - 1 ft = 12 in

EXACT NUMBERS

- Significant numbers do not apply!

- Exact numbers do not affect the number of significant figures in a calculation (see section 2.3)



CHAPTER 2

- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- 2.3 – Significant Figures and Calculations
- 2.4 – Prefixes and Equalities
- 2.5 – Writing Conversion Factors
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

2.3 – SIGNIFICANT FIGURES IN CALCULATIONS

- Adjust calculated numbers to give the correct number of significant figures

ROUNDING

- If the first digit to be dropped is *4 or less*, round down
  - 3.4
- If the first digit to be dropped is *5 or more,* round up
  - 3.6

MULTIPLICATION/DIVISION WITH MEASURED NUMBERS

- In multiplication and division, the final answer is written so that it has the same number of significant figure (SFs) as the measurement with the fewest SFs.

7.2 * 1.33

$$\frac{(2.075 * 0.585)}{8.42}$$

ADDITION/SUBSTRACTION WITH MEASURED NUMBERS

- In addition and subtraction, the final answer is written so that it ha the same number of decimal places as the measurement having the fewest decimal places.

```
  2.045
+ 34.1
_______
```

```
104.45
  0.838
+ 46
________
```

ADDING SIGNIFICANT ZEROS

$25.0 \div 5.0 = 5$

+/- AND */÷ WITH MEASURED NUMBERS

- In addition/subtraction AND division/multiplication are present, follow order of operations.
  - Parentheses first – follow rules pertaining to that calculation.
    - Make a note of "correct SFs" but keep the entire number for use in final calculation.
  - Perform division/multiplication – follow those rules *using the "correct" number from the first step*

$$\frac{(27.1 + 2.33)}{2.112}$$

+/- AND */÷ WITH MEASURED NUMBERS

(16.22 + 7.133) * 0.661

SIG FIGS CALCULATIONS SUMMARY

- **Multiplication/Division** – fewest number of SFs in original numbers = SFs in answer
- **Addition/Subtraction** – fewest decimal place in original numbers = number of decimal places in answer
- **Multiplication/Division AND Addition/Subtraction**
  - Follow order of operations (or parentheses)
    - Apply rule for operation done in parentheses
    - Use full number on calculator in next calculation
  - Do final calculation
    - Apply rule for final operation.

STUDY CHECK

11.11 - 2.5 - 7.000 = 1.610000000

72.11 ÷ 1.1 = 65.55454545

STUDY CHECK

(14.1 + 21.12) * 5.00 = 176.1000000

$$\frac{(1.5 + 73)}{2.14} = 34.8130$$

CHAPTER 2

- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- ~~2.3 – Significant Figures and Calculations~~
- 2.4 – Prefixes and Equalities
- 2.5 – Writing Conversion Factors
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

2.4 – Prefixes and Equalities

Use numerical values as prefixes to write a metric equality.

PREFIXES

A special feature of the SI and metric systems is that a **prefix may be placed** in front of any unit to increase or decrease its size by some factor of ten.

For example, the prefixes *milli* and *micro* are used to make smaller units.

milligram	(mg)
microgram	(μg or mcg)

micro(μ) and milli(m)

Prefixes can be applied to grams, meters, liters, and more

TABLE 2.5 Daily Values for Selected Nutrients

Nutrient	Amount Recommended
Protein	50 g
Vitamin C	60 mg
Vitamin B_{12}	6 μg (6 mcg)
Calcium	1000 mg
Copper	2 mg
Iodine	150 μg (150 mcg)
Iron	18 mg
Magnesium	400 mg
Niacin	20 mg
Potassium	3500 mg
Selenium	70 μg (70 mcg)
Sodium	2400 mg
Zinc	15 mg

centi (c) and deci (d)

Prefixes can be applied to grams, meters, liters, and more

kilo (k) and mega (M)

TABLE 2.4 Metric and SI Prefixes

Prefix	Symbol	Numerical Value	Scientific Notation	Equality
Prefixes That Increase the Size of the Unit				
peta	P	1 000 000 000 000 000	10^{15}	$1\ \text{Pg} = 10^{15}\ \text{g}$ $1\ \text{g} = 10^{-15}\ \text{Pg}$
tera	T	1 000 000 000 000	10^{12}	$1\ \text{Ts} = 1 \times 10^{12}\ \text{s}$ $1\ \text{s} = 1 \times 10^{-12}\ \text{Ts}$
giga	G	1 000 000 000	10^{9}	$1\ \text{Gm} = 1 \times 10^{9}\ \text{m}$ $1\ \text{m} = 1 \times 10^{-9}\ \text{Gm}$
mega	M	1 000 000	10^{6}	$1\ \text{Mg} = 1 \times 10^{6}\ \text{g}$ $1\ \text{g} = 1 \times 10^{-6}\ \text{Mg}$
kilo	k	1 000	10^{3}	$1\ \text{km} = 1 \times 10^{3}\ \text{m}$ $1\ \text{m} = 1 \times 10^{-3}\ \text{km}$

Prefixes That Decrease the Size of the Unit

deci	d	0.1	10^{-1}	$1\ dL = 1 \times 10^{-1}\ L$ $1\ L = 10\ dL$
centi	c	0.01	10^{-2}	$1\ cm = 1 \times 10^{-2}\ m$ $1\ m = 100\ cm$
milli	m	0.001	10^{-3}	$1\ ms = 1 \times 10^{-3}\ s$ $1\ s = 1 \times 10^{3}\ ms$
micro	μ*	0.000 001	10^{-6}	$1\ \mu g = 1 \times 10^{-6}\ g$ $1\ g = 1 \times 10^{6}\ \mu g$
nano	n	0.000 000 001	10^{-9}	$1\ nm = 1 \times 10^{-9}\ m$ $1\ m = 1 \times 10^{9}\ nm$
pico	p	0.000 000 000 001	10^{-12}	$1\ ps = 1 \times 10^{-12}\ s$ $1\ s = 1 \times 10^{12}\ ps$
femto	f	0.000 000 000 000 001	10^{-15}	$1\ fs = 10^{-15}\ s$ $1\ s = 10^{15}\ fs$

*In medicine and nursing, the abbreviation mc for the prefix micro is used because the symbol μ may be misread, which could result in a medication error. Thus, 1 μg would be written as 1 mcg.

MEASURING LENGTH - EXAMPLE

- Ophthalmologist measure the diameter of the eye's retina in centimeters (cm), while a surgeon measure the length of a nerve in millimeters (mm).

- Each of the following **equalities** describes the same length in a different unit:

  1 m = 10 dm

  1 m = 100 cm

  1 m = 1000 mm

Equalities: comparisons that show the relationship between two units.

MEASURING MASS - EXAMPLE

- When you visit the doctor, he or she records your mass in kilograms (kg) and laboratory results often in micrograms (μg or mcg).

1000 g = 1 kg

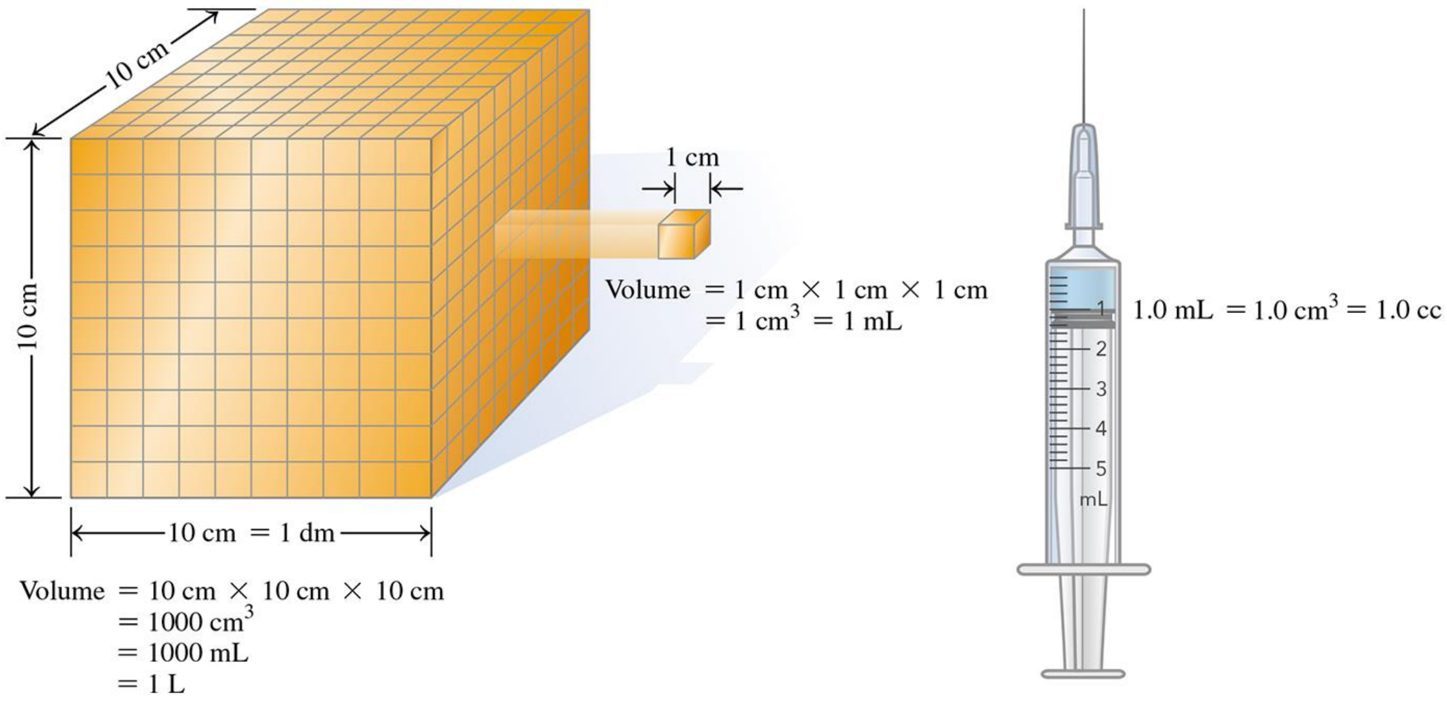
1 g = 1000 mg

1 g = 100 cg

TABLE 2.6 Some Typical Laboratory Test Values

Substance in Blood	Typical Range
Albumin	3.5–5.0 g/dL
Ammonia	20–150 mcg/dL
Calcium	8.5–10.5 mg/dL
Cholesterol	105–250 mg/dL
Iron (male)	80–160 mcg/dL
Protein (total)	6.0–8.0 g/dL

mL = cm^3 = cc



The **cubic centimeter** (abbreviated as cm^3 or cc) is the volume of a cube whose dimensions are 1 cm on each side.

A cubic centimeter has the same volume as a milliliter, and the units are often used interchangeably.

1 cm^3 = 1 cc = 1 mL and

1000 cm^3 = 1000 mL = 1 L

STUDY CHECK

Identify the larger unit:

mm or cm

Prefixes That Decrease the Size of the Unit

deci	d	0.1	10^{-1}	$1\ dL = 1 \times 10^{-1}\ L$ $1\ L = 10\ dL$
centi	c	0.01	10^{-2}	$1\ cm = 1 \times 10^{-2}\ m$ $1\ m = 100\ cm$
milli	m	0.001	10^{-3}	$1\ ms = 1 \times 10^{-3}\ s$ $1\ s = 1 \times 10^{3}\ ms$
micro	μ*	0.000 001	10^{-6}	$1\ \mu g = 1 \times 10^{-6}\ g$ $1\ g = 1 \times 10^{6}\ \mu g$
nano	n	0.000 000 001	10^{-9}	$1\ nm = 1 \times 10^{-9}\ m$ $1\ m = 1 \times 10^{9}\ nm$
pico	p	0.000 000 000 001	10^{-12}	$1\ ps = 1 \times 10^{-12}\ s$ $1\ s = 1 \times 10^{12}\ ps$
femto	f	0.000 000 000 000 001	10^{-15}	$1\ fs = 10^{-15}\ s$ $1\ s = 10^{15}\ fs$

*In medicine and nursing, the abbreviation mc for the prefix micro is used because the symbol μ may be misread, which could result in a medication error. Thus, 1 μg would be written as 1 mcg.

STUDY CHECK

Identify the larger unit:

kilogram or centigram

TABLE 2.4 Metric and SI Prefixes

Prefix	Symbol	Numerical Value	Scientific Notation	Equality
Prefixes That Increase the Size of the Unit				
peta	P	1 000 000 000 000 000	10^{15}	1 Pg = 10^{15} g 1 g = 10^{-15} Pg
tera	T	1 000 000 000 000	10^{12}	1 Ts = 1×10^{12} s 1 s = 1×10^{-12} Ts
giga	G	1 000 000 000	10^{9}	1 Gm = 1×10^{9} m 1 m = 1×10^{-9} Gm
mega	M	1 000 000	10^{6}	1 Mg = 1×10^{6} g 1 g = 1×10^{-6} Mg
kilo	k	1 000	10^{3}	1 km = 1×10^{3} m 1 m = 1×10^{-3} km
Prefixes That Decrease the Size of the Unit				
deci	d	0.1	10^{-1}	1 dL = 1×10^{-1} L 1 L = 10 dL
centi	c	0.01	10^{-2}	1 cm = 1×10^{-2} m 1 m = 100 cm
milli	m	0.001	10^{-3}	1 ms = 1×10^{-3} s 1 s = 1×10^{3} ms
micro	μ*	0.000 001	10^{-6}	1 μg = 1×10^{-6} g 1 g = 1×10^{6} μg
nano	n	0.000 000 001	10^{-9}	1 nm = 1×10^{-9} m 1 m = 1×10^{9} nm
pico	p	0.000 000 000 001	10^{-12}	1 ps = 1×10^{-12} s 1 s = 1×10^{12} ps
femto	f	0.000 000 000 000 001	10^{-15}	1 fs = 10^{-15} s 1 s = 10^{15} fs

*In medicine and nursing, the abbreviation mc for the prefix micro is used because the symbol μ may be misread, which could result in a medication error. Thus, 1 μg would be written as 1 mcg.

STUDY CHECK

Identify the larger unit:

kL or μL

TABLE 2.4 Metric and SI Prefixes

Prefix	Symbol	Numerical Value	Scientific Notation	Equality
Prefixes That Increase the Size of the Unit				
peta	P	1 000 000 000 000 000	10^{15}	1 Pg = 10^{15} g 1 g = 10^{-15} Pg
tera	T	1 000 000 000 000	10^{12}	1 Ts = 1×10^{12} s 1 s = 1×10^{-12} Ts
giga	G	1 000 000 000	10^{9}	1 Gm = 1×10^{9} m 1 m = 1×10^{-9} Gm
mega	M	1 000 000	10^{6}	1 Mg = 1×10^{6} g 1 g = 1×10^{-6} Mg
kilo	k	1 000	10^{3}	1 km = 1×10^{3} m 1 m = 1×10^{-3} km
Prefixes That Decrease the Size of the Unit				
deci	d	0.1	10^{-1}	1 dL = 1×10^{-1} L 1 L = 10 dL
centi	c	0.01	10^{-2}	1 cm = 1×10^{-2} m 1 m = 100 cm
milli	m	0.001	10^{-3}	1 ms = 1×10^{-3} s 1 s = 1×10^{3} ms
micro	μ*	0.000 001	10^{-6}	1 μg = 1×10^{-6} g 1 g = 1×10^{6} μg
nano	n	0.000 000 001	10^{-9}	1 nm = 1×10^{-9} m 1 m = 1×10^{9} nm
pico	p	0.000 000 000 001	10^{-12}	1 ps = 1×10^{-12} s 1 s = 1×10^{12} ps
femto	f	0.000 000 000 000 001	10^{-15}	1 fs = 10^{-15} s 1 s = 10^{15} fs

*In medicine and nursing, the abbreviation mc for the prefix micro is used because the symbol μ may be misread, which could result in a medication error. Thus, 1 μg would be written as 1 mcg.

CHAPTER 2

- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- ~~2.3 – Significant Figures and Calculations~~
- ~~2.4 – Prefixes and Equalities~~
- 2.5 – Writing Conversion Factors
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

2.5 – Writing Conversion Factors

Write a **conversion factor** for two units that describe the same quantity.

EQUALITIES

Equalities: use two different units to describe the same measured amount!

1 m = 1000 mm (10^3 mm)

1 lb = 16 oz

2.20 lb = 1 kg

- Many problems in chemistry and the health sciences require you to change from one unit to another unit.

You do this everyday…

- For example: suppose you worked 2 hours on your homework. A friend asked how many minutes you worked. You say "120 minutes."

When you expressed 2 hr as 120 mins, you did not change the amount of time you spent studying. **You changed which unit you used to describe it.**

CONVERSION FACTORS

Any equality can be written as fractions called **conversion factors** with one of the quantities in the numerator and the other quantity in the denominator.

Equality: 1 hour = 60 minutes

Equality: 100 cm = 1 m

Be sure to include units!

Two conversion factors are always possible for any equality.

CONVERSION FACTORS AND SIG FIGS

The numbers in:

- any equality **between two metric units OR between two U.S. system units** are obtained by definition and are, therefore, exact numbers.

- **a definition** are exact and are not used to determine significant figures.

- an equality **between metric and U.S. units** contain one number obtained by measurement and count toward the significant figures.

Exception: The equality 1 in. = 2.54 cm has been defined as an exact relationship. Therefore, 2.54 is an exact number.

Prefix	Symbol	Numerical Value	Notation	Equality
Prefixes That Increase the Size of the Unit				
peta	P	1 000 000 000 000 000	10^{15}	$1\ Pg = 10^{15}\ g$ $1\ g = 10^{-15}\ Pg$
tera	T	1 000 000 000 000	10^{12}	$1\ Ts = 1 \times 10^{12}\ s$ $1\ s = 1 \times 10^{-12}\ Ts$
giga	G	1 000 000 000	10^{9}	$1\ Gm = 1 \times 10^{9}\ m$ $1\ m = 1 \times 10^{-9}\ Gm$
mega	M	1 000 000	10^{6}	$1\ Mg = 1 \times 10^{6}\ g$ $1\ g = 1 \times 10^{-6}\ Mg$
kilo	k	1 000	10^{3}	$1\ km = 1 \times 10^{3}\ m$ $1\ m = 1 \times 10^{-3}\ km$
deci	d	0.1	10^{-1}	$1\ dL = 1 \times 10^{-1}\ L$ $1\ L = 10\ dL$
centi	c	0.01	10^{-2}	$1\ cm = 1 \times 10^{-2}\ m$ $1\ m = 100\ cm$
milli	m	0.001	10^{-3}	$1\ ms = 1 \times 10^{-3}\ s$ $1\ s = 1 \times 10^{3}\ ms$
micro	μ*	0.000 001	10^{-6}	$1\ \mu g = 1 \times 10^{-6}\ g$ $1\ g = 1 \times 10^{6}\ \mu g$
nano	n	0.000 000 001	10^{-9}	$1\ nm = 1 \times 10^{-9}\ m$ $1\ m = 1 \times 10^{9}\ nm$
pico	p	0.000 000 000 001	10^{-12}	$1\ ps = 1 \times 10^{-12}\ s$ $1\ s = 1 \times 10^{12}\ ps$
femto	f	0.000 000 000 000 001	10^{-15}	$1\ fs = 10^{-15}\ s$ $1\ s = 10^{15}\ fs$

TABLE 2.7 Some Common Equalities

Quantity	Metric (SI)	U.S.	Metric–U.S.
Length	1 km = 1000 m	1 ft = 12 in.	2.54 cm = 1 in. (exact)
	1 m = 1000 mm	1 yd = 3 ft	1 m = 39.4 in.
	1 cm = 10 mm	1 mi = 5280 ft	1 km = 0.621 mi
Volume	1 L = 1000 mL	1 qt = 4 cups	946 mL = 1 qt
	1 dL = 100 mL	1 qt = 2 pt	1 L = 1.06 qt
	1 mL = 1 cm^3	1 gal = 4 qt	473 mL = 1 pt
	1 mL = 1 cc*		1 mL = 15 drops*
			5 mL = 1 tsp*
			15 mL = 1 T (tbsp)*
Mass	1 kg = 1000 g	1 lb = 16 oz	1 kg = 2.20 lb
	1 g = 1000 mg		454 g = 1 lb
	1 mg = 1000 mcg*		
Time	1 h = 60 min	1 h = 60 min	
	1 min = 60 s	1 min = 60 s	

*Used in nursing and medicine.

STUDY CHECK

Write the conversion factors from the equalities:

liters and milliliters

meters and inches (1 m = 39.4 in)

meters and kilometers

Prefix	Symbol	Numerical Value	Notation	Equality
Prefixes That Increase the Size of the Unit				
peta	P	1 000 000 000 000 000	10^{15}	$1\ Pg = 10^{15}\ g$ $1\ g = 10^{-15}\ Pg$
tera	T	1 000 000 000 000	10^{12}	$1\ Ts = 1 \times 10^{12}\ s$ $1\ s = 1 \times 10^{-12}\ Ts$
giga	G	1 000 000 000	10^{9}	$1\ Gm = 1 \times 10^{9}\ m$ $1\ m = 1 \times 10^{-9}\ Gm$
mega	M	1 000 000	10^{6}	$1\ Mg = 1 \times 10^{6}\ g$ $1\ g = 1 \times 10^{-6}\ Mg$
kilo	k	1 000	10^{3}	$1\ km = 1 \times 10^{3}\ m$ $1\ m = 1 \times 10^{-3}\ km$
Prefixes That Decrease the Size of the Unit				
deci	d	0.1	10^{-1}	$1\ dL = 1 \times 10^{-1}\ L$ $1\ L = 10\ dL$
centi	c	0.01	10^{-2}	$1\ cm = 1 \times 10^{-2}\ m$ $1\ m = 100\ cm$
milli	m	0.001	10^{-3}	$1\ ms = 1 \times 10^{-3}\ s$ $1\ s = 1 \times 10^{3}\ ms$
micro	μ*	0.000 001	10^{-6}	$1\ \mu g = 1 \times 10^{-6}\ g$ $1\ g = 1 \times 10^{6}\ \mu g$
nano	n	0.000 000 001	10^{-9}	$1\ nm = 1 \times 10^{-9}\ m$ $1\ m = 1 \times 10^{9}\ nm$
pico	p	0.000 000 000 001	10^{-12}	$1\ ps = 1 \times 10^{-12}\ s$ $1\ s = 1 \times 10^{12}\ ps$
femto	f	0.000 000 000 000 001	10^{-15}	$1\ fs = 10^{-15}\ s$ $1\ s = 10^{15}\ fs$

EQUALITIES AND CONVERSION FACTORS
WITHIN A PROBLEM

An equality may also be stated within a problem that applies only to that problem.

The car was traveling at a speed of 85 km/h.

One tablet contains 500 mg of vitamin C.

EQUALITIES AND CONVERSION FACTORS

DOSAGE PROBLEMS

Equalities stated within dosage problems for medication can also be written as conversion factors.

Keflex (Cephalexin), an antibiotic used for respiratory and ear infections, is available in 250-mg capsules.

EQUALITIES AND CONVERSION FACTORS

percentage

A percentage (%) is written as a conversion factor by choosing a unit and expressing the numerical relationship of the parts of this unit to 100 parts of the whole.

A person might have 18% body fat by mass.

EQUALITIES AND CONVERSION FACTORS

ppm, ppb

- To indicate very small ratios, we use parts per million (ppm) and parts per billion (ppb).

Ratio	Units
parts per million (ppm)	milligrams per kilogram (mg/kg)
parts per billion (ppb)	micrograms per kilogram (μg/kg, mcg/kg)

STUDY CHECK

Write the equality and its corresponding conversion factors.

Salmon contains 1.9% omega-3 fatty acids by mass.

STUDY CHECK

Write the equality and its corresponding conversion factors.

Meters and centimeters (length)

STUDY CHECK

Write the equality and its corresponding conversion factors.

Jewelry that contains 18% gold (percentage)

STUDY CHECK

Write the equality and its corresponding conversion factors.

One gallon of gas is $3.40

CHAPTER 2

- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- ~~2.3 – Significant Figures and Calculations~~
- ~~2.4 – Prefixes and Equalities~~
- ~~2.5 – Writing Conversion Factors~~
- 2.6 – Problem Solving using Unit Conversion
- 2.7 – Density

2.6 – Problem Solving Using Unit Conversion

Use conversion factors to change from one unit to another.

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

The process of problem solving in chemistry often requires one or more conversion factors to change a given unit to the needed unit.

Problem solving in chemistry requires:

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

- If a person weights 164 lb, what is the body mass in kilograms? (1 kg = 2.20 lb)

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

GUIDE TO PROBLEM SOLVING

USING UNIT CONVERSION

- A rattlesnake is 2.44 m long. How many centimeters long is the snake?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

GUIDE TO PROBLEM SOLVING

USING UNIT CONVERSION

- The Daily Value (DV) for phosphorus is 800 mg. How many grams of phosphorus is that?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

- The "train tracks" method of writing can help keep problem solving neat.

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

- Two or more conversion factors are often needed to complete the change of units.
- In setting up these problems, one factor follows the other.
- Each factor is arranged to cancel the proceeding unit until the needed unit is obtained.

$$3\ days\ x\ \frac{24\ hours}{1\ day}\ x\ \frac{60\ mins}{1\ hour}\ x\ \frac{60\ secs}{1\ min} = 259200\ seconds$$

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

- How many minutes are in 1.4 days?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

- A doctor prescribed a dosage of 0.150 mg of Synthroid. If tablets contain 75μg of Synthroid, how many tablets are required?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

GUIDE TO PROBLEM SOLVING
USING UNIT CONVERSION

- If your pace on a treadmill is 65 meters per minute, how many minutes will it take you to walk 7.5 kilometers?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

CHAPTER 2

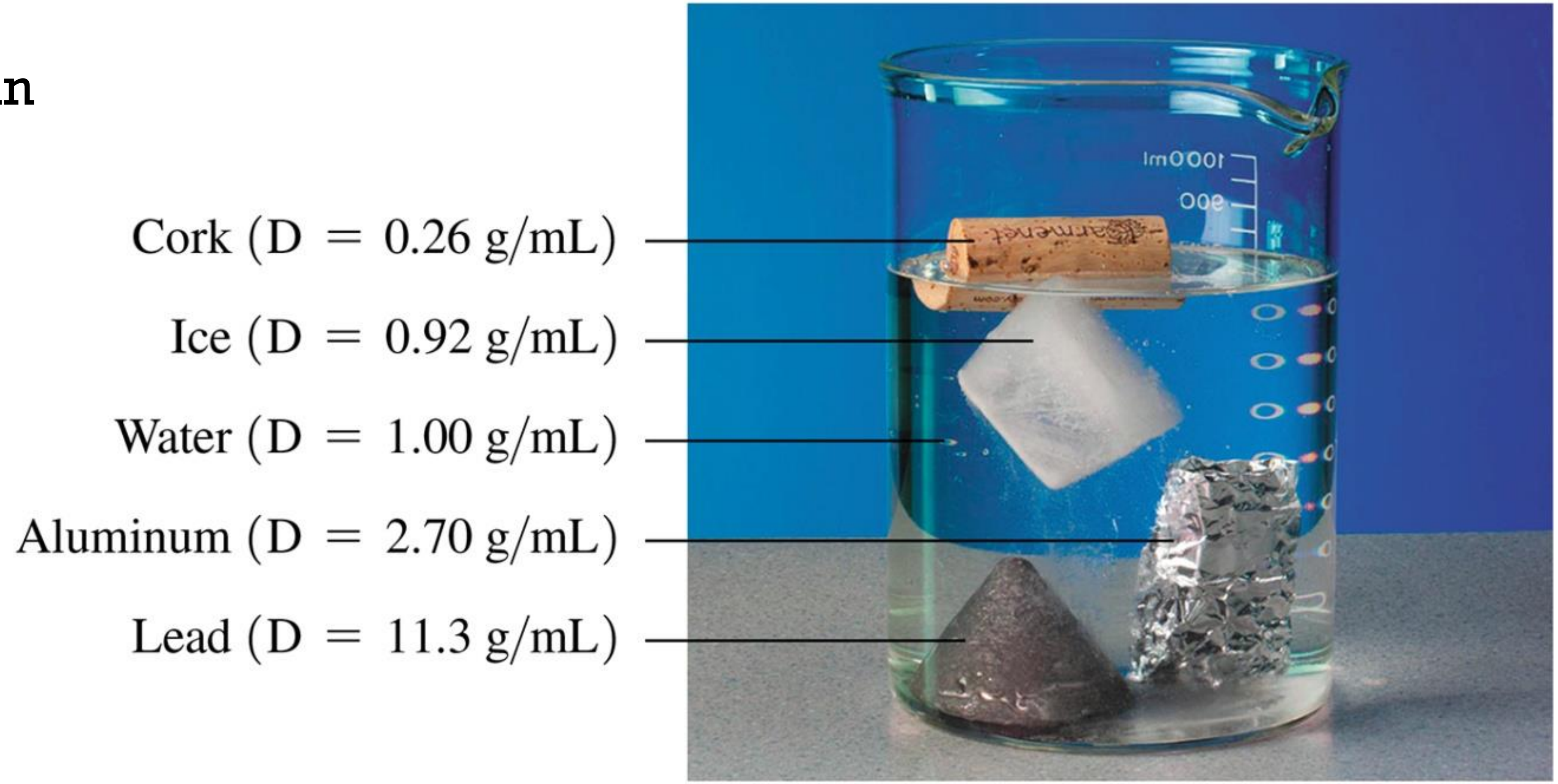
- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- ~~2.3 – Significant Figures and Calculations~~
- ~~2.4 – Prefixes and Equalities~~
- ~~2.5 – Writing Conversion Factors~~
- ~~2.6 – Problem Solving using Unit Conversion~~
- 2.7 – Density

2.7 - DENSITY

Calculate the density of a substance; use the density to calculate the mass or volume of a substance.

DENSITY

Objects that sink in water are more dense than water; objects that float are less dense.



CALCULATING DENSITY

Density compares the mass of an object to its volume.

$$\text{Density} = \frac{\text{mass of a substance}}{\text{volume of a substance}}$$

$$\text{Density of solids, liquids} = \frac{g}{cm^3} \text{ or } \frac{g}{mL}$$

$$\text{Density of gas} = \frac{g}{L}$$

Note: $1\ mL = 1\ cm^3$

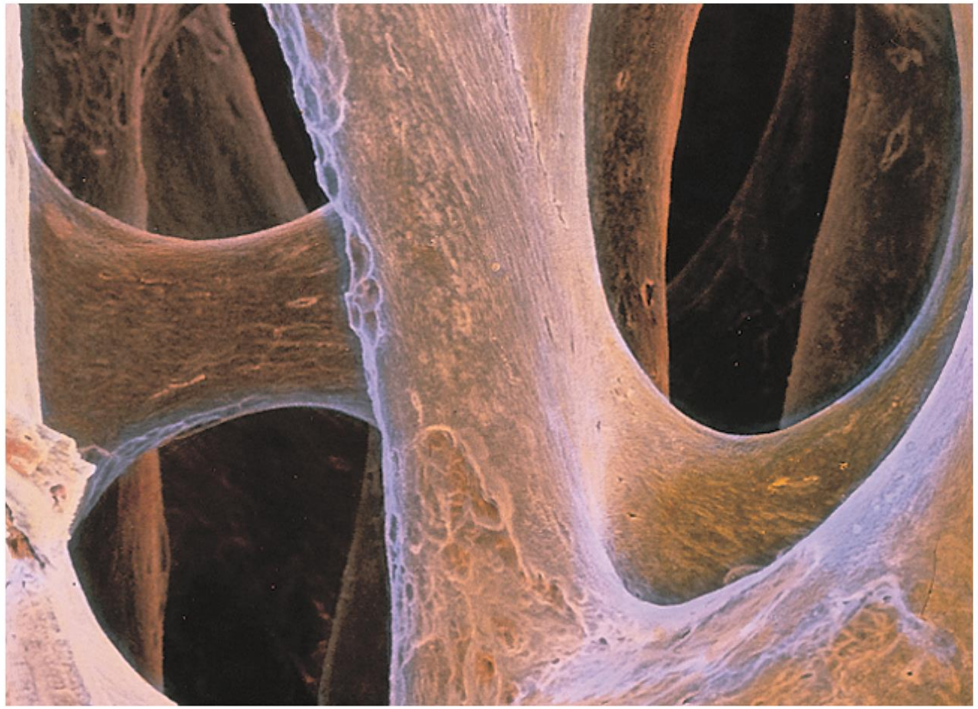
TABLE 2.9 Densities of Some Common Substances

Solids (at 25 °C)	Density (g/mL)	Liquids (at 25 °C)	Density (g/mL)	Gases (at 0 °C)	Density (g/L)
Cork	0.26	Gasoline	0.74	Hydrogen	0.090
Body fat	0.909	Ethanol	0.79	Helium	0.179
Ice (at 0 °C)	0.92	Olive oil	0.92	Methane	0.714
Muscle	1.06	Water (at 4 °C)	1.00	Neon	0.902
Sugar	1.59	Urine	1.012–1.030	Nitrogen	1.25
Bone	1.80	Plasma (blood)	1.03	Air (dry)	1.29
Salt (NaCl)	2.16	Milk	1.04	Oxygen	1.43
Aluminum	2.70	Blood	1.06	Carbon dioxide	1.96
Iron	7.86	Mercury	13.6		
Copper	8.92				
Silver	10.5				
Lead	11.3				
Gold	19.3				

OSTEOPOROSIS AND BONE DENSITY

When young, bone grows faster than it degenerates…

…but as we age, growth slows, which can lead to loss of bone density.



(a) Normal bone

(b) Bone with osteoporosis

To prevent osteoporosis, bones need calcium and vitamin D. Also, increasing muscle strength increases bone strength.

PROBLEM SOLVING USING DENSITY

John took 2.0 teaspoons (tsp) of cough syrup. If the syrup had a density of 1.20 g/mL and there is 5.0 mL in 1 tsp, what was the mass, in grams, of the cough syrup?

Step 1: State the given and needed quantities (units).

Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

PROBLEM SOLVING USING DENSITY

An unknown liquid has a density of 1.32 g/mL. What is the volume (mL) of a 14.7 g sample of the liquid?

Step 1: State the given and needed quantities (units).

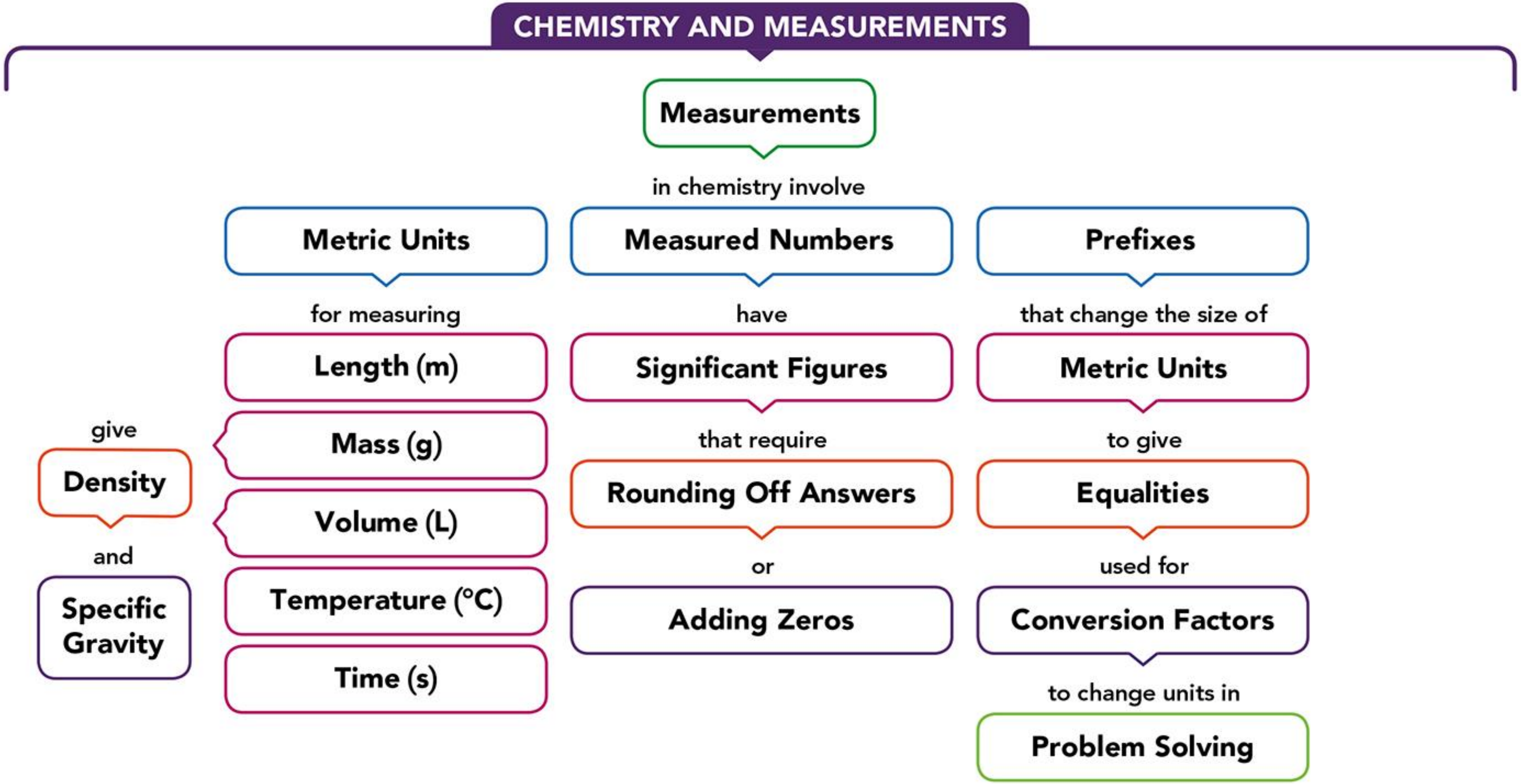
Step 2: Write a plan to convert the given unit to the needed unit.

Step 3: State the equalities and conversion factors

Step 4: Set up the problem to cancel units and calculate the answer.

CHAPTER 2

- ~~2.1 – Units of Measurement~~
- ~~2.2 – Measured Numbers and Significant Figures~~
- ~~2.3 – Significant Figures and Calculations~~
- ~~2.4 – Prefixes and Equalities~~
- ~~2.5 – Writing Conversion Factors~~
- ~~2.6 – Problem Solving using Unit Conversion~~
- ~~2.7 – Density~~


CHEMISTRY AND MEASUREMENTS
Measurements
in chemistry involve
Metric Units
Measured Numbers
Prefixes
for measuring
have
that change the size of
Length (m)
Significant Figures
Metric Units
give
Mass (g)
that require
to give
Density
Volume (L)
Rounding Off Answers
Equalities
and
or
used for
Specific Gravity
Temperature (°C)
Adding Zeros
Conversion Factors
Time (s)
to change units in
Problem Solving