Chapter 2

Goals:

- ✓ To be able to use the metric and SI units to express measurements in mass, length, volume, density and temperature.
- ✓ To be able to convert quantities from one unit to another.
- ✓ To be able to express measurements and answers to the correct number of significant figures.
- ✓ To be able to use scientific notation when necessary to reflect the correct significant figures.

Metric System

Based on the decimal system, the metric system is the common system used for scientific measurements.

TABLE 2.2 Some Prefixes for Multiples of Metric and SI Units

PREFIX	SYMBOL	BASE UNIT MULTIPLIED BY*	EXAMPLE
mega	M	1,000,000 = 10^6	1 megameter (Mm) = 10^6 m
kilo	k	1000 = 10^3	1 kilogram (kg) = 10^3 g
hecto	h	100 = 10^2	1 hectogram (hg) = 100 g
deka	da	10 = 10^1	1 dekaliter (daL) = 10 L
deci	d	0.1 = 10^{-1}	1 deciliter (dL) = 0.1 L
centi	c	0.01 = 10^{-2}	1 centimeter (cm) = 0.01 cm
milli	m	0.001 = 10^{-3}	1 milligram (mg) = 0.001 g
micro	μ	0.000 001 = 10^{-6}	1 micrometer (μm) = 10^{-6} m
nano	n	0.000 000 001 = 10^{-9}	1 nanogram (ng) = 10^{-9} g
pico	p	0.000 000 000 001 = 10^{-12}	1 picogram (pg) = 10^{-12} g
femto	f	0.000 000 000 000 001 = 10^{-15}	1 femtogram = 10^{-15} g

**The scientific notation method of writing large and small numbers (for example, 10^6 for 1,000,000) is explained in Section 2.5.*

International System of Units (SI Units)

Internationally agreed upon choice of metric units; consists of base units from which all other units can be derived.

TABLE 2.1 Some SI and Metric Units and Their Equivalents

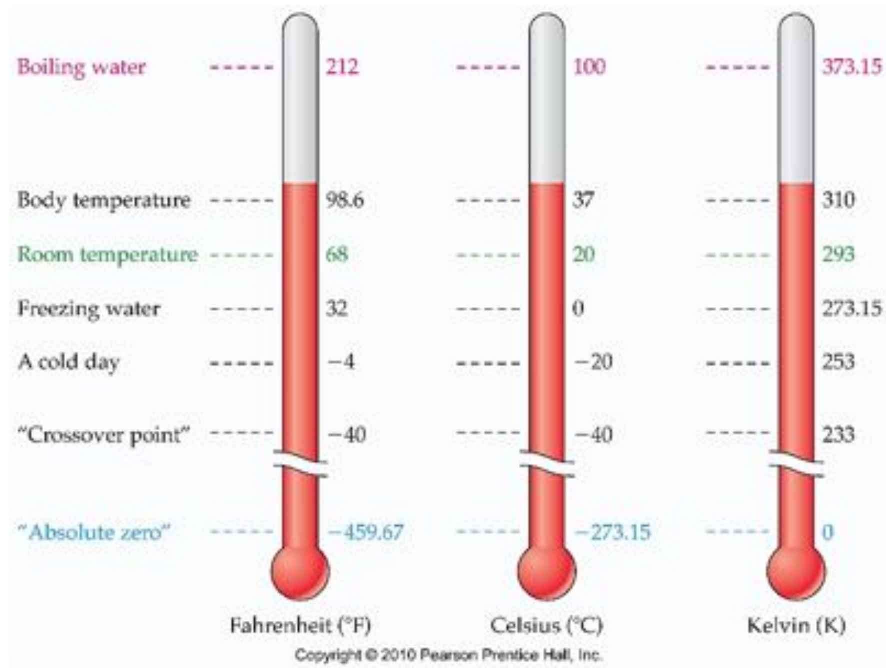
QUANTITY	SI UNIT (SYMBOL)	METRIC UNIT (SYMBOL)	EQUIVALENTS
Mass	Kilogram (kg)	Gram (g)	1 kg = 1000 g = 2.205 lb
Length	Meter (m)	Meter (m)	1 m = 3.280 ft
Volume	Cubic meter (m^3)	Liter (L)	1 m^3 = 1000 L = 264.2 gal
Temperature	Kelvin (K)	Celsius degree (°C)	See Section 2.9
Time	Second (s)	Second (s)	—

Temperature: The measure of how hot or cold an object is.

- **SI Unit:** Kelvin (K)
- **Common Units:** Celsius (ºC) or Fahrenheit (ºF)

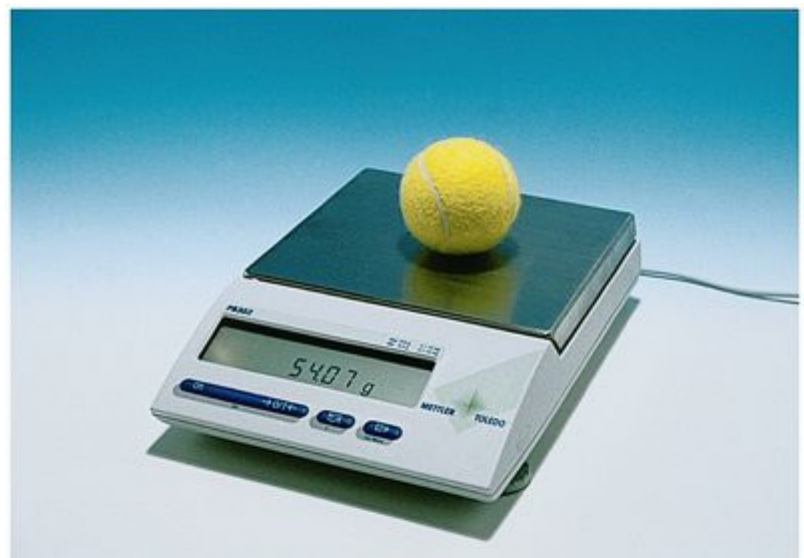
Converting between K and ºC:
K=ºC+273
ºC=K-273

Examples:
0 ºC = 273 K
25 ºC = 298 K
200 K = -73 ºC



Mass: The amount of matter in a body.

- **SI Units:** kilogram (kg)
- **Common Units:**
  pounds (lbs) and ounces (oz)
  1 kg is approx. 2.2 lbs
  1 kg = 1000 g
  1 oz = 28.35 g



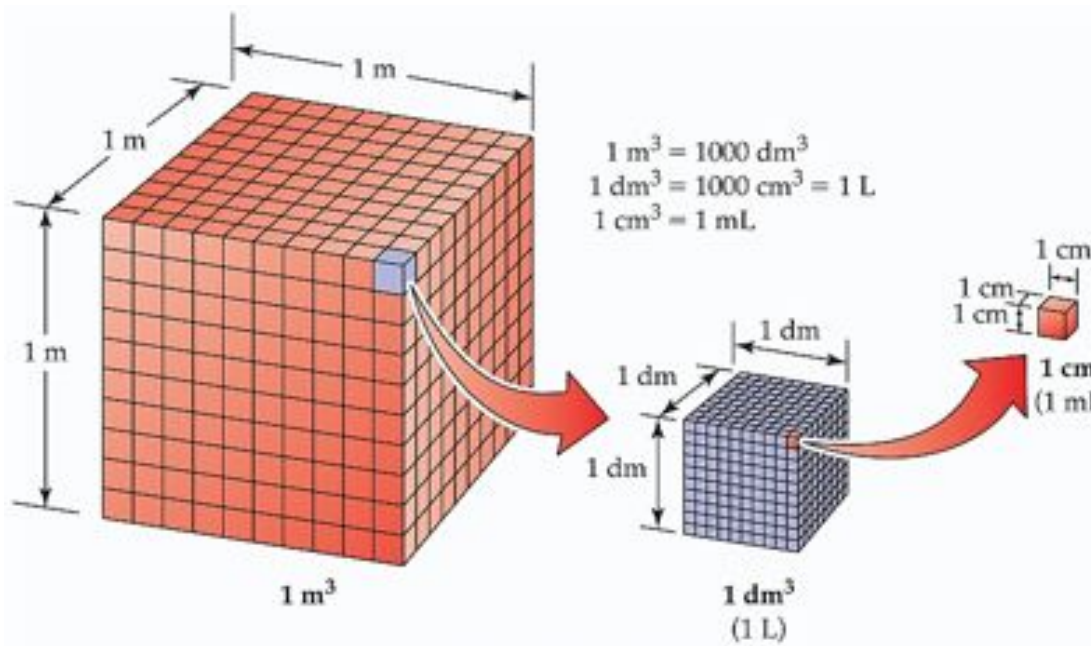
Length: A measure of distance.

- **SI Unit:** meter (m)

- **Common Units:** inches (in); miles (mi)
  1 in = 2.54 cm = 0.0254 m
  1 mi = 1.609 km = 1609 m

Volume: Amount of space occupied by a body.

- **SI Unit:** cubic meter (m^3)
- **Common Units:** Liter (L) or milliliter (mL) or cubic centimeter (cm^3)



Density: Amount of mass per unit volume of a substance.

- **SI Units:** kg/m^3
- **Common Units:** g/cm^3 or g/mL

Problem: Drunken Donny steals an unknown alcohol from the chemistry lab at work. He does not know that there are numerous different types of alcohols. Methyl alcohol has a density of 0.792 g/mL and is poisonous if consumed. Ethyl alcohol has a density of 0.772 g/mL and is the common alcohol which Drunken Donny loves to drink. If the stolen unknown alcohol has a measured mass of 71.28 g and a measured volume of 90.0 mL, which alcohol did Drunken Donny steal to drink?

Uncertainty in Measurements

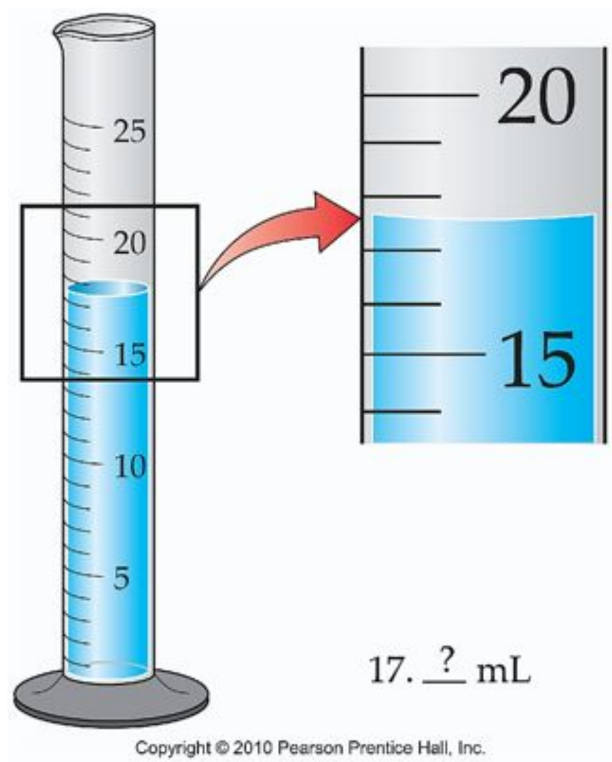
- **Exact numbers:** numbers that have a definite value.

- **Examples of exact numbers:**
  - If you buy a dozen eggs you have bought exactly 12 eggs
  - 1 kg is equal to exactly 1000 g
  - Any counted number such as number of people in a room or number of skittles in a bag

- **Inexact numbers:** numbers that do not have a definite value and contain some uncertainty. There is always uncertainty in measured quantities!

Significant Figures

All digits in a measured quantity are considered significant. The last digit of a measured quantity contains uncertainty.



Rules for Sig Figs

1) All nonzero digits are significant.
   - 457 cm has 3 sig figs
   - 2.5 g has 2 sig figs

2) Zeros between nonzero digits are significant.
   - 1007 kg has 4 sig figs
   - 1.033 g has 4 sig figs

3) Zeros to the left of the first nonzero digit are not significant. They are not actually measured, but are place holders.
   - 0.0022 g has 2 sig figs
   - 0.0000022 kg has 2 sig fig

4) Zeros at the end of a number and to the right of a decimal are significant. They are assumed to be measured numbers.
   - 0.002200 g has 4 sig figs
   - 0.20 has 2 sig figs
   - 7.000 has 4 sig figs

5) When a number ends in zero but contains no decimal place, the zeros may or may not be significant. We use scientific (aka exponential) notation to specify.
   - 7000 kg may have 1, 2, 3 or 4 sig figs!

Scientific Notation

- Move the decimal behind the first nonzero digit (this will make the number between 1 and 10).

- Multiply the number by 10 to the appropriate power.

- **Examples:**
  1) 0.0001 cm = 1×10^{-4} cm
  2) 10,000 m (expressed to 1 sig fig) = 1×10^{4} m
  3) 13,333 g = 1.3333×10^{4} g
  4) 10,000 m (expressed to 3 sig figs) = 1.00×10^{4} m

NOTE: All zeros after the decimal are significant. The exponent is not counted as a sig fig.

Sig Figs In Calculations

- **Mult/Div:** Answer must contain the same number of sig figs as there are in the measurement with the least number of sig figs.

```
  2.8723
x   1.6
--------
  4.59568
    ⇓ rounding
   4.6
```

- **Add/Sub:** Round answer to the same number of decimal places as there are in the measurement with the fewest decimal places.

```
  4.7832
  1.234
+ 2.02
--------
  8.0372
   ⇓ rounding
  8.04
```

Rounding Calculations

- **Rounding:** If the left-most digit to be removed is less than 5, do not round up. If the left-most digit to be removed is greater than or equal to 5, round up.

Examples:

(6.221 cm)(5.2 cm) = 32.3492 cm^2 = 32 cm^2

(6.221 cm)(5.200 cm) = 32.3492 cm^2 = 32.35 cm^2

NOTE: Do not round until the last calculation has been performed. Rounding at each step introduces more error.

NOTE: Exact numbers (not measured numbers) are indefinitely precise and have indefinite sig figs, thus they do not ever determine the number of sig figs in a final answer! All metric conversions are exact.

NOTE: If a problem requires both addition/subtraction and multiplication/division then each rule is applied separately.

Dimensional Analysis (Factor-Labeled Method)

- Provides a systematic way to solve problems (easy and hard).
- Checks your answers via the unit cancellation method.
- Makes it easy to locate errors.
- **Conversion Factor:** A conversion factor is a fraction with a numerator and a denominator that are equal quantities with different units. Thus, a conversion factor is equal to 1!

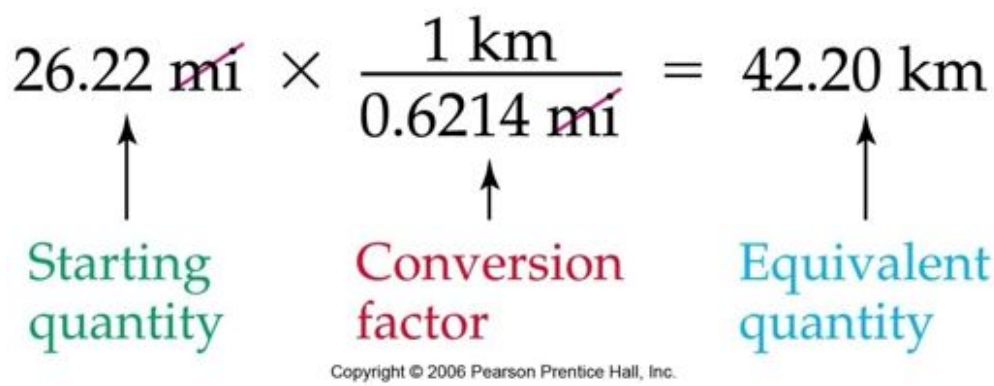
Conversion factors between kilometers and miles

$$\frac{1\ \text{km}}{0.6214\ \text{mi}} = 1 \quad \text{or} \quad \frac{0.6214\ \text{mi}}{1\ \text{km}} = 1$$

Dimensional Analysis Problem

Problem: You are traveling 26.22 miles. How many kilometers is this?

Use dimensional analysis to convert miles to kilometers.



Chapter 2 Questions

1) Write a conversion factor that could be used to convert m to cm.

2) A hydrogen atom has a volume of approximately 6.2×10^{-31} m^3. What is the volume in cm^3?

3) A chemist needs 15.0 grams of ethanol for a reaction. If the density of ethanol is 0.789 g/mL, how many milliliters of alcohol should be used? Show your final answer with units and correct sig figs.