Chapter 2

MEASUREMENT- a quantitative piece of data that contains **both** a number and a unit.

Chapter 2, Section1

SCIENTIFIC NOTATION- is a method of expressing very large and very small numbers using a number between 1 and 10 (but not 10) multiplied by a power of 10.

Scientific Notation looks like this: 5.7×10^{5}

In Scientific Notation the exponent tells you about the number.

A positive exponent means the number is larger than 1.

A negative exponent means the number is smaller than 1.

You must be able to put numbers into and take them out of scientific notation.

See the following examples:

A number greater than 1 into scientific notation:

93,000,000 → 9.3×10^{7}

I must move the decimal place 7 times to make a number between 1 and 10.

My exponent is positive because my number is greater than 1.

A number greater than 1 out of scientific notation:

4.589×10^{5} → 4589 00 → 458900

I must move the decimal place 5 times according to my exponent.

My number must be greater than 1 because it is a positive exponent.

A number less than 1 into scientific notation:

0.00000672 → 6.72×10^{-6}

I must move the decimal place 6 times to make a number between 1 and 10

My exponent is negative because my number is less than 1.

A number less than 1 out of scientific notation:

3.56×10^{-4} → .000 356 → 0.000356

I must move the decimal place 4 times according to my exponent.

My number must be less than 1 because it is a negative exponent.

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UNITS- a necessary part of a measurement that provides meaning to the number.

You have grown up with the English system.

Examples: inches, feet, yards, miles, ounces, pounds, tons, cups, quarts, gallons, etc.

Most of the world is base on a system of measurement known as the International System which is based on the metric system and is abbreviated: SI System

The metric system is a base 10 system, meaning that small units are related to larger units by some factor of 10. This simplifies conversions.

Types of Measurements:

Length (distance): The standard SI unit for distance is the METER.

Mass: The standard SI unit for mass is the KILOGRAM.

Be careful with this one! When you are using the metric prefixes the base unit for mass is the GRAM.

Volume: The standard SI unit for volume is the LITER.

Time: The standard SI unit for time is the SECOND.

The Metric System Prefixes and Associated Powers of 10 (You need to know these!!)

Prefix	Abbreviation	Power of 10
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
No prefix- base unit --- meter, gram, liter, second, etc		10^{0} (1)
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ µ (Greek letter "Mu")	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

SIGNIFICANT FIGURES

- indicates the level of certainty in an answer

Rules:

1. Nonzero numbers (1-9), are ALWAYS significant

2. Zero is sometimes significant
   a. Leading zeros are NEVER significant
      Example: 0.0025 has only 2 sig. figs.

   b. Captive zeros are ALWAYS significant
      Example: 1.008 has 4 sig. figs.

   c. Trailing zeros are significant if written with a decimal point
      Example: 100 has 1 sig. fig., but 100. has three sig. figs.

3. Exact numbers NEVER limit significant figures in a calculation.
   Example: counting- 3 apples
   Definitions- 1 inch = 2.54 cm

ROUNDING

When removing uncertain numbers, the need to round off occurs

Rules:

1. If the number to be removed is
   a. Less than 5, the preceding digit stays the same
      Example: 1.333 = 1.33
   b. Equal to or greater than 5, the preceding digit increases by 1
      Example: 1.366 = 1.37
2. Ideally all figures should be carried through all operations with rounding occurring only at the final answer to correct for significant figures.

HOW TO APPLY SIGNIFICANT FIGURES IN CALCULATIONS

Addition or Subtraction Calculations:

Round your answer to the same number of decimal places as your least accurate number in the problem.

Example:

$$\begin{array}{r} 100.5 \\ 35.45 \\ +\quad 3.687 \\ \hline 139.637 \end{array}$$

is the answer your calculator would give you.

The answer shown with the correct number of significant digits is 139.6

$$\begin{array}{r} 100.5 \\ 35.45 \\ +\quad 3.687 \\ \hline 139.6 \end{array}$$

This is your least accurate number (10^{th}'s)

Therefore you must round your answer to the same decimal place. (10^{th}'s)

Multiplication or Division Calculations:

Round your answer to the same number of significant digits as number in the problem with the least number of significant digits.

Example:

475/1000 = 0.475 is the answer your calculator would give you.

The answer shown with the correct number of significant digits is 0.5

475/1000 = 0.475

This number has 3 significant figure. This number has 1 significant figure

Therefore, the answer must be rounded to 1 significant figure. The 7 makes the 4 round to a 5.

Chapter 2

Problem Solving

Dimensional Analysis- a problem solving technique that involves changing from one unit to another using conversion factors which are based on the equivalence statements between the units in the question.

EQUIVALENCE STATEMENT- a relationship between two units

Example: 2.54 centimeters = 1 inch

CONVERSION FACTOR= a ratio that relates two units.

Example: $\frac{2.54 \text{ cm}}{1 \text{ inch}}$

Every EQUIVALENCE STATEMENT yields two CONVERSION FACTORS.

Example: 2.54 centimeters = 1 inch

$\frac{2.54 \text{ cm}}{1 \text{ inch}}$ and $\frac{1 \text{ inch}}{2.54 \text{ cm}}$

In order to use this information to convert you need to be able to choose the correct CONVERSION FACTOR for the problem.

Key Point: you want to choose that CONVERSION FACTOR that will allow you to cancel the unit you no longer want and get the unit that you are looking for.

Example: How many centimeters are in 5 inches?

I want to go from inches to centimeters. I need an EQUIVALENCE STATEMENT that relates these two units. My EQUIVALENCE STATEMENT is 2.54 centimeters = 1 inch. I now need to choose between the two possible CONVERSION FACTORS $\frac{2.54 \text{ cm}}{1 \text{ inch}}$ and $\frac{1 \text{ inch}}{2.54 \text{ cm}}$

To do this I look at my problem. I begin with 5 inches. I need a way to cancel inches and get cm. Therefore I need to choose the CONVERSION FACTOR with inches on the bottom.

$5 \text{ inches} \times \frac{2.54 \text{ cm}}{1 \text{ inch}}$

This allows inches to cancel and leaves units of cm remaining.

$5 \cancel{\text{inches}} \times \frac{2.54 \text{ cm}}{1 \cancel{\text{inch}}} = 12.7 \text{ cm}$

Sometimes multiple steps are required to convert. Each step is evaluated for the EQUIVALENCE STATEMENT and the CONVERSION FACTORS that apply.

See Example 2.7 in the textbook on page 32-33.

Always look at your answer to make sure it makes sense. Often you can catch careless errors.

Round to the correct number of significant figures at the end of the problem.

Metric Conversions

When you need to convert from one metric unit to another you need to use the metric chart. The powers of 10 associated with each prefix tell you how many base units are in that prefix unit.

Example: If you need to know how many meters are in 3.4 kilometers.

The prefix kilo has the associated power of 10^3; therefore the equivalence statement for meters and kilometers or kilometers and meters is 1×10^3 meters = 1 kilometer.

From this equivalence statement you develop the needed conversion factor.

$$3.4\ \cancel{\text{kilometers}} \times \frac{1\times10^3\ \text{meters}}{1\ \cancel{\text{kilometer}}} = 3400\ \text{meters}$$

If you are converting from one prefix unit to another prefix unit, covert to your base unit first, then to the new prefix. It is a two step process, but you will make fewer mistakes.

Example: If you need to know how many centimeters are in 3.4 kilometers.

Take kilometers to meters first, then meters to centimeters.

The prefix kilo has the associated power of 10^3; therefore the equivalence statement for meters and kilometers or kilometers and meters is 1×10^3 meters = 1 kilometer.

From this equivalence statement you develop the needed conversion factor.

$$3.4\ \cancel{\text{kilometers}} \times \frac{1\times10^3\ \text{meters}}{1\ \cancel{\text{kilometer}}} = 3400\ \text{meters}$$

Next we need the relationship between meter and centimeter. The prefix centi has the associated power of 10^{-2}; therefore the equivalence statement for meters and centmeters or centimeters and meters is 1×10^{-2} meters = 1 centimeter.

$$3400\ \cancel{\text{meters}} \times \frac{1\text{centimeters}}{1\times10^{-2}\ \cancel{\text{meter}}} = 340{,}000\ \text{centimeters}$$

Chapter 2

Temperature Conversions

Fahrenheit Scale- °F
Celsius Scale- °C
Kelvin Scale- K (kelvins -NO DEGREE SIGN!!!)

	Freezing Water	Boiling Water
Fahrenheit Scale	32	212
Celsius Scale	0	100
Kelvin Scale	273	373

Converting from Kelvin to Celsius and Celsius to Kelvin:

$T_K = T_{°C} + 273$

$T_{°C} = T_K - 273$

Converting from Fahrenheit to Celsius and Celsius to Fahrenheit:

$T_{°F} = 1.80T_{°C} + 32$

$$T_{°C} = \frac{T_{°F} - 32}{1.80}$$

If you need to convert from Kelvin to Fahrenheit or Fahrenheit to Kelvin you must first convert to Celsius.

Chapter 2

DENSITY: amount of matter in a given volume of substance.

DENSITY= MASS / VOLUME

Example: What is the density of a liquid if 23.50 mL of the liquid has a mass of 35.062 grams?

Density = mass/volume ; therefore Density = 35.062 grams/23.50 mL

Density = 1.492 grams/mL

The most common unit for density is grams/mL or grams/cm^3, but density could be expressed as any unit of mass over any unit of volume.

At this point it is important to discuss the fact that: 1mL = 1 cm^3

Mass is most obviously determined using a balance (electronic or triple beam)

Volume can be determined in two ways:

Measurement for liquids can be with a graduated cylinder and for regular solids a metric ruler can provide accurate data.

Irregular solids pose a particular challenge. They cannot easily have their dimensions measured and calculated volume be determined with a formula. These types of materials need to have volume determined using a method called WATER DISPLACEMENT.

WATER DISPLACEMENT: is a method of volume determination that involves submerging a sample in a known volume of liquid (most commonly water) and the increase in volume is measured. This increase in volume is the volume of the sample.

In the lab we often will use a graduated cylinder to perform this calculation.

Example: An irregular sample is presented to a student. The student places 20.0 mL of water in a 50.0 mL graduated cylinder. The student then submerges the sample in the graduated cylinder. The new water level reading in the graduated cylinder is 28.9 mL. This means the sample volume is 8.9 mL (28.9-20.0 = 8.9)

Density can be used to identify materials:

Example: If an unknown substance has a mass of 28.1 grams per 35.8 mL it has a density of 0.785 g/mL (28.1/35.8). If the possible substance identities are as follows:

Chloroform	1.483 g/mL
Diethyl ether	0.714 g/mL
Isopropyl alcohol	0.785 g/mL
Toluene	0.867 g/mL

The identity of the substance would be isopropyl alcohol.

We can also use density in calculation to determine how much volume of a substance we need to have a given mass of the material.

This is achieved by mathematically rearranging the density equation.

Density = mass/ volume can be reorganized mathematically to be:

Volume= mass/density or Mass = density x volume

This allows calculation of volume from a given mass and density or mass from a given density and volume. You can either learn these two additional formulas or you can remember just the original density formula and rearrange it mathematically on your own.

Example: If mercury has a density of 13.6 g/mL, what volume of mercury is necessary to have 225 g of mercury?

The two pieces of data that you have are density and mass, you need to solve for volume.

Using either the original density formula and rearranging it or by using one of the other two equations solve for volume.

Volume = mass /density , volume= 225g / 13.6 g/mL = 16.5 mL

Some additional notes related to density:

Density is temperature dependent, this is of particular importance for liquids and gases, but even solids can be affected.

For gases the pressure also becomes important.

Temperature influences the volume component of density.

SPECIFIC GRAVITY is a ratio of the density of a sample to the density of water at 4 degrees Celsius.

Specific Gravity does not have any units because it is a ratio (all units cancel).

Specific Gravity is used to determine charge status of car batteries (lead acid) and the amount of antifreeze that is in your car's radiator system.

Specific Gravity can also be used to test urine to help detect kidney malfunction.