Notes Chapter 2: Measurements and Calculations

Scientific Notation

- It is used to easily and simply write very large numbers, and very small numbers.

- It begins with a number greater than zero & less than 10. In other words, one digit before the decimal point.

- This number is multiplied by an appropriate power of 10

<table>
<thead>
<tr>
<th>Powers of 10 – positive exponents</th>
<th>Scientific notation of numbers greater than 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^0 = 1$</td>
<td>$136 = 1.36 \times 10^2$</td>
</tr>
<tr>
<td>$10^1 = 10$</td>
<td>$15,000 = 1.5 \times 10^4$</td>
</tr>
<tr>
<td>$10^2 = 100$</td>
<td>$10,200 = 1.02 \times 10^4$</td>
</tr>
<tr>
<td>$10^3 = 1,000$</td>
<td>$105,000,000 = 1.05 \times 10^8$</td>
</tr>
<tr>
<td>$10^4 = 10,000$</td>
<td></td>
</tr>
<tr>
<td>$10^5 = 100,000$</td>
<td></td>
</tr>
<tr>
<td>$10^6 = 1,000,000$</td>
<td></td>
</tr>
<tr>
<td>$10^7 = 10,000,000$</td>
<td></td>
</tr>
<tr>
<td>$10^8 = 100,000,000$</td>
<td></td>
</tr>
<tr>
<td>$10^9 = 1,000,000,000$</td>
<td></td>
</tr>
</tbody>
</table>
### Powers of 10 – negative exponents

<table>
<thead>
<tr>
<th>Exponent</th>
<th>Value</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^0$</td>
<td>1</td>
<td>$1$</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>0.1</td>
<td>$\frac{1}{10}$</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>0.01</td>
<td>$\frac{1}{100}$</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>0.001</td>
<td>$\frac{1}{1,000}$</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>0.0001</td>
<td>$\frac{1}{10,000}$</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>0.00001</td>
<td>$\frac{1}{100,000}$</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>0.000001</td>
<td>$\frac{1}{1,000,000}$</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>0.0000001</td>
<td>$\frac{1}{10,000,000}$</td>
</tr>
</tbody>
</table>

### Scientific notation of numbers less than 1

- $0.136 = 1.36 \times 10^{-1}$
- $0.0560 = 5.6 \times 10^{-2}$
- $0.0000352 = 3.52 \times 10^{-5}$
- $0.00000105 = 1.05 \times 10^{-6}$

### To Review:

**Positive exponents** tells you how many decimal places you must move the decimal point **to the right** to get to the real number. They indicate numbers that are **greater than 1**.

- $6.21 \times 10^3$ says you must move the decimal point 3 places to the right to get to the real number.

$$6.21 \times 10^3 = 6,210.$$
Negative exponents tells you how many decimal places you must move the decimal point to the left to get to the real number. They indicate numbers that are less than 1.

6.21 x 10^{-3} says you must move the decimal point 3 places to the left to get to the real number.

6.21 x 10^{-3} = 0.00621

Self-Check: Write the following using scientific notation.

a) 93,000,000  \quad 9.3 \times 10^7

b) 0.000,000,000,105  \quad 1.05 \times 10^{-10}

c) one million  \quad 1.0 \times 10^6

d) one millionth  \quad 1.0 \times 10^{-6}
### International System of Measurements

**a.k.a. Metric System a.k.a. SI**

<table>
<thead>
<tr>
<th>Metric Unit</th>
<th>British Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Meter (m)</td>
</tr>
<tr>
<td>Volume (space)</td>
<td>Liter (L)</td>
</tr>
<tr>
<td>Mass (not weight)</td>
<td>Gram (g)</td>
</tr>
</tbody>
</table>

#### Prefixes (multiples of the basic unit)

**Example**

- \( \sqrt{\text{kilo}} \ 1,000 \times \text{unit} \)  
  1 kilogram = 1,000 grams

- \( \sqrt{\text{hecto}} \ 100 \times \text{unit} \)  
  1 hectogram = 100 grams

- \( \sqrt{\text{deca}} \ 10 \times \text{unit} \)  
  1 decagram = 10 grams

- \( \sqrt{\text{deci}} \ 0.1 \times \text{unit} \)  
  1 decigram = 0.1 gram

- \( \sqrt{\text{centi}} \ 0.01 \times \text{unit} \)  
  1 centigram = 0.01 gram

- \( \sqrt{\text{milli}} \ 0.001 \times \text{unit} \)  
  1 milligram = 0.001 gram

<table>
<thead>
<tr>
<th>kilometer (km)</th>
<th>hectometer (hm)</th>
<th>decameter (dam)</th>
<th>decimeter (dm)</th>
<th>centimeter (cm)</th>
<th>millimeter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>hg</td>
<td>dag</td>
<td>GRAM</td>
<td>dg</td>
<td>cg</td>
</tr>
<tr>
<td>kL</td>
<td>hL</td>
<td>daL</td>
<td>LITER</td>
<td>dL</td>
<td>cL</td>
</tr>
</tbody>
</table>
# International System of Measurements

a.k.a. **Metric System** a.k.a. **SI**

## Basic Unit

<table>
<thead>
<tr>
<th>kilometer</th>
<th>hectometer</th>
<th>deca meter</th>
<th>centimeter</th>
<th>millimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>km</td>
<td>hm</td>
<td>dam</td>
<td>cm</td>
<td>mm</td>
</tr>
<tr>
<td>kg</td>
<td>hg</td>
<td>dag</td>
<td>cg</td>
<td>mg</td>
</tr>
<tr>
<td>kL</td>
<td>hL</td>
<td>daL</td>
<td>dL</td>
<td>mL</td>
</tr>
</tbody>
</table>

### Prefixes

<table>
<thead>
<tr>
<th>mega</th>
<th>kilo</th>
<th>hecto</th>
<th>deca</th>
<th>Basic Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>k</td>
<td>h</td>
<td>da</td>
<td>gram (g)</td>
</tr>
<tr>
<td>1,000,000</td>
<td>1,000</td>
<td>100</td>
<td>10</td>
<td>liter (L)</td>
</tr>
<tr>
<td>$10^6$</td>
<td>$10^3$</td>
<td>$10^2$</td>
<td>$10^1$</td>
<td>meter (m)</td>
</tr>
</tbody>
</table>

### Conversion Factors

<table>
<thead>
<tr>
<th></th>
<th>1/10</th>
<th>1/100</th>
<th>1/1,000</th>
<th>1/1,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.01</td>
<td>0.001</td>
<td>0.000001</td>
</tr>
</tbody>
</table>

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Chemistry-1
Notes Chapter 2
Page 5
Measuring Volume

Method #1: by Linear Measurement

Volume = length x width x height

= L \times W \times H

= 10 \text{ cm} \times 10 \text{ cm} \times 10 \text{ cm}

= (10 \times 10 \times 10) \text{ (cm x cm x cm)}

= 1,000 \text{ cm}^3

We multiplied the numbers AND the Units.

1,000 \text{ cm}^3 = 1 \text{ L}

1 \text{ cm}^3 = 1 \text{ mL}
Method #2: by Water Displacement

We read a graduated cylinder at the bottom of the meniscus.

The units are milliliters.

Remember: 1 mL = 1 cm³

to determine the volume of the object:

\[
\frac{\text{volume of object} \& \text{ water}}{\text{volume of water}} = \text{volume of object}
\]

\[\begin{align*}
79.0 \text{ mL} - 38.0 \text{ mL} &= 41.0 \text{ mL} \\
\end{align*}\]

Volume of Object
Measuring Liquid Volume

What volume is indicated on each of the graduated cylinders below? Don’t forget to write the units.

1) ________
2) ________
3) ________
4) ________
5) ________
6) ________
7) ________
8) ________
9) ________
Measuring Liquid Volume

What volume is indicated on each of the graduated cylinders below?
Don’t forget to write the units.

1) 56.0 mL
2) 4.35 mL
3) 23.5 mL
4) 16.5 mL
5) 76.0 mL
6) 5.3 mL
7) 32 mL
8) 3.5 mL
9) 47.0 mL
Measuring Mass

Actually, mass and weight are different. Mass is the amount of matter in an object while weight is the pull of gravity on an object. If you weigh 120 lbs on Earth, you’d weigh 20 lbs on the Moon, but you’d still have the same mass.

Weight = 120 lbs
Mass = 120 lbs

Weight = 20 lbs
Mass = 120 lbs.

Mass is measured with a balance. This electronic balance is accurate to 0.01 g. The mass of the geode is

32.47 g

Not 32.5 g
Not 32.50 g
Not 32.470 g
What Is Density?

It’s the mass of each cubic centimeter of an object.
It’s the mass of the object compared to its size.
It’s how compact the matter is in the object.
We use it to compare masses like price per pound.
Measuring Density

\[
\begin{align*}
\text{Density} &= \frac{\text{mass of the object}}{\text{volume of the object}} = \frac{\text{grams}}{\text{mL or cm}^3} \\
\text{The Unit of Density is always:} & \quad \text{g/cm}^3 \\
\text{The Density of Pure Liquid Water is:} & \quad 1.0 \text{ g/cm}^3
\end{align*}
\]

What is the density of the object whose volume was measured by water displacement to be 41.0 mL?

You must also measure the mass of that object.

\[
\begin{align*}
\text{Density} &= \frac{\text{Mass}}{\text{Volume}} \\
\text{Density} &= \frac{72.42 \text{ g}}{41.0 \text{ mL}} \\
\text{Density} &= 1.76634146 \\
\text{Density} &= 1.77 \text{ g/cm}^3
\end{align*}
\]

HW: Questions & Problems 2.8: # 86, 92, 97, 99
Significant Figures
or How Accurate Do You Have To Be?

Isn’t 22 cm$^3$ the same as 22.0 cm$^3$? NO!!

22.0 cm$^3$ is 10 times more accurate than 22 cm$^3$

22 cm$^3$ includes all measures from
21.5 cm$^3$ to 22.4 cm$^3$ – a spread of 0.9 cm$^3$.

22.0 cm$^3$ includes all measures from
21.95 cm$^3$ to 22.04 cm$^3$ – a spread of 0.9 cm$^3$.

When making measurements, you are as accurate as your measuring instrument.

If the smallest units in a 10 mL graduate is the tenths, or 0.1 mL,
Then, your measurements are to 0.1 mL;
Examples: 24.0 mL; 24.7 mL not 24 mL

If your electronic balance can measure to the hundredths of a gram,
Then your measurements are to 0.01 g
Examples: 24.00 g; 24.76 g not 24 g
The significant digits of a number tells how exact that number is.

1 g is less exact than 1.0 g which is less exact than 1.00 g.

Do you round off when you do computations? YES!

Your answer cannot be any more accurate than your least accurate measurement

\[
\begin{align*}
\text{Volume} &= 4.03 \text{ cm} \times 2.413 \text{ cm} \times 6.3721 \text{ cm} \\
&= 61.964785519 \text{ cm}^3 \\
&= 61.9 \text{ cm}^3 \quad \text{Answer has 3 sig figs}
\end{align*}
\]
Spink’s Handy Rules for Handling Numbers in Chemistry

1. Don’t round until you get to your final answer.

2. All non-zero numbers are significant.
   Examples: 1, 2, 3, 4, 5, 6, 7, 8, and 9

3. Zeros are significant ONLY when
   a) they are between significant figures
      Examples: 802 & 4.06 each have 3 sig. figs.
      or
   b) they are ending zeros in a number with a decimal point.
      Examples: 400. & 6.00 each have 3 sig. figs.
   c) 470.00 has five sig. figs. The last zero is an ending zero in a number with a decimal point, so the first zero is between 2 sig. figs.

Examples of numbers with zeros that are NOT significant.
   a) 4,300 has two sig. figs. The number does not have a decimal point.
   b) 0.00621 has three sig. figs. The zeros are not ending zeros.
When we say zeros are not significant, we are NOT saying they are not important. They are place – holders which are important. There is a big difference between $3,200 and $3,200,000 even though each number has two sig. figs.

When we say zeros are not significant, we are saying they don’t make the measurement more accurate.

6,200 cm and 62,000,000 cm are both accurate to two significant figures. The zeros in the 2nd number makes it larger, not more accurate.

620.0 cm is less accurate than 620.000 cm. The 2nd measurement was made with a more precise ruler.

4. When you add or subtract measured numbers, the answer must have the same number of digits after the decimal point as the measurement with the smallest number of digits after the decimal point.

2 decimal places  
6.32
3 decimal places  
4.721
4 decimal places  
6.2053

\[ 17.2463 = \boxed{17.25} \]

2 decimal places
5. When you **multiply** or **divide** measured numbers, the answer must have the **same** number of **significant figures** as the measurement with the **smallest** number of **significant figures**.

3 sig. figs. \[ x \] 6.32  
4 sig. figs. \[ \times \] 4.721  
\[ \underline{29.83672} = \text{29.8} \]  
3 sig. figs.

4 sig. figs. \[ \underline{\underline{\underline{7.246}}} \]  
3 sig. figs. \[ \underline{\underline{\underline{16.8}}} \]  
\[ = \text{0.43109} = \text{0.431} \]  
3 sig. figs.

6. When you are rounding off your answer to . . . say 3 sig. figs for example, you look at the **fourth** sig. fig. If it is 5 or greater, the 3\(^{rd}\) sig. fig. goes up one. If it is 4 or lower, the 3\(^{rd}\) sig. fig. stays the same.

\[ \underline{47.6372} = \boxed{47.6} \]  
\[ \underline{\uparrow} \]  
so this stays a 6

\[ \underline{47.6732} = \boxed{47.7} \]  
\[ \underline{\uparrow} \]  
so this becomes a 7
7. When you are rounding off your answer to 3 sig. figs, the numbers after the decimal point are dropped, but the numbers before the decimal become zeros.

\[ 62.3785406 = 62.4 \quad 62,587,865 = 62,600,000 \]

8. Counting numbers and conversion factors* are not considered when determining the number of sig. figs. you must round your answer to. They are considered to be exact. You only look at the measurements given in the problem.

* Conversion factors are equivalencies written as fractions so you can convert from one unit of measurement to another.
Dimensional Analysis

a.k.a. Factor Label Method

a.k.a. Unit Cancellation

We use this method to solve many problems by using the relationship of one unit to another. For example, 12 inches = 1 foot. Since these two numbers represent the same value, the fractions are equal to 1.

\[
\frac{1 \text{ ft.}}{12 \text{ in.}} = 1 \quad \text{and} \quad \frac{12 \text{ in.}}{1 \text{ ft.}} = 1
\]

When you multiply another number by the number one, you do not change its value. However, you may change its unit.

Example 1: Convert 2.00 miles to inches.

\[
\frac{2.00 \text{ miles}}{1} \times \frac{5,280 \text{ ft.}}{1 \text{ mile}} \times \frac{12 \text{ in.}}{1 \text{ ft.}} = 126,720 \text{ in.}
\]

Answer using significant digits:

\[
2.00 \text{ mi.} = 127,000 \text{ in.}
\]
Example 2a: How many seconds are in 4.00 days?

\[
\frac{4.00 \text{ days}}{1} \times \frac{24 \text{ hrs.}}{1 \text{ day}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} \times \frac{60 \text{ sec.}}{1 \text{ min.}} = 345,600 \text{ sec.}
\]

Answer using significant digits:

\[
4 \text{ days} = 346,000 \text{ sec.}
\]

Still don’t see how the Unit Cancellation method can help you solve conversion problems?

1. You don’t have to memorize whether to multiply by 24 hrs. / day, or to divide by it.

2. You write the conversion factor so that the unit you are changing from is cancelled out.

Example 2b: How many minutes are in 4.00 days?

\[
\frac{4.00 \text{ days}}{1} \times \frac{24 \text{ hrs.}}{1 \text{ day}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = 346,000 \text{ sec.}
\]

Start with the given information
Change days to hours by having the days cancel out.
Change hours to minutes by having the hours cancel out.

Round your answer to 3 sig. figs. because 4.00 days has 3 sig. figs.

\[
= 346,000 \text{ sec.}
\]
Preparing for Test Chapter 2

You should be able to do the problems we practiced in class and the ones assigned to you for homework.

- change regular numbers into scientific notation
- change scientific notation into regular numbers

- know the units of mass, volume, length, and density
  - know that $1 \text{ cm}^3 = 1 \text{ mL}$
  - know that $1,000 \text{ cm}^3 = 1,000 \text{ mL} = 1 \text{ L}$

- do conversion problems w/ different metric prefixes as well as metric & English prefixes (metric / English conversion factors are given to you in the problem)

- know the rules for counting significant digits
- know the rules for rounding numbers when calculating numbers using significant digits.

- know how to do calculations in density problem
- know the density of pure water and how to determine whether an object will float or sink in water.