Chemistry Chapter 2 – Data Analysis

2.1 Units of Measurement

Properties of Matter are described either as:
Qualitative - a property is described without measurement.
Quantitative - a property is measured and described by a number of standard units.

Quantitative Measurements have two parts: NUMBER & UNIT

International System (SI) Units - standard science units of measurement-metric system.

Prefix (how much) + Unit (what type measurement)

SI Prefix:	Symbol	Meaning	Multiplier
tera	T	trillion	10^{12}
giga	G	billion	10^{9}
mega	M	million	10^{6}
kilo	**k**	**thousand**	**10^{3}**
hecto	h	hundred	10^{2}
deka	da	ten	10^{1}
		one	1
deci	**d**	**tenth**	**10^{-1}**
centi	**c**	**hundredth**	**10^{-2}**
milli	**m**	**thousandth**	**10^{-3}**
micro	u	millionth	10^{-6}
nano	n	billionth	10^{-9}
pico	p	trillionth	10^{-12}
femto	f	quadrillionth	10^{-15}
atto	a	quintillionth	10^{-18}

SI Base Units:

Type of Unit	Name	Symbol
1. Length	meter	m
2. Mass	kilogram	kg
3. Time	second	s
4. Amount of Substance	mole	mol
5. Thermodynamic Temperature	kelvin	K
6. Electric Current	ampere	A
7. Luminous Intensity	candela	c

Types of Measurements and their Units:
Mass - a measure of the quantity of matter. **Weight** is a measure of the force of gravity between two objects which changes from place to place.
Equipment used to measure - **balance**.
Unit – **gram (g)**
Length – distance.
Equipment used to measure - **ruler**

Unit – **meter (m)**

Time – frequency of microwave radiation given off by a Cesium-133 atom = 1 **second**

Derived Units – a unit that is derived from a combination of two or more base units:
ex. Volume (length cubed), Density (mass/volume)

Volume - the amount of space that an object occupies.

Equipment to measure:

Cubic or Rectangular Solid - measure the sides with a **ruler**.
(length x width x height)
Unit – **cm^3 or dm^3**

Irregular Solid - put the solid into a **graduated cylinder** with a volume of water. The difference in height between the two water levels is the volume of the solid.
Unit – **Liter (l) or milliliter (mL)**

Liquid - measure with a graduated piece of equipment such as:
Graduated Cylinder
Volumetric Flask
Pipet (volumetric or graduated)

Volume Unit Equivalents:

1 L = 1 dm^3
1 mL = 1 cm^3
1 L = 1000 mL = 1 dm^3 = 1000 cm^3

Density (D) - the amount of mass (m) per unit of volume (v) of an object.

$$D = \frac{m}{V}$$

ex. What is the density in g/cm^3 of a liquid that is 29.2 g and 27.0 cm^3?
What is the density of this liquid in g/dm^3?

ex. What is the density in g/mL of a liquid that is 365 g and 21.5 cm^3?
What is the density of this liquid in g/L?

ex. What is the density in g/mL of a liquid that is 453 mg and 0.362 mL?

Temperature: a measure of the average kinetic energy of a substance (the energy of motion). Particles move faster with higher temperatures and slower with lower temperatures.

Celcius (C) - temperature scale based on the freezing point of water (0C) and the boiling point of water (100C). Named after Swedish astronomer Anders Celcius.

Kelvin (K) – the absolute temperature scale based on absolute zero where all molecular motion ceases. Named after English physicist & mathematician Lord Kelvin.

K = C + 273
C = K - 273

ex. What is the temperature in Celcius or Kelvin for the following:

0 C = ?K
0 K = ?C
25C = ?K
100 K = ?C

2.2 Scientific Notation:

Scientific Notation is a method used to express relatively large as well as relatively small numbers in exponential form as powers of ten. * The only form that is referred to as scientific notation is just when one non-zero digit is to the left of the decimal.

Two advantages: a. the number is simplified
b. the numbers of significant figures are indicated

.001	=	1×10^{-3}	=	1/1000
.01	=	1×10^{-2}	=	1/100 or 1/10 x 10
.1	=	1×10^{-1}	=	1/10
1.	=	1×10^{0}	=	1 x 1
10.	=	1×10^{1}	=	1 x 10
100.	=	1×10^{2}	=	1 x 100
1000.	=	1×10^{3}	=	1 x 1000

___ . ___ x 10 ±

(one digit only left of the decimal) (exponent is either positive or negative)

For Numbers Greater (>) Than One:

1. Move the **decimal point** to the **left** until only one digit remains to the left of the decimal point.

2. Count the number of places was moved and this number becomes the **positive exponent** of 10 by which the new number is multiplied.

ex. $125{,}000 = 1.25 \times 10^{5}$
$5{,}200{,}000{,}000 = 5.2 \times 10^{9}$

For Numbers Less (<) Than One:

1. Move the **decimal point** to the **right** until one digit other than zero remains to the left of the decimal point.

2. Count the number of places the decimal point was moved and this number becomes the **negative exponent** of 10 by which the number is multiplied.

ex. $0.000962 = 9.62 \times 10^{-4}$
$0.183 = 1.83 \times 10^{-1}$

1. 2 310 000 =
2. 40.0 =
3. .00050 =
4. 514 =
5. .173 =
6. 1 725 200 =
7. .0071 =
8. .004250 =
9. 5 280 =
10. .000006 =
11. 30 040 =
12. 69.9 =
13. 1.00 =
14. .08700 =

Your CALCULATOR in Chemistry:

A. Multiplying & Dividing Numbers in Combination

$\frac{4 \times 5 \times 6}{7 \times 8 \times 9}$

1. Press *multiply* after each top number
2. Press *equal* sign
3. Press *divide* after each bottom number
4. Press *equal* sign for final answer

B. Entering & Reading Scientific Notation

1. Enter number (part before the x 10 part of number)
2. Press **exponent key** (EXP or EE or E or $x10^x$) for the x 10 part of number
3. Press **+/- or (-) key** for a negative exponent
4. Enter exponent value

****Never** enter **x 10** for that part of the number. The exponent key enters the x 10.

How to Setup Math Problems in Chemistry the EASY Way:

2.2 Dimensional Analysis: (Unit Cancellation, or Factor Label Method)

This is the single most powerful technique in solving problems in chemistry. It allows you to set up the problem and check for logic errors before performing calculations, and allows you also to determine intermediate answers en-route to the solution.

Vocabulary:

Equivalent or equivalence statement - the numerical relation between two different units that allows them to be equal in value.

ex. 12 inches = 1 foot

Conversion factor - a ratio or fraction form of equivalent values used to express the same quantity in different units. A conversion factor is always equal to 1. It changes the units of a quantity without changing its value.

Ex. $\frac{12 \text{ inches}}{1 \text{ foot}}$ or $\frac{1 \text{ foot}}{12 \text{ inches}}$

Remember that measurements always have **two** parts: a **number** and a **unit**!

When you convert from a large unit to a small unit, the number of smaller units must then be bigger. When you convert from a small unit to a large unit, the number of larger units must then be smaller.

Five Steps:

1. Unknown: Write the unit(s) of the desired product (the unknown) on the left side of the equal sign. (It is like a road sign to guide you to where you are headed. It will not be involved in the calculation or be cancelled.)

2. Known (given value): Write the known or given value(s) along with their associated units, on the right side of the equal sign.

3. Conversion factors: Choose relevant equivalent(s) by choosing those that have both the given unit and the unknown unit in them to make the conversion factor(s).

4. Cancel Units: Place the conversion factors in so that the unit(s) of the known are on the bottom and the unknown unit is on the top of the fraction. Cancel units and it should leave units that are the same as those of the unknown on the left side of the equal sign.

If the units are not equal, then the problem has not been set up correctly, and further changes in the setup must be made.

5. Calculation: Perform the calculation only after you have analyzed all the units and made sure that both sides of your equation have equivalent units. Multiply values across the top and divide by values in the bottom to calculate the answer.

Note: Do NOT change given units or make up new units! Just use what is given in the question and the appropriate conversions needed with their given units.

Basic set up: The horizontal line is a dividing line like in a fraction.

$$\text{? unknown unit} = \frac{\text{known value \& unit}}{1} \times \frac{\text{conversion factor unknown unit}}{\text{conversion factor given unit}}$$

Example: Racing cars at the Indianapolis Motor Speedway now routinely travel around the track at 225 miles/hour. What is the speed in kilometers per minute? Equivalents: 1 kilometer = 0.62 miles, 1 hour = 60 minutes

2.3 How Reliable are Measurements?

Accuracy – how close a measurement is to the true or correct value for a quantity. It depends upon:

a. Reliability of the measuring instrument.
b. Proficiency of the person doing the measurement.
c. The last digit of each measurement is always an estimate.

Precision – how close a series of measurements are to each other.

Percent Error: To evaluate the accuracy of experimental data, the difference between the experimental and accepted value is calculated **(error).** The ratio of the error to the accepted value is

$$\textbf{percent error} = \frac{\textbf{experimental} - \textbf{accepted value}}{\textbf{accepted value}} \times 100$$

Significant Figures (Digits) - indicate the exactness of a measurement. The last digit of a measurement is considered an approximation. **Significant** means **measured**. **Non-significant** digits are important as **place holders** only.

Rules for counting significant digits (sig figs): (all the examples here have 4 sig figs)

1. Nonzero integers - all nonzero integers (1-9) are **always significant.**

.4291 4.291 42.91 429.1 4291.

2. Zeroes -

a. Captive zeroes are zeroes that are sandwiched or fall between two nonzero digits. They are **always** significant.

.9067 9.007 90.07 900.7 9007.

b. Trailing zeroes are zeroes that trail to the right end of the number (trailers).

Trailing zeroes with a decimal are **always** significant**.**

.7800 7.800 78.00 780.0 7800.

Trailing zeroes without a decimal are **never** significant**.**

35110 296500 47630000

c. Leading zeroes – are zeroes that precede all the nonzero digits. They are **never** significant.

0.9844 0.06277 0.0005184 .00006813

3. Exact numbers – have an **unlimited** number of significant digits and include:

a. Counted numbers – are those that were not determined by measuring equipment.

4 pencils 10 beakers

b. Equivalence statements (conversion factors, definitions) are numbers where one quantity is equal to another with a different unit.

12 inches = 1 foot

Rounding Numbers:

1. Determine how many digits you want to keep.
2. If the **digit to be removed** is:
    a. **less than 5**, the preceding digit stays the **same**.
    b. **equal to or greater than 5**, the preceding digit is **increased by 1.**

3. If you **remove digits** to the **left of the decimal,** then **change those digits to 0's** and **use no decimal.**
   If you **remove digits** to **the right of the decimal,** just **drop off the digits.**

4. In a **series of calculations**, carry the extra digits through to the final result, then round off.

ex. 125.4692 Round this number to the following # significant digits:

6 sig figs = 125.469
5 sig figs = 125.47
4 sig figs = 125.5
3 sig figs = 125
2 sig figs = 130
1 sig figs = 100