These Notes are to <u>SUPPLEMENT</u> the Text, They do NOT Replace reading the Text Material. Additional material that is in the Text will be on your tests! To get the most information, <u>READ THE CHAPTER</u> prior to the Lecture, bring in these lecture notes and make comments on these notes. These notes alone are NOT enough to pass any test! The author is not responsible for typos in these notes.

Chapter 1, Basic Concepts of Chemistry

Forensic Chemistry: 1991 a hiker found a human body. It was found to be 530 (53 Centuries) old and the person was about 46 years old when he died. Stomach food contained mica from stones used to grind grain. Isotopic analysis says the mica came from a certain area of the Alps. Copper and Arsenic in his hair and an ax made of copper indicated he was involved in copper smelting. Analysis of one fingernail's appearance showed he was sick 3 times in the past 6 months. Blood / DNA analysis from an arrow tip showed he possibly killed two different people.

Chemistry is about Change. It s not about staring at one rock and determining it's properties. It is the study on the change of one compound or substance or into another (charcoal into carbon dioxide, water and energy as it burns).

$$5\ O_2 + C_3H_8 \text{ (Propane)} \rightarrow 3\ CO_2 + 4\ H_2O + \Delta \text{ (energy)}$$

Or it can be about the combination of several compounds into a different compound: Sodium metal and Chlorine Gas reacts to from Table Salt: $2\ Na + Cl_2 \rightarrow 2\ NaCl$

Chemistry is important because it aids us in the understanding of Biology, Geology, Material Science, Medicine, Physics and Engineering.

Hypotheses: is a tentative explanation or predication based on experimental observations

Quantitative: Information is numerical in nature – a specific temperature or pressure
Qualitative: Information is non-numerical in nature: The color is red, the shape is round

Laws: is a concise verbal or mathematical statement of a behavior or a relation that seems always to be the same under some conditions.

Sodium will react with Chlorine to form salt.

The mass of the substances produced in a chemical reaction is exactly the same as the sum of the mass of the starting materials. 22.99 g Na + 35.45 g Cl → 58.44 g NaCl,

The Law of conservation of matter states "Mass is always conserved in Chemical Reactions"

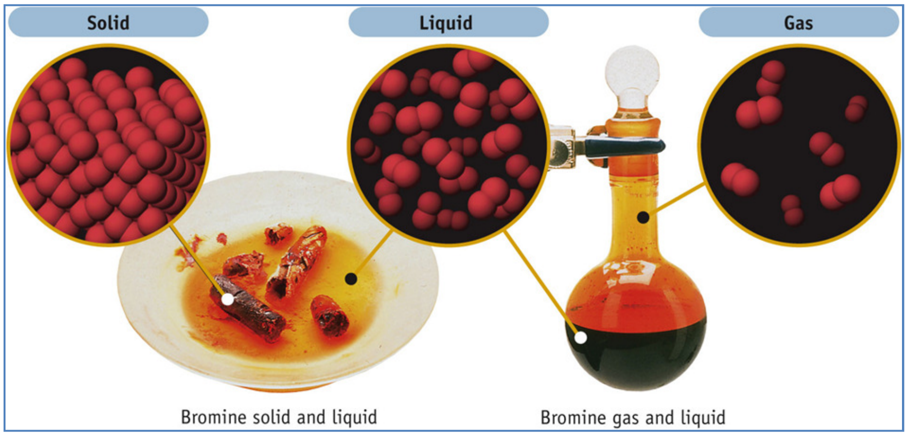
Theory: is a well tested, unifying principal that explains a body of facts and the laws based on them. It is based on carefully determined and reproducible evidence.

Guide to Scientific Practice:

- Experimental results should be reproducible
- Conclusions should be reasonable and unbiased
- Credit should be given where it is due.

Green Chemistry: It is better to prevent waste than to treat or clean up waste after it is formed

Discuss Chemistry Labs and other examples (class discussion)



States of Matter: is a property of matter

Solid:	Rigid shape, fixed volume that changes little with temperature and pressure
Liquid	Fixed volume, is fluid, takes the shape of its container
Gas	A fluid, volume is determined by the size of its container and volume varies with changes in temperature and pressure

At a low enough temperature (absolute zero) all matter is in the solid state

Kinetic-Molecular Theory of Matter: all matter consists of extremely tiny particles called atoms. These atoms make up molecules and ions and are in constant motion

Solid:
- Particles are packed closely together in a regular array
- Particles vibrate back in forth about their average position
- Particles do not squeeze past their immediate neighbors

Liquid
- Particles are arranged randomly rather than in a regular pattern
- Liquid is Fluid, the particles not confined to a specific location and can move past each other

Gas
- Particles are far apart
- Molecules move extremely rapidly and are not constrained by their neighbor
- Molecules collide with one another and with the container walls
- The random motion allows the gas molecules to fill their container
- The volume of the gas sample is the volume of the container

Temperature: The higher the temperature, the faster the particles move.

Kinetic Energy: The energy of motion of particles

Macroscopic view: observations using samples large enough to be seen, measured and handled: color, solubility (dissolves in water), conducts electricity

Submicroscopic or Particulate view: observations at the level of individual particles that make up matter. How a chemical reaction occurs: $Na + Cl \rightarrow NaCl$.

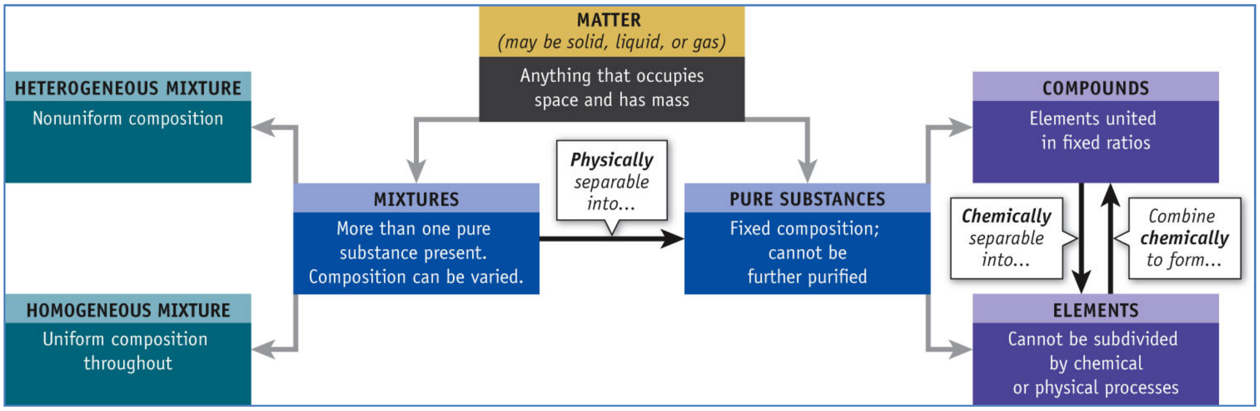
Pure Substances is a chemical substance with a specific chemical composition and cannot be separated into two or more different species. It has a unique set of properties: MP, BP, color, etc

Mixtures: consist of 2 or more pure substances that can be separate by physical techniques

Heterogeneous: have an uneven texture; the properties in one region are different from those in another region (a mixture of salt and pepper).

Homogeneous: consists of 2 or more substances in the same phase. (a mixture of salt and water) Homogeneous mixtures are often called **Solutions.**

In separating a mixture into its pure components, the components are said to be purified.



Elements: One type of atom (see the periodic table)

Periodic Table: is a tabular arrangement of chemical elements organized on the basis of atomic numbers.

Atom: the basic unit of a chemical element (from a Chemistry point of view)

1.5 Compounds

Chemical Bonds: Force that holds together 2 or more different elements

Chemical Compound: 2 or more different elements held together by a chemical bond

Mixture of elements Can be prepared in varying proportions of the components

Chemical Compound: No variation in composition, definite % of composition by mass
Distinctly different from its parent elements

Ions: Electrically charged atoms or groups of atoms

Molecules the smallest discrete unit that retains the composition and chemical characteristics of the compound

Chemical Formula: The representation of the composition of any compound (NaCl)

Table 1.1 Some Physical Properties

Property	Using the Property to Distinguish Substances
Color	Is the substance colored or colorless? What is the color, and what is its intensity?
State of matter	Is it a solid, liquid, or gas? If it is a solid, what is the shape of the particles?
Melting point	At what temperature does a solid melt?
Boiling point	At what temperature does a liquid boil?
Density	What is the substance's density (mass per unit volume)?
Solubility	What mass of substance can dissolve in a given volume of water or other solvent?
Electric conductivity	Does the substance conduct electricity?
Malleability	How easily can a solid be deformed?
Ductility	How easily can a solid be drawn into a wire?
Viscosity	How easily will a liquid flow?

1.6 Physical Properties: properties that can be observed and measured without changing the composition of a substance. Density, MP, BP, vapour pressure, solubility Color, State of matter, Electric Conductivity, Malleability, Ductility, Viscosity

Density: The radio of the mass (weight) of an object to its volume.
Density = mass / volume The density of water varies according to temperature (ice floats).

Temperature: A measurement related to the molecular motion of a sample (^{o}F, ^{o}C, K)

Extensive Properties depend on the amount of a substance (the volume of a certain mass of a material, amount of energy given off by burning an amount of gasoline).

Intensive Properties do not depend on the amount of a substance (melting point of ice)

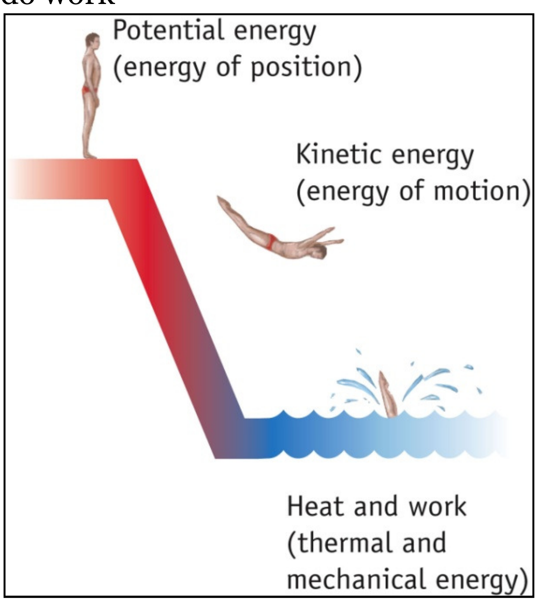
1.7 Physical & Chemical Changes

Changes in Physical Properties are Physical Changes. The identity of a substance is preserved, it may have undergone a change in physical state, size or shape. (ice melting to liquid the boiling to steam. MP = Physical

A Chemical Change is where one or more substances (reactants) are transformed into one more different substances (products). Na + Cl → NaCl
Reactants Products

The Chemical Equation shows the representation of the change using chemical formulae.
A Chemical Property shows how readily a material undergoes a chemical change.

1.8 Energy: is the capacity to do work



Kinetic Energy: Energy associated with motion
Potential Energy Capacity from an object's position

Conservation of Energy: Energy can neither be created nor destroyed – the total energy of the universe is constant.

Tools of Quantitative Chemistry

1. Units of Measurement

Metric System / SI – is the currently used Decimal System with derived base units

Temperature Celsius & Kelvin (We use degrees Fahrenheit)

SI Base Units

Mass	Kilogram	Kg
Length	Meter	m
Time	Second	s
Temperature	Kelvin	K
Amount of Substance	Mole	mol
Electric Current	Ampere	A
Luminous Intensity	Candela	cd

Prefixes

Giga	G	10^9	billion	Gigahertz = 1 x 10^9 Hz
Mega	M	10^6	million	Megaton = 1 x 10^6 tons
Kilo	k	10^3	Thousand	Kilogram (kg) = 1 x 10^3 g
Deci	d	10^{-1}	Tenth	1 decimeter (dm) = 0.1 m (10^{-1})
Centi	c	10^{-2}	hundredth	1 cm = 0.02 m (10^{-2})
Milli	m	10^{-3}	thousandth	1 mm = 0.001 m (10^{-3})
Micro	µ	10^{-6}	millionth	1 µm = 10^{-6} m
Nano	n	10^{-9}	billionth	1 nm = 10^{-9} m
Pico	p	10^{-12}		1 pm = 10^{-12} m
Femto	f	10^{-15}		1 fm = 10^{-15} m

Celsius 0^oC is the freezing point of water, and 100 ^oC is the boiling point of water
Kelvin Absolute zero = -273.15 oC

	Absolute Zero	**FP Water**	**MP Water**
F		32^o	212^o
C	-273.15^o	0^o	100^o
K	0^o	273.15^o	373.15^o

T (K) = 1 K / 1 ^{o}C (T ^{o}C + 273.15 ^{o}C)

Length Meter. Frequent units are meter, centimeter, millimeters, micrometers

Volume Cubic meter, but we use the Liter L or milliliter ml 1 L = 1000 ml
Milliliter (ml) and cubic centimeter (cm^3 or cc) are used interchangeably
Deciliter (dl) = 0.100 L – 100. ml

Mass Kilogram (Kg), but gram (g) or milligram (mg) are often used
1 Kg = 1000. g. 1. g = 1000. mg

Energy Joule = 1 kg m^2/s^2 kJ is often used = 1000 J
1 calorie (cal) = 4.184 joules (J)
US dietary Calorie (Cal) = 1 Kcal = 1000. calories

2. Measurements

Precision: How well several determinations of the same quantity agree
Throw 4 darts at a dart board and they all are together in the upper right side

Accuracy An agreement of a measurement with the accepted values of the quantity
Throw 2 darts at a dart board and they land in the center

Percent Error Difference between your result and the accepted value
% Errror = 100% * (error in measurement) / (accepted value)

Example 2 WORK AT BOARD

Problem A coin has an "accepted" diameter of 28.054 mm. In an experiment, two students measure this diameter. Student A makes four measurements of the diameter of the coin using a precision tool called a micrometer. Student B measures the same coin using a simple plastic ruler. The two students report the following results:

Student A	Student B
28.246 mm	27.9 mm
28.244	28.0
28.246	27.8
28.248	28.1

What is the average diameter and percent error obtained in each case? Which student's data are more accurate?

What Do You Know? You know the data collected by the two students and want to compare them with the "accepted" value by calculating the percent error.

Strategy For each set of values, we calculate the average of the results and then compare this average with 28.054 mm.

Solution The average for each set of data is obtained by summing the four values and dividing by 4.

Average value for Student A = 28.246 mm
Average value for Student B = 28.0 mm

Although Student A has four results very close to one another (and so of high precision), Student A's result is less accurate than that of Student B. The average diameter for Student A differs from the "accepted" value by 0.192 mm and has a percent error of 0.684%:

$$\text{Percent error} = \frac{28.246\ \text{mm} - 28.054\ \text{mm}}{28.054\ \text{mm}} \times 100\% = 0.684\%$$

Student B's measurement has a percent error of only about −0.2%.

Think about Your Answer Although Student A had less accurate results than Student B, they were more precise; the standard deviation for Student A is 2×10^{-3} (calculated as described below), in contrast to Student B's larger value (standard deviation = 0.14). Possible reasons for the error in Student A's result are incorrect use of the micrometer or a flaw in the instrument.

Check Your Understanding

Two students measured the freezing point of an unknown liquid. Student A used an ordinary laboratory thermometer calibrated in 0.1 °C units. Student B used a thermometer certified by NIST (National Institute of Standards and Technology) and calibrated in 0.01 °C units. Their results were as follows:

Student A: −0.3 °C, 0.2 °C, 0.0 °C, −0.3 °C

Student B: −0.02 °C, +0.02 °C, 0.00 °C, +0.04 °C

Calculate the average value for A and B and, knowing the liquid was water (and using kelvins for temperature), calculate the percent error for each student. Which student has the smaller error?

Standard Deviation = a calculation that shows when a large number of measurements are used the result has 68% of the values are within 1 std of the value determined and 95% within 2 std.

Suppose you carefully measured the mass of water delivered by a 10-mL pipet. (A pipet containing a green solution is shown in Figure 4.) For five attempts at the measurement (shown in column 2 of the following table), the standard deviation is found as follows. First, the average of the measurements is calculated (here, 9.984). Next, the deviation of each individual measurement from this value is determined (column 3). These values are squared, giving the values in column 4, and the sum of these values is determined. The standard deviation is then calculated by dividing this sum by the number of determinations minus 1 (= 4) and taking the square root of the result.

Determination	Measured Mass (g)	Difference between Measurement and Average (g)	Square of Difference
1	9.990	0.006	4×10^{-5}
2	9.993	0.009	8×10^{-5}
3	9.973	−0.011	12×10^{-5}
4	9.980	−0.004	2×10^{-5}
5	9.982	−0.002	0.4×10^{-5}

Average mass = 9.984 g

Sum of squares of differences = 26×10^{-5}

$$\text{Standard deviation} = \sqrt{\frac{26 \times 10^{-5}}{4}} = 0.008$$

Based on this calculation, it would be appropriate to represent the measured mass as 9.984 ± 0.008 g. This would tell a reader that if this experiment were repeated, a majority of the values would fall in the range from 9.976 g to 9.992 g.

3 Math of Chemistry

Fixed Notation Numbers expressed as a series of digits with/WO a decmil point

Exponential or Scientific Notation A number is expressed as he product of two numbers.

<u>N x 10^x</u> The first term is the digit term and is a number between 1. And 9.999

The second term is the exponential term where x represents the power of 10 and can have values of ...+2, +1, 0, -1, -2 ... This is used to express large and small values

$$1234 = 1.234 \text{ x } 10^3 = 1.234 \text{ x } 1000.$$

<u>DISCUSS THIS, EXPECIALLY THE FIRST VALUE</u>

Adding and subtracting Scientific Numbers

Both must have the same power of 10

Multiplication of Scientific Numbers

Multiply the first term, add the powers of 10, reduce the first term to between 1. and 9.999

Division of Scientific Numbers

Divide the first term values, subtract the powers of 10, and reduce the first term to between 1. and 9.999

Significant Figures are digits in a measured quantity that were observed with the measuring device

You see 3 digits for the weight of an object, you must report 3 digits, not 2 or 4!

***** Leading zero's do not count, trailing zero's do count

<u>Give examples and determine the number of SF</u>

Rule 1: Adding / Subtracting numbers. Line up the decimal and add or subtract
The number of decimal places in the answer equals the number of decimal places in the number with the fewest digits.

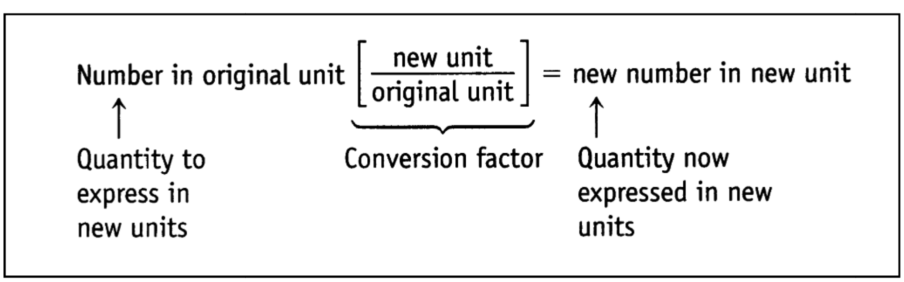
Rule 2 In multiplication or division, the number of SF in the answer is determined by the number with the fewest SF

Rule 3 When a number is rounded off, the last digit to be retained is increased by one, only if the following digit is 5 or greater

<u>DO SOME EXAMPLES.</u>

Dimensional Analysis is a problem solving approach that uses the dimensions or units of each value to guide us through calculations. DA uses **Conversion Factors** to express the equivalence of a measurement in two different units.

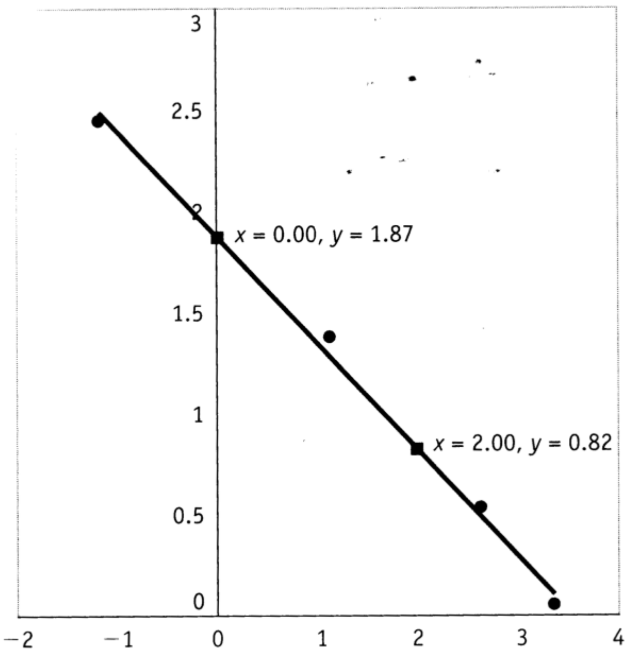
$$\boxed{3.1 \text{ mm} \times \frac{1 \text{ cm}}{10 \text{ mm}} = 0.31 \text{ cm}}$$



Units in conversion errors: Book example of a new 767 running out of fuel
Mars Satellite did not have enough engine thrust to land on Mars

Go over various conversion units

Graphs & Graphing y = mx + b is the graph of a straight line



Experimental data

x	y
3.35	0.0565
2.59	0.520
1.08	1.38
−1.19	2.45

Using the points marked with a square, the slope of the line is:

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{0.82 - 1.87}{2.00 - 0.00} = -0.525$$