HONORS CHEMISTRY
Unit A: Matter and Measurements
CHAPTER ONE: MATTER AND CHANGE
WHAT IS CHEMISTRY?

CHEMISTRY is the study of the composition, structure, and properties of matter, the process that matter undergoes, and the energy changes that accompany these processes.
WHAT IS MATTER?

- MATTER is anything that has mass and volume – no matter how small the measurement.
- MASS is a measure of the amount of matter
- VOLUME is a measure of the space taken up by matter
WHAT IS AN ATOM?

ATOMS are the smallest unit of an element that maintains the chemical identity of that element.
WHAT IS AN ELEMENT?

ELEMENTS are pure substances that cannot be broken down into simpler, stable substances and are made of only a single kind of atom.
WHAT IS A COMPOUND?

COMPOUNDS are substances that can be broken down into simple stable substances. Compounds are made from two or more elements that are chemically bonded.
PROPERTIES OF MATTER

- PROPERTIES of matter help to define and classify substances. They can reveal the identity of an unknown substance.
- EXTENSIVE PROPERTIES depend on the amount of matter present
  - Ex. MASS, VOLUME, ENERGY
- INTENSIVE PROPERTIES do not depend on the amount of matter present
  - Ex. DENSITY, m.p., b.p., CONDUCTIVITY
PHYSICAL PROPERTIES of matter can be observed w/o changing the identity of the substance.

PHYSICAL CHANGE doesn’t change the identity of the substance

Ex. Cutting, Grinding, Phase Changes
CHEMICAL PROPERTIES of matter relate to a substance’s ability to undergo change to form a new substance.

CHEMICAL CHANGE results in a substance(s) being converted to a new substance(s).

- Ex. Combustion, Oxidation, Decomposition
CHEMICAL REACTION

- CHEMICAL REACTION is a process that involves a chemical change
- Reactants change to form new Products

\[
\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})
\]
CONSERVATION OF ENERGY & MATTER

- In a chemical reaction matter is neither created nor destroyed. It can be accounted for and converted.
- In a chemical reaction energy can be absorbed (endothermic) or released (exothermic), but not created or destroyed.
Matter exists in a variety of forms and divided into two major types: Mixtures & Pure Substances.
MIXTURES

MIXTURES are a blend of two or more kinds of matter. Each substance retains its own properties.
MIXTURE GROUPS

- HOMOGENEOUS MIXTURES are uniform and appear as a single substance. Homogeneous mixtures are also called solutions.
- HETEROGENEOUS MIXTURES are non-uniform.
- Mixtures can often be physically separated by filtration, vaporization, or other lab techniques.
PURE SUBSTANCES

PURE SUBSTANCES have a fixed composition for all samples. They are either Elements or Compounds.
The Periodic Table of the Elements

- Elements are organized on The Periodic Table
- Over 100 elements are known
- Elements are organized into Groups/Families and Periods.
- Elements are also classified as Metals, Nonmetals, and Metalloids.
Types of Elements

- METALS are good conductors, malleable, and are ductile and have luster. (Cu)
- NONMETALS are poor conductors, brittle, and usually gases at room temperature. (Ne)
- METALLOIDS are a small group of elements that share characteristics with metals and nonmetals. (Si)
HONORS CHEMISTRY
Unit A: Matter and Measurements
CHAPTER TWO: MEASUREMENTS & CALCULATIONS
SI Measurement

- SI is the universal measurement system used by scientists
- MEASUREMENTS represent quantities (descriptive amounts)
- QUANTITY is something that has magnitude, size, or amount (numerical value)
SI BASES

- There are 7 SI bases and many derived or combination units
- The “Big 5” are LENGTH, MASS, TIME, TEMPERATURE, and AMOUNT OF SUBSTANCES

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>meter</td>
<td>m</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>Temperature</td>
<td>Kelvin</td>
<td>K</td>
</tr>
<tr>
<td>Amount</td>
<td>mole</td>
<td>mol</td>
</tr>
<tr>
<td>Current</td>
<td>ampere</td>
<td>A</td>
</tr>
<tr>
<td>Luminous</td>
<td>candela</td>
<td>cd</td>
</tr>
</tbody>
</table>
MASS

- SI Unit: Kilogram (kg)
- 1 kg = 1,000 g = 1,000,000 mg
- MASS is not the same as WEIGHT
- WEIGHT is a force dependent upon gravity
LENGTH

- SI Unit: Meter (m)
- 1 km = 1,000 m = 1,000,000 mm

### Table 1.3  Common Decimal Prefixes Used with SI Units

<table>
<thead>
<tr>
<th>Prefix*</th>
<th>Symbol</th>
<th>Word</th>
<th>Conventional Notation</th>
<th>Exponential Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tera</td>
<td>T</td>
<td>trillion</td>
<td>1,000,000,000,000</td>
<td>$1 \times 10^{12}$</td>
</tr>
<tr>
<td>Giga</td>
<td>G</td>
<td>billion</td>
<td>1,000,000,000</td>
<td>$1 \times 10^{9}$</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>million</td>
<td>1,000,000</td>
<td>$1 \times 10^{6}$</td>
</tr>
<tr>
<td>Kilo</td>
<td>k</td>
<td>thousand</td>
<td>1,000</td>
<td>$1 \times 10^{3}$</td>
</tr>
<tr>
<td>Hecto</td>
<td>h</td>
<td>hundred</td>
<td>100</td>
<td>$1 \times 10^{2}$</td>
</tr>
<tr>
<td>Deka</td>
<td>da</td>
<td>ten</td>
<td>10</td>
<td>$1 \times 10^{1}$</td>
</tr>
<tr>
<td>Deci</td>
<td>d</td>
<td>tenth</td>
<td>0.1</td>
<td>$1 \times 10^{-1}$</td>
</tr>
<tr>
<td>Centi</td>
<td>c</td>
<td>hundredth</td>
<td>0.01</td>
<td>$1 \times 10^{-2}$</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>thousandth</td>
<td>0.001</td>
<td>$1 \times 10^{-3}$</td>
</tr>
<tr>
<td>Micro</td>
<td>μ</td>
<td>millionth</td>
<td>0.000001</td>
<td>$1 \times 10^{-6}$</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>billionth</td>
<td>0.00000001</td>
<td>$1 \times 10^{-9}$</td>
</tr>
<tr>
<td>Pico</td>
<td>p</td>
<td>trillionth</td>
<td>0.0000000001</td>
<td>$1 \times 10^{-12}$</td>
</tr>
<tr>
<td>Femto</td>
<td>f</td>
<td>quadrillionth</td>
<td>0.000000000001</td>
<td>$1 \times 10^{-15}$</td>
</tr>
</tbody>
</table>

*The prefixes most frequently used by chemists appear in bold type.
AMOUNT (of a substance)

- SI Unit: Mole (mol)
- 1 mole = $6.02 \times 10^{23}$
- The MOLE is a really large number that is useful when quantifying really small things like atoms
TEMPERATURE

- SI Unit: Kelvin (K)
- The KELVIN scale has no negative values and has incremental change equal to the CELCIUS scale
- $\Delta 1^\circ C = \Delta 1 K$
- $0 K = -273 ^\circ C$
- $K \rightarrow ^\circ C$ (subtract 273)
- $^\circ C \rightarrow K$ (add 273)
VOLUME

- SI Unit: Meter ($m^3$)
- VOLUME is a derived unit – length in 3D
- VOLUME units are often expressed as:
  - Liters (L), Mililiters (mL), Cubic Centimeters ($cm^3$)
  - 1 L = 1,000 mL = 1,000 cm$^3$
DENSITY

- DENSITY is the ratio of mass per unit volume
- DENSITY = \( D = \frac{M}{V} \)
- DENSITY units are often expressed as:
  - Kilograms per cubic meter (kg/m\(^3\))
  - Grams per cubic milliliter (g/mL)
CONVERSION FACTORS

- A ratio derived from an equality between two different units
- Used to convert one unit to another
- Formatted as FRACTIONS
  - Desired “New” unit on TOP
  - Starting “Old” unit on BOTTOM
DIMENSIONAL ANALYSIS

- Math technique that uses conversion factors to solve problems with units of measure
- Multiplication & Fractions!
- Examples on the board:
  - Time, Mass, Moles
ACCURACY & PRECISION

- ACCURACY refers to the closeness of a measurement to the correct or accepted value.
- PRECISION refers to the closeness of a set of measurements of the same quantity.
PERCENT ERROR

- % ERROR compares the accuracy of an experimental value with an accepted value
- Kind of like “grade” for your experimental measurements or data
- Values closer to 0% are best

\[
\% \text{ Error} = \left| \frac{\text{measured} - \text{accepted}}{\text{accepted}} \right| \times 100
\]
Measurement Error

- No measurements are “perfect”
- Errors in measurement are due to human and instrumental limitations
- Estimation is involved in the final questionable digit of a measurement
  - Examples: 2.5 days vs. 2 days, 12 hours, 1.5 minutes
  - Sun vs. Clock
**Sig Figs**

SIGNIFICANT FIGURES in a measurement consist of all the digits known with certainty plus one final digit, which is estimated or uncertain.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1. Zeros between other nonzero digits are significant. | a. 50.3 m has three significant figures.  
|       | b. 3.0025 s has five significant figures. |
| 2. Zeros in front of nonzero digits are not significant. | a. 0.892 kg has three significant figures.  
|       | b. 0.0008 ms has one significant figure. |
| 3. Zeros that are at the end of a number and also to the right of the decimal are significant. | a. 57.00 g has four significant figures.  
|       | b. 2,000,000 kg has seven significant figures. |
| 4. Zeros at the end of a number but to the left of a decimal are significant if they have been measured or are the first estimated digit; otherwise, they are not significant. In this book, they will be treated as not significant. (Some books place a bar over a zero at the end of a number to indicate that it is significant. This textbook will use scientific notation for these cases instead.) | a. 1000 m may contain from one to four significant figures, depending on the precision of the measurement, but in this book it will be assumed that measurements like this have one significant figure.  
|       | b. 20 m may contain one or two significant figures, but in this book it will be assumed to have one significant figure. |
Sig Fig Operations

- ADDITION & SUBTRACTION: the answer must have the same number of digits to the right of the decimal point as there are in the measurement with the fewest digits to the right of the decimal point.

1.0236
- 0.97268
  \[ \frac{0.05092}{\text{downward rounding}} \]

\[ \begin{array}{c}
23.445 \\
+ 7.83 \\
\hline
31.275 \\
\end{array} \]
Corrected \[ \frac{31.28}{\text{By rounding up to the lowest number of significant figures}} \]

\[ \begin{array}{c}
2,450 \\
+ 14.23 \\
\hline
2,464.23 \\
\end{array} \]
= 2,460
**Sig Fig Operations**

- **MULTIPLICATION & DIVISION:** the answer can only have as many significant figures as the measurement with the fewest sig figs.

---

3.69 \times 2.3059 = 8.5088 \rightarrow 8.51

- Three sig. fig.
- Five sig. fig.
- To be rounded to three sig. fig.

---

60021 \times 0.0071 \rightarrow 426.1

- 2 significant digits

426.149 \rightarrow 426.1

0.00032 \div 11.2 \rightarrow 0.000029

- 2 significant digits

10^{-3.9} \times 10^{-1.12} = 10^{-5.0} \rightarrow 10^{-5.0}

- 2 significant digits
Scientific Notation

- SCIENTIFIC NOTATION expresses quantities with non-significant zeros in a compact form.
- \( M \times 10^n \) (Avogadro’s # \( 6.02 \times 10^{23} \))
- The “M” value must be greater than or equal to 1 and less than 10.

Scientific Notation

\[ a \times 10^b \]

where

- \( 1 \leq |a| < 10 \)
- \( b \) is an integer
- A number greater than or equal to 1 but less than 10.

Convert to Scientific Notation

<table>
<thead>
<tr>
<th>( 3.25 \times 10^9 )</th>
<th>( 0.0000004 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 units to the LEFT</td>
<td>7 units to the RIGHT</td>
</tr>
<tr>
<td>LEFT ( \to ) positive exponent</td>
<td>RIGHT ( \to ) negative exponent</td>
</tr>
</tbody>
</table>

Scientific Notation to Numbers

Scientific Notation involves moving decimals.

- \( 1.5 \times 10^4 \)
  - Because the exponent is Positive
  - Move the decimal point 4 places to the right.
  - Result: \( 15000 \)

- \( 5.8 \times 10^{-4} \)
  - Because the exponent is Negative
  - Move the decimal point 4 places to the left.
  - Result: \( 0.00058 \)
**Scientific Notation Rules**

**Addition and Subtraction in Scientific Notation**
- Get the exponents the same before adding or subtracting
  
  \[
  (5.30 \times 10^3) + (6.0 \times 10^2) = \\
  (5.30 \times 10^3) + (0.60 \times 10^3) = \\
  5.90 \times 10^3
  \]

**Multiplication and Division of With Scientific Notation**
- Multiplication – Multiply Coefficients and add Exponents of 10
  
  \[
  (2.0 \times 10^4) \times (4.0 \times 10^3) = (2.0 \times 4.0) \times 10^{4+3} = 8 \times 10^7
  \]

- Division – Divide Coefficients and subtract Exponents of 10
  
  \[
  \frac{4.0 \times 10^2}{2.0 \times 10^2} = \frac{4.0}{2.0} \times 10^{2-2} = 2 \times 10^{-2}
  \]
Proportionality

- **DIRECTLY PROPORTIONAL:** the quotient of the two variables is constant \((y/x = \text{constant})\)
  - Temperature & Volume
- **INVERSELY PROPORTIONAL:** the product of the two variables is constant \((xy = \text{constant})\)
  - Pressure & Volume
Directly Proportional and Inversely Proportional Graphs

**Directly Proportional**

As the independent variable increases, the dependent variable increases as well.

**Inversely Proportional**

As the independent variable increases, the dependent variable decreases.