Some Elementary Topics and Terms

1. What is Chemistry?
   - the study of matter and its changes
   - the "central science"

2. The Scientific Method
   - **OBSERVATION**
     - (empirical facts, then "laws")
   - **EXPLANATION**
     - (hypothesis and theory)

3. Matter and Energy
   - **matter** occupies space and has mass
     - (mass is the amount of matter, **weight** is force of gravitational attraction on the mass)
   - **energy** is ability to do work: **kinetic** (motion) or **potential** (stored)

4. Heat and Temperature
   - **Heat** is a form of energy (internal motions of atoms and molecules)
   - **Temperature** is a measure of the intensity of heat

Elements, Compounds, and Mixtures

1. Classification of Matter
   - **Mixtures** (homogeneous or heterogeneous)
   - **Pure Substances** (elements and compounds)
   - **Atom**: smallest component of an element
   - **Molecule**: combination of two or more atoms
     - smallest component of a compound
2. The "Language of Chemistry"

"alphabet"  **symbols** for the elements, e.g. C, N, F, Mg, Fe, etc.

"words"  **chemical formulas**, e.g. H₂O, N₂, Fe₂(CO₃)₃, etc.

counting atoms in formulas:
1 molecule of H₂O contains 2 hydrogen atoms and 1 oxygen atom
the formula Fe₂(CO₃)₃ represents:
2 iron atoms, 3 carbon atoms, and 9 oxygen atoms

"sentences"  **chemical equations** (reactants and products)

\[
\text{Mg(OH)}_2 (s) + 2 \text{HCl (aq)} \rightarrow \text{MgCl}_2 (aq) + 2 \text{H}_2\text{O (l)}
\]

**coefficients** are used to "balance" the equation
**subscripts** indicate states of matter (optional)
**balanced equation:**
same number of atoms of each element on both sides of arrow

**Units of Measurement**

1. **Système International** International units

Base units: length m meter (39.37 inches)
mass kg kilogram (2.205 lb)
time s second
temp K Kelvin

Derived units: e.g., volume = length x length x length (e.g., m³)
1 mL = cm³ and 1 L = 1,000 mL = 1,000 cm³

2. The Metric System (Table 1.2)

**KNOW Decimal Multipliers and Metric Prefixes**

e.g.,  \( k = \text{kilo} = 10^3 \)  1 km = 10³ m

\( n = \text{nano} = 10^{-9} \)  1 nm = 10⁻⁹ m
3. Metric - English Conversions (Table 1.3)

KNOW at least:

- **length**: 1 inch = 2.54 cm or 1 m = 39.37 inches
- **mass**: 1 kg = 2.205 lb or 1 lb = 454 g
- **volume**: 1 L = 1.057 qt or 1 gal = 3.786 L

4. Temperature Scales (Figure 1.11)

- **Fahrenheit** °F \[ T_F = \left(\frac{9}{5}\right) T_C + 32 \]
- **Celsius** °C \[ T_C = \left(\frac{5}{9}\right) (T_F - 32) \]
- **Kelvin** K \[ T_K = T_C + 273.15 \]

Calculations and Significant Figures

1. Accuracy and Precision

   - **accuracy** - how close to the "true" value? (systematic errors)
   - **precision** - how reproducible is the measurement? (random errors)

2. Significant Figures

   # of "significant figures" shows degree of uncertainty in measurement

   e.g., a certain distance, in inches, could be 11.1, or 11.08, or 11.083 depending on how carefully it was measured (to 3, 4, or 5 sig figs)

3. Exact Numbers

   values that are exactly **counted** or **defined** can be assumed to have an infinite number of sig figs,

   e.g., 25 people or 1 foot = 12 inches
4. Calculations with Sig Figs

*multiplication and division*
look for factor with fewest # of sig figs

*addition and subtraction*
look for value with fewest # of decimal places

eexample:

\[
\frac{12.5 \times 0.004215}{3.6 + 1.247} = \frac{"905.95755"}{906} = 9.1 \times 10^2
\]

5. Unit Conversions:  the **FACTOR - LABEL** method
(aka "Dimensional Analysis")

e.g.,  "48 inches is 4 ft"  how is this shown in a calculation?

given quantity \( \times \) conversion factor(s) = desired quantity

\[
\text{given quantity} \times \frac{1 \text{ ft}}{12 \text{ inches}} = 4 \text{ ft}
\]

now, what is 48 inches in meters?

\[
(48 \text{ in}) \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1.22 \text{ m}
\]

another example: convert 25 miles/gal to km/L:

\[
\begin{array}{cccccccc}
25 \text{ mi} & 5,280 \text{ ft} & 12 \text{ in} & 2.54 \text{ cm} & 10^{-2} \text{ m} & 1 \text{ km} & 1 \text{ gal} & = 10.6 \text{ km} \\
\text{gal} & \text{mi} & \text{ft} & \text{in} & \text{cm} & \text{m} & \text{L} & \text{L}
\end{array}
\]
Density and Specific Gravity

**density:** \( d = \text{mass/volume} \) (usually \( \text{g/cm}^3 \) or \( \text{g/mL} \))

e.g., density of water is 1.00 \( \text{g/cm}^3 \) or 1.00 \( \text{g/mL} \)

density of iron is 7.86 \( \text{g/mL} \)

**specific gravity:** \( \frac{d_{\text{substance}}}{d_{\text{water}}} \) (a dimensionless quantity)

e.g., specific gravity of iron is 7.86

(i.e., iron is 7.86 times more dense than water)