Matter, Measurement, and Problem Solving (Chapter 1)

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. H_2O, N_2, $Fe_2(CO_3)_3$, etc.

counting atoms in formulas:

1 molecule of H_2O contains 2 hydrogen atoms and 1 oxygen atom

the formula $Fe_2(CO_3)_3$ represents:

2 iron atoms, 3 carbon atoms, and 9 oxygen atoms

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

$$Mg(OH)_{2\,(s)} + 2\,HCl_{\,(aq)} \longrightarrow MgCl_{2\,(aq)} + 2\,H_2O_{\,(l)}$$

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. **S**ystèm **I**nternational 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., m^3)

1 mL = cm^3 and 1 L = 1,000 mL = 1,000 cm^3

2. The Metric System (Table 1.2)

KNOW Decimal Multipliers and Metric Prefixes

e.g., *k* = *kilo* = 10^3 1 km = 10^3 m

n = *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	$T_F = (9/5)\, T_C + 32$
Celsius	°C	$T_C = (5/9)\, (T_F - 32)$
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

example:

$$\frac{12.5 + 1.247}{3.6 \times 0.004215} = \text{"905.95755"} = 906 = \boxed{9.1 \times 10^2}$$

$$\rightarrow \frac{13.7}{0.015}$$

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 x **conversion factor(s)** = **desired quantity**

(starting units) (target units)

(48 ~~inches~~) x (1 ft/12 ~~inches~~) = 4 ft

now, what is 48 inches in meters?

(48 ~~in~~) x (2.54 ~~cm~~/~~in~~) x (1 m/100 ~~cm~~) = 1.22 m

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

$$\frac{25\ \text{~~mi~~} \mid 5{,}280\ \text{~~ft~~} \mid 12\ \text{~~in~~} \mid 2.54\ \text{~~cm~~} \mid 10^{-2}\ \text{~~m~~} \mid 1\ \text{km} \mid 1\ \text{~~gal~~}}{\text{~~gal~~} \mid \text{~~mi~~} \mid \text{~~ft~~} \mid \text{~~in~~} \mid \text{~~cm~~} \mid 10^{3}\ \text{~~m~~} \mid 3.785\ \text{L}} = \frac{10.6\ \text{km}}{\text{L}}$$

Density and Specific Gravity

density: d = mass/volume (usually g/cm^3 or g/mL)

e.g., density of water is 1.00 g/cm^3 or 1.00 g/mL

density of iron is 7.86 g/mL

specific gravity: $d_{substance} / d_{water}$ (a dimensionless quantity)

e.g., specific gravity of iron is 7.86
(i.e., iron is 7.86 times more dense than water)