**Atoms, Isotopes, Ions & Molecules: The VERY Short Story**

*Covered in Chapter 3 of Brown et al.*

**Mole:** a unit used to commonly express the amount of atoms, ions, isotopes or molecules

* The number of carbon-12 atoms in 12 grams [aka Avogadro’s number]
* An enormously large number
* A conversion factor
* Expressed as 6.02 x 1023 atoms/1 mole (or molecules/ 1 mole)

**Atomic mass or molecular weight (aka MW molar mass)**: mass (in grams) of one mole of atom or molecule; calculated from molecular formula

* Expressed as XXX grams/1 mole
* Allows us to weigh out moles of an element or molecule
* Example: H3(PO4) 🡪 (3)(1.00794) + (1)(32.066) + (4)(15.99) = 98 g/mole

**Interconversion** using these new conversion factors:



* Note that a problem requires conversion of molecule ***to*** atoms you must use formula subscripts as a conversion factor. For example, 2 atoms of H in 1 molecule of H2O
* Again, railroad track conversion will get you where you need to go

**Percent composition:** expresses what percentage of a molecule’s mass is made up of a single element. Sum of all % composition values should be 100.

 %X = (atoms of X in formula)(atomic mass of X) \* 100

 total MW

**Empirical formula** can be calculated from % composition:

* Assume a 100-g sample, so change % sign to “g”;
* Convert g to mol;
* Calculate mol ratios of the elements;
* Use ratios as formula subscripts.

**Molecular formulas** can be calculated from empirical formulas or % composition if MW is provided. The ratio f MW/empirical weight should be used as a multiplier to turn empirical formula subscripts into molecular formula subscripts.

**Balanced chemical equations** have the same number & type of atoms on each side of the equation (reactants on the left 🡪 products on the right)

* Balanced equations obey the Law of Conservation of Mass
* When balancing equations, coefficients can be increased but never decreased

**Stoichiometry**: the proportions or ratios between molecules shown as coefficients in a balanced chemical equation

* Stoichiometric coefficients are the numbers shown to the left of formulas in chemical equations
* Represent the number of molecules or moles (but never mass) of compounds
* Can be used as conversion factors when taken from a balanced chemical equation

**Patterns of chemical reactivity** – recognize these four patterns

1. Combustion: fuel + O2 🡪 CO2 + H2O [fuels contain carbon]
2. Combination: several reactants combine to form 1 product
3. Decomposition: 1 reactant comes apart to form several products
4. Exchange: two ionic compounds react and exchange partners
* “inner-inner” & “outer-outer”
* the metal atom is always listed first
* ionic products must be balanced for a net charge of zero using subscripts

**Physical states** of reactants & products are shown using abbreviations:

* s = solid
* l = a liquid pure substance (usually water!)
* g = gas
* aq = aqueous solution made by dissolving an ionic compound in water

**Limiting reactants** are molecules that are completely consumed (used up) in a chemical reaction; determined by reaction stoichiometry

**Excess reactants** are molecules of reactant that remain (are leftover) when a chemical reaction is complete; determined by reaction stoichiometry.

**Theoretical yield:** the yield of product formed by the limiting reactant

**Percent yield** = (actual yield/theoretical yield)(100)

Solving limiting reactant / theoretical yield problems:

* Use MW and stoichiometry to determine yield of product from each of the two reactants.
* The reactant that produces LESS product is LIMITING.
* Theoretical yield is the amount of product produced by the limiting reactant.