Determining a Formula from Percent Composition

1. Convert weight percentages into grams of each element.

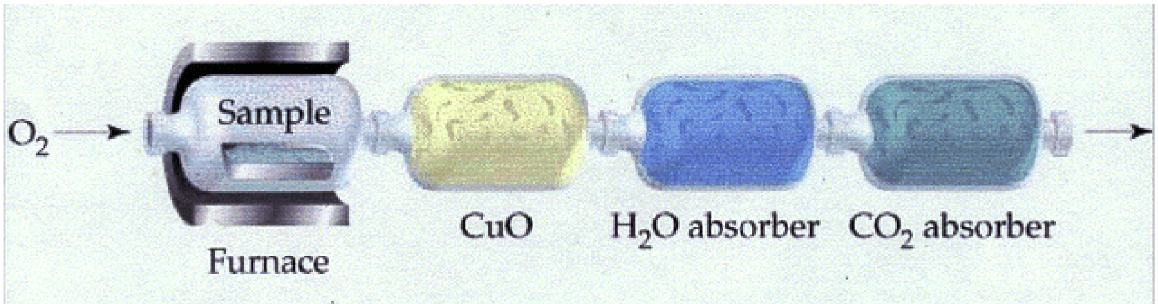
2. Convert grams of each element into moles of each element, using atomic weights.

3. Find the lowest whole number ratios among the moles of elements.

4. Write the empirical formula, using the same ratios between atoms of each element as the ratios among moles of elements.

5. If the molecular weight is known, divide the formula weight for the empirical formula into the molecular weight to determine the number of formula units in the molecular formula. Using this integer factor, multiply all the subscripts (including any implied 1's) in the empirical formula to obtain the molecular formula.

Combustion Analysis of Organic Compounds



$$\text{sample} + xO_2 \; 6 \; yCO_2 + zH_2O$$

1. All C in the sample is converted to CO_2.

2. All H in the sample is converted to H_2O.

3. Amounts of C and H in the sample can be calculated from the weights of CO_2 and H_2O collected.

4. If the sample compound also contains O, its mass can be determined by subtracting the masses of C and H from the sample mass.

5. Using the masses of the elements, the moles of each element can be calculated and the empirical formula determined in the usual way.

Calculations Based on Chemical Equations

L A balanced chemical equation states the relationships between amounts of reactants and products in terms of ratios.

- We initially looked at these ratios in terms of numbers of atoms and molecules.
- Numbers of *moles* of atoms and molecules will have the same ratios.

$$2H_2(g) + O_2(g)\ 6\ 2H_2O(l)$$

U For every two moles of hydrogen gas and one mole of oxygen gas, two moles of liquid water are formed.

L Statements of mole ratios among reactants and products are the basis of conversion factors for doing chemical calculations related to reaction equations by dimensional analysis.

Theoretical Yield and Percent Yield

P The **theoretical yield** of a reaction is the amount of product that could be formed from complete conversion of the reactants into products.

P The **percent yield** of a reaction is a comparison of the actual yield to the calculated theoretical yield, expressed as a percentage.

$$\%\ \text{yield}\ '\ \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Limiting Reagent

P For a reaction in which the reactants are present in amounts different from their exact stoichiometric ratio in the balanced equation, the reagent that is in shortest supply (on the basis of the stoichiometry of the equation) will limit the amount of product(s) that can theoretically be produced.

  P The reactant in shortest supply is the **limiting reagent**.

L In any case where amounts of reactants are specified, determine the moles of each present, and then determine which is the limiting reagent.

L All calculations of the theoretical yield for the reaction (or any other stoichiometric calculations) *must* be based on the amount of the limiting reagent.

A Limiting Reagent Analogy

Boston's Best Baby Buggy Co. is preparing to fill a large order for their Beaucoup Model Baby Buggy, which is constructed from one chassis, four wheels, and two bumpers. At the time the order is received, the parts inventory at BBBB consists of the following:

152 chassis
972 wheels
222 bumpers

How many Beaucoup Buggies can be constructed without reordering more parts?

(152 chassis)(1 buggy/1 chassis) = 152 buggies
(972 wheels)(1 buggy/4 wheels) = 243 buggies
(222 bumpers)(1 buggy/2 bumpers) = 111 buggies

The bumpers will run out first, so they are the "limiting reagent". We can only make 111 buggies, regardless of all the extra chassis and wheels.

A Systematic Method for Identifying the Limiting Reagent

1. Determine the number of moles of each reactant.

2. Divide each number of moles by the stoichiometric coefficient for the species in the balanced chemical equation.

    T This calculation gives the number of molar "sets" of each species available for reaction.

3. The species with the smallest number of "sets" is the limiting reagent.

    T Use the number of **moles** of this species (*not* its number of "sets") in all subsequent stoichiometric calculations.