

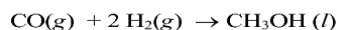
### Chemical Stoichiometry Problems

Calculating the yield of a chemical reaction is a process at the heart of chemistry. While there are many ways a problem can be phrased, in all cases the *stoichiometric coefficients* in the balanced reaction are used to determine the *mole ratios* between reactants and products. Thus the *first step* is usually *calculating the moles of each species available*. If an amount is given in grams, the molar mass is used as a conversion factor to change grams to moles.

#### Limiting Reagent Problems

In some problems, amounts of *more than one* species are given. In that case your first task is to determine which species is the *limiting reagent*. Just as you can make only 1 bicycle from 2 wheels and 4 handlebars (with 3 handlebars left over), and only 2 bicycles from 8 wheels and 2 handlebars (with 4 wheels left over), in chemical reactions some species are *limiting* while others may be *present in excess*.

In the case of a bicycle, we need  $\left(\frac{2 \text{ wheels}}{1 \text{ handlebar}}\right)$ . We obtain analogous information about the relative amounts of species that react from the *stoichiometric coefficients* in a balanced chemical equation. For example, in Exercise (2) below the equation



tells us we need  $\left(\frac{2 \text{ mol H}_2}{1 \text{ mol CO}}\right)$ . If we have *more* than 2 moles of H<sub>2</sub> for each mole of CO, CO will be the *limiting reagent* and the excess H<sub>2</sub> will not react. Conversely, if we have *more* than 1 mole of CO for every 2 moles of H<sub>2</sub>, H<sub>2</sub> will be the *limiting reagent* and the excess CO(g) will be left over. In each case, the yield of CH<sub>3</sub>OH is determined by the moles of limiting reagent available.

#### Calculating the Theoretical Yield

The theoretical (maximum possible) yield is based on the amount of limiting reagent available. The yield is calculated in steps:

- Calculate *moles* of all reactants *available*. If amounts are given in grams, convert grams to moles using the *molar mass* of each reactant as your conversion factor:  $\left(\frac{1 \text{ mole reactant}}{\# \text{ g reactant}}\right)$ .
- **NOTE:** Skip this step if you have already identified the limiting reagent. To determine which reagent is limiting, use the *mole ratio* obtained from the balanced equation for the reaction to find the *moles of reactant B needed* to react with the *available* moles of reactant A. If the moles of B *available* are *less* than the moles of B *needed*, reactant B is the *limiting reagent* and reactant A is in excess. Conversely, if the moles of B *available* are *more* than the moles of B *needed*, A is the *limiting reagent* and B is in excess.
- Calculate the *moles* of product *based on the moles of limiting reagent available*; use the stoichiometric ratio of  $\left(\frac{\# \text{ moles product}}{\# \text{ moles limiting reagent}}\right)$  as the conversion factor.