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

$$CO(g) + 2\ H_2(g) \rightarrow CH_3OH\ (l)$$

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_2 for each mole of CO, CO will be the *limiting reagent* and the excess H_2 will not react. Conversely, if we have *more* than 1 mole of CO for every 2 moles of H_2, H_2 will be the *limiting reagent* and the excess CO(g) will be left over. In each case, the yield of CH_3OH 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.