Chem 30A

Ch 8. Quantities in Chemical Reactions

Stoichiometry: Mole-to-Mole Ratio

Quantities in Chemical Reactions

- Stoichiometry: the process of using a balanced chemical equation to determine the relative quantities of substances in a reaction

The Balanced Chemical Equation

Coefficients are relative numbers of molecules!

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

1 molecule	3 molecules	2 molecules	3 molecules
1 dozen	3 dozens	2 dozens	3 dozens
1 mole	3 moles	2 moles	3 moles

Mole-to-Mole Relationship

$$C_2H_5OH + \underline{3}O_2 \rightarrow \underline{2}CO_2 + \underline{3}H_2O$$

- Using a balanced equation, we can find the <u>mole-to-mole</u> relationship between any two substances in a chemical reaction:
  - 3 mol O_2 produces 2 mol CO_2
  - 1 mol C_2H_5OH reacts exactly with 3 mol O_2
- Ratios of coefficients tell the <u>mole-to-mole ratios</u> of the substances in a chemical reaction.

$$\frac{3 \text{ mol } O_2}{2 \text{ mol } CO_2} \qquad \frac{1 \text{ mol } C_2H_5OH}{3 \text{ mol } O_2}$$

Mole-to-Mole Conversions

- The mole-to-mole ratios can be used to convert between the amounts of any two substances in a reaction.

Eg. How many moles of oxygen are required to react exactly with 10.0 mol copper(I) sulfide?

Given: $2Cu_2S(s) + 3O_2(g) \rightarrow 2Cu_2O(s) + 2SO_2(g)$

$$10.0 \text{ mol } Cu_2S \times \frac{(3 \text{ mol } O_2)}{2 \text{ mol } Cu_2S} = 15.0 \text{ mol } O_2$$

Ex Probs

Mole-to-Mass and Mass-to-Mass Conversions

Similarly, we can also convert from:

- mole of one substance to the mass (g) of another substance in a chemical rxn (mole-to-mass conversion)

- Mass (g) of one substance to the mass (g) of another substance in a chemical rxn (mass-to-mass conversion)

But you must always go through the mole-to-mole ratio! (Why?)

Steps for Stoichiometric Calculations

First, balance the equation(!), and determine the two substances whose amounts are being related.

1. If needed, convert the given g of substance to moles of substance.
2. Use the mole-to-mole ratio to calculate moles of the desired substance.
3. If needed, convert moles of desired substance to g of desired substance.

Ex Probs

Stoichiometry:
Limiting Reactant and Percent Yield

Limiting Reactant/Reagent

In a reaction with two or more reactants:

- Limiting reactant: the reactant that runs out first and thus limits the amounts of product(s) that can form.
- The other reactant is said to be "in excess."
- Theoretical yield: the maximum amount of product obtained if the limiting reactant is completely consumed

Example Limiting Reactant Problem

You're making ham sandwiches. You have 10 slices of bread and 3 slices of ham.

2 slices bread + 1 slice ham → 1 sandwich

- Which is limiting ingredient?
- Which is the ingredient in excess?
- What is the theoretical yield?

Limiting Reactant Problems

In limiting reactant problems, the amounts of both reactants are given.

1. Find limiting reactant:
   a) Calculate moles of product possible from each given amount of reactant.
   b) The limiting reactant is the one that produces the fewer moles of product.
2. Calculate the theoretical yield based on the limiting reactant amount.

Theoretical yield is limited by the amount of limiting reactant!

Ex Probs

Percent Yield

$$\% \text{ Yield} = \frac{\text{Actual Yield [g]}}{\text{Theoretical Yield [g]}} \times 100$$

- Actual yield: the experimental yield

Actual Yields

What are reasons for the actual yield being smaller than the theoretical yield?

- Side reactions
- Incomplete reactions
- Physical loss (esp. from purification steps)

Finding Percent Yield

1. Balance the equation.
2. Find limiting reactant, if necessary.
3. Calculate theoretical yield of product based on the limiting reactant.
4. Calculate % yield:

$$\% \text{ Yield} = \frac{\text{Actual Yield [g]}}{\text{Theoretical Yield [g]}} \times 100$$

Ex probs