

## Ch 8. Quantities in Chemical Reactions

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# Stoichiometry: Mole-to-Mole Ratio

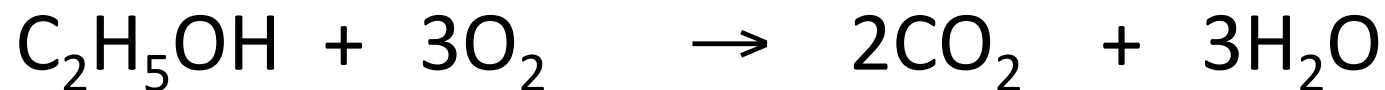
Stoichiometry: Mole-to-Mole Ratio

# 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!



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



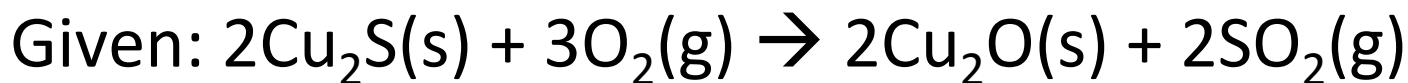
- Using a balanced equation, we can find the mole-to-mole relationship between any two substances in a chemical reaction:
  - 3 mol O<sub>2</sub> produces 2 mol CO<sub>2</sub>
  - 1 mol C<sub>2</sub>H<sub>5</sub>OH reacts exactly with 3 mol O<sub>2</sub>
- Ratios of coefficients tell the mole-to-mole ratios of the substances in a chemical reaction.

$$\frac{3 \text{ mol O}_2}{2 \text{ mol CO}_2} \qquad \frac{1 \text{ mol C}_2\text{H}_5\text{OH}}{3 \text{ mol O}_2}$$

# 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?



$$10.0 \text{ mol Cu}_2\text{S} \times \frac{(3 \text{ mol O}_2)}{2 \text{ mol Cu}_2\text{S}} = 15.0 \text{ mol O}_2$$

# 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.



# Stoichiometry: Limiting Reactant and Percent Yield

Limiting Reactant and Percent Yield  
Stoichiometry:

## 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  $\rightarrow$  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!**

## 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