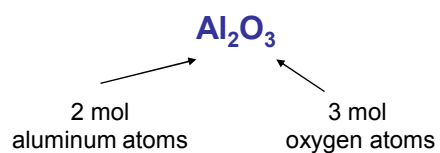


Chapter 3 – part II

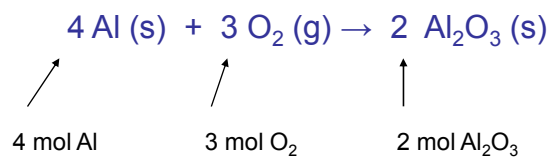
Stoichiometry

Mole Ratios

When you have a compound you can tell the mol of each atom:



The same is true with the *coefficients* from a balanced equation:



Mole-Mole Relationships



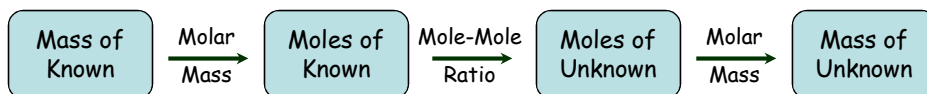
1 mol Fe_2O_3 reacts with 3 mol CO : $\frac{1 \text{ mol Fe}_2\text{O}_3}{3 \text{ mol CO}}$ and $\frac{3 \text{ mol CO}}{1 \text{ mol Fe}_2\text{O}_3}$

3 mol CO reacts to produce 2 mol Fe

2 mol Fe and 3 mol CO_2 are produced

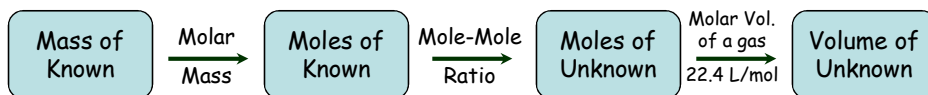
1 mol Fe_2O_3 produces 3 mol CO_2

Mass - Mass Stoichiometry



1. Calculate the mass of iron (II) oxide needed to react completely with 5.55 g of molten aluminum.
2. Calculate the mass of aluminum oxide produced when 10.25 g of molten aluminum reacts completely.
3. Calculate the mass of molten iron produced when 25.25 g of molten aluminum oxide is produced.

Mass - Volume Stoichiometry



Calculate the volume (in L) of oxygen gas that reacts at STP to produce 100.0 g of aluminum oxide.



Calculate the mass of sodium azide (NaN_3) needed to produce 120.0 L of nitrogen gas at STP.

Percent Yield

Theoretical Yield

The amount of product formed from the *complete* conversion of the given amount of reactant to product.

Actual Yield (experimental yield)

The amount of product formed *experimentally*. Often side reactions or incomplete reactions occur causing the actual yield to be less than theoretically planned.

$$\text{Percent Yield} : (\text{Actual Yield} / \text{Theoretical Yield}) \times 100\%$$

A solution containing excess sodium sulfate is added to a second solution containing 3.18 g of barium nitrate. Barium sulfate precipitates and 1.85 g is collected and dried. What is the percent yield?

1. Write a balanced equation
2. Calculate theoretical yield.
3. Calculate percent yield.

A procedure for preparing sodium sulfate typically produces a 79.8% yield in a manufacturing plant.



Find the number of grams of sodium sulfate recovered from the reaction of 36.9 g sodium hydroxide with excess reagents.

Limiting Reagent

If we were making up some baskets of flowers and each basket was to have 5 red roses, 2 yellow roses, and 3 white roses and we started with

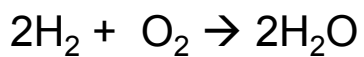
20 red roses
30 yellow roses
30 white roses

How many baskets can we make?

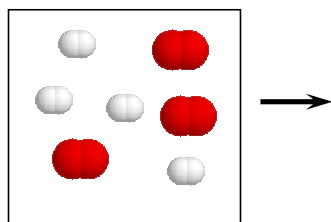
Red roses: $20/5 = 4$ baskets
Yellow roses: $30/2 = 15$ baskets
White roses: $30/3 = 10$ baskets

We can only make 4 baskets because we are *limited* by the number of red roses we have!

Limiting Reagents

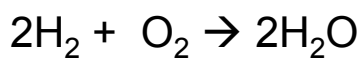


What is the limiting reactant?

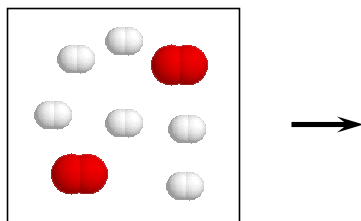


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Limiting Reagents

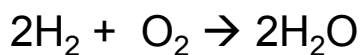


What is the limiting reactant?

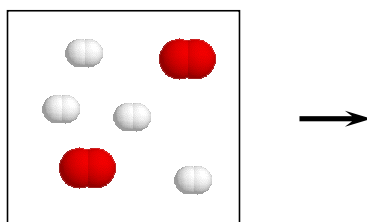


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Limiting Reagents



What is the limiting reactant?



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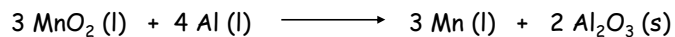
Method

1. Write a balanced equation.
2. Determine grams of product produced from each reagent required to completely react.
3. Determine the limiting reagent (the one that forms the LEAST amount of product is the limiting reagent).
4. This is the amount of product formed.

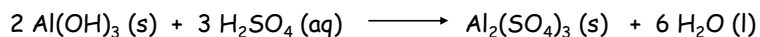
Iron reacts with oxygen to form iron (III) oxide.

If a student starts with 5.00 g iron and 2.56 g of oxygen,
How much product will form?

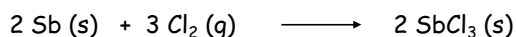
In a reaction, 50.0 g of manganese (IV) oxide reacts with 25.0 g of aluminum. Calculate the mass of manganese metal produced.



If 1.00 g of aluminum hydroxide reacts with 0.605 g of sulfuric acid, what is the mass of aluminum sulfate?



When 2.35 g of powdered antimony (Sb) is sprinkled into a flask containing 4.69 g chlorine gas, how much antimony trichloride is produced?



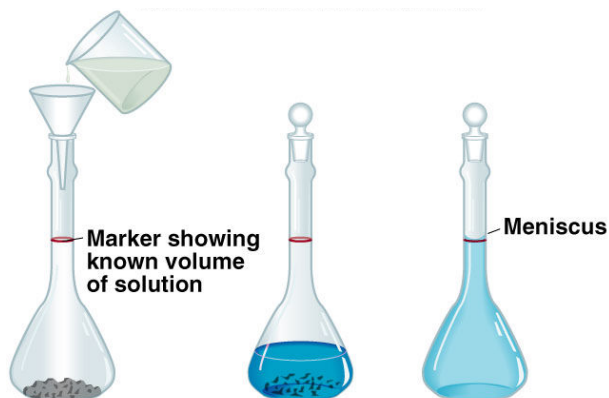
Limiting Reagent with Percent Yield

A student mixes an aqueous solution containing 3.50 g of lithium phosphate with an aqueous solution containing 2.89 g magnesium nitrate. The student filters and dries the precipitate and finds it has a mass of 1.45 g. What is the student's percent yield?

Concentrations of Reactants in Solution: Molarity

Reactants exist in solution and the tool used to determine the quantity in solution is molarity.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liter of total solution}} = \frac{\text{mol}}{\text{L}} = \text{M}$$

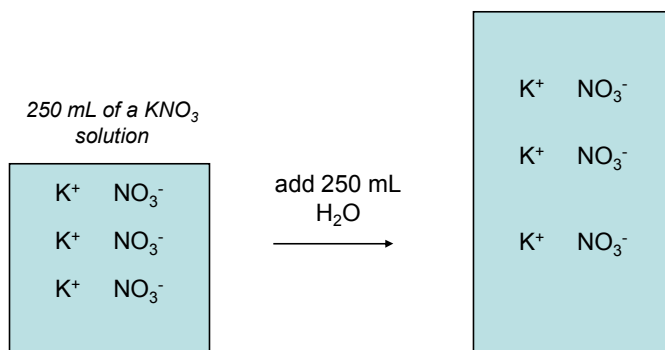


What is the molarity of a solution made by dissolving 3.678 g of NaOH in water and diluting to a final volume of 500.0 mL?

What is the mass of solute in 250.0 mL of a 5.00 M solution?

How many mL of a 2.50 M glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) solution are needed to provide a total of 30.0 g of glucose?

Diluting Concentrated Solutions



Moles of solute remains *unchanged*, only the volume of the solution changes.

$$M_i \times V_i = M_f \times V_f$$

Dilution Calculations

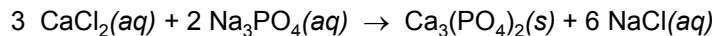
What is the final concentration of a 100.0 mL solution of 3.00 M HCl if the final volume is 400.0 mL?

What is the initial concentration of a 250.0 mL solution that was diluted to 6.50 M with a final volume of 600.0 mL?

How would you prepare 500.0 mL of a 0.500 M solution of H_2SO_4 starting with concentrated (18 M) solution? *Remember to add acid to water.*

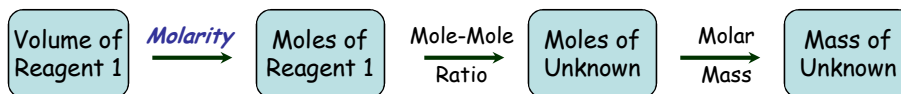
How much water do you need to add to 25.0 mL of a 4.50 M solution of NaOH to make a 1.00 M NaOH solution?

Solution Stoichiometry



If we mix 25.0 mL of 0.200 M CaCl_2 solution with 50.0 mL of 0.250 M Na_3PO_4 solution, what mass of $\text{Ca}_3(\text{PO}_4)_2(\text{s})$ is formed?

This is a limiting reagent problem with solution stoichiometry!



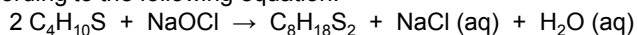
Repeat for Reagent 2

Whatever produces the smallest amount of product = L.R.

Solution Stoichiometry Example

Note: Not all problems will be L.R. problems.

The odor of skunks is caused by chemical compounds called thiols. These compounds can be deodorized by reaction with household bleach (NaOCl) according to the following equation:



How many grams of butanethiol can be deodorized by the reaction with 5.00 mL of 0.0985 M NaOCl ?

Titration

Titration: method of determining the concentration of an unknown solution by using a solution with a known concentration (standard)

Equivalence point: point at which acid has completely reacted with/been neutralized by base.



End point: (or equivalence point) point at which the indicator changes color (slight change in solution's pH).

Why does the indicator change color?

Example: phenolphthalin = colorless in acids, pink in bases

A student used 23.78 mL of 0.2500 M NaOH to neutralize 20.00 mL of HCl.
What is the concentration of the HCl solution?

1. Write a balanced equation
2. Calculate mol of unknown using solution stoichiometry
3. Determine Molarity (mol/L)

More Titration Examples

How many mL of 1.018 M H₂SO₄ are needed to neutralize 20.00 mL of 0.9989 M NaOH?

Oxalic acid, H₂C₂O₄, is a toxic substance found in spinach leaves. What is the molarity of a solution by dissolving 12.0 g of oxalic acid in enough water to give 400.0 mL of solution? How many mL of 0.100 M KOH would you need to titrate 25.0 mL of the oxalic acid solution according to the following equation?

