Chemistry 101 Laboratory
Fall 2005 -2006

Lecture 3

Effect of Limiting the Concentration of a Reactant

Purpose

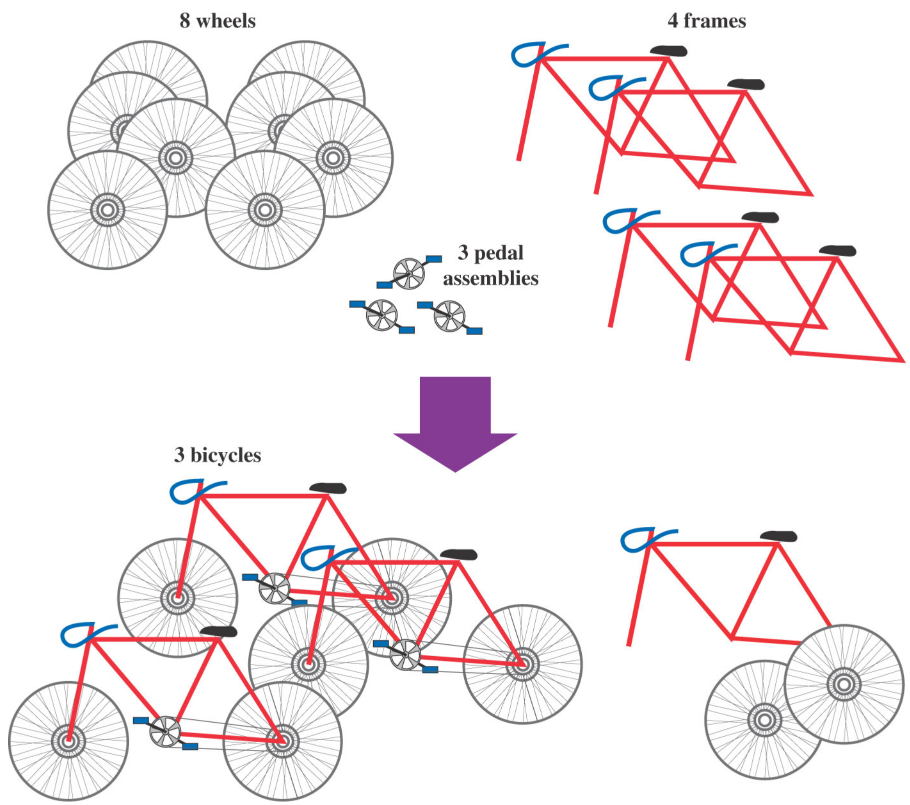
- To determine the limiting reactant in a salt mixture
- To observe the effects of a limiting reactant.
- To manipulate calculations involving ions concentration.

Limiting Reactants

Example: How many bicycles can be assembled from the parts shown?

The limiting part is the number of pedal assemblies.

A maximum of three bicycles can be assembled



Limiting Reactants (cont'd)

Limiting reagent: is the reactant that limits the amount of products formed.

Example:

a- How many moles of ammonia can be produced by reacting 8.00 moles of nitrogen with 18.0 moles hydrogen?

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

n_{N2} needed to react with 18.0 mol. Hydrogen =

$$18.0 \text{ mol. } H_2 \times \frac{1 \text{ mol. } N_2}{3 \text{ mol. } H_2} = 6.00 \text{ mol } N_2$$

8.00 mol. N_2 > 6.00 mol. N_2 (N_2 is in excess)

Therefore hydrogen is limiting.

Or (second method)

n_{H2} needed to react with 8.00 mol. N_2=

$$8.00 \text{ mol. } N_2 \times \frac{3 \text{ mol. } H_2}{1 \text{ mol. } N_2} = 24.0 \text{ mol } H_2$$

18.0 mol. H_2 < 24.0 mol. H_2

Therefore hydrogen is the limiting reagent.

$$n_{NH3} \text{ formed} = 18.0 \text{ mol } H_2 \times \frac{2 \text{ mol. } NH_3}{3 \text{ mol. } H_2}$$

$$= 12.0 \text{ mol.}$$

b- Calculate the mass of ammonia formed.

$$\text{Mass of } NH_3 = 12.0 \text{ mol. x } \frac{17.03 \text{ g}}{\text{l mol}} = 204 \text{ g}$$

c- Calculate the mass of excess reactant.

n_{N2} reacted = 6.00 mol.

n_{N2} in excess = 8.00 – 6.00 = 2.00 mol.

$$\text{Mass of } N_2 = 2.00 \text{ mol x } \frac{28.01 \text{ g}}{1 \text{ mol.}} = 56.0 \text{ g}$$

Solutions

A **solution** is a homogenous mixture of 2 or more substances

The **solute** is(are) the substance(s) present in the smaller amount(s)

The **solvent** is the substance present in the larger amount

Concentration of Solutions

- The **concentration** of a solution is the amount of solute present in a given quantity of solvent or solution.

- **Expression of concentration:**

✓ ***percent by mass:*** g solute/100g solution

✓ ***percent by volume:*** mL solute/100mL solution

✓ ***Molarity (molar concentration):***

Molarity = mol. solute/volume(L) solution

M = n / V

Examples

1- How many moles are there in 5.0mL of 0.50M sodium carbonate ?

$M = n / V$, $n = M \times V$

$n = 0.50\ mol/L \times (5.0 \times 10^{-3}\ L)$

$= 2.5 \times 10^{-3} mol$

Examples (cont'd)

2- How many grams of calcium chloride are needed to prepare 1.0L of 0.50M solution ?

$M = n / V$, $n = M \times V$

$n = 0.50 \text{ mol/L} \times 1.0 \text{ L} = 0.50 \text{ mol.}$

$n = \text{mass} / \text{molar mass}$,

$\text{mass} = 0.50 \text{ mol} \times 111.1 \text{ g/mol} = 56 \text{ g}$

Concentration of ions in salts that dissociate completely

Examples :

1- $CaCl_2(s) \xrightarrow{H_2O} Ca^{2+}(aq) + 2Cl^-(aq)$

In 1M $CaCl_2$ solution: $[Ca^{2+}] = 1M$

$[Cl^-] = 2M$

2- $Na_2CO_3(s) \xrightarrow{H_2O} 2\ Na^+(aq) + CO_3^{2-}(aq)$

In 0.50M Na_2CO_3 solution: $[Na^+] = 2 \times 0.50$

$= 1.0M$

$[CO_3^{2-}] = 0.50M$

Examples (cont'd)

3- How many moles of Na^+ ions are there in 5.0 ml of 2.0M sodium carbonate (Na_2CO_3)?

n of sodium carbonate = M x V

= 2.0 mol/L x (5.0 x 10^{-3}L) = 0.010 mol

n of Na^+ = 2 x 0.010 mol = 0.020 mol

Experiment

$Na_2CO_{3(}aq) + CaCl_2(aq) \longrightarrow CaCO_3(s) + 2NaCl(aq)$

white

Net ionic equation :

$Ca^{++}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

- Label 5 test tubes of the same diameter.
- Pipet 10 mls of sodium carbonate(M_1) and 10 mls of calcium chloride (M_2) in the first tube.
- Repeat by varying M_1 and M_2.

Relate the height of the solid $CaCO_3$ to the amount of the limiting reagent.

Report

Table 1

Tube No.	Using 10ml each with a Concentration of: Na_2CO_3	$CaCl_2$	Comparative Volume of Precipitate Formed*	Millimoles of Na_2CO_3 in 10ml of Solution Used	Millimoles of $CaCl_2$ in 10ml of Solution Used	Calculated Millimoles of $CaCO_3$ formed
1	1 M	1 M				
2	1 M	0.5 M				
3	0.5 M	0.5 M	Reference (x cm)			
4	0.5 M	1 M				
5	0.5 M	0.1 M				

Report (cont'd)

Table II

Decantate of test tube no.	Added solution	Observation	Conclusion (Ion in excess)