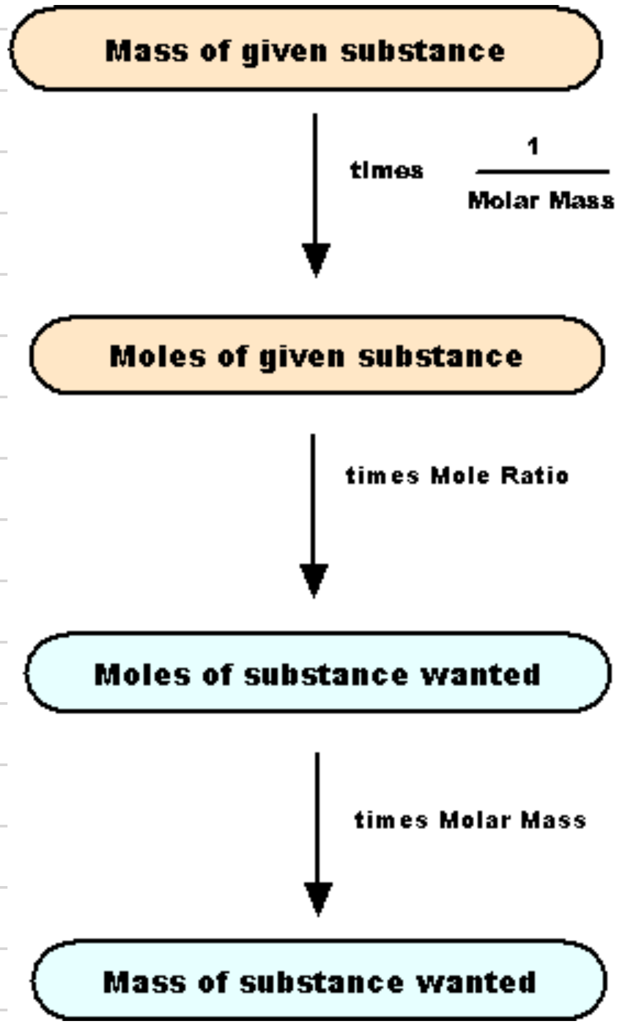
Stoichiometry

-Stoichiometry is the branch of science that deals with mass relationships between reactants and products. It uses molar and mass-mole ratios to find amounts.



Steps:

1. Write a balanced chemical equation
2. Use the chemical equation to find the mole ratio.
3. Use the factor labels (what you want/what you have) to find the mole amount.

Mole ratio- conversion factor that relates what you have to what you want

Theoretical mole ratio- the ratio obtained from the coefficients of elements in the balanced chemical equation (rarely occurs in real life)

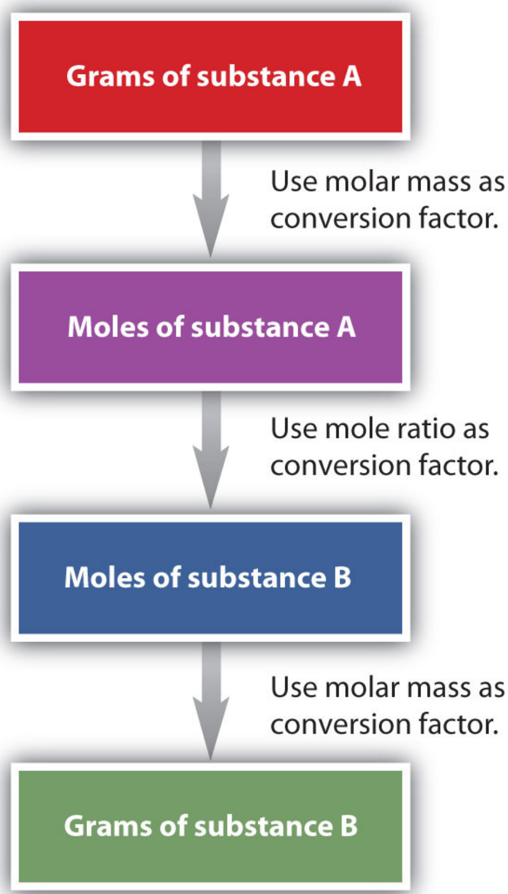
Experimental mole ratio (also referred to as actual mole ratio)- the ratio obtained from data collected during a lab.

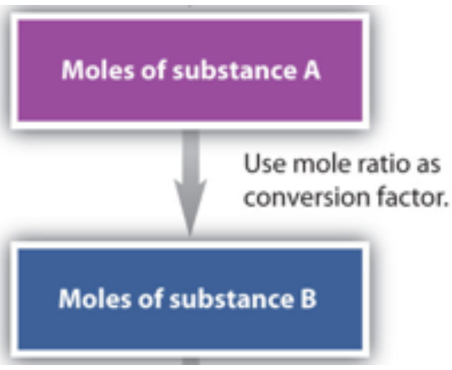
Types of Stoichiometry Problems

There are 4 types of Stoichiometry problems:

1. Mole-mole
2. Mole-mass
3. Mass-mole
4. Mass-mass

All equations are based off of this chart →





1. Mole-mole

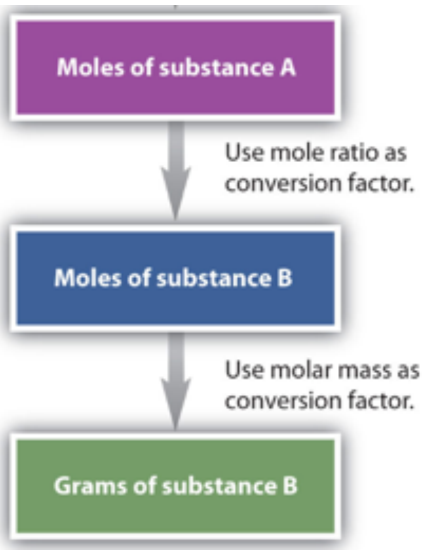
•in these problems, the moles of one substance are given and the moles of another substance must be found

$3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$

given: 6 mol H_2

Find: moles NH_3

$6\text{ mol } H_2 \cdot \frac{2\text{ mol } NH_3}{3\text{ mol } H_2} = 4\text{ moles } NH_3$



2. Mole-mass

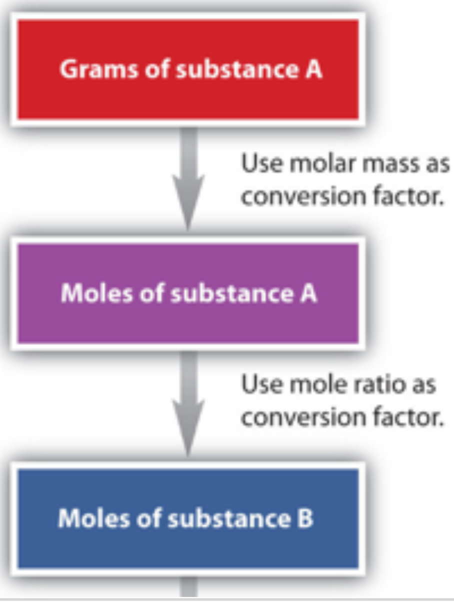
- In these problems, the moles of one substance are given, and the mass of another substance must be found

$1Mg_{(s)} + 2HCl_{(aq)} \rightarrow 1MgCl_{2(aq)} + 1H_{2(g)}$

given: 2.5 moles Mg

find: mass of HCl

$$2.5 \text{ mol Mg} \cdot \frac{2 \text{ mol HCl}}{1 \text{ mol Mg}} \cdot \frac{36.5 \text{ g}}{1 \text{ mol HCl}} = 182.5 \text{ g HCl}$$



3. Mass-mole

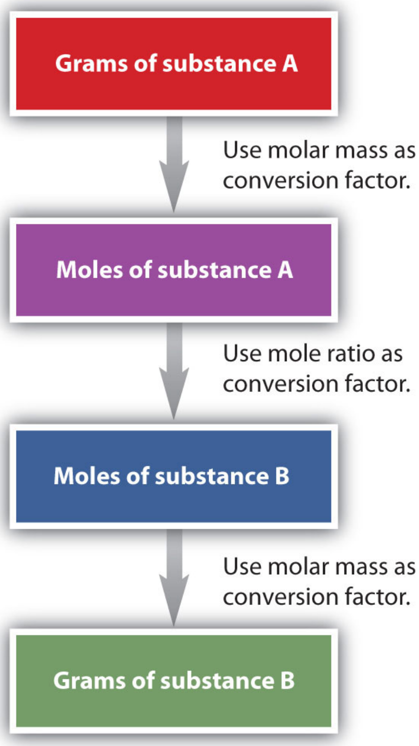
- In this type of equation, the mass of a substance is given, and the mole amount of another substance must be found.

$CaC_{2(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(aq)}$

given: 32 g CaC_2

find: moles of H_2O

$$32 \text{ g } CaC_2 \cdot \frac{1 \text{ mol}}{64 \text{ g } CaC_2} \cdot \frac{2 \text{ mol } H_2O}{1 \text{ mol } CaC_2} = 1 \text{ mol } H_2O$$



Mass-mass

In these problems, the mass of one substance is given, and the mass of another substance must be found.

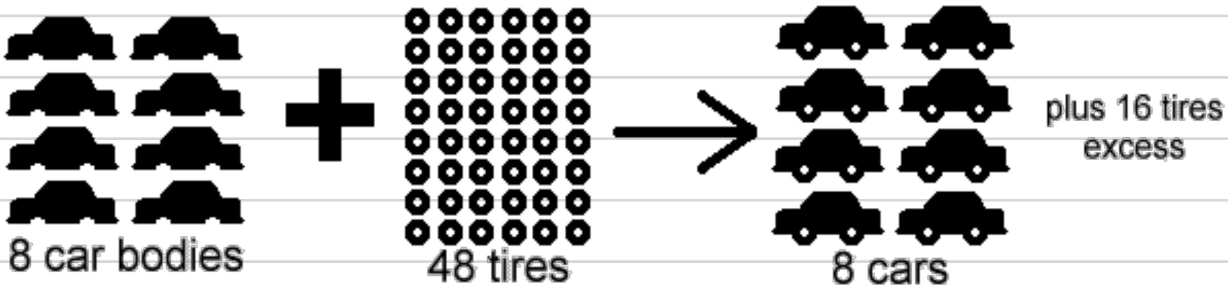
$$NaCl_{(s)} + AgNO_{3(aq)} \longrightarrow NaNO_3 + AgCl_{(s)}$$

given: 75.0g $AgNO_3$

find: Mass of AgCl

$$75g\ AgCl \cdot \frac{1\ mol}{170g} \cdot \frac{1\ Mol\ AgCl}{1\ mol\ AgNO_3} \cdot \frac{143.5g}{1\ mol\ AgCl} = \boxed{63.14g\ AgCl}$$

Excess and Limiting Reactants



Limiting Reactant - the reactant that limits the amount of a product formed

Excess Reactant - the reactant that is added to a reaction in greater quantities than what is necessary

•When doing a reaction, add extra of one reactant to ensure the other reacts fully.

*Only the limiting factor can be used for calculations.

•If you have more of a reactant than what you need, then that is the excess reactant.

•What you have is given and what you need must be calculated.

ex:) $SiO_{2(s)} + 4\,HF_{(g)} \rightarrow SiF_{4(s)} + 2H_2O_{(l)}$

given: 2mol HF
4.5mol SiO_2

$4.5\text{mol } SiO_2 \cdot \frac{4\text{mol } HF}{1\text{mol } SiO_2} = 18\text{ mol } HF$ needed

need 18 moles HF
have 2 moles HF available
therefore, HF is limiting

*To find the amount of excess reactant, use the limiting reactant to calculate the amount of the excess reactant needed. Then, subtract the amount needed from the amount available.

Percent Yield

Theoretical yield - maximum amount of a product that can be produced from a given amount of reactant

Actual yield - amount of a product generated in a lab

*percent yield must always be calculated using the limiting reactant

%yield = actual yield / theoretical yield * 100%

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\%$$

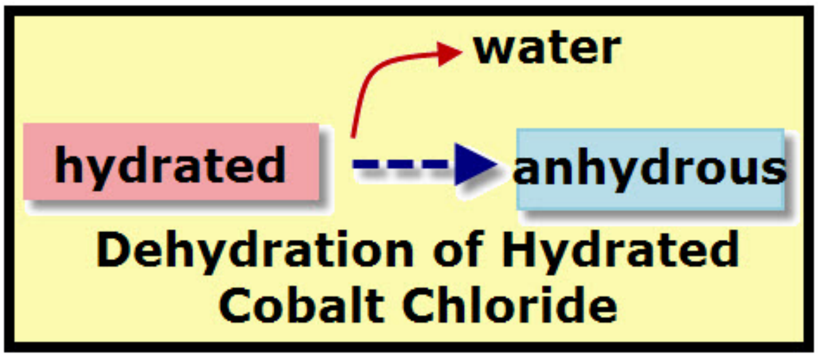
Steps:

1. Theoretical yield is found by converting limiting factor to the product.
2. Actual yield is given (in problems) or obtained from the lab.
3. Divide actual yield by theoretical yield and multiply by 100%

*it is impossible to have a percent yield greater than 100% because that would be producing more than what you started with (Law of Conservation of Mass).

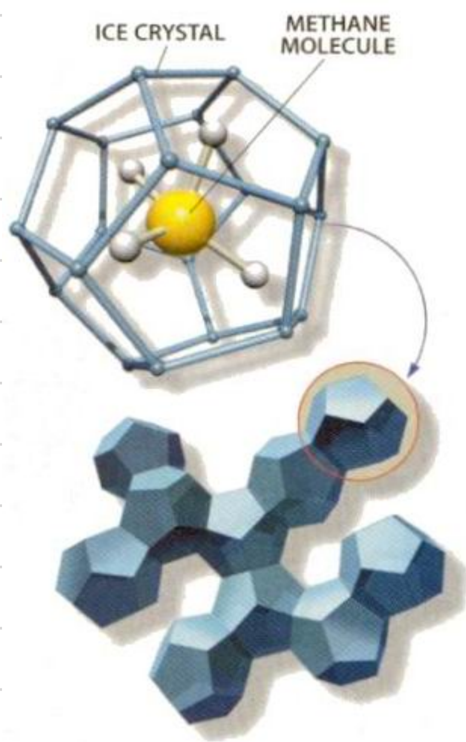
Hydrates

Hydrate - chemicals that contain water in their chemical structure
Water of hydration - the water in the crystal (also called water of crystallization
Effloresce - the release of water from the crystal when the pressure of air is less than the pressure the water is exerting outward.
This creates an anhydrous version of the solid.

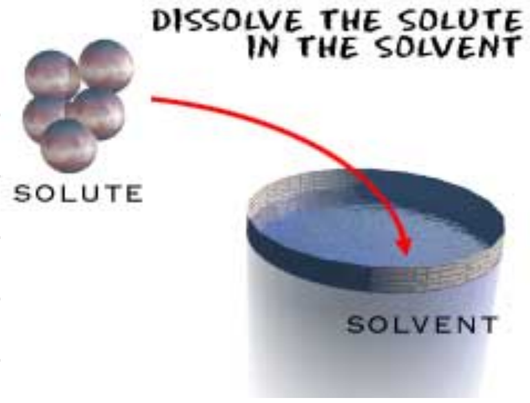


Anhydrous - lacking water

Compounds that gain water instead of lose are called hygroscopic. Since they suck moisture from the air, they are often used in vacuums as dessicants or moisture detectors.



Solutions



A solution is a type of homogenous mixture that occurs when one component dissolves another. The two components of a solution are the solvent and the solute.

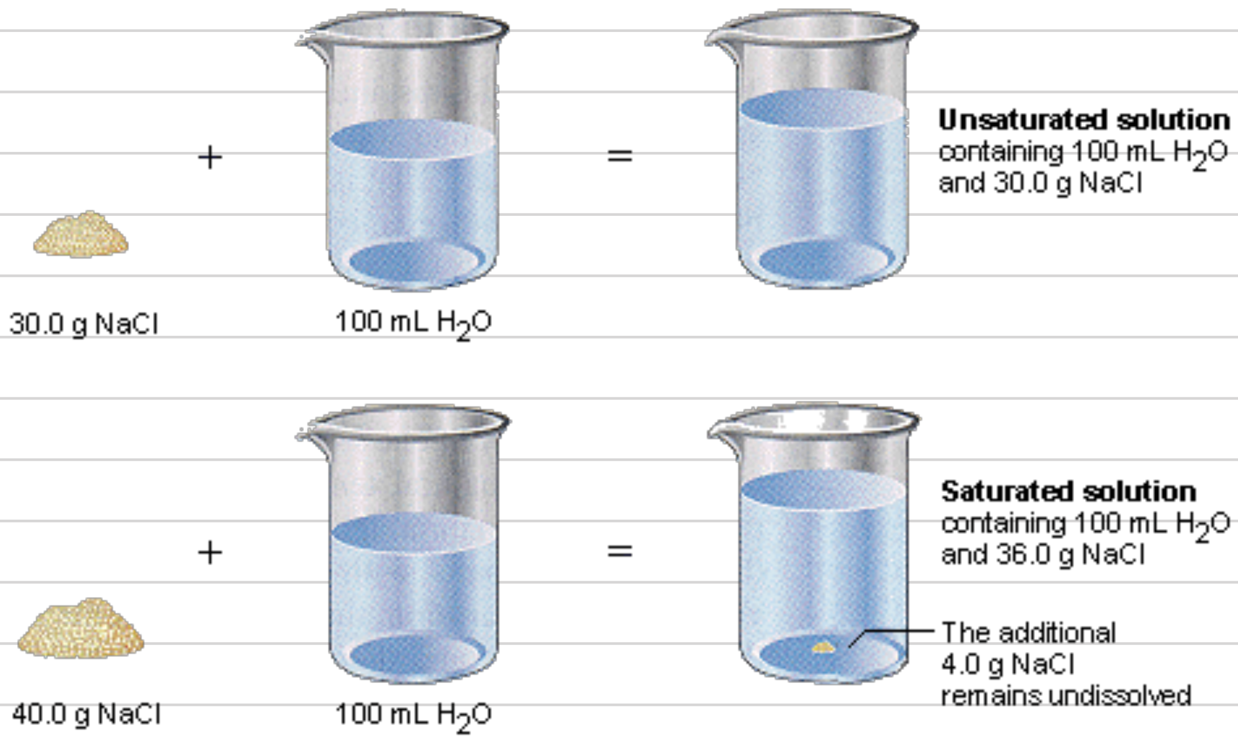
Solvent- the component that does the dissolving

Solute- the component that gets dissolved

*remember, likes dissolve likes: polar solvents dissolve polar and ionic compounds, while nonpolar solvents only dissolve nonpolar compounds.

Three levels of saturation:

1. Unsaturated- being able to hold more solute
2. Saturated- maximum concentration; no more solute can be dissolved
3. Supersaturated (supercooling)- a liquid's saturation level is exceeded without crystallization occurring

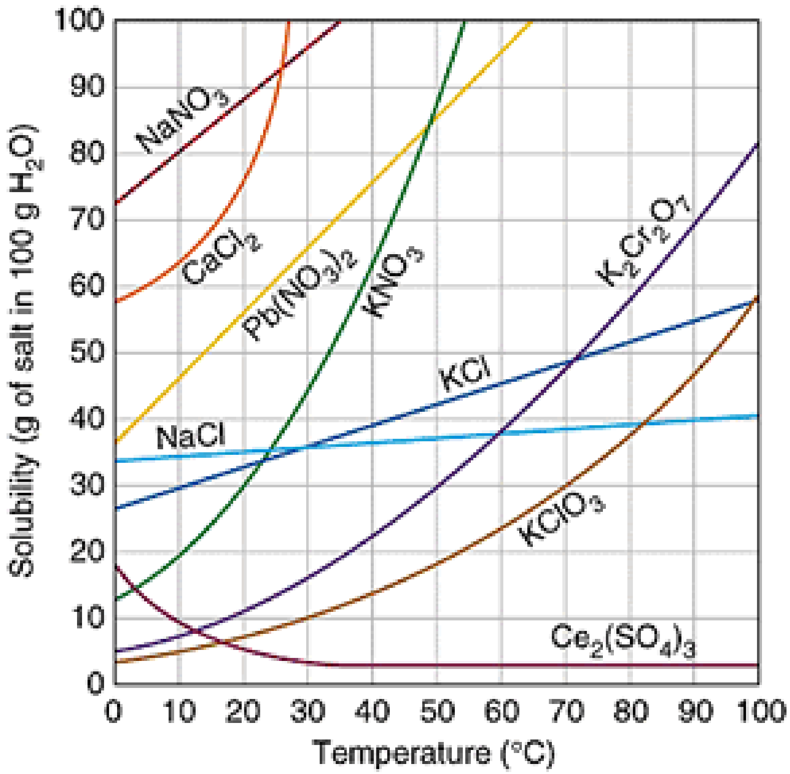


Solubility Curves

Solubility curves demonstrate how much of a compound can be dissolved in (usually) 100 grams of water at a certain temperature.

The y-axis displays the amount of the substance that is able to be dissolved in 100g of water, and the x-axis shows the temperature that it must be dissolved at.

Solubility Chart



$$\text{molarity (M)} = \frac{\text{moles of solute (moles)}}{\text{1 liter of solution (L)}}$$

Molarity

Molarity- the concentration of a solution. It is measured in grams of solute/liters of solvent

*This equation can be rearranged depending what informationis given and what must be found