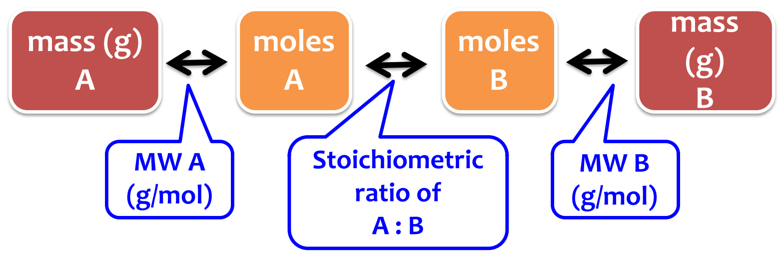
CHE1031 guide: Limiting reactants and theoretical yield

Steps to problem solving:

1. Start with a balanced chemical equation.
2. Calculate any need MWs.
3. Start twin, or paired, railroad track conversion problems:
   (a) Reactant A to product of interest; and
   (b) Reactant B to product of interest.
4. The reactant that produces the *lowest* yield of product (in either grams or moles) is limiting.
5. Theoretical yields of product are calculated (in 2.) in either grams or moles.
6. Excess reactant can be calculated by using stoichiometry to determine exactly how much of the reactant present in excess is needed to react with the limiting reactant.
7. Percent yield is (actual/theoretical)(100)



***Example*:**

Solutions of sodium carbonate and silver nitrate react to form solid silver carbonate and aqueous sodium nitrate. If a solution containing 3.50 g of sodium carbonate is mixed with one containing 5.00 g of silver nitrate, what is the theoretical yield of silver carbonate in grams? How many grams of excess reactant are left? If the actual yield is 4.00 g, what is the percent yield?

1. $Na_2(CO_3)\ (aq) + 2Ag(NO_3)\ (aq) \rightarrow Ag_2(CO_3)\ (ppt/s) + 2Na(NO_3)\ (aq)$

2. $Na_2(CO_3)$ = 105.98 g/mol
   $Ag(NO_3)$ = 169.88 g/mol
   $Ag_2(CO_3)$ = 275.74 g/mol

3-5. *Parallel calculation of yield from each reactant using reactant---product stoichiometry:*

$$\frac{3.50\text{ g } Na_2(CO_3)}{} \;\frac{1\text{ mol } Na_2(CO_3)}{105.98\text{ g}} \;\frac{1\text{ mol } Ag_2(CO_3)}{1\text{ mol } Na_2(CO_3)} \;\frac{275.74\text{ g}}{1\text{ mol } Ag_2(CO_3)} = 9.11\text{ g } Ag_2(CO_3)$$

$$\frac{5.00\text{ g } Ag(NO_3)}{} \;\frac{1\text{ mol } Ag(NO_3)}{169.88\text{ g}} \;\frac{1\text{ mol } Ag_2(CO_3)}{2\text{ mol } Ag(NO_3)} \;\frac{275.74\text{ g}}{1\text{ mol } Ag_2(CO_3)} = 4.06\text{ g } Ag_2(CO_3)$$

Lower yield = limiting!!

So at this point I know which reactant is limiting ($Ag(NO_3)$) and I know the theoretical yield (4.06 g of $Ag_2(CO_3)$).

6. *Next, I'll calculate moles of leftover $Na_2(CO_3)$ using reactant to reactant stoichiometry.*

$$\frac{5.00\text{ g } Ag(NO_3)}{} \;\frac{1\text{ mol } Ag(NO_3)}{169.88\text{ g}} \;\frac{1\text{ mol } Na_2(CO_3)}{2\text{ mol } Ag(NO_3)} \;\frac{105.98\text{ g}}{1\text{ mol } Na_2(CO_3)} = 1.56\text{ g } Na_2(CO_3)$$

So, leftover $Na_2(CO_3)$ = 3.50 g provided – 1.56 g needed = 1.94 g of $Na_2(CO_3)$

7. Percent yield = (4.00 g/4.06 g)(100) = 98.5 %