PERCENT YIELD

- Chemical reactions do not always go to completion! Things may happen that prevent the conversion of reactants to the desired/expected product!

(1) SIDE REACTIONS:

$$C + O_2 \longrightarrow CO_2$$

This reaction occurs when there is a large amount of oxygen available

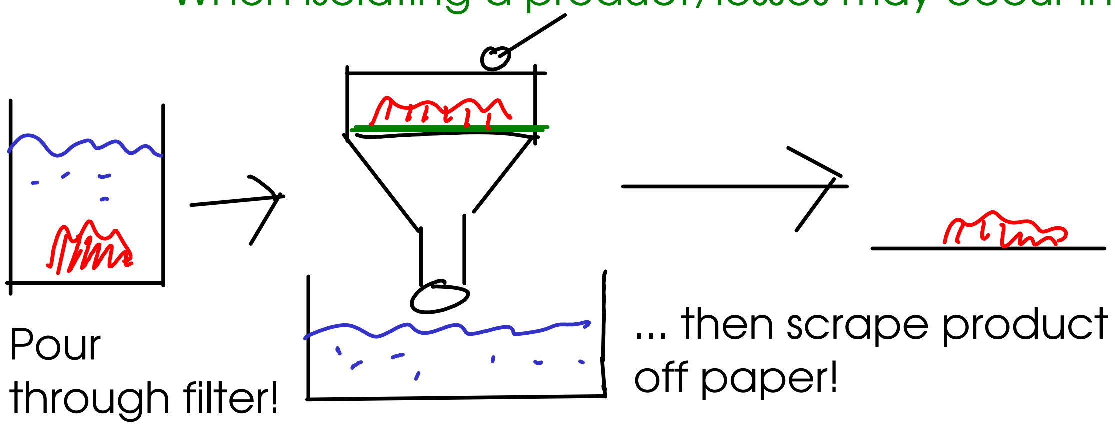
$$2C + O_2 \longrightarrow 2CO$$

... while this reaction is more favorable in low-oxygen environments!

... so in a low-oxygen environment, you may produce less carbon dioxide than expected!

(2) TRANSFER AND OTHER LOSSES

- When isolating a product, losses may occur in the process. Example: filtering



During each step of this process, some amount of product loss will occur!

(3) EQUILIBRIUM

- Reactions may reach an equilbrium between prodcuts and reactants. We'll talk more about this in CHM 111. The net results is that the reaction will appear to stop before all reactants have been consumed!

- All of these factors cause a chemical reaction to produce LESS product than calculated. For many reactions, this difference isn't significant. But for others, we need to report the PERCENT YIELD.

Determined EXPERIMENTALLY! (→ ACTUAL YIELD)

$$\text{PERCENT YIELD} = \frac{\text{ACTUAL YIELD}}{\text{THEORETICAL YIELD}} \times 100\%$$

(THEORETICAL YIELD ←) Calculated based on the limiting reactant. (The chemical calculations you've done up to now have been theoretical yields!)

... the percent yield of a reaction can never be greater than 100% due to conservation of mass! If you determine that a percent yield is greater than 100%, then you've made a mistake somewhere - either in a calculation or in the experiment itself!

78.114 g/mol 123.111 g/mol <- Formula weights

22.4 g 31.6 g ACTUAL

$$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$$

benzene nitric acid nitrobenzene

22.4 grams of benzene are reacted with excess nitric acid. If 31.6 grams of nitrobenzene are collected from the reaction, what is the percent yield?

To determine percent yield, we need to know the ACTUAL YIELD (31.6 g) and the THEORETICAL YIELD (we'll need to calculate this - start with 22.4 grams of benzene).

78.114 g C_6H_6 = mol C_6H_6 | mol C_6H_6 = mol $C_6H_5NO_2$

123.111 g $C_6H_5NO_2$ = mol $C_6H_5NO_2$

$$22.4\,g\,C_6H_6 \times \frac{mol\,C_6H_6}{78.114\,g\,C_6H_6} \times \frac{mol\,C_6H_5NO_2}{mol\,C_6H_6} \times \frac{123.111\,g\,C_6H_5NO_2}{mol\,C_6H_5NO_2} =$$

$= 35.3\,g\,C_6H_5NO_2$ (theoretical yield)

$$\text{PRECENT YIELD} = \frac{\text{ACTUAL YIELD}}{\text{THEORETICAL YIELD}} \times 100\% = \frac{31.6\,g}{35.3\,g} \times 100\% = \boxed{89.5\%}$$

25.0 mL of acetic acid solution requires 37.3 mL of 0.150 M sodium hydroxide for complete reaction. The equation for this reaction is:

$$NaOH + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2O$$

What is the molar concentration of the acetic acid?

$$\frac{mol\ HC_2H_3O_2}{L\ solution} \leftarrow = 25.0\ mL\ or\ 0.02500\ L$$

Note: This is the calculation procedure for the main results of Experiment 4C!

Since we already know the VOLUME of the acid, all we really have to do is to calculate the moles of acetic acid in that volume.

$mL = 10^{-3}\ L$ $\quad 0.150\ mol\ NaOH = L$ $\quad mol\ NaOH = mol\ HC_2H_3O_2$

$$37.3\ mL \times \frac{10^{-3}\ L}{mL} \times \frac{0.150\ mol\ NaOH}{L} \times \frac{mol\ HC_2H_3O_2}{mol\ NaOH} = 0.005595\ mol\ HC_2H_3O_2$$

To get concentration, divide by the volume:

$$M = \frac{mol\ HC_2H_3O_2}{L\ solution} = \frac{0.005595\ mol\ HC_2H_3O_2}{0.02500\ L} = \boxed{0.224\ M\ HC_2H_3O_2}$$

$$\overset{42.081\ g/mol}{4\,C_3H_6} + 6\,NO \longrightarrow \overset{53.064\ g/mol}{4\,C_3H_3N} + 6\,H_2O + N_2$$

propylene — acrylonitrile

Calculate how many grams of acrylonitrile could be obtained from 651 kg of propylene, assuming there is excess NO present.

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1 - Convert 651 kg propylene to moles using FORMULA WEIGHT and a kg -> g conversion.
2 - Convert moles propylene to moles acrylonitrile using chemical equation.
3 - Convert moles acrylonitrile to mass using FORMULA WEIGHT.

$42.081\ g\ C_3H_6 = mol\ C_3H_6$ | $kg = 10^3\ g$ | $4\ mol\ C_3H_6 = 4\ mol\ C_3H_3N$

$53.064\ g\ C_3H_3N = mol\ C_3H_3N$

$$651\ kg\ C_3H_6 \times \frac{10^3\ g}{kg} \times \frac{mol\ C_3H_6}{42.081\ g\ C_3H_6} \times \frac{4\ mol\ C_3H_3N}{4\ mol\ C_3H_6} \times \frac{53.064\ g\ C_3H_3N}{mol\ C_3H_3N} =$$

(1) (2)

$$= \boxed{821000\ g\ C_3H_3N} \quad (821\ kg)$$

151.90 g/mol

$$10\,FeSO_4 + 2\,KMnO_4 + 8\,H_2SO_4 \rightarrow 5\,Fe_2(SO_4)_3 + 2\,MnSO_4 + K_2SO_4 + 8\,H_2O$$

How many mL of 0.250M potassium permangenate are needed to react with 3.36 g of iron(II) sulfate?

1 - Convert mass iron(II) sulfate to moles using FORMULA WEIGHT.
2 - Convert moles iron(II) sulfate to moles potassium permangenate using chemical equation.
3 - Convert moles potassium permangenate to volume using MOLAR CONCENTRATION.

151.90 g $FeSO_4$ = mol $FeSO_4$	10 mol $FeSO_4$ = 2 mol $KMnO_4$
0.250 mol $KMnO_4$ = L	mL = 10^{-3} L

$$3.36\,g\,FeSO_4 \times \frac{mol\,FeSO_4}{151.90\,g\,FeSO_4} \times \frac{2\,mol\,KMnO_4}{10\,mol\,FeSO_4} \times \frac{L}{0.250\,mol\,KMnO_4} \times \frac{mL}{10^{-3}\,L} =$$

= **17.7 mL of 0.250M $KMnO_4$**

Electrolytes and Ionic Theory

- electrolytes: substances that dissolve in water to form charge-carrying solutions

* Electrolytes form ions in solution - (ions that are mobile are able to carry charge!). These IONS can undergo certain kinds of chemistry!

IONIC THEORY

- the idea that certain compounds DISSOCIATE in water to form free IONS

What kind of compounds?

- Soluble ionic compounds
- Acids (strong AND weak)
- Bases (strong AND weak)

The ions formed may interact with each other to form NEW compounds!

Strong vs weak?

- If an electrolyte COMPLETELY IONIZES in water, it's said to be STRONG
- If an electrolyte only PARTIALLY IONIZES in water, it's said to be WEAK
- Both kinds of electrolyte undergo similar kinds of chemistry.