LIMITING REACTANT CALCULATIONS

- To find the limiting reactant, calculate how much product would be produced from ALL given reactants. Whichever produces the SMALLEST amouht of product is the limiting reactant, and the smallest anount of product is the actual amount of product produced.

Example:

56.08 12.01 64.10 <- Formula weights

$$CaO(s) + 3C(s) \xrightarrow{\Delta} CaC_2(s) + CO(g)$$

If you start with 100. g of each reactant, how much calcium carbide would be produced?

CaO: 56.08 g CaO = mol CaO | mol CaO = mol CaC_2 | 64.10 g CaC_2 = mol CaC_2

$$100.\,g\ CaO \times \frac{mol\ CaO}{56.08\,g\ CaO} \times \frac{mol\ CaC_2}{mol\ CaO} \times \frac{64.10\,g\ CaC_2}{mol\ CaC_2} = \boxed{114\,g\ CaC_2}$$

C: 12.01 g C = mol C | 3 mol C = mol CaC_2 | 64.10 g CaC_2 = mol CaC_2

$$100.\,g\ C \times \frac{mol\ C}{12.01\,g\ C} \times \frac{mol\ CaC_2}{3\,mol\ C} \times \frac{64.10\,g\ CaC_2}{mol\ CaC_2} = 178\,g\ CaC_2$$

The reaction stops when 114 g of calcium carbide is produced. It stops because we have run out of CaO at this point. There is still unreacted carbon remaining, but it no longer has anything to react with! We say that CaO is limiting, and C is present in excess.

Limiting reactant situations happen when MORE THAN ONE reactant has a specified amount!

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

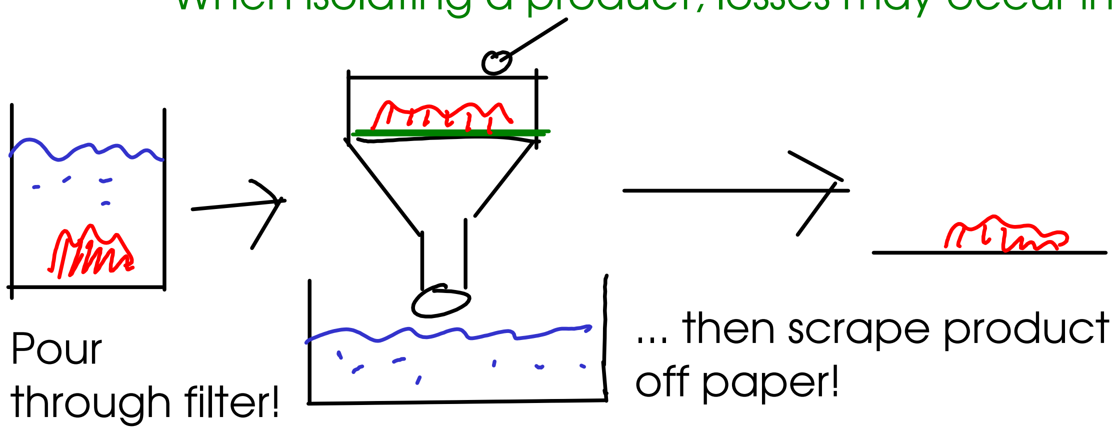
$$2C + O_2 \longrightarrow 2CO$$

... 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 equilibrium 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.

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

ACTUAL YIELD ← Determined EXPERIMENTALLY!

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?

We already know that the ACTUAL YIELD is 31.6 g nitrobenzene. To calculate the THEORETICAL YIELD, start with the reactant - 22.4 g 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 $C_6H_5NO_2$

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

$$= 35.3033563 g\ C_6H_5NO_2$$ <-- THEORETICAL YIELD!

$$\text{PERCENT YIELD} = \frac{\text{ACTUAL YIELD}}{\text{THEORETICAL YIELD}} \times 100\% = \frac{31.6 g}{35.3033563 g} \times 100\% = \boxed{89.5\%}$$

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 interact with one another and undergo certain kinds of chemistry!

IONIC THEORY

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

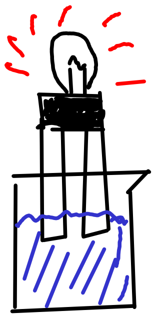
Strong vs weak?

- 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.

Ionic theory experiment



Simple conductivity tester: The stronger the electrolyte, the brighter the light.

SOME PURE COMPOUNDS (MOLECULAR AND IONIC)

DISTILLED WATER

Nonconductor. This is typical for MOLECULAR liquids.

SOLID SODIUM CHLORIDE

Nonconductor. Typical for IONIC SOLIDS. NaCl's ions are unable to move due to being locked in the solid structure.

SOLID SUCROSE $C_{12}H_{22}O_{11}$

Nonconductor, like most MOLECULAR SOLIDS.

MOLECULAR AND IONIC SOLUTIONS

SODIUM CHLORIDE + WATER

Bright light. NaCl is an ELECTROLYTE. Like other soluble ionic compounds, it dissolves in water to release FREE IONS - which can move independently and carry curren!

SUCROSE + WATER

No light. Sucrose is a NONELECTROLYTE. Sucrose molecules do not form ions in water. This is typical molecule behavior.

ACIDS

PURE (GLACIAL) ACETIC ACID

Nonconductor (like other molecular liquids).

ACETIC ACID + WATER

Dim light. Acetic acid is an ELECTROLYTE (probably weak).

2M ACETIC ACID (AQUEOUS)

Dimmer light than HCl. Acetic acid is a WEAK elecrolyte (not completely ionized)

2M HYDROCHLORIC ACID (AQUEOUS)

Bright light. Stronger electrolyte than acetic acid.