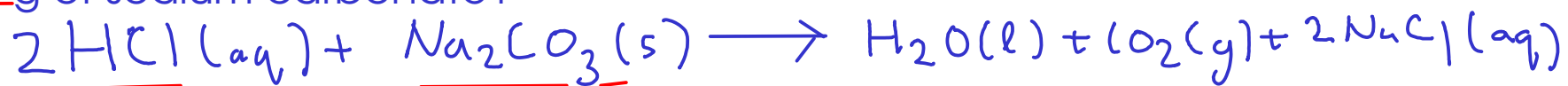


How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?



- 
- 1 - Convert 25.0 g sodium carbonate to moles. Use FORMULA WEIGHT.
  - 2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION.
  - 3 - Convert moles HCl to solution volume. Use MOLARITY.
- 

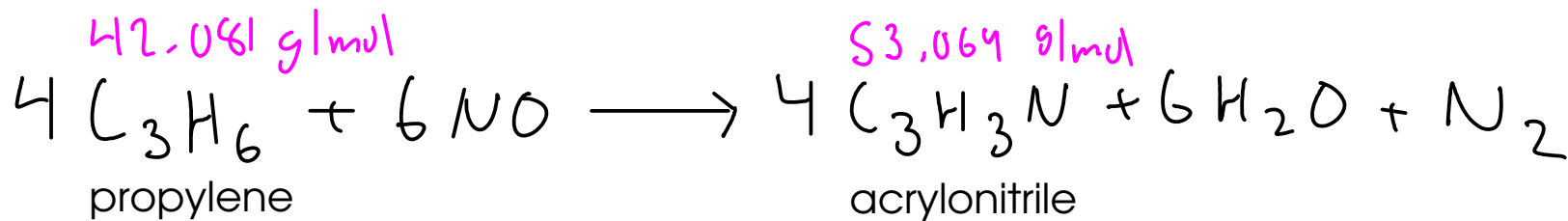
③  $6.00 \text{ mol HCl} = \text{L}$

$$0.4717426172 \text{ mol HCl} \times \frac{\text{L}}{6.00 \text{ mol HCl}} = 0.0786 \text{ L of 6.00 M HCl}$$

The problem specifies the answer should be in mL, so convert units...

$$\text{mL} = 10^{-3} \text{ L}$$

$$0.0786 \text{ L} \times \frac{\text{mL}}{10^{-3} \text{ L}} = \boxed{78.6 \text{ mL of 6.00 M HCl}}$$



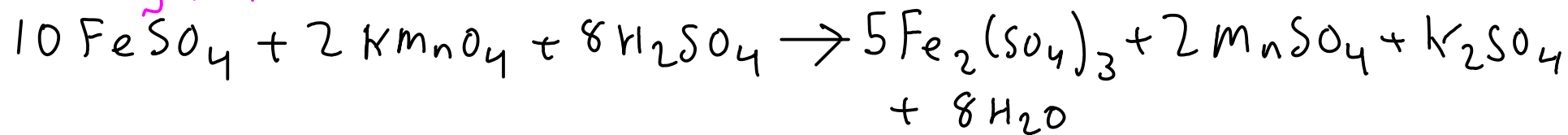
Calculate how many grams of acrylonitrile could be obtained from 651 g of propylene, assuming there is excess NO present.

- 1 - Convert 651 grams propylene to moles. Use FORMULA WEIGHT.
- 2 - Convert moles propylene to moles acrylonitrile. Use CHEMICAL EQUATION.
- 3 - Convert moles acrylonitrile to mass acrylonitrile. Use FORMULA WEIGHT.

- ①  $42.081 \text{ g C}_3\text{H}_6 = \text{mol C}_3\text{H}_6$
- ②  $4 \text{ mol C}_3\text{H}_6 = 4 \text{ mol C}_3\text{H}_3\text{N}$
- ③  $53.064 \text{ g C}_3\text{H}_3\text{N} = \text{mol C}_3\text{H}_3\text{N}$

$$651 \text{ g C}_3\text{H}_6 \times \frac{\text{mol C}_3\text{H}_6}{42.081 \text{ g C}_3\text{H}_6} \times \frac{4 \text{ mol C}_3\text{H}_3\text{N}}{4 \text{ mol C}_3\text{H}_6} \times \frac{53.064 \text{ g C}_3\text{H}_3\text{N}}{\text{mol C}_3\text{H}_3\text{N}} = 821 \text{ g C}_3\text{H}_3\text{N}$$

$$151.90 \text{ g/mol}$$



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

- 1 - Convert 3.36 g iron(II) sulfate to moles. Use FORMULA WEIGHT.
- 2 - Convert moles iron(II) sulfate to moles potassium permanganate. Use CHEMICAL EQUATION.
- 3 - Convert moles potassium permanganate to volume. Use MOLARITY.

$$\textcircled{1} \quad 151.90 \text{ g FeSO}_4 = \text{mol FeSO}_4$$

$$\textcircled{2} \quad 10 \text{ mol FeSO}_4 = 2 \text{ mol KMnO}_4$$

$$\textcircled{3} \quad 0.250 \text{ mol KMnO}_4 = \text{L}$$

$$3.36 \text{ g FeSO}_4 \times \frac{1 \text{ mol FeSO}_4}{151.90 \text{ g FeSO}_4} \times \frac{2 \text{ mol KMnO}_4}{10 \text{ mol FeSO}_4} \times \frac{\text{L}}{0.250 \text{ mol KMnO}_4} = 0.0177 \text{ L}$$

$\textcircled{1}$ 
 $\textcircled{2}$ 
 $\textcircled{3}$

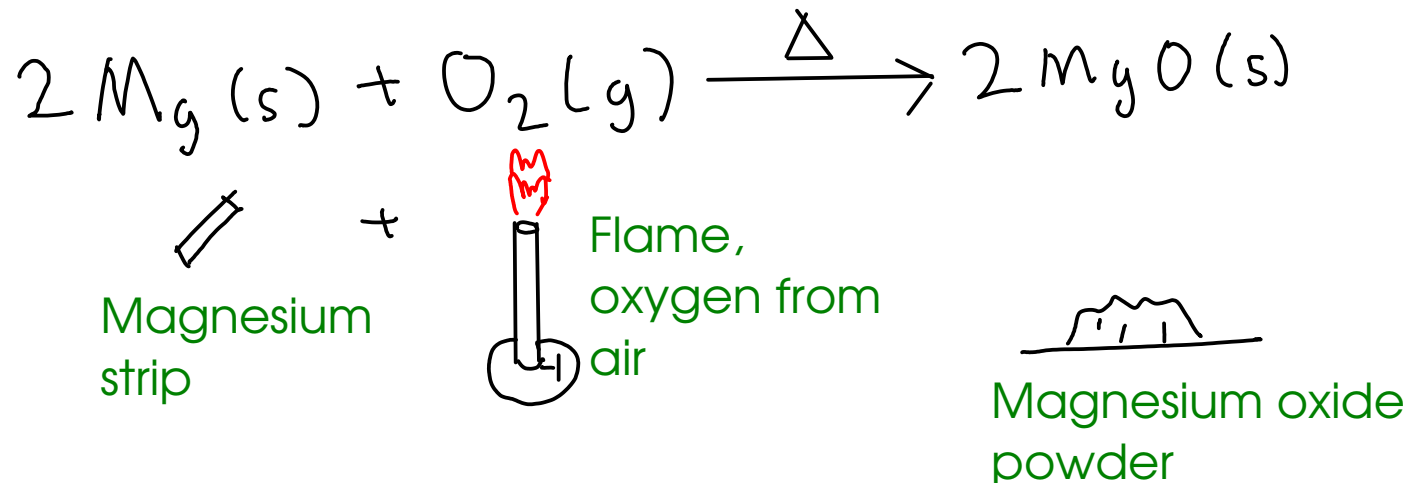
As before, the problem wants the answer in mL, so we'll convert units:

$$\text{mL} = 10^{-3} \text{ L}$$

$$0.0177 \text{ L} \times \frac{\text{mL}}{10^{-3} \text{ L}} = \boxed{17.7 \text{ mL of } 0.250 \text{ M KMnO}_4}$$

## CONCEPT OF LIMITING REACTANT

- When does a chemical reaction STOP?



- When does this reaction stop? When burned in open air, this reaction stops when all the MAGNESIUM STRIP is gone. We say that the magnesium is LIMITING.

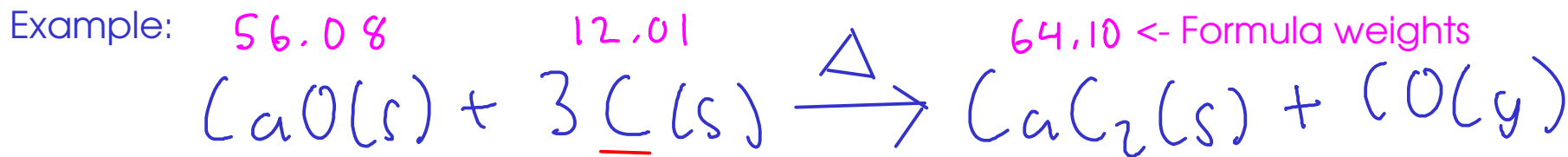
- This reaction is controlled by the amount of available magnesium

- At the end of a chemical reaction, the LIMITING REACTANT will be completely consumed but there may be amount of OTHER reactants remaining. We do chemical calculations in part to minimize these "leftovers".

These are often called "excess" reactants, or reactants present "in excess"

## LIMITING REACTANT CALCULATIONS

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



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

①  $56.08 \text{ g CaO} = \text{mol CaO}$  ②  $\text{mol CaO} = \text{mol CaC}_2$  ③  $64.10 \text{ g CaC}_2 = \text{mol CaC}_2$

$$100. \text{ g CaO} \times \frac{\text{mol CaO}}{56.08 \text{ g CaO}} \times \frac{\text{mol CaC}_2}{\text{mol CaO}} \times \frac{64.10 \text{ g CaC}_2}{\text{mol CaC}_2} = 114 \text{ g CaC}_2$$

①  $12.01 \text{ g C} = \text{mol C}$  ②  $3 \text{ mol C} = \text{mol CaC}_2$  ③  $64.10 \text{ g CaC}_2 = \text{mol CaC}_2$

$$100. \text{ g C} \times \frac{\text{mol C}}{12.01 \text{ g C}} \times \frac{\text{mol CaC}_2}{3 \text{ mol C}} \times \frac{64.10 \text{ g CaC}_2}{\text{mol CaC}_2} = 178 \text{ g CaC}_2$$

The reaction produces 114 grams calcium carbide. At that point, there is no more CaO remaining for the carbon to react with. (We can say that CaO is LIMITING and C is present IN EXCESS.)

## PERCENT YIELD

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

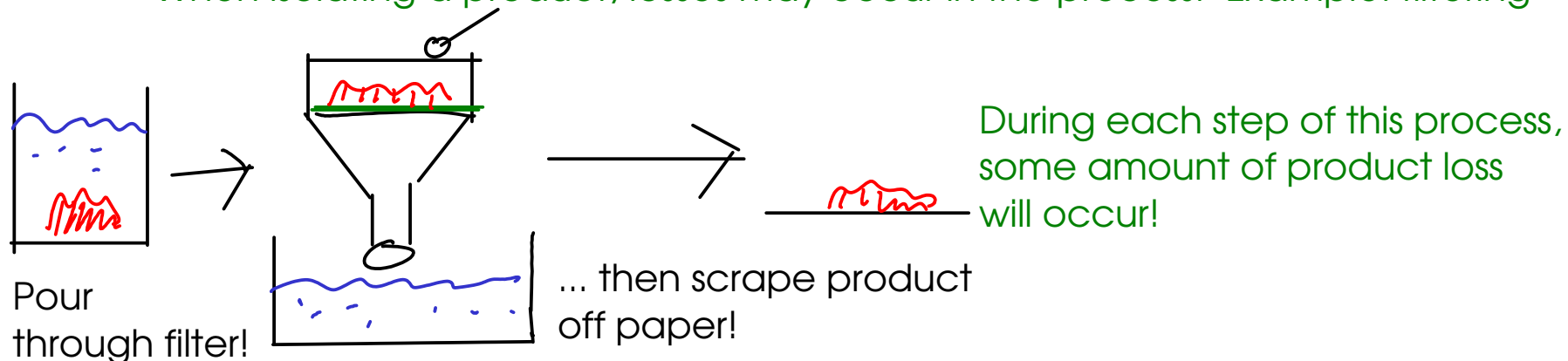
### ① SIDE REACTIONS:



... 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



### ③ EQUILIBRIUM

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

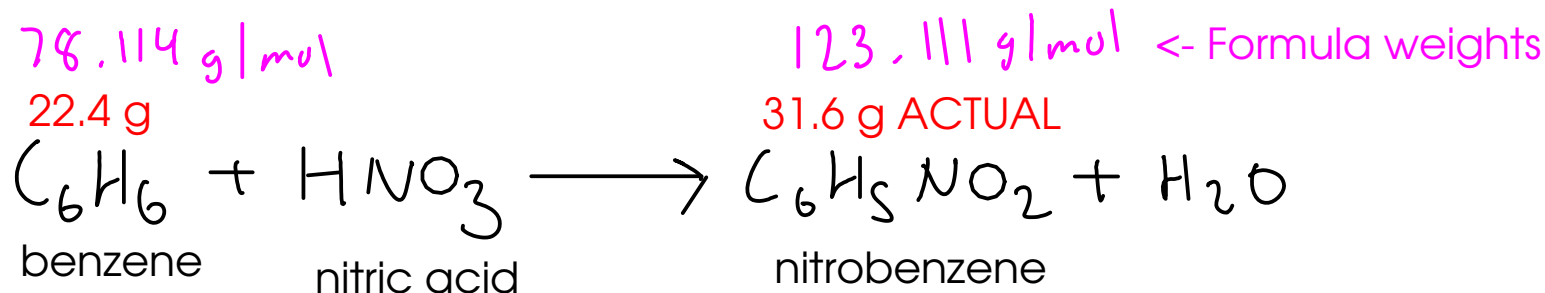
- All of these factors cause a chemical reaction to produce LESS product than calculated. For many reactions, this difference isn't significant. But for others, we need to report the PERCENT YIELD.

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

↙ Determined EXPERIMENTALLY!

↑ 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!



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?

First, calculate the THEORETICAL YIELD of nitrobenzene based on the starting amount of benzene.

$$\textcircled{1} \quad 78.114 \text{ g C}_6\text{H}_6 = \text{mol C}_6\text{H}_6$$

$$\textcircled{2} \quad \text{mol C}_6\text{H}_6 = \text{mol C}_6\text{H}_5\text{NO}_2$$

$$\textcircled{3} \quad 123.111 \text{ g C}_6\text{H}_5\text{NO}_2 = \text{mol C}_6\text{H}_5\text{NO}_2$$

$$22.4 \text{ g C}_6\text{H}_6 \times \frac{\text{mol C}_6\text{H}_6 \textcircled{1}}{78.114 \text{ g C}_6\text{H}_6} \times \frac{\text{mol C}_6\text{H}_5\text{NO}_2 \textcircled{2}}{\text{mol C}_6\text{H}_6} \times \frac{123.111 \text{ g C}_6\text{H}_5\text{NO}_2 \textcircled{3}}{\text{mol C}_6\text{H}_5\text{NO}_2} = 35.3 \text{ g C}_6\text{H}_5\text{NO}_2 \text{ (theoretical)}$$

$$\% \text{ yield} = \frac{\text{actual}}{\text{theor.}} \times 100 = \frac{31.6 \text{ g C}_6\text{H}_5\text{NO}_2}{35.3 \text{ g C}_6\text{H}_5\text{NO}_2} \times 100 = \boxed{89.5\%}$$



## 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!

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### 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

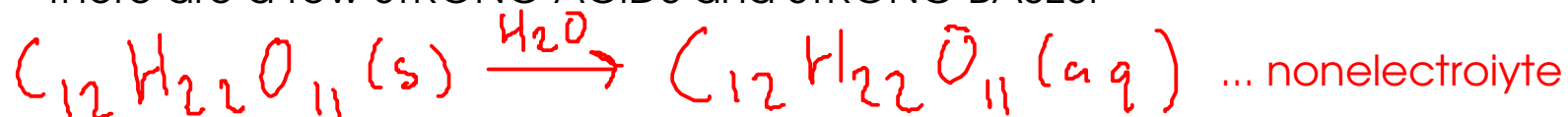
- If an electrolyte only PARTIALLY IONIZES in water,  
it's said to be WEAK

- Both kinds of electrolyte undergo similar kinds of  
chemistry.

What kinds of compounds are electrolytes?

### MOLECULAR COMPOUNDS

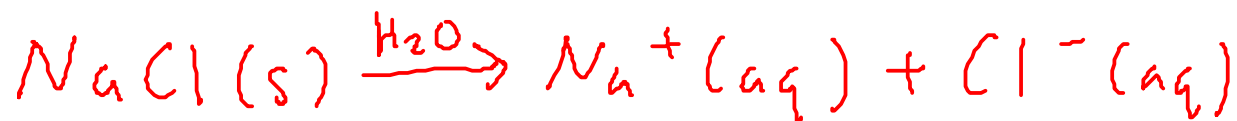
- Most molecular compounds are NONELECTROLYTES - they don't ionize in water
- ACIDS and BASES will ionize in water. Most of these are WEAK ELECTROLYTES, but there are a few STRONG ACIDS and STRONG BASES.



... acetic acid (electrolyte)

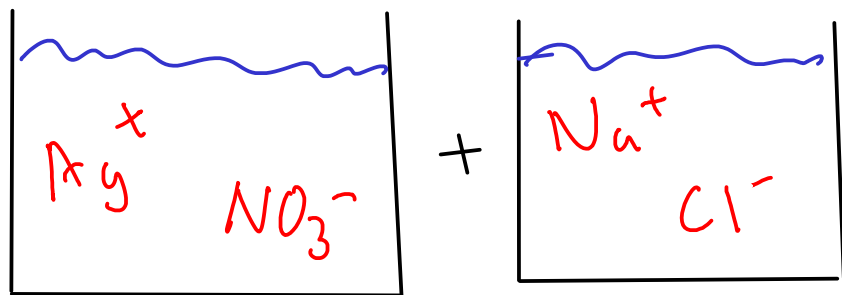
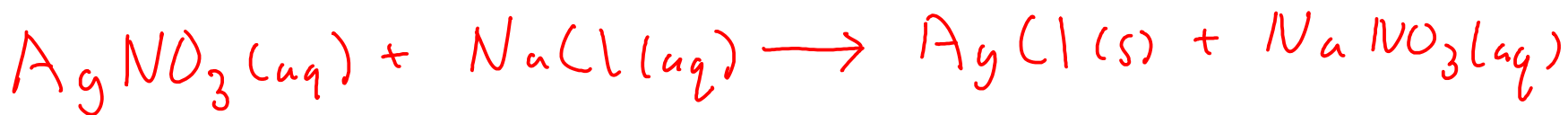
### IONIC COMPOUNDS

- SOLUBLE ionic compounds are STRONG ELECTROLYTES - they completely ionize in water.
- Not all ionic compounds are water soluble, however!

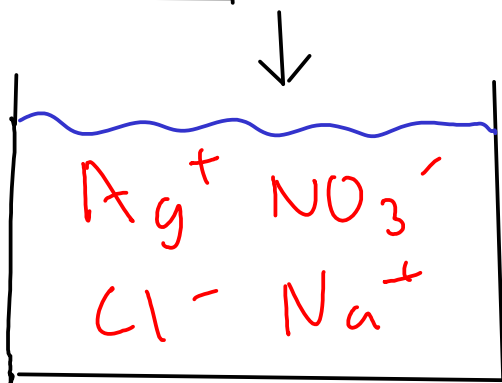


112 - What good is ionic theory?

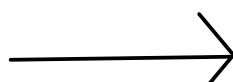
- provides an easy-to-understand MECHANISM for certain kinds of chemical reactions.
  - "Exchange" reactions. (a.k.a "double replacement" reactions)



These free ions mix and can interact with each other!

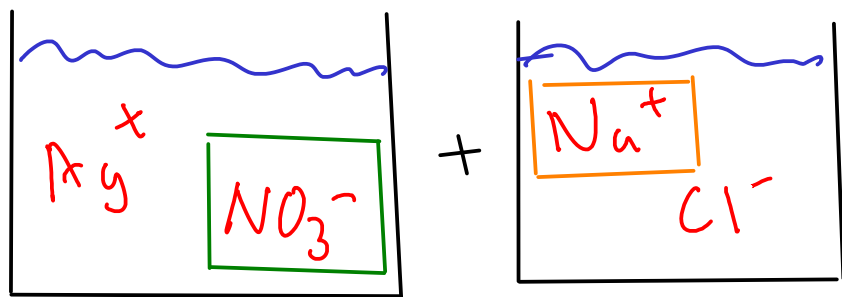


"ion soup"!

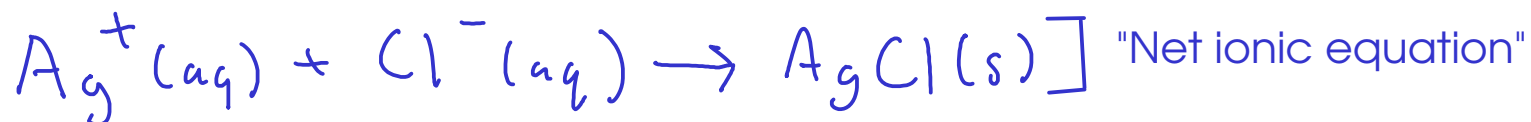
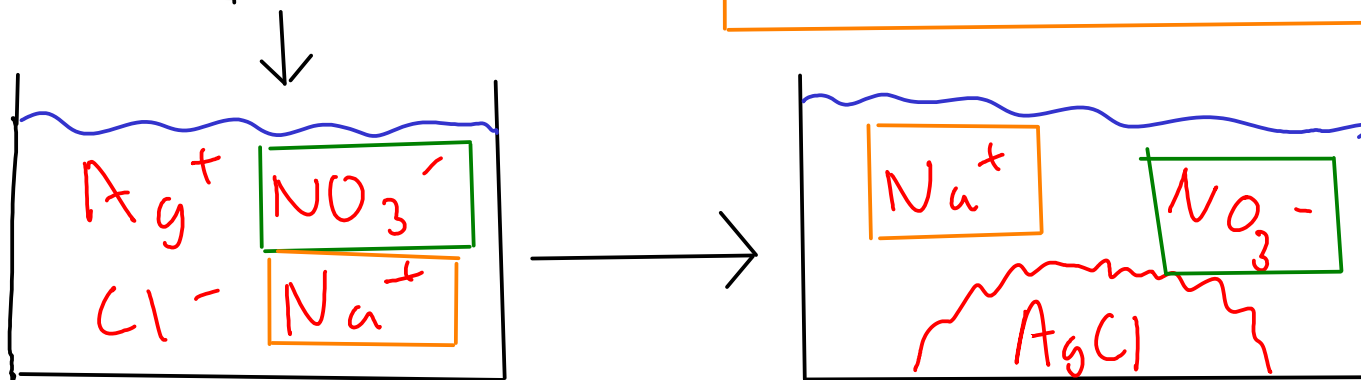


Insoluble  $\text{AgCl}$  falls out of solution as it is formed - "precipitation"

Looking a bit more closely...



The nitrate and sodium ions do not really participate in this reaction. They start and end in exactly the same state. We call them "SPECTATOR IONS".



(The net ionic equation shows only ions and substances that change during the course of the reaction!)

- The net ionic equation tells us that any source of aqueous silver and chloride ions will exhibit this same chemistry, not just silver nitrate and sodium chloride!