# CLASSIFYING REACTIONS

## 4 SINGLE REPLACEMENT REACTIONS

- Reactions where one element REPLACES another element in a compound.

- Can be predicted via an ACTIVITY SERIES (more on that later!)

- Form: $A + BC \longrightarrow AC + B$ "A" and "B" are elements., often metals.

- Easy to spot, since there is an element "by itself" on each side of the equation.

Examples:

$$Cu(s) + 2AgNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

# CLASSIFYING REACTIONS

## 5 DOUBLE REPLACEMENT REACTIONS

- Also called "exchange" reactions

- The ions in two ionic compounds (one compound may also be an acid) EXCHANGE PARTNERS, forming two new compounds.

- Form: $AB + CD \longrightarrow AD + CB$

"A" and "C" are CATIONS
"B" and "D" are ANIONS

- Can be predicted based on the characteristics of the potential products (More on that later!)

- Occur in AQUEOUS SOLUTION

- Do not involve electron transfer.

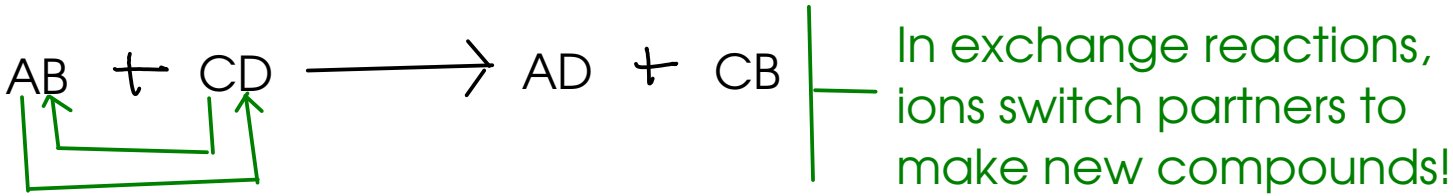
Examples:

Precipitation!

$$3MgCl_2(aq) + 2Na_3PO_4(aq) \longrightarrow Mg_3(PO_4)_2(s) + 6NaCl(aq)$$

$$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$$

# DOUBLE REPLACEMENT (EXCHANGE) REACTIONS



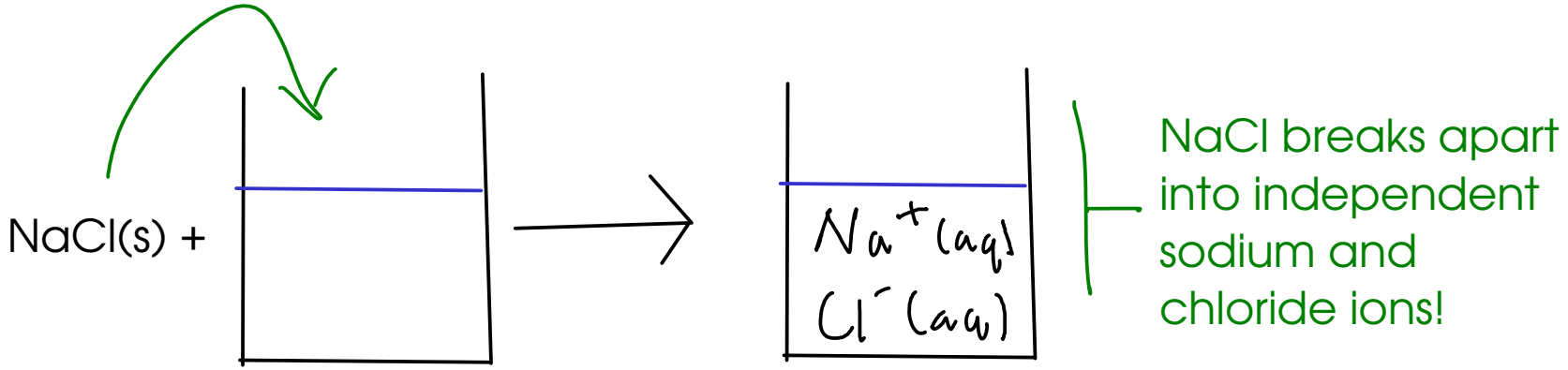

... but HOW do they switch partners?

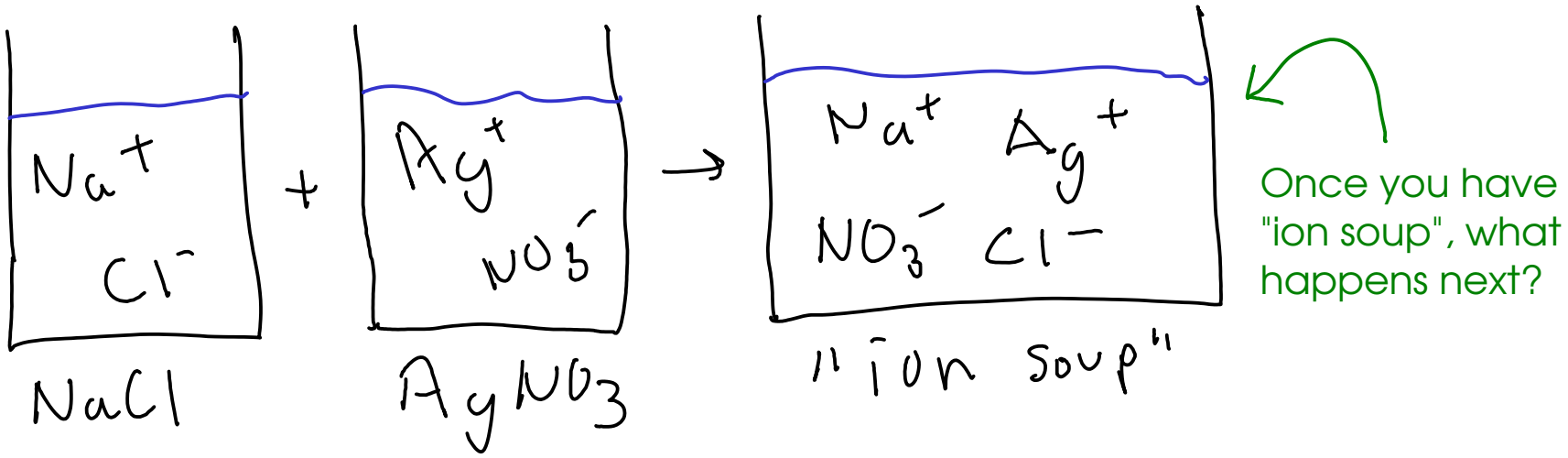
1. Exchange reactions almost always take place in AQUEOUS SOLUTION

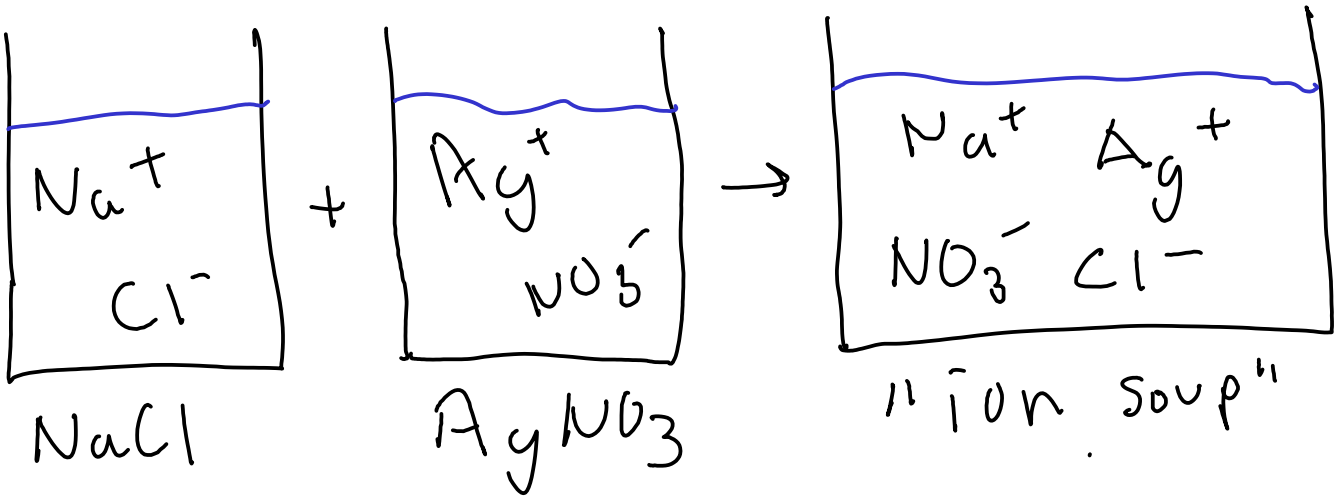
2. In aqueous solution, IONIC THEORY applies!

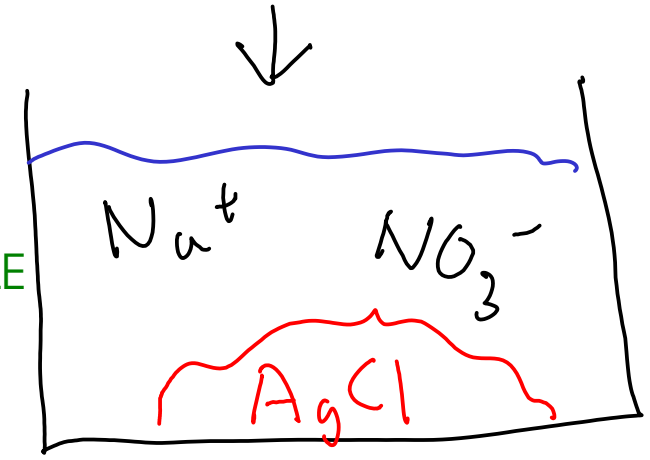
# IONIC THEORY OF SOLUTIONS

- Briefly, ionic theory states that certain substances (like soluble ionic componds) break apart into their component ions when dissolved in water!






"precipitate"

When silver and chloride ions meet, they form an INSOLUBLE compound, silver(I) chloride. This falls out of the solution

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

Formation of AgCl drives this reaction!

For an exchange reaction to proceed, there must be something (a new product) DRIVING the reaction.

3 kinds of exchange chemistry:

1. Reactions that form PRECIPITATES (insoluble ionic compounds)

2. Reaction that form STABLE MOLECULES like water
   - if water forms, reaction is called "neutralization"

3. Reactions that form UNSTABLE MOLECULES that break down into other small molecules, often gases.

If any of these three possibilities form from the "ion soup", a reaction will occur.

If not, NO reaction occurs.

# PRECIPITATION

- Form an insoluble ionic compound

Experiment 10 in your laboratory involves EXCHANGE REACTIONS!

$MgCl_2(aq) + Na_3PO_4(aq) \rightarrow$ ???

$Mg^{2+}$ $Cl^-$ $Na^+$ $PO_4^{3-}$

Potential products:

$Na^+ Cl^-$ / $NaCl$

$Mg^{2+}$ $PO_4^{3-}$

$Mg^{2+}$ $PO_4^{3-}$

$Mg^{2+}$

/ $Mg_3(PO_4)_2$

Remember, IONS exchange partners. That means that you need to write out the IONS, including their charges, and pair them up. The formulas of the products are controlled by the CHARGES of the IONS in the new compounds!

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$3MgCl_2(aq) + 2Na_3PO_4(aq) \rightarrow 6NaCl(aq) + Mg_3(PO_4)_2(s)$ ✓

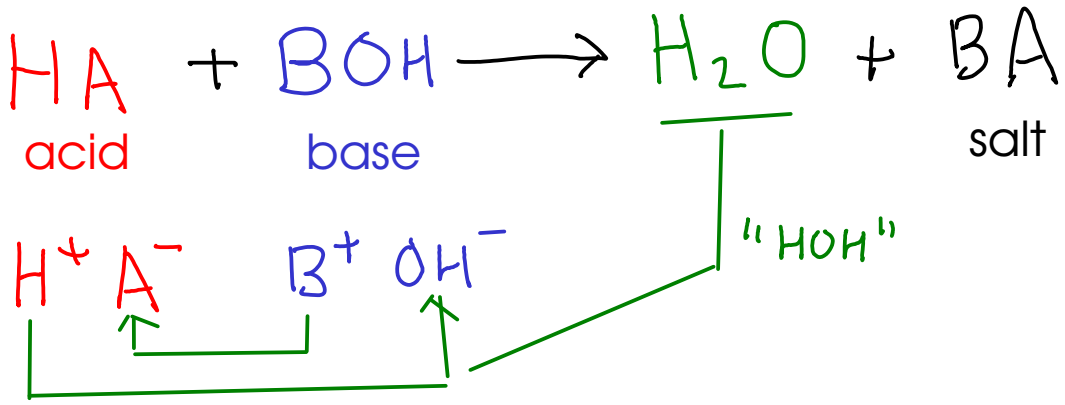
- Does a solid (insoluble) ionic compound form? Check DATA (p 170 in book)

* When writing exchange reactions, figure out the formulas of the products FIRST, and THEN balance the equation.

# FORMATION OF STABLE MOLECULES

- There are several stable molecules that may be formed in double replacement reactions, but the most common is WATER!

- Double replacement reactions that form water are also called "neutralizations"




* To make water ( $H_2O$ ), you need a source of hydrogen ion ( $H^+$ ) and hydroxide ion ( $OH^-$ )

# ACIDS

- compounds that release hydrogen ion ($H^+$), when dissolved in water.

## Properties of acids:

- Corrosive: React with most metals to give off hydrogen gas
- Cause chemical burns on contact
- Taste sour (like citrus - citric acid!)
- Changes litmus indicator to RED

# BASES

- Substances that release hydroxide ion ($OH^-$) when dissolved in water

## Properties of bases:

- Caustic: Attack and dissolve organic matter (think lye, which is NaOH)
- Cause skin/eye damage on contact
- Taste bitter
- changes litmus indicator to BLUE

Due to the dissolving action of base on your skin, bases will feel "slippery". The base ITSELF is not particularly slippery, but what's left of your skin IS!

Examples of acid-base chemistry:

When a neutralization reaction occurs, energy is released. There will be a temperature increase!

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow 2H_2O(l) + Na_2SO_4(aq)$$

$H^+$ $SO_4^{2-}$ $Na^+$ $OH^-$

Potential products:

$H^+$ $OH^-$ → $H_2O$

$Na^+$ $SO_4^{2-}$, $Na^+$ → $Na_2SO_4$

Why "neutralization?

*The products of the reaction (water and a "salt") do not have any of the characteristic properties of acids and bases. These properties can be said to be "neutralized".

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$$HCl(aq) + NH_4OH(aq) \longrightarrow H_2O(l) + NH_4Cl(aq)$$

$H^+$ $Cl^-$ $NH_4^+$ $OH^-$

# DOUBLE REPLACEMENTS THAT FORM GASES

1. Formation of hydrogen sulfide: $H_2S$

- need an ACID (source of hydrogen ion) and a SULFIDE

$$H_2SO_4(aq) + Na_2S(aq) \longrightarrow Na_2SO_4(aq) + H_2S(g)$$

$H^+$ $SO_4^{2-}$ $Na^+$ $S^{2-}$

$H^+$ $S^{2-}$ | $H_2S$

$H^+$

$Na^+$ $SO_4^{2-}$ | $Na_2SO_4$

$Na^+$

Gas with rotten-egg odor!
Observation: Odor and visible gas bubbles

2. Formation of carbonic acid and carbon dioxide:

$$H_2CO_3(aq) \longrightarrow H_2O(l) + CO_2(g)$$

- to form carbonic acid by double replacement, you need a source of hydrogen ion (ACID) and a source of carbonate (can be CARBONATE or BICARBONATE)

$CO_3^{2-}$ $HCO_3^-$