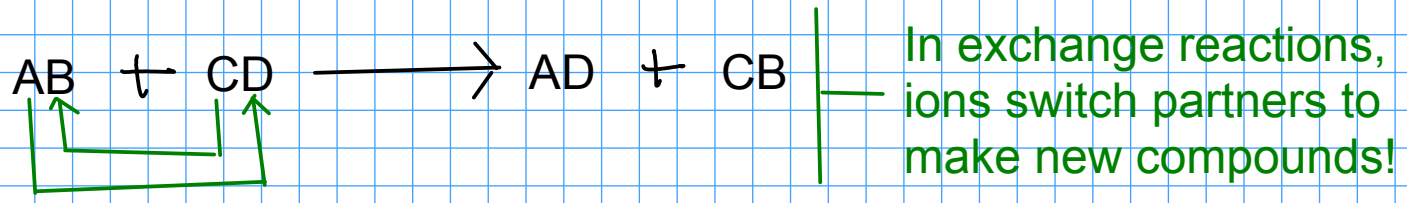
DOUBLE REPLACEMENT (EXCHANGE) REACTIONS



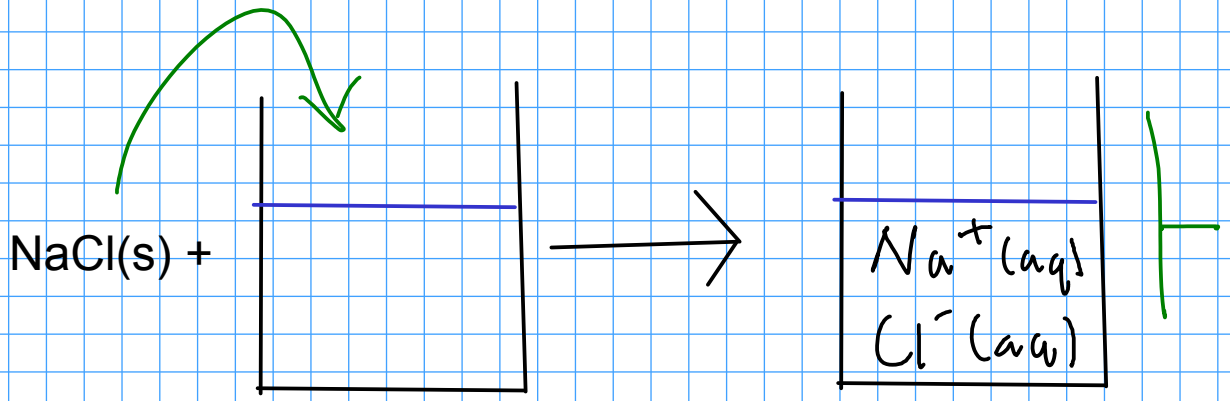
... but HOW do they switch partners?

1. Exchange reactions almost always take place in AQUEOUS SOLUTION

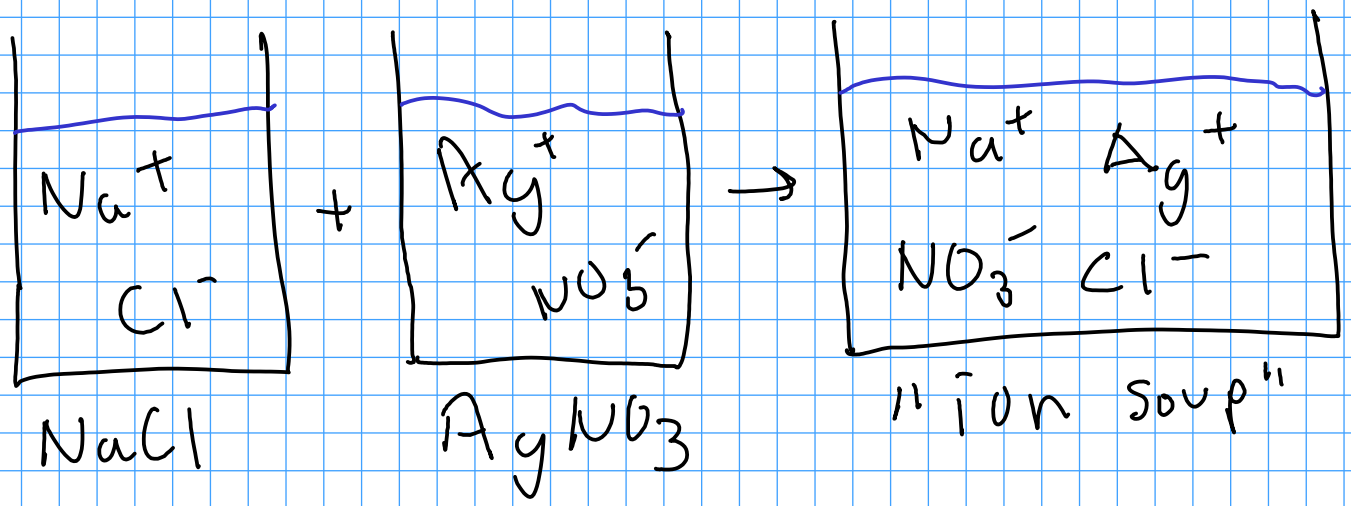
2. In aqueous solution, IONIC THEORY applies!

IONIC THEORY OF SOLUTIONS

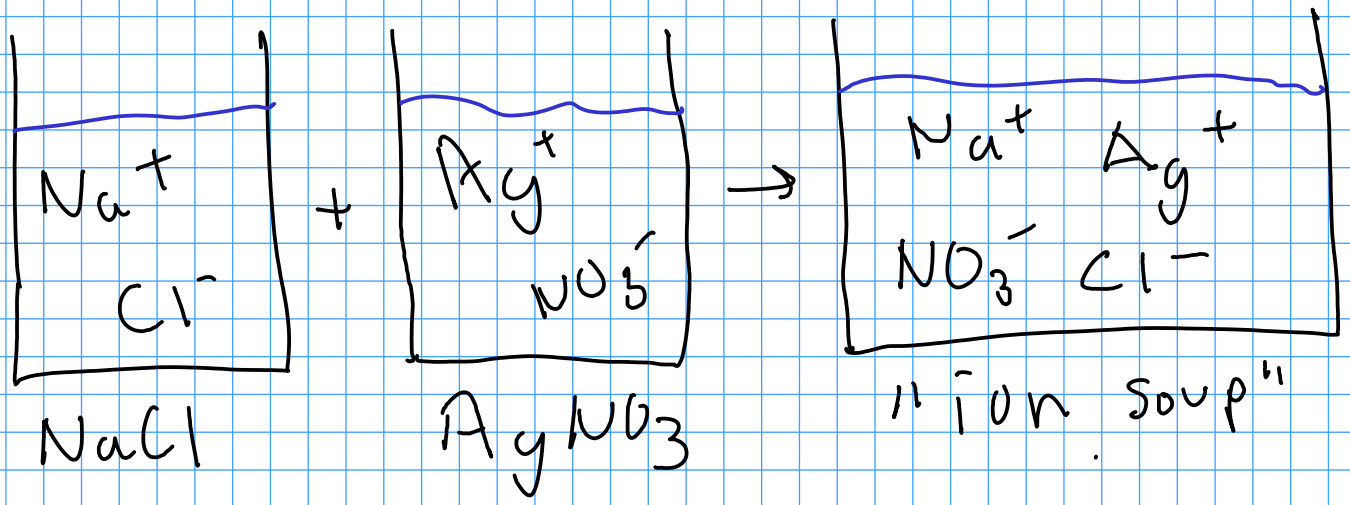
- Briefly, ionic theory states that certain substances (like soluble ionic componds) break apart into their component ions when dissolved in water!

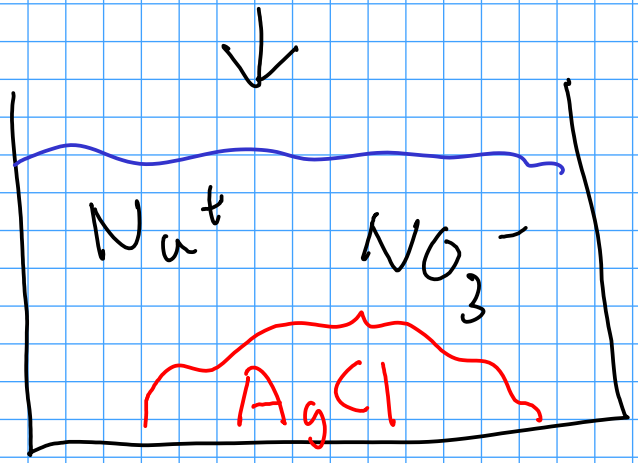


NaCl breaks apart into independent sodium and chloride ions!



Once you have "ion soup", what happens next?





"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!

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

Mg^{2+} Cl^- Na^+ PO_4^{3-} $NaCl$ $Mg_3(PO_4)_2$

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!

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

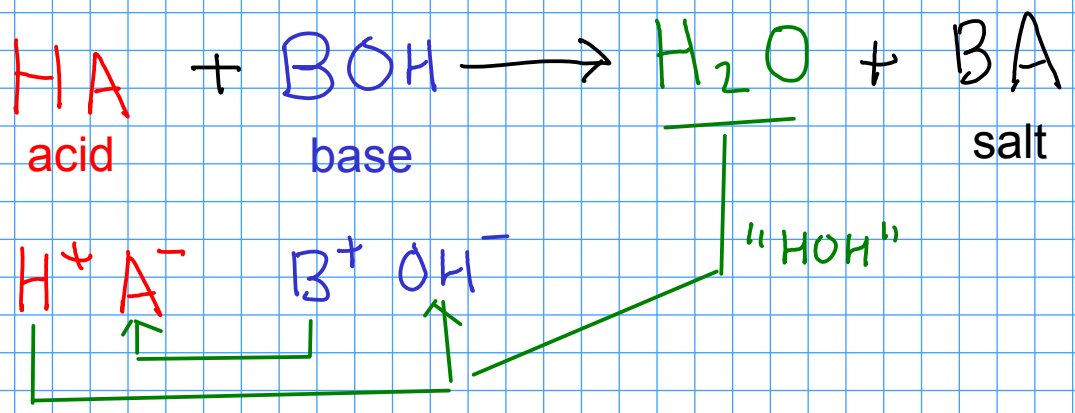
- Does a solid (insoluble) ionic compound form? Check DATA (p 170 in book)

* 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:

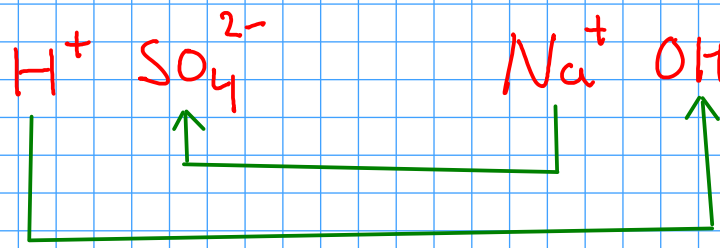
- Caustic: Attack and dissolve organic matter (think lye, which is NaOH)
- Cause skin/eye damage on contact
- Taste bitter
- changes litmus indicator to BLUE

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!

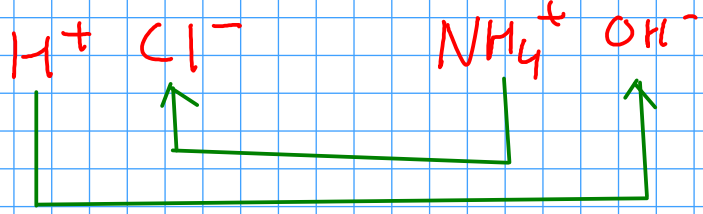
$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow 2H_2O(l) + Na_2SO_4(aq)$$



H_2O Na_2SO_4

Use the SOLUBILITY CHART on p170 of your textbook to predict whether these substances dissolve!

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



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-}

Gas with rotten-egg odor!

Observation: Odor and visible gas bubbles

2. Formation of carbonic acid and carbon dioxide:

- Carbonic acid DECOMPOSES when formed in double replacement reactions!

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

- 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^-

Example of a reactions that forms carbonic acid, then gas: The "baking soda volcano"!

VINEGAR

BAKING SODA

$2HC_2H_3O_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaC_2H_3O_2(aq) + H_2CO_3$

H^+ $C_2H_3O_2^-$ Na^+ CO_3^{2-}

H_2CO_3, $NaC_2H_3O_2$

$2HC_2H_3O_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$

This is the overall process. We show carbon dioxide and water as products, since we want to show the reaction as it's actually observed -with carbonic acid broken down to water and (gaseous) carbon dioxide.