PRECIPITATION

- Form an insoluble ionic compound

Experiment 11 in your laboratory involves EXCHANGE REACTIONS!

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

Ions: Mg^{2+} Cl^- Na^+ PO_4^{3-}

Potential products:

Na^+ Cl^- → $NaCl$

Mg^{2+} Mg^{2+} Mg^{2+} PO_4^{3-} PO_4^{3-} → $Mg_3(PO_4)_2$

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!

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

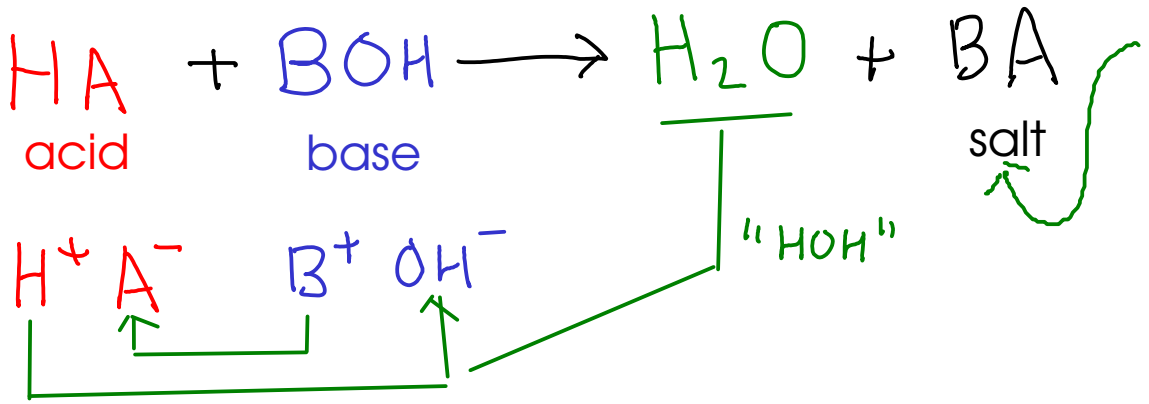
- Does a solid (insoluble) ionic compound form? Check DATA (p 172 in book) (Table 7.1)

* 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"



A "salt" is a generic name for ionic compounds. (Technically, a salt is a compound that can be formed by reaction of an acid with a base, but that includes almost all ionic compounds!)

* 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".

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

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

(p172 - solubility chart)

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:

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

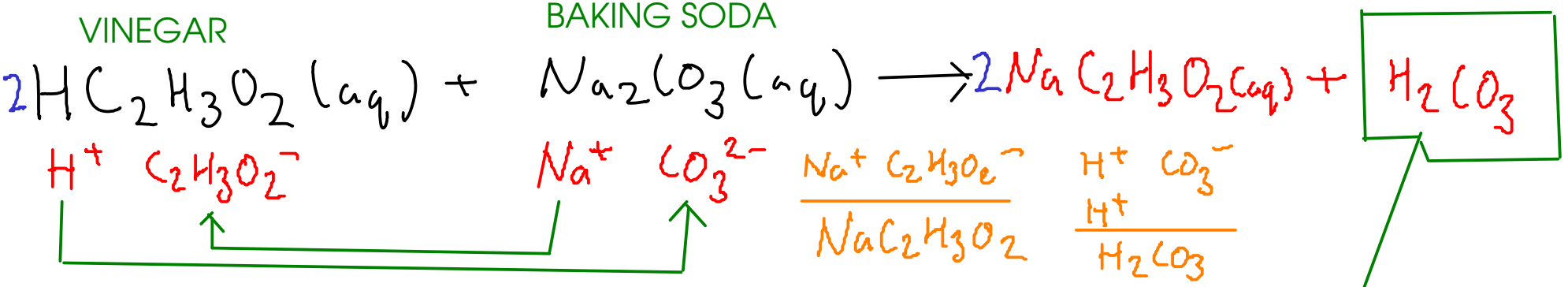
- to form carbonic acid by double replacement, you need a source of hydrogen ion (ACID) and a source of carbonate (can be CARBONATE or BICARBONATE)

CO_3^{2-} HCO_3^-

Example of a reactions that forms carbonic acid, then gas:

VINEGAR

BAKING SODA



... but carbonic acid decomposes, and we get GAS BUBBLES

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

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.

A few more double replacement / exchange examples:

See page 172 for a solubility chart

$CaCl_2(aq) + 2AgNO_3(aq) \longrightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$

Ca^{2+} Cl^- Ag^+ NO_3^-

PRECIPITATION of AgCl drives this reaction!

$H_3PO_4(aq) + 3NaOH(aq) \longrightarrow 3H_2O(l) + Na_3PO_4(aq)$

H^+ PO_4^{3-} Na^+ OH^-

Formation of WATER MOLECULES drives this reaction. It's a NEUTRALIZATION.

$KCl(aq) + NaNO_3(aq) \longrightarrow$ ~~$KNO_3(aq) + NaCl(aq)$~~ NO REACTION

K^+ Cl^- Na^+ NO_3^-

NO REACTION occurs. There is no DRIVING FORCE, since both sodium chloride and potassium nitrate are soluble ionic compounds. They exist in water as free ions ; which is exactly how they existed before being mixed.

$H_2SO_4(aq) + 2NaHCO_3(aq) \longrightarrow Na_2SO_4(aq) + 2H_2CO_3$

H^+ SO_4^{2-} Na^+ HCO_3^-

CARBONIC ACID decomposes when formed to make water and carbon dioxide gas - which escapes as bubbles

$H_2SO_4(aq) + 2NaHCO_3(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$

*Transition metals do not change their charge in exchange reactions!

Reminder: Transition metals do not change charge during an exchange reaction!

$Fe(NO_3)_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + Fe(OH)_3(s)$

Fe^{3+} NO_3^- Na^+ OH^-

Formation of solid iron(III) hydroxide drives this reaction.

$HCl(aq) + Pb(NO_3)_2(aq) \rightarrow HNO_3(aq) + PbCl_2(s)$

H^+ Cl^- Pb^{2+} NO_3^-

Formation of solid lead(II) chloride drives this reaction!

Reactions involving acids or bases can be PRECIPITATIONS, too!