$MgCl_2(aq) + NaC_2H_3O_2(aq) \rightarrow$ NO REACTION!*

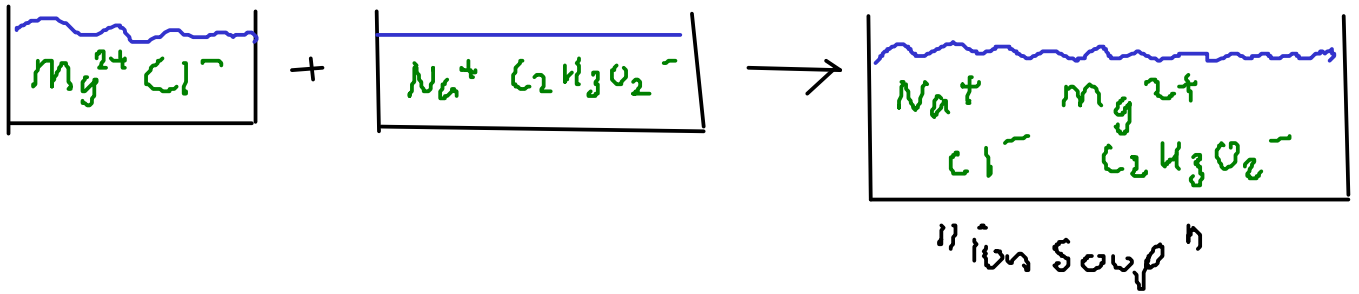
ions: Mg^{2+} Cl^- Na^+ $C_2H_3O_2^-$

"exchange"

$Mg(C_2H_3O_2)_2$ ... dissolves in water

$NaCl$ ... dissolves in water

So, no solid forms here. All possible combinations of these four ions result in compounds that dissolve readily in water.



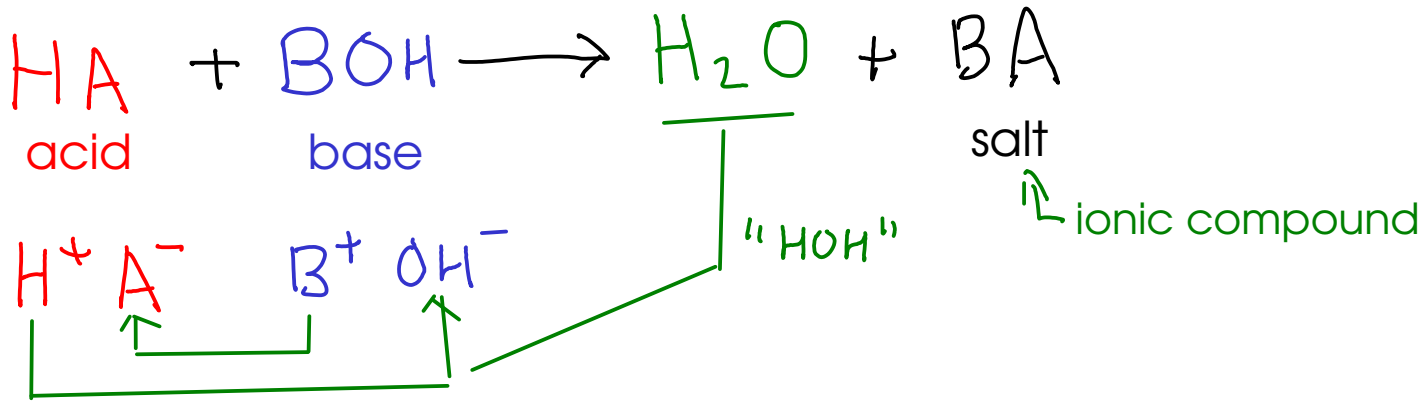
NO CHANGE, therefore NO DRIVING FORCE, and NO REACTION

* We will learn about other driving forces than the formation of solid, but these driving forces do not apply to this reaction

ACID/BASE REACTIONS (also called NEUTRALIZATION REACTIONS)

- 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^-)

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

This is the NET IONIC EQUATION for many neutralizations

... assumes you're reacting STRONG acid with STRONG base!

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!

ACID/BASE or NEUTRALIZATION reactions continued

- the driving force of these reactions is the formation of water molecules.

$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$] Net ionic equation

From the acid From the base

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

ions: H^+ SO_4^{2-} Na^+ OH^-

Potential products: H_2O, Na_2SO_4

- How can this reaction be detected?
  - pH detector (indicator paper, etc.)
  - do the products have similar chemical properties to the reactants?
  - release of heat!

... formation of water is usually accompanied by a release of heat

GAS FORMATION / OTHER MOLECULES

- There are a few other molecules that can be made with exchange-type chemistry.
- Most of these molecules are unstable and can break apart to form gases.

- Formation of a weak acid:

  - The formation of ANY weak acid in an exchange-type reaction can be a driving force.
  - Some weak acids are unstable and can break apart into gas molecules.

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

Gas bubbles can leave solution!

... but how would you form carbonic acid in an exchange-type reaction?

acid + carbonate CO_3^{2-}

OR

acid + bicarbonate HCO_3^-

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow 2\boxed{H_2CO_3(aq)} + Na_2SO_4(aq)$$

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

Driving force ... formation of the weak acid carbonic acid.

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

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

... but when we mix sulfuric acid and sodium bicarbonate, we observe BUBBLES. We need to write an equation that agrees with our observations. We know that carbonic acid decomposes, so we go ahead and put that into our equation.

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

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell) + 2CO_2(g)$$

Other molecules of interest:

H_2SO_3 : sulfurous acid - React an ACID with a SULFITE

$$H_2SO_3(aq) \rightarrow H_2O(\ell) + SO_2(g)$$

H_2S : hydrogen sulfide (gas) - React an ACID with a SULFIDE

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

A few more exchange examples:

* Transition metals don't change their charges during exchange reactions...

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

$Ca^{2+}\ Cl^-$ $\quad$ $Ag^+\ NO_3^-$

PRECIPITATION of AgCl drives this reaction!

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

$H^+\ PO_4^{3-}$ $\quad$ $Na^+\ OH^-$

Formation of liquid WATER drives this NEUTRALIZATION reaction. Detect by release of heat!

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

K^+Cl^- $\quad$ $Na^+\ NO_3^-$

Both "products" are water-soluble ionic compounds, present in water as FREE IONS. This is the same state they were in in before they were mixed. We conclude that there's no driving force and ... NO REACTION.

$H_2SO_4(aq) + Na_2CO_3(aq) \longrightarrow H_2CO_3(aq) + Na_2SO_4(aq)$

$H^+\ SO_4^-$ $\quad$ $Na^+\ CO_3^{2-}$

$H_2CO_3 \rightarrow H_2O + CO_2$

$H_2SO_4(aq) + Na_2CO_3(aq) \longrightarrow H_2O(l) + CO_2(g) + Na_2SO_4(aq)$

Formation of carbonic acid (and its decomposition to water and carbon dioxide gas) is our driving force. We will observe gas bubbles being given off during this reaction.

OXIDATION / REDUCTION CHEMISTRY

- Exchange reactions involve ions pairing up, but the ions themseves are not formed in exchange reactions. Exchanges start with pre-existing ions.

... but the ions have to be produced somehow - through a chemistry that involves the transfer of electrons.

- oxidation / reduction chemistry ("redox" chemistry) involves transfer of electrons and can make ions.