PRECIPITATION REACTIONS

- driving force is the formation of an insoluble ionic compound.

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

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

Potential Products:

$NaCl$

$Mg_3(PO_4)_2$

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

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

Mg^{2+}

The formation of INSOLUBLE magnesium phosphate DRIVES this reaction!

When you're trying to complete a precipitation reaction:

① Write the IONS that form when the reactants are dissolved.

② Make NEW compounds by pairing up cations with anions. Don't forget that the positive and negative charges must balance each other out!

③ Use the solubility rules to determine the PHASE of each new compound - solid or aqueous.

④ Balance the overall equation.

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

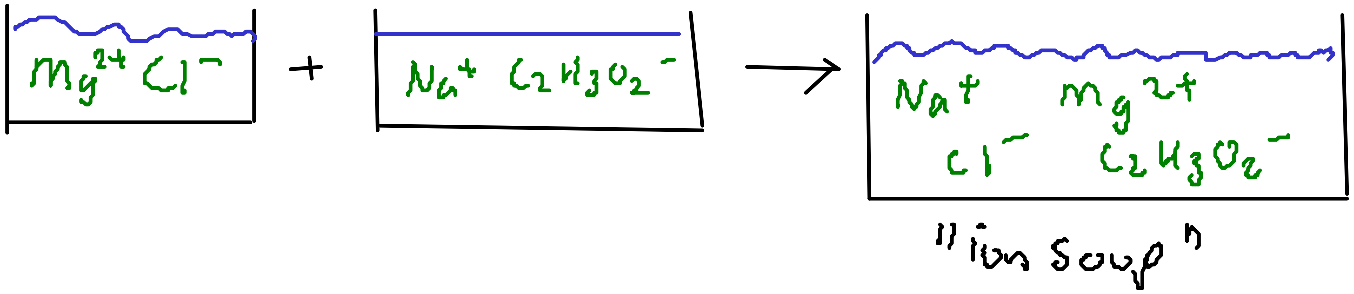
ions: Mg^{2+} Cl^- Na^+ $C_2H_3O_2^-$

"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.



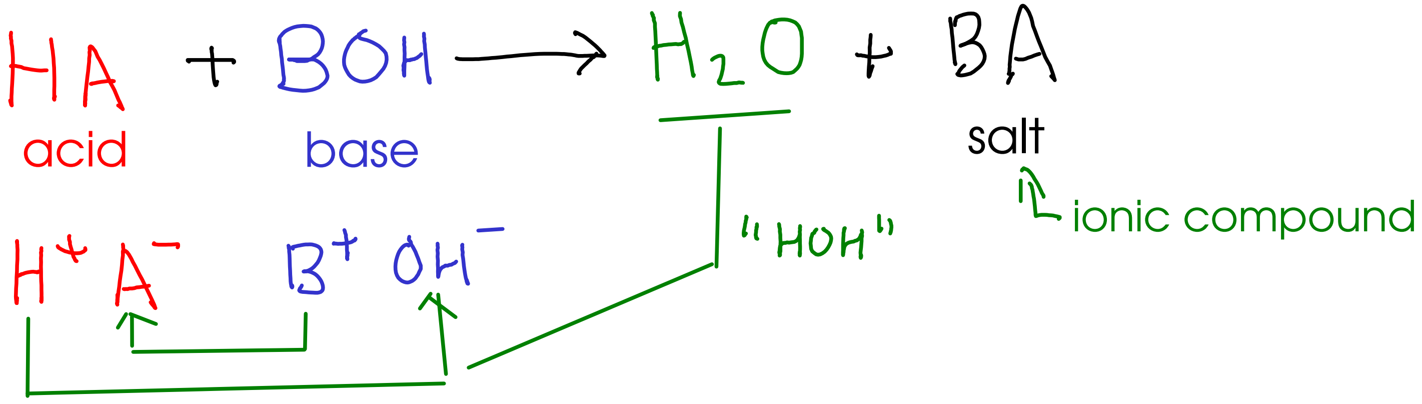
NO CHANGE, therefore
NO DRIVING FORCE,
and NOREACTION

*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"



$$HA + BOH \longrightarrow \underline{H_2O} + BA$$

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

$$\underbrace{H^+(aq) + OH^-(aq)} \longrightarrow H_2O(l)$$

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.

$$\underbrace{H^+(aq)}_{\text{From the acid}} + \underbrace{OH^-(aq)}_{\text{From the base}} \longrightarrow H_2O(l)$$

Net ionic equation

DRIVING FORCE!

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow 2\boxed{H_2O(l)} + Na_2SO_4(aq)$$ ✓

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

Potential products:

H^+ OH^- > H_2O

Na^+ SO_4^{2-} Na^+ > 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^-

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

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.

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

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

Other molecules of interest:

H_2SO_3 : sulfurous acid - React an ACID with a SULFITE

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

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

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

A few more exchange examples: *

* Transition metals DO NOT change their charge in exchange reactions!

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

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 drives this reaction. It's a NEUTRALIZATION, detectable by release of heat!

$$KCl(aq) + NaNO_3(aq) \longrightarrow \cancel{NaCl(aq) + KNO_3(aq)}$$

NO REACTION

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

Both "products" are soluble ionic compounds - present in water as free ions. Since this is exactly how these compounds existed before, 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^{2-} Na^+ CO_3^{2-}

$$H_2CO_3 \rightarrow H_2O + CO_2$$

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

Driving force is the formation of CARBONIC ACID, which decomposes into WATER and CARBON DIOXIDE GAS.