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_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".

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

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

Observation: Odor gas bubbles.

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

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

H^+ S^{2-} → H^+ → H_2S

Na^+ SO_4^{2-} → Na^+ → Na_2SO_4

Hydrogen sulfide (common name) is a gas with a distinct rotten-egg smell.

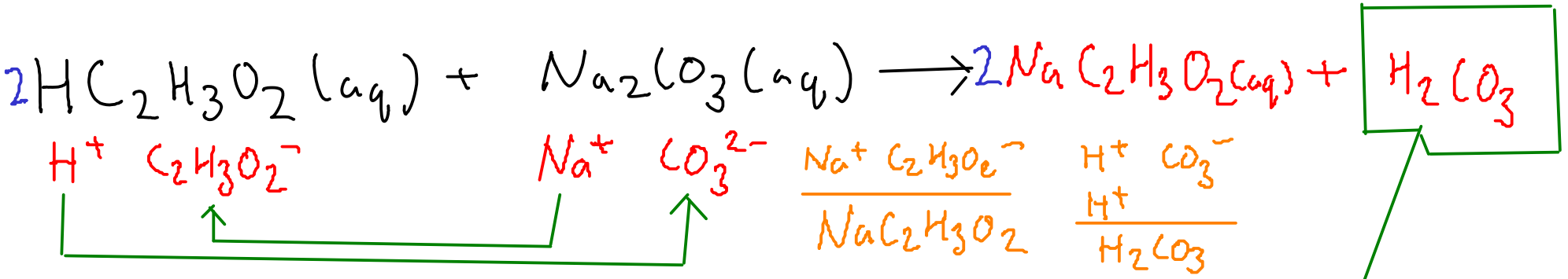
2. Formation of carbonic acid and carbon dioxide:

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

- 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:



... 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

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

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

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 WATER MOLECULES drives this NEUTRALIZATION reaction!

This NEUTRALIZATION can be detected by looking for a RELEASE OF HEAT!

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

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

NO REACTION occurs. There is no DRIVING FORCE for reaction here, since both "products" are SOLUBLE ionic compounds - whi exist as FREE IONS in solution - just like in the original compounds

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

$H^+\ SO_4^{2-}$ $\quad$ $Na^+\ HCO_3^-$

CARBONIC ACID decomposes when formed to produce WATER and CARBON DIOXIDE gas!

$H_2CO_3 \rightarrow H_2O + CO_2$

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

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

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

$Fe(NO_3)_3(aq) + 3\,NaOH(aq) \rightarrow 3\,NaNO_3(aq) + Fe(OH)_3(s)$

$Fe^{3+}\ NO_3^-$ $\qquad$ $Na^+\ OH^-$

Formation of insoluble iron(III) hydroxide drives this PRECIPITATION reaction.

$2\,HCl(aq) + Pb(NO_3)_2(aq) \rightarrow PbCl_2(s) + 2\,HNO_3(aq)$

$H^+\ Cl^-$ $\qquad$ $Pb^{2+}\ NO_3^-$

Formation of insoluble lead(II) chloride drives this PRECIPITATION reaction!

Reactions involving acids or bases with other compounds can be precipitations, too!