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"

$$\underset{\text{acid}}{HA} + \underset{\text{base}}{BOH} \longrightarrow H_2O + \underset{\text{salt}}{BA}$$

salt ⇐ ionic compound

$H^+ \ A^- \qquad B^+ \ OH^-$

"HOH"

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

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$$

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.

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

$$H_2SO_4(aq) + NaOH(aq) \rightarrow H_2O(l) + Na_2SO_4(aq)$$

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

This reaction is driven by the formation of water molecules.

- 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

A few examples of precipitation and acid/base:

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

$$CaCl_2(aq) + 2\overset{*}{Ag}NO_3(aq) \longrightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$$

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

This reaction is driven be the formation of solid AgCl. (precipitation)

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

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

This reaction is driven by the formation of water molecules. (neutralization or acid-base chemistry)

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

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

The possible products are two soluble ionic compounds, so we have no driving force and therefore NO REACTION (possible driving forces here would be formation of water molecules or formation of an INsoluble ionic compound!)

$$Ca(NO_3)_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaNO_3(aq) + CaCO_3(s)$$

Ca^{2+} NO_3^- Na^+ CO_3^{2-}

Driven by formation of solid calcium carbonate (precipitation)

OXIDATION / REDUCTION CHEMISTRY

- Precipitation reactions involve ions pairing up, but the ions themseves are not formed in precipitation reactions. Precipitation reactions (and quite a few others) start with pre-existing ions.

... but 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.

$$2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$$

Elemental, metallic aluminum. Uncharged!

Al^0

Aluminum cation

Al^{3+}

These are called "half-reactions"

$$Al \rightarrow Al^{3+} + \underbrace{3e^-}_{\text{electron}}$$

oxidation: loss of electrons

$$Br_2 + 2e^- \rightarrow 2Br^-$$

reduction: gain of electrons

- oxidation and reduction always occur together. In other words, we can't just make free electrons using oxidation without giving them somewhere to go.

- Many of the types of reactions that you might have heard of before are actually redox reactions!

- SINGLE REPLACEMENT reactions

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

$$Cu \rightarrow Cu^{2+} + 2e^- \quad \text{oxidation}$$

$$2Ag^+ + 2e^- \rightarrow 2Ag(s) \quad \text{reduction}$$

net ionic → $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

- COMBUSTION reactions (burning)

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

$$2Mg(s) \rightarrow 2Mg^{2+} + 4e^- \quad \text{oxidation}$$

$$O_2(g) + 4e^- \rightarrow 2O^{2-} \quad \text{reduction}$$