A few more double replacement / exchange examples:

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

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

PRECIPITATION of silver(I) chloride drives this reaction!

* In double replacement reactions, transition metals DO NOT change their charge!

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acid base

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

salt

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

NEUTRALIZATION: Water forms as a product

NO REACTION

$$KCl(aq) + NaNO_3(aq) \longrightarrow KNO_3(aq) + NaCl(aq)$$

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

NO REACTION occurs! There is no driving force. (1) No solid forms, (2) no stable molecules form (no water), (3) no gas forms. So we don't observe anything!

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

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

Carbonic acid is unstable in water, and decomposes to form water and carbon dioxide gas!

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

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

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

This is a precipitation reaction, forming iron(III) hydroxide.

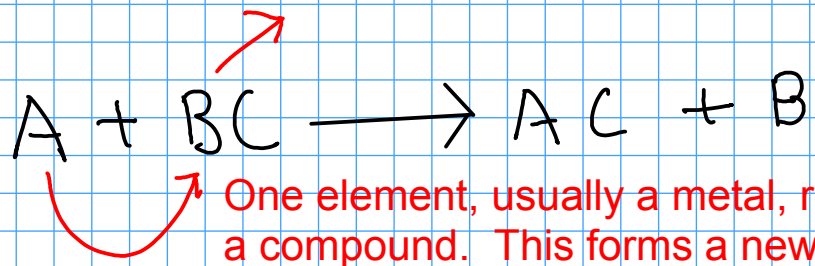
$2\,HCl(aq) + Pb(NO_3)_2(aq) \rightarrow 2\,HNO_3(aq) + PbCl_2(s)$

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

This is another PRECIPITATION reaction, driven by the formation of insoluble lead(II) chloride. But be careful, since the other product is an acid!

This is NOT neutralization ... we still have an acid as a product.

SINGLE REPLACEMENT REACTIONS



One element, usually a metal, replaces another element in a compound. This forms a new compound and leaves behind a new free element!

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

(Cu: 0 → +2; Ag: +1 → 0)

Copper loses electrons, goes from 0 charge to +2 charge!

Silver gains electrons, goes from +1 charge to 0 charge!

... but just because you combine an element and a compound doesn't mean that a reaction will occur. Some combinations react, some don't!

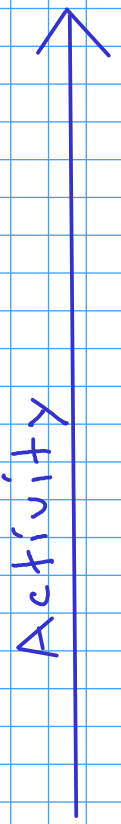
- Whether a reaction occurs depends on how easily the replacing and replaced elements lose electrons. An atom that loses electrons more easily will end up in IONIC form (in other words, in the compound). An atom that loses electrons less easily will end up as a free element.

- We say that an atom that loses elecrons more easily that another is MORE ACTIVE than the other element. But how would you get information about ACTIVITY?

ACTIVITY SERIES p164 - text

- comes from experiental data. It's a list of elements in order of their ACTIVITY - more active elements are higher in the series!

A sample activity series



Sodium Na^{+}

Magnesium Mg^{2+}

Aluminum Al^{3+}

Very active metals will replace hydrogen in acids AND in water!

Zinc Zn^{2+}

Iron Fe^{2+}

Lead Pb^{2+}

Metals more active than hydrogen will replace hydrogen in acids!

Hydrogen H^{+}

Copper Cu^{2+}

Silver Ag^{+}

Gold Au^{3+}

These metals are unreactive to most acids!

PREDICTING SINGLE REPLACEMENT REACTIONS

$Ag(s) + H_2SO_4(aq) \rightarrow$ NO REACTION

Silver is LESS ACTIVE than hydrogen, so we would expect no reaction to occur. The more active element has ALREADY lost electrons.

$Mg(s) + ZnSO_4(aq) \rightarrow MgSO_4(aq) + Zn(s)$

Magnesium is MORE ACTIVE than zinc, so we would expect that magnesium will replace the zinc from zinc(II) sulfate.

$Pb(s) + HCl(aq) \rightarrow$

$Pb(NO_3)_2(aq) + Zn(s) \rightarrow$