A few more double replacement / exchange examples:

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

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

PRECIPITATION of silver(I) chloride drives this reaction!

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

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

Formation of WATER is the driving force for this reaction. It's a NEUTRALIZATION

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

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

NO REACTION occurs. There's no driving force. In other words, (1) no solid forms (2) no stable molecule forms, and (3) no unstable molecule forms. We're left with our original "ion soup"

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

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

Carbonic acid is unstable under these conditions!

$H_2CO_3 \rightarrow H_2O + CO_2$

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

The driving force is the formation (and decomposition) of carbonic acid!

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

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

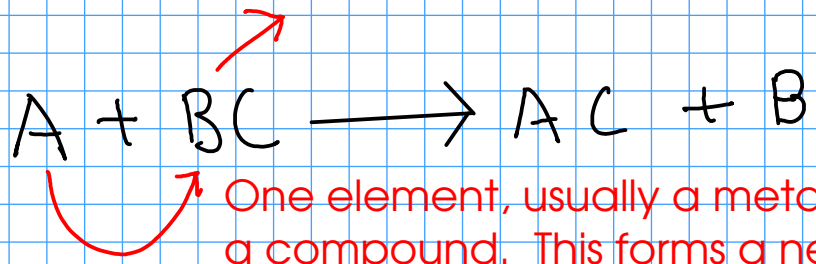
Formation of the insoluble iron(III) hydroxide drives this reaction. (PRECIPITATION)

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

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

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

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.

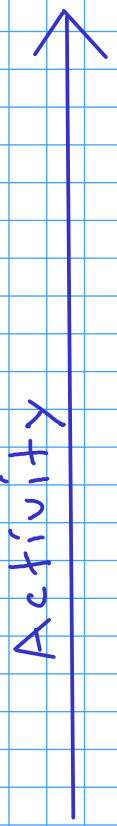
- We say that an atom that loses elecrons more easily that another is MORE ACTIVE than the other element. But how would you get information about ACTIVITY?

A single replacement reaction is an example of a reaction where ELECTRON TRANSFER is a driving force. Electron transfer reactipns are generally called OXIDATION-REDUCTION reactions.

ACTIVITY SERIES

- 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+}

Zinc Zn^{2+}

Iron Fe^{2+}

Lead Pb^{2+}

Hydrogen H^{+}

Copper Cu^{2+}

Silver Ag^{+}

Gold Au^{3+}

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

Metals more active than hydrogen will replace hydrogen in acids!

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 not expect a reaction to occur.

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

Magnesium is MORE ACTIVE than zinc, so we expect it to replace zinc in the compound.

$Pb(s) + 2HCl(aq) \rightarrow PbCl_2(s) + H_2(g)$

Lead is MORE ACTIVE than hydrogen, so we would expect to see a reaction.

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

Zinc is MORE ACTIVE than lead, so we expect to see a reaction!

(It doesn't matter that we've written the