A few more double replacement / exchange examples:

See page 172 for a solubility chart

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

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 liquid WATER drives this neutralization reaction!

Detect this reaction by release of HEAT!

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

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

NO REACTION occurs. There's no DRIVING FORCE for reaction, since our potential products are soluble ionic compounds - which exist in solution as free ions. That's also how these ions existed before mixing!

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

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

$H_2CO_3 \rightarrow H_2O + CO_2$

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

* TRANSITION METALS do not change their charge in exchange reactions!

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

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

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

PRECIPITATION of insoluble iron(III) hydroxide drives this reaction!

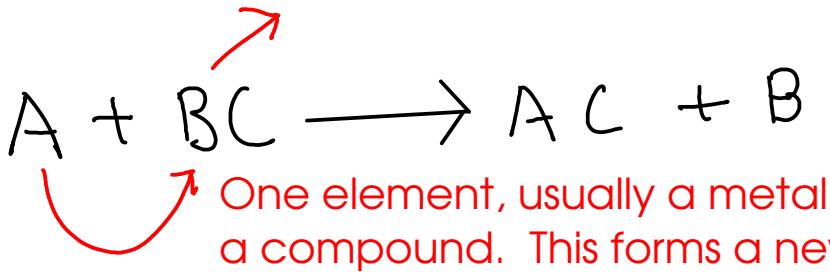
$2HCl(aq) + Pb(NO_3)_2(aq) \rightarrow 2HNO_3(aq) + PbCl_2(s)$

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

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

Reactions involving acids or bases reacting with other compounds MAY be PRECIPITATION reactions, too!

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

(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.

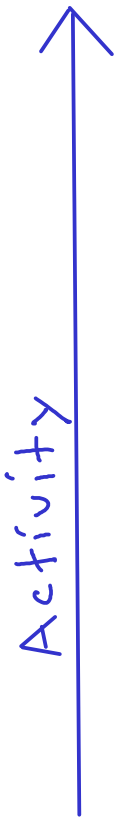
- We say that an atom that loses elecrons more easily that another is MORE ACTIVE than the other element. But how would you get information about ACTIVITY?

A single replacement reaction is an example of a reaction where ELECTRON TRANSFER is a driving force. Electron transfer reactions 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^{+}

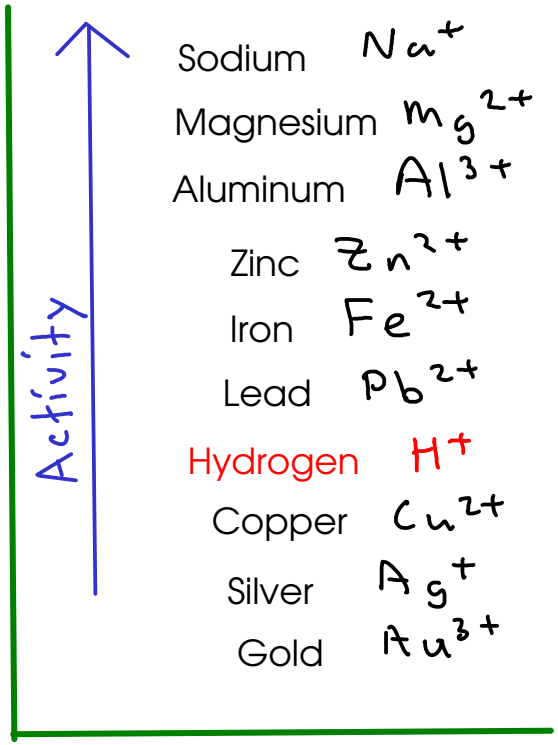
Gold Au^{3+}

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



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

Lead is more active than hydrogen, so it will replace hydrogen in HCl.

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

Zinc is more active than lead, so it will replace lead in lead(II) nitrate!

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

Silver is LESS ACTIVE than hydrogen, so it will not replace hydrogen in sulfuric acid.

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

Magnesium is more active than zinc, so it will replace zinc in zinc(II) nitrate.