Example of a reactions that forms carbonic acid, then gas: The "baking soda volcano"!

VINEGAR

BAKING SODA

$2HC_2H_3O_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaC_2H_3O_2(aq) + H_2CO_3$

H^+ $C_2H_3O_2^-$ Na^+ CO_3^{2-} $NaC_2H_3O_2$ H_2CO_3

... but carbonic acid decomposes, and we get GAS BUBBLES

$$2HC_2H_3O_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaC_2H_3O_2(aq) + H_2O(\ell) + CO_2(g)$$

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 170 for a solubility chart

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

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

In exchange reactions, transition metal ions DO NOT change charge!

PRECIPITATION of silver(I) chloride drives this reaction!

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

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

The FORMATION OF WATER drives this reaction. It's a NEUTRALIZATION. Detect by evolution of HEAT

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

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

NO REACTION occurs There is no DRIVING FORCE, since both sodium chloride and potassium nitrate are both soluble ionic compounds, They exist in water as free ions (just like the original compounds do)

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

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

CARBONIC ACID decomposes under these conditions to form WATER and CARBON DIOXIDE GAS (which escapes as bubbles!)

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

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

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

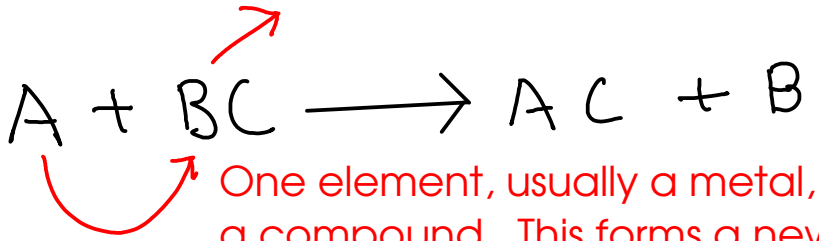
Formation of insoluble iron(III) hydroxide drives this PRECIPITATION reaction

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

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

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

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.

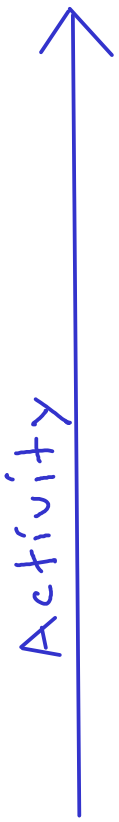
- We say that an atom that loses elecrons more easily that another is MORE ACTIVE than the other element. But how would you get information about ACTIVITY?

A single replacement reaction is an example of a reaction where ELECTRON TRANSFER is a driving force. Electron transfer 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!