Example of a reactions that forms carbonic acid, then gas:

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

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

$\frac{Na^+ \; C_2H_3O_2^-}{NaC_2H_3O_2}$ $\frac{H^+ \; CO_3^- \; H^+}{H_2CO_3}$

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

$$2HC_2H_3O_2(aq) + Na_2CO_3(aq) \rightarrow 2NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$$

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 172 for a solubility chart

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

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

Formation of insoluble AgCl drives this PRECIPITATION reaction!

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

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

Formation of WATER drives this NEUTRALIZATION reaction!

$$KCl(aq) + NaNO_3(aq) \longrightarrow \text{~~KNO}_3\text{(aq) + NaCl(aq)~~ NO REACTION}$$

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

We conclude that there's NO REACTION. We form no molecules or insoluble solids, and the ions remain floating around in solution exactly as they were before mixing.

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

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

$$H_2CO_3 \rightarrow H_2O + CO_2$$

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

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

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

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

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

Formation of insoluble iron)III) hydroxide drives this precipitation reaction!

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

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

Formation of solid lead(II) chloride drives this precipitation reaction!

SINGLE REPLACEMENT REACTIONS

$$A + BC \longrightarrow AC + B$$

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

example: $\underset{0}{Cu}(s) + 2\,\underset{+1}{Ag}NO_3(aq) \longrightarrow \underset{+2}{Cu}(NO_3)_2(aq) + 2\,\underset{0}{Ag}(s)$

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

↑ Activity

- 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+}

Sodium, Magnesium: Very active metals will replace hydrogen in acids AND in water!

Aluminum, Zinc, Iron, Lead: Metals more active than hydrogen will replace hydrogen in acids!

Copper, Silver, Gold: These metals are unreactive to most acids!

PREDICTING SINGLE REPLACEMENT REACTIONS

Activity (↑)	
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+}

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

Since LEAD is more active than hydrogen, we expect it to replace H in HCl.

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

Since ZINC is more active than lead, we expect it to replace Pb in lead(II) chloride.

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

Since HYDROGEN is more active than silver, silver will not be able to 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 this reaction.