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

$H^+ \quad SO_4^{2-} \quad Na^+ \quad HCO_3^-$

... but when we mix sulfuric acid and sodium bicarbonate, we observe BUBBLES. We need to write an equation that agrees with our observations. We know that carbonic acid decomposes, so we go ahead and put that into our equation.

$H_2CO_3(aq) \longrightarrow H_2O(\ell) + CO_2(g)$

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

Other molecules of interest:

H_2SO_3 : sulfurous acid - React an ACID with a SULFITE

$H_2SO_3(aq) \rightarrow H_2O(\ell) + SO_2(g)$

H_2S : hydrogen sulfide (gas) - React an ACID with a SULFIDE

$H_2SO_4(aq) + Na_2S(aq) \rightarrow Na_2SO_4(aq) + H_2S(g)$

A few more exchange examples:

* Transition metals DO NOT change their charge in exchange reactions!

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

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

Formation of solid AgCl drives this PRECIPITATION

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

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

Formation of WATER drives this ACID-BASE reaction.

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

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

There are no ionic solids. There are no molecules formed. So, there's no driving force and NO REACTION.

$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow H_2CO_3(aq) + Na_2SO_4(aq)$

H^+ SO_4^{2-} Na^+ CO_3^{2-}

$H_2CO_3 \rightarrow H_2O + CO_2$

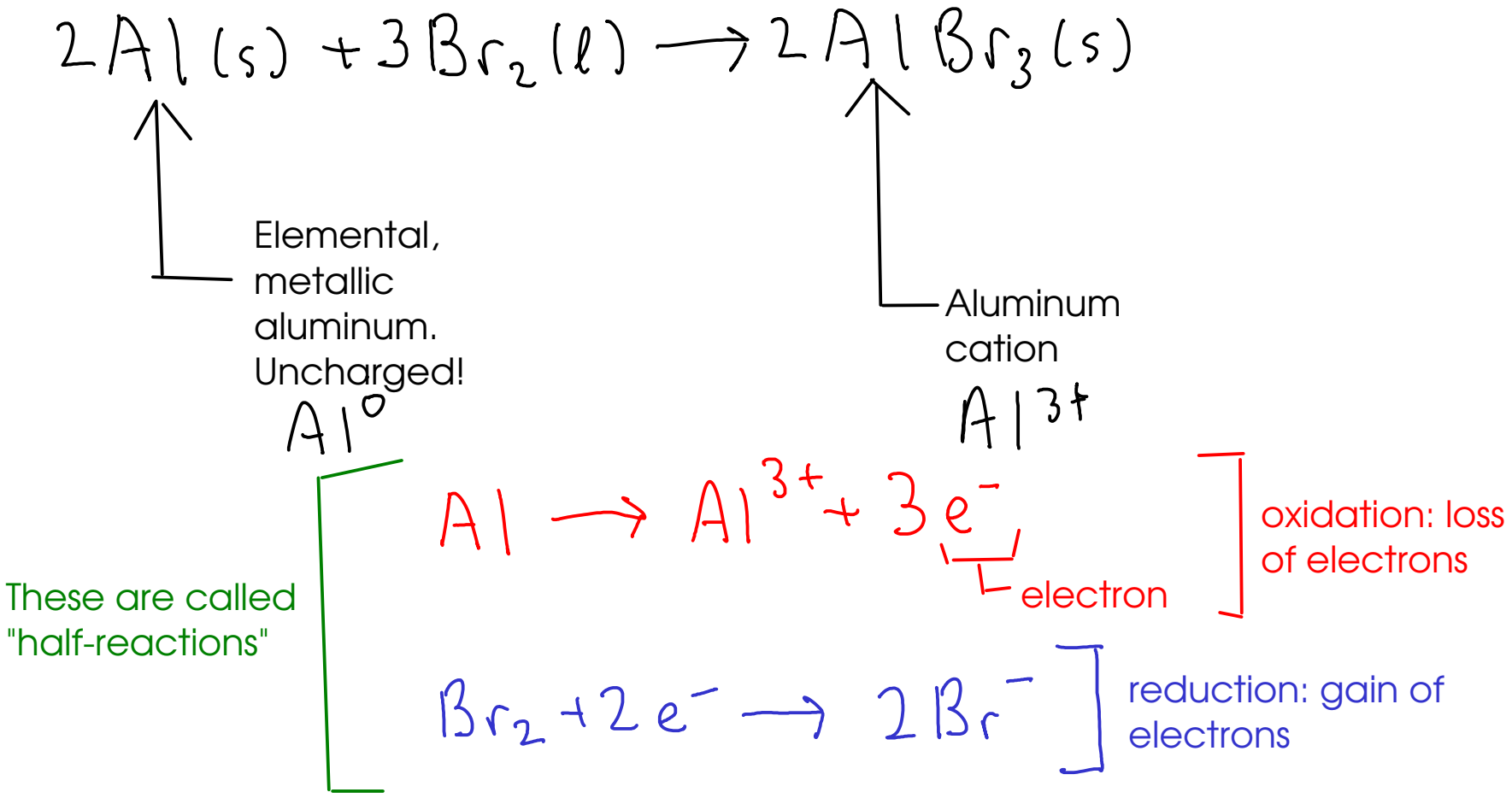
$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) + Na_2SO_4(aq)$ ✓

OXIDATION / REDUCTION CHEMISTRY

- Exchange reactions involve ions pairing up, but the ions themseves are not formed in exchange reactions. Exchanges start with pre-existing ions.

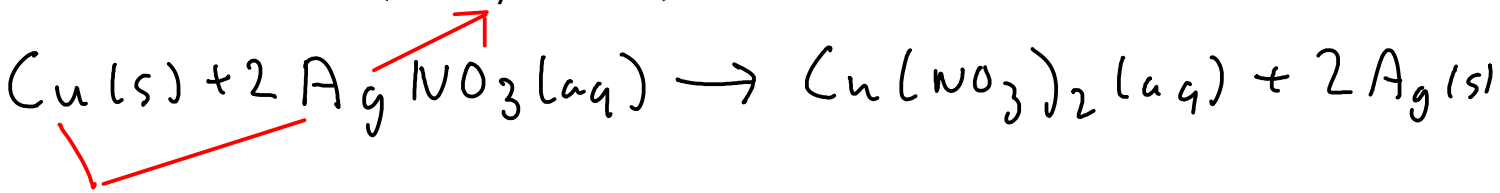
... but the ions have to be produced somehow - through a chemistry that involves the transfer of electrons.

- oxidation / reduction chemistry ("redox" chemistry) involves transfer of electrons and can make ions.



- oxidation and reduction always occur together. In other words, we can't just make free electrons using oxidation without giving them somewhere to go.
- Many of the types of reactions that we learned about in previous courses are redox reactions!

- COMBINATIONS (often but not always redox)
- DECOMPOSITIONS (often redox)
- SINGLE REPLACEMENT (always redox)

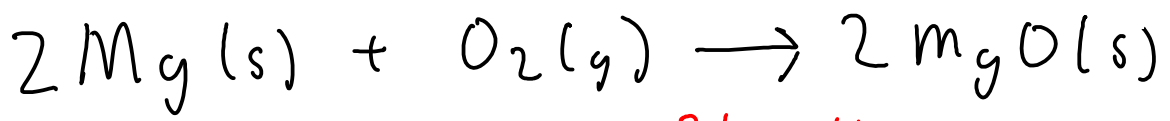


$Cu \rightarrow Cu^{2+} + 2e^-$ oxidation

$2Ag^+ + 2e^- \rightarrow 2Ag(s)$ reduction

net ionic → $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

- COMBUSTION



$2Mg(s) \rightarrow 2Mg^{2+} + 4e^-$ oxidation

$O_2(g) + 4e^- \rightarrow 2O^{2-}$ reduction

A review of the reaction types we just mentioned:

1 COMBINATION REACTIONS

- Reactions that involve two or more simple substances COMBINING to form a SINGLE product

- Often involve large energy changes. Sometimes violent!

- Form: $A + B + \ldots \longrightarrow C$

Example:

$$2\,Al(s) + 3\,Br_2(l) \longrightarrow 2\,AlBr_3(s)$$

2 DECOMPOSITION REACTIONS

- Reactions where a SINGLE REACTANT breaks apart into several products

- Form: $A \longrightarrow B + C + \ldots$

Example:

$$2\,H_2O_2(\ell) \longrightarrow 2\,H_2O(\ell) + O_2(g)$$

* This reaction is NOT a combustion reaction, even though O_2 is involved!

* Combustion reactions CONSUME O_2, while this reaction PRODUCES O_2

3 COMBUSTION REACTIONS

- Reactions of substances with MOLECULAR OXYGEN (O_2) to form OXIDES.
- Combustion forms an OXIDE of EACH ELEMENT in the burned substance!

- Form: $AB + O_2 \longrightarrow AO + BO$

Oxide: a compound containing OXYGEN and one other element!

* Combustion of hydrocarbons makes carbon dioxide and water, if enough oxygen is present. In low-oxygen environments, carbon monoxide is made instead!

Examples:

Oxides!

$$C_3H_8(g) + 5O_2(g) \longrightarrow 4H_2O(g) + 3CO_2(g)$$

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

This reaction can also be called a combination!
Two reactants form a single product.

4 SINGLE REPLACEMENT REACTIONS

- Reactions where one element REPLACES another element in a compound.

- Can be predicted via an ACTIVITY SERIES (p151, 9th edition) (p153, 10th ed)

- Form: $A + BC \longrightarrow AC + B$ "A" and "B" are elements., often metals.

- Easy to spot, since there is an element "by itself" on each side of the equation.

Examples:

$$\overset{0}{Cu}(s) + 2\overset{+1}{Ag}NO_3(aq) \longrightarrow \overset{+2}{Cu}(NO_3)_2(aq) + 2\overset{0}{Ag}(s)$$

$$\overset{0}{Zn}(s) + \overset{+1}{H_2}SO_4(aq) \longrightarrow \overset{+2}{Zn}SO_4(aq) + \overset{0}{H_2}(g)$$