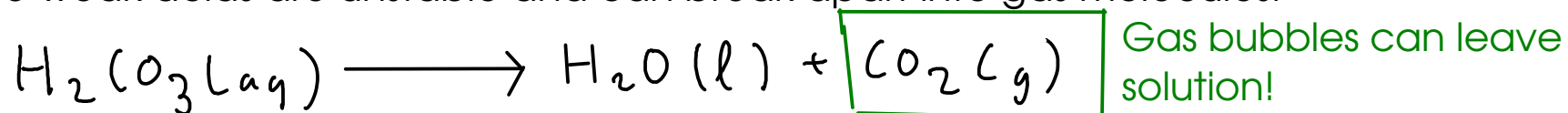


## GAS FORMATION / OTHER MOLECULES

- There are a few other molecules that can be made with exchange-type chemistry.
- Most of these molecules are unstable and can break apart to form gases.

### - Formation of a weak acid:

- The formation of ANY weak acid in an exchange-type reaction can be a driving force.
- Some weak acids are unstable and can break apart into gas molecules.

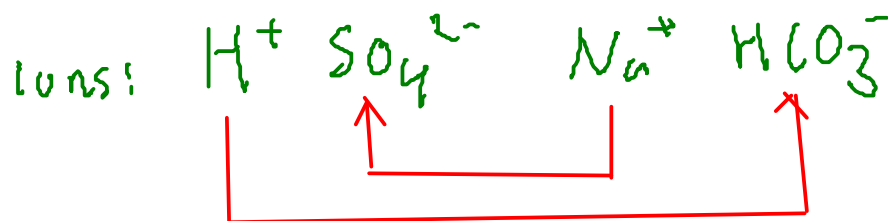
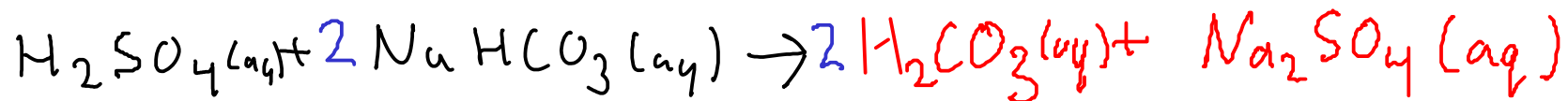


... but how would you form carbonic acid in an exchange-type reaction?

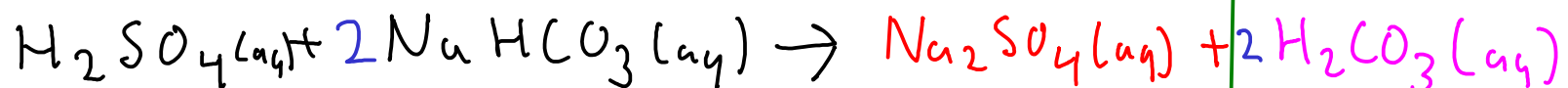
acid + carbonate  $\text{CO}_3^{2-}$

OR

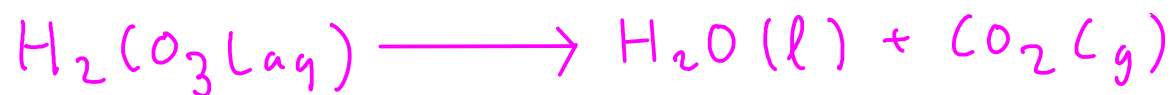
acid + bicarbonate  $\text{HCO}_3^-$



Formation of carbonic acid drives the reaction ... BUT ...

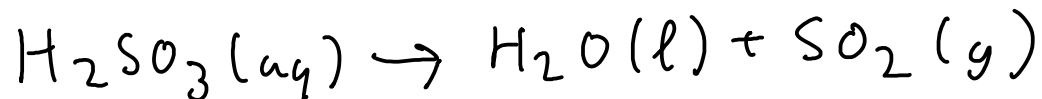


... but when we mix sulfuric acid and sodium bicarbonate, we observe BUBBLES. We need to write an equation that agrees with our observations. We know that carbonic acid decomposes, so we go ahead and put that into our equation.

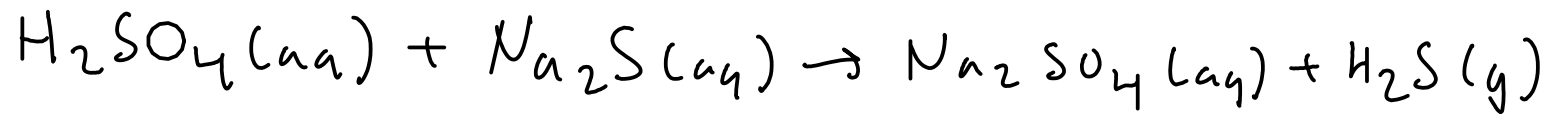


Other molecules of interest:

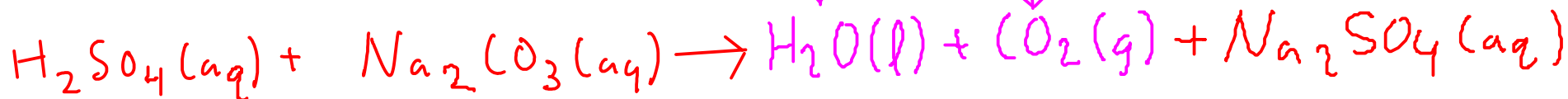
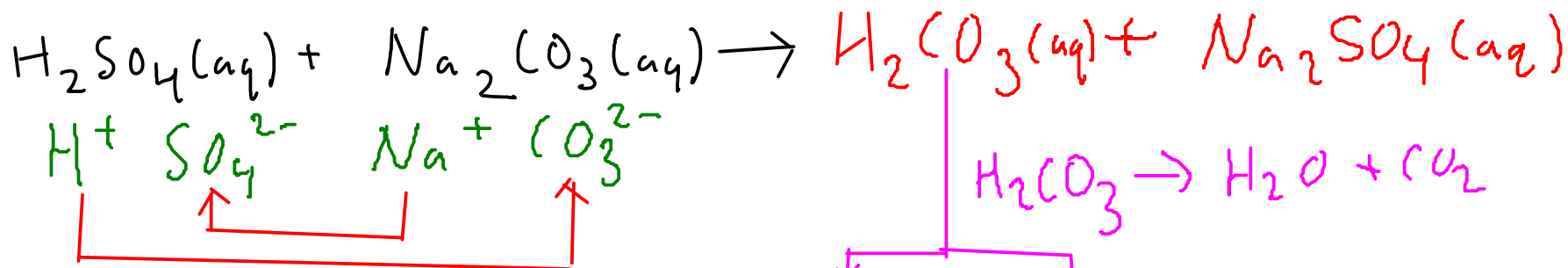
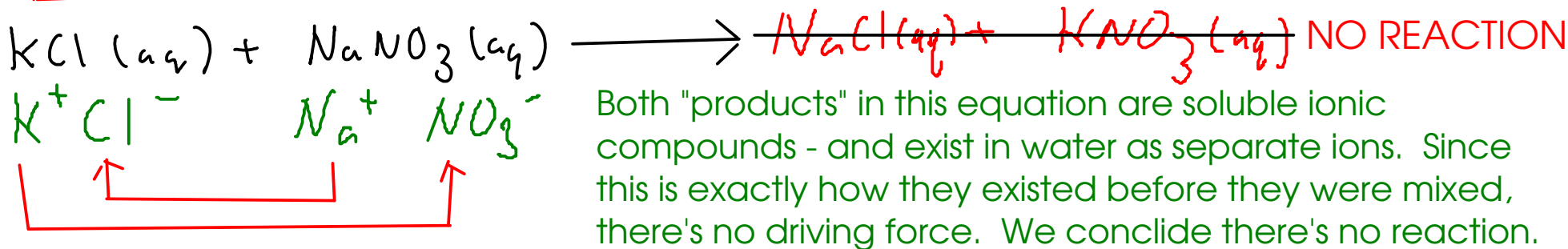
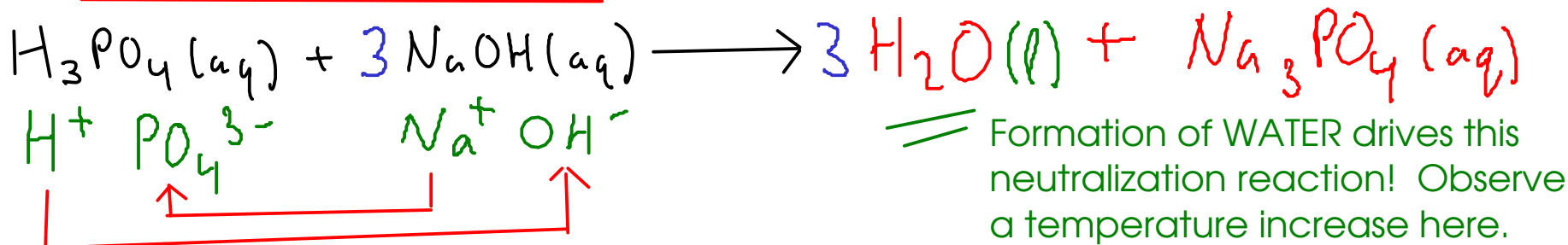
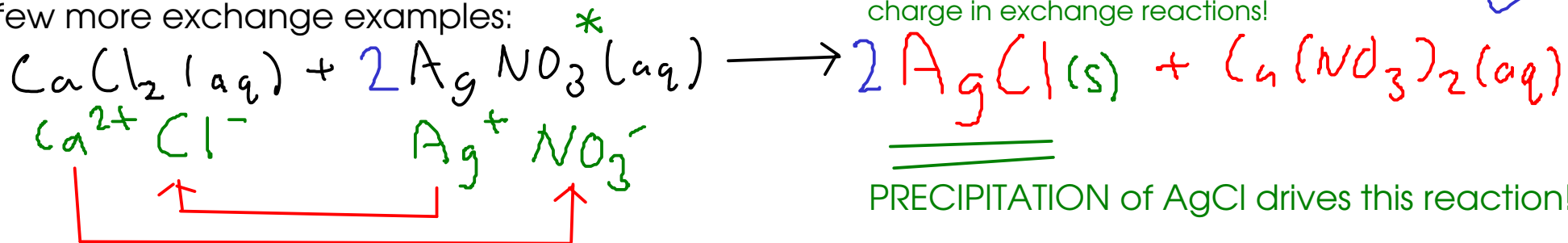
$\text{H}_2\text{SO}_3$  : sulfurous acid - React an ACID with a SULFITE



$\text{H}_2\text{S}$  : hydrogen sulfide (gas) - React an ACID with a SULFIDE



A few more exchange examples:



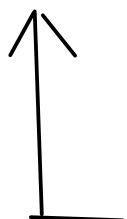
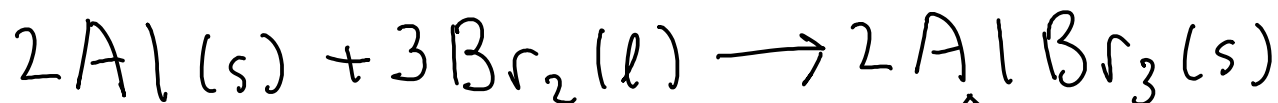
Formation of carbonic acid molecules (and their decomposition) drives this reaction. We will observe gas bubbles as the reaction proceeds. ✓

126 OXIDATION / REDUCTION CHEMISTRY

- Exchange reactions involve ions pairing up, but the ions themselves 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.

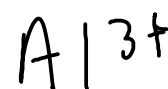
- oxidation / reduction chemistry ("redox" chemistry) involves transfer of electrons and can make ions.



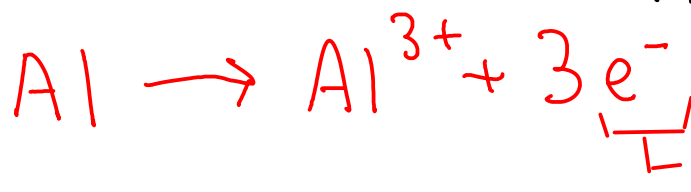
Elemental,  
metallic  
aluminum.  
Uncharged!



Aluminum  
cation



These are called  
"half-reactions"



electron

oxidation: loss  
of electrons



reduction: gain of  
electrons

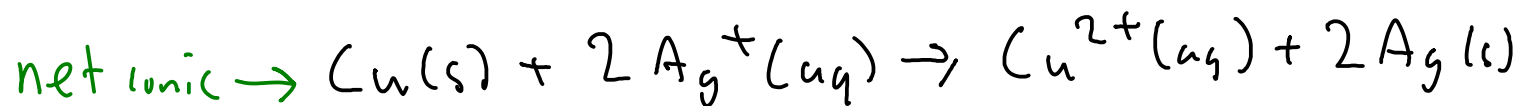
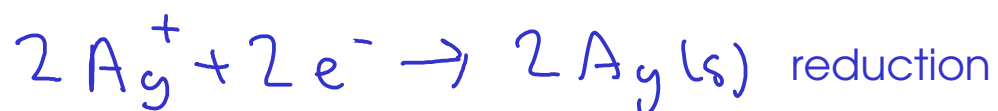
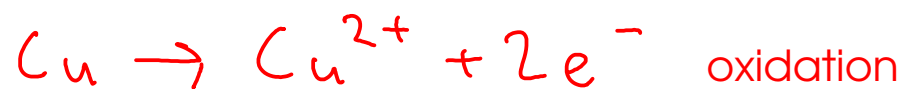
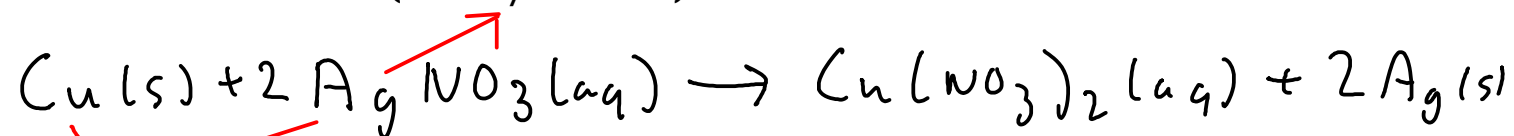
- oxidation and reduction always occur together. In other words, we can't just make free electrons using oxidation without giving them somewhere to go.

- Many of the types of reactions that we learned about in previous courses are redox reactions!

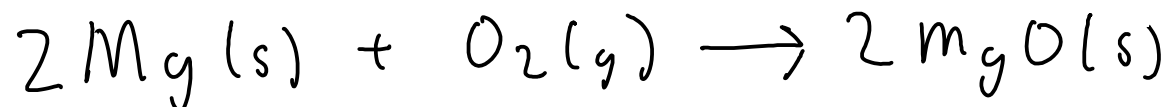
- COMBINATIONS (often but not always redox)

- DECOMPOSITIONS (often redox)

- SINGLE REPLACEMENT (always redox)



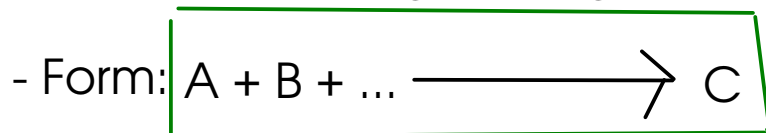
- COMBUSTION



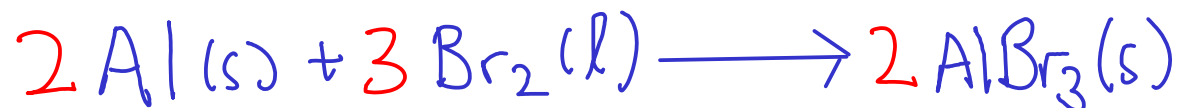
A review of the reaction types we just mentioned:

## ① COMBINATION REACTIONS

- Reactions that involve two or more simple substances COMBINING to form a SINGLE product
- Often involve large energy changes. Sometimes violent!



Example:



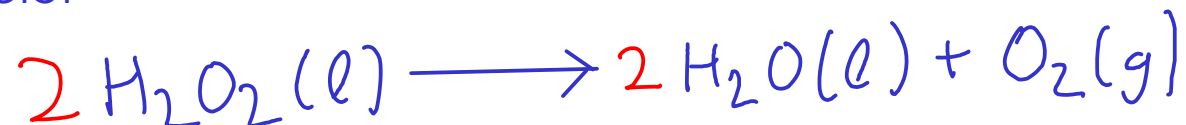
## ② DECOMPOSITION REACTIONS

- Reactions where a SINGLE REACTANT breaks apart into several products

- Form:



Example:

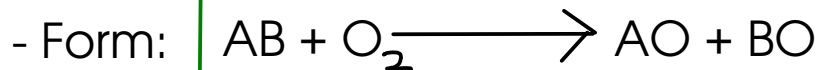


\* This reaction is NOT a combustion reaction, even though  $\text{O}_2$  is involved!

\* Combustion reactions CONSUME  $\text{O}_2$ , while this reaction PRODUCES  $\text{O}_2$

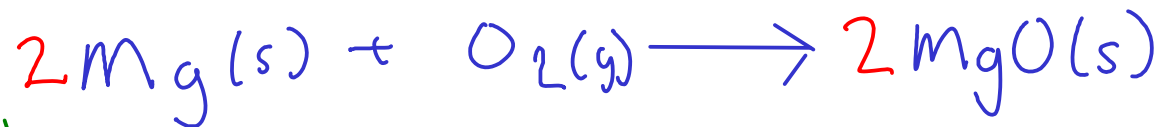
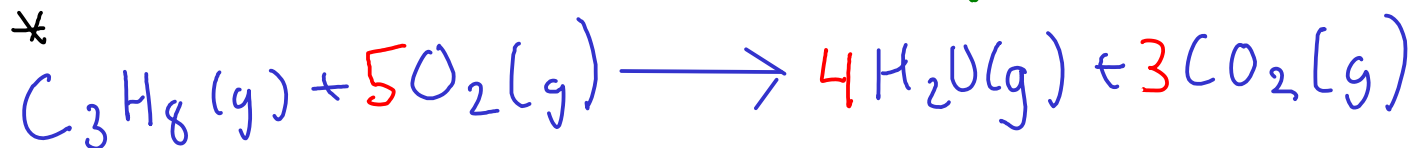
### 3 COMBUSTION REACTIONS

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



Oxide: a compound containing OXYGEN and one other element!

Examples:



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

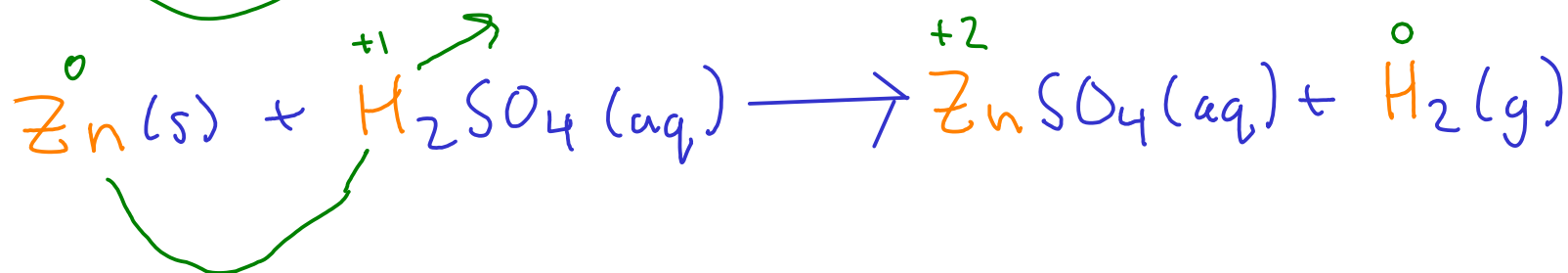
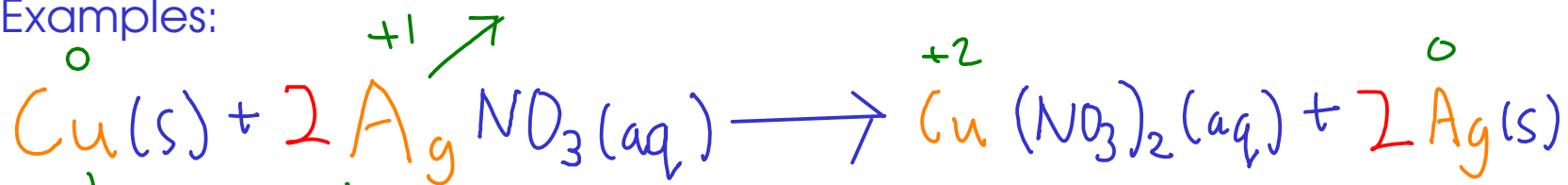
\* Combustion of hydrocarbons makes carbon dioxide and water, if enough oxygen is present. In low-oxygen environments, carbon monoxide is made instead!



## 4 SINGLE REPLACEMENT REACTIONS

- Reactions where one element REPLACES another element in a compound.
- Can be predicted via an ACTIVITY SERIES (p151, 9th edition)
- 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.

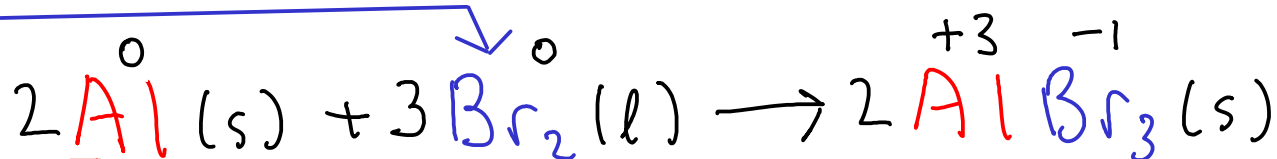
Examples:



REDOX LANGUAGE

"oxidizer"

- "Oxidation" is loss of electrons, but an OXIDIZING AGENT is something that causes ANOTHER substance to lose electrons. An oxidizing agent is itself reduced during a redox reaction.
- "Reduction" is gain of electrons, but a REDUCING AGENT is something that causes ANOTHER substance to gain electrons. Reducing agents are themselves oxidized during a redox reaction.



Aluminum is OXIDIZED during this process. We say that metallic aluminum is a REDUCING AGENT!

Bromine is REDUCED during this process. We say that bromine is an OXIDIZING AGENT!

\* Strong oxidizers (oxidizing agents) can cause spontaneous fires if placed into contact with combustibles (safety issue!).

\* Reactive metals tend to be REDUCING AGENTS, while oxygen-rich ions like NITRATES tend to be OXIDIZING AGENTS. HALOGENS (Group VIIA) also tend to be OXIDIZING AGENTS

END OF CHAPTER 4 MATERIAL