CHEMICAL EQUATIONS

- are the "recipes" in chemistry
- show the substances going into a reaction, substances coming out of the reaction, and give other information about the process

"yields"

$$MgCl_2(aq) + 2AgNO_3(aq) \longrightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

REACTANTS - materials that are needed for a reaction

PRODUCTS - materials that are formed in a reaction

COEFFICIENTS - give the ratio of molecules/atoms of one substance to the others

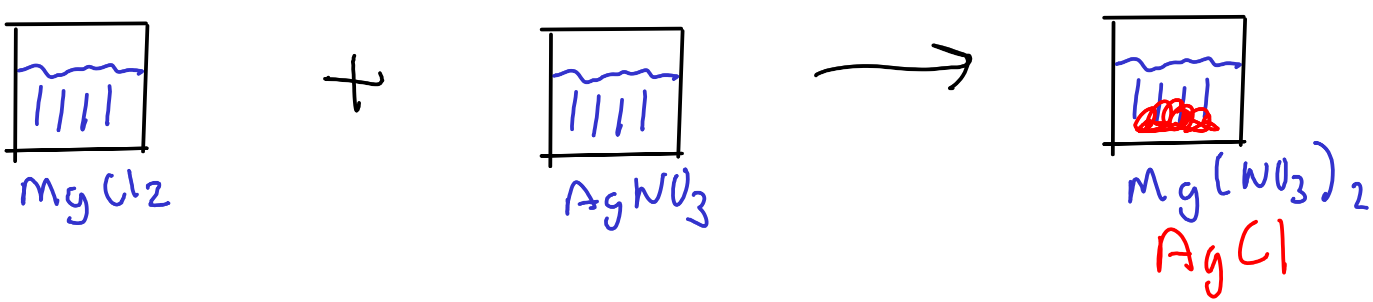
PHASE LABELS - give the physical state of a substance:

(s) -solid

(l) - liquid

(g) - gas

(aq) - aqueous. In other words, dissolved in water



CHEMICAL EQUATIONS

$$2Mg_{(s)} + O_{2(g)} \xrightarrow{\Delta} 2MgO_{(s)}$$

REACTION CONDITIONS - give conditions necessary for chemical reaction to occur. May be:

- Δ apply heat
- catalysts - substances that will help reaction proceed faster
- other conditions, such as required temperatures

- Reaction conditions are usually written above the arrow, but may also be written below if the reaction requires several steps or several different conditions

COEFFICIENTS

- Experimentally, we can usually determine the reactants and products of a reaction

- We can determine the proper ratios of reactants and products WITHOUT further experiments, using a process called BALANCING

- BALANCING a chemical equation is making sure the same number of atoms of each element go into a reaction as come out of it.

- A properly balanced chemical equation has the smallest whole number ratio of reactants and products.

- There are several ways to do this, but we will use a modified trial-and-error procedure.

BALANCING

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

oxygen : ~~7~~ 10 | 6 + 4 = 10

1. Pick an element. Avoid (if possible) elements that appear in more than one substance on each side of the equation.

2. Change the coefficients on substances containing this element so that the same number of atoms of the element are present on each side. CHANGE AS LITTLE AS POSSIBLE!

3. Repeat 1-2 until all elements are done.

4. Go back and quickly VERIFY that you have the same number of atoms of each element on each side, If you used any fractional coefficients, multiply each coefficient by the DENOMINATOR of your fraction.

Use SMALLEST WHOLE NUMBER RATIOS!

BALANCING

$$3MgCl_2 + 2Na_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6NaCl$$ ✓

$$C_2H_2 + 2\tfrac{1}{2}O_2 \rightarrow 2CO_2 + H_2O$$

~~4~~ 5 | 4 + 1 = 5

We need WHOLE NUMBERS. To get rid of the fractional coefficient, we'll multiply ALL coefficients by the denominator of the fraction (2, in this case)...

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$ ✓

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$ ✓

1 - Avoid H, balance S instead. (H shows up in sulfuric acid AND NaOH on the left!)
2 - Avoid O, balance Na. (O shows up in ALL FOUR substances!)
3 - Balance H (should be easier to do than O)
4 - Balance O. (already fixed!)

IDENTIFYING REACTIONS

You may see one or more of these signs when a chemical reaction occurs

(1) - A change in temperature that can't be explained in another way.

(2) - Emission of light that can't be explained in another way

(3) - The formation of a solid - or PRECIPITATION - in a previously liquid solution. (Not a simple phase change!) or gas formation.

(4) - Color change (not simply lightening of color caused by diluting a solution!)

CLASSIFYING REACTIONS

- It's simpler to talk about different reactions if we can classify them into a small number of classes.

- Most of these reaction classes are reactions that involve TRANSFER OF ELECTRONS from one atom to another. The LAST class or reactions we will discuss does NOT involve electron transfer!

(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:

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

CLASSIFYING REACTIONS

(2) DECOMPOSITION REACTIONS

- Reactions where a SINGLE REACTANT breaks apart into several products

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

Example:

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

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

* Combustion reactions CONSUME O_2, while this reaction PRODUCES O_2

CLASSIFYING REACTIONS

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 (more on that later!)
- 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:

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

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

* Single replacement reactions are all examples of ELECTRON TRANSFER or OXIDATION-REDUCTION chemistry!