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

$$C_3H_8 + 5\,O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$$

$\frac{7}{2}$ 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 DENOMIMATOR 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

Problem: We have a coefficient of 2 1/2 for oxygen, because we neede five oxygen atoms on the left. We can't leave this as a fraction, though, because we're supposed to use whole numbers. Solution: Multiply ALL the coefficients by the smallest number that will get rid of the fraction (here, that's 2).

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

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

1 - Avoid H, balance S instead. (H shows up twice on reactant side)
2 - Avoid O, balance Na. (O shows up in all four chemicals!)
3 - Balance H (should be easier than O).
4 - Balance O.

MOLECULAR AND IONIC EQUATIONS

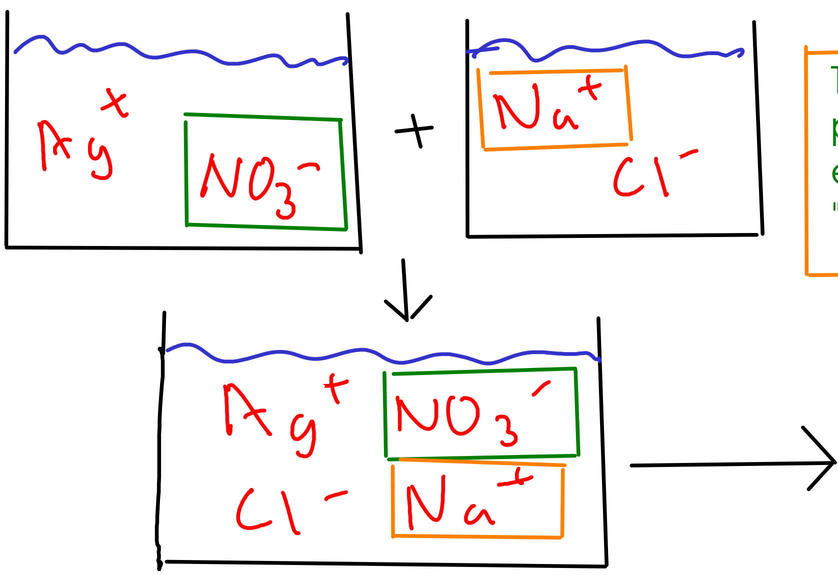
- A MOLECULAR EQUATION shows all compounds, whether or not they contain ions, as complete compounds.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

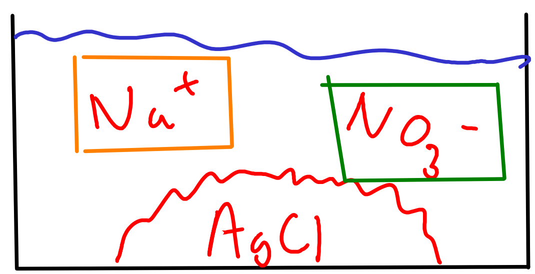
- Since an ionic compound breaks apart when dissolved in water, it's sometimes useful to show these ions separately. An IONIC EQUATION shows ionic compounds as separate ions when they are dissolved in water, better representing the actual species that are reacting.

$$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$$

- The above equation is a COMPLETE IONIC EQUATION. It shows every dissolved ion. But ...



The nitrate and sodium ions do not really participate in this reaction. They start and end in exactly the same state. We call them "SPECTATOR IONS".



MOLECULAR AND IONIC EQUATIONS

- Ions that show up IN THE SAME FORM on the left and right sides of a chemical equation are called SPECTATOR IONS. If we rewrite an ionic equation to leave out the spectator ions, we get a NET IONIC EQUATION.

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

- The net ionic equation is more general than the complete ionic equation. It tells us that ANY source of aqueous silver ions will react with ANY source of aqueous chloride ions to make solid silver chloride.

(In experiment 1A, you're told to dissolve your unlnown sample in distilled water instead of tap water. That's because tap water contains choride ions and will react with silver nitrate in the same way as sodium chloride would!)

TYPES OF REACTIONS

- There are many kinds of chemical reaction. We'll begin with three types:

1. PRECIPITATION REACTIONS

2. ACID-BASE REACTIONS

3. OXIDATION-REDUCTION REACTIONS

- Not every possible mixture of chemicals will react. Most reactions require a DRIVING FORCE, which is usually some stable substance that forms to push a reaction forward.

PRECIPITATION REACTIONS

- Driven by the formation of an insoluble ionic compound.

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

ions: Mg^{2+} Cl^- Na^+ PO_4^{3-}

This precipitation reaction is driven by the formation of solid (INSOLUBLE) magnesium phosphate

(See p181 in OpenStax to see which compounds dissolve in water!)

When you're trying to complete a precipitation reaction:

1. Write the IONS that form when the reactants are dissolved.
2. Make NEW compounds by pairing up cations with anions. Don't forget that the positive and negative charges must balance each other out!
3. Use the solubility rules to determine the PHASE of each new compound - solid or aqueous.
4. Balance the overall equation.

$MgCl_2(aq) + NaC_2H_3O_2(aq) \rightarrow$ NO REACTION!*

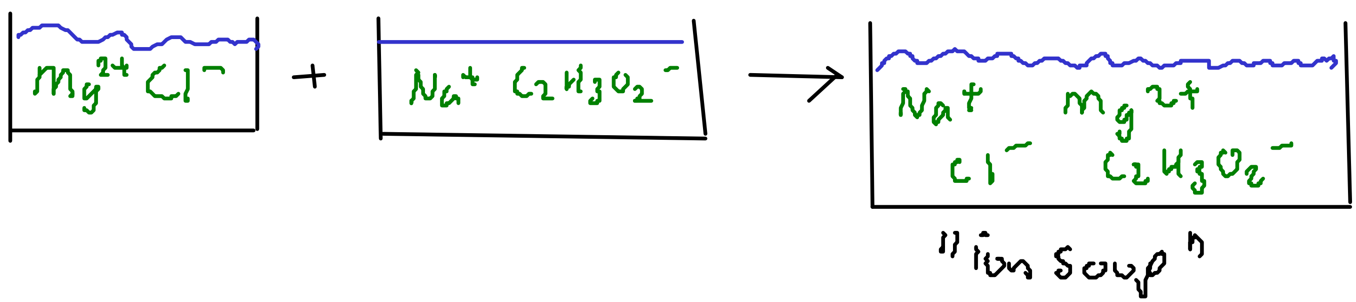
ions: Mg^{2+} Cl^- Na^+ $C_2H_3O_2^-$

"exchange"

$Mg(C_2H_3O_2)_2$ ... dissolves in water

$NaCl$ ... dissolves in water

So, no solid forms here. All possible combinations of these four ions result in compounds that dissolve readily in water.



NO CHANGE, therefore NO DRIVING FORCE, and NO REACTION

* We will learn about other driving forces than the formation of solid, but these driving forces do not apply to this reaction