$$M_1V_1 = M_2V_2$$ ... the "DILUTION EQUATION"

M_1 = molarity of concentrated solution

V_1 = volume of concentrated solution

M_2 = molarity of dilute solution

V_2 = volume of dilute solution (total volume, not volume of added solvent!)

The volumes don't HAVE to be in liters, as long as you use the same volume UNIT for both volumes!

Example: Take the 0.500 M sodium sulfate we discussed in the previous example and dilute it to make 150. mL of 0.333 M solution. How many mL of the original solution will we need to dilute?

$$M_1V_1 = M_2V_2$$

$$(0.500\ M)V_1 = (0.333\ M)(150.\ mL)$$

$$V_1 = 99.9\ mL \text{ of } 0.500\ M \text{ solution}$$

$M_1 = 0.500\ M$

$V_1 = ?$

$M_2 = 0.333\ M$

$V_2 = 150.\ mL$

Measure out 99.9 mL of 0.500 M sodium sulfate, then add water to it (dilute) until the total solution volume is 150. mL. (You can do this in a single large graduated cylinder!)

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 fot a reaction

PRODUCTS - materials that are formed in a reaction

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

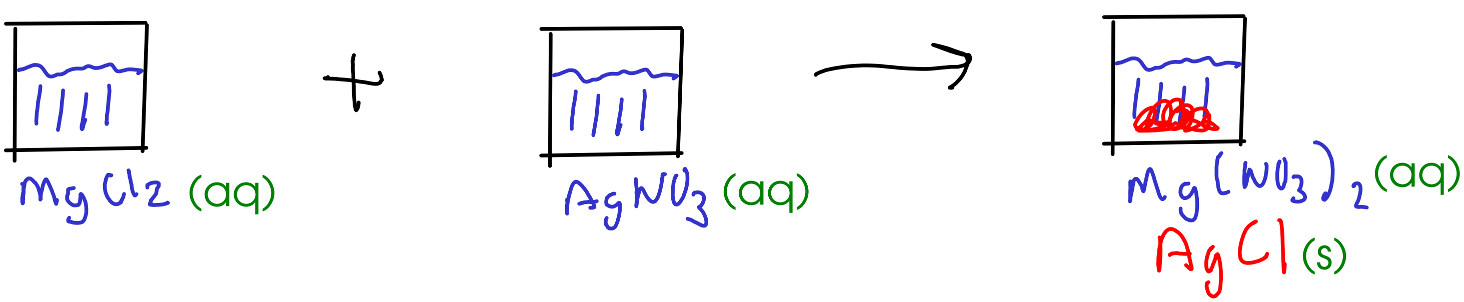
PHASE LABELS - give the physical state of a substance:

(s) -solid

(l) - liquid

(g) - gas

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



CHEMICAL EQUATIONS

$$2\,Mg(s) + O_2(g) \xrightarrow{\Delta} 2\,MgO(s)$$

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

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

$\frac{2}{10}$ | $6 + 4 = 10$

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

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

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

$$\not{4}\ 5 \qquad 4 + 1 = 5$$

We had to use a coefficient of 2 1/2 for oxygen as a reactant to balance the oxygen atoms. We need whole numbers for coefficients, so we need to multiply ALL of the coefficients by the denomnator of the fraction (here, 2). This will give us all whole numbers!

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

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

1 - Avoid H (shows up twice on the left), balance S.
2 - Avoid O, balance Na.
3 - Balance H.
4 - Balance O.

MOLECULAR AND IONIC EQUATIONS

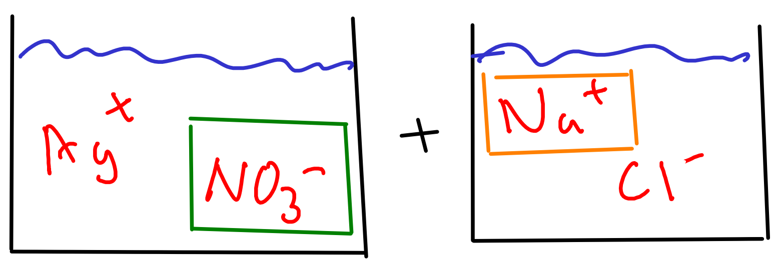
- A MOLECULAR EQUATION shows all compounds, whether or not they contain ions, as complete compounds.

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

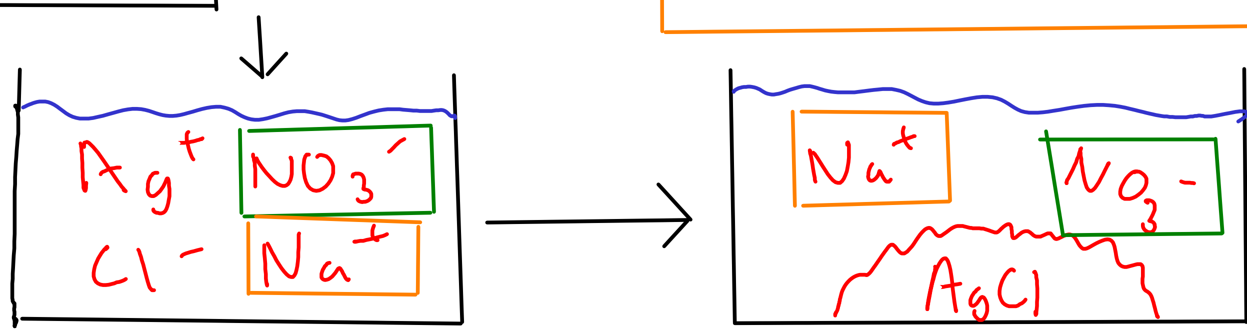
- Since an ionic compound breaks apart when dissolved in water, it's sometimes useful to show these ions separately. An IONIC EQUATION shows ionic compounds as separate ions when they are dissolved in water, better representing the actual species that are reacting.

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

- 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.

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

- 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 unknown 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!)