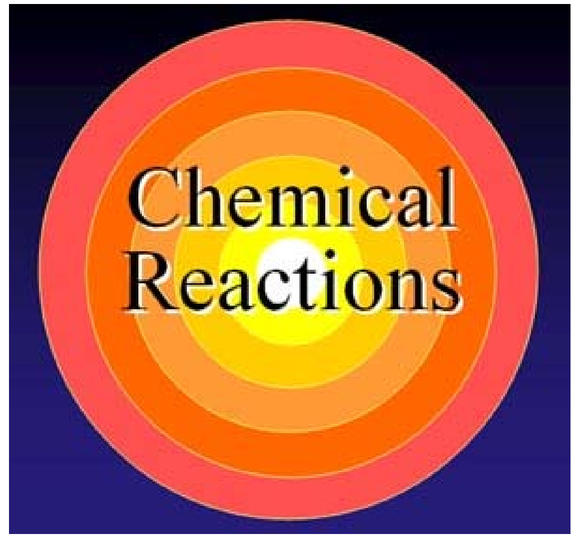
Chemical Reactions Diary



There are 5 basic reactions in this chemistry class (but more are coming later in the year). They are synthesis, decomposition, single replacement, double replacement, and combustion.

You will be expected to recognize them with real chemistry symbols, or with "abstract" letters that stand in for actual chemicals. Examples for each are below. Each reaction has certain characteristics that make it different from the other types of reactions. Memorize these five, along with their example reactions so that you can draw upon this later in the year.

Word equations describe the chemical reaction in words only. The "skeleton" equation is when you introduce the chemical symbols, all written with proper ion to ion - or atom to atom ratios - but the equation is NOT balanced.

Balancing reactions takes practice. It converts the skeleton into proper final form, so that the law of conservation of matter is taken into consideration (the number of atoms or moles in the reactants equals the number of atoms or moles in the products). You can never have an unbalanced equation and be correct.

Balanced equations include PHASE SYMBOLS, indicating what phase of matter (solid, liquid, gas, or aqueous solution) that the substance is in during that part of the reaction. Abbreviations are S, L, G, and AQ, put into subscript parenthesis.

EXAMPLES: $H_2O_{(L)}$ for liquid water, $H_2O_{(S)}$ for ice, or $H_2O_{(G)}$ for steam.

$HCl_{(AQ)}$ for hydrochloric acid - hydrogen chloride dissolved into water as a solution. Water cannot be aqueous by itself.

A reminder: ionic compounds are almost always solids at normal temperatures and pressure. All elements on the periodic table exist as single atoms - except for the HONClBrIF twins, which are diatomic molecules.

Molecular compounds can be gases or solids (you'll have to know what the compound actually is and think, or you have to ask). A few elements are liquids (mercury and bromine). In water ionic compounds will become aqueous solutions, or they won't - you will have to check TABLE F (more on that later).

THE SYNTHESIS REACTION (1/5)

Defined, it is the reaction that puts smaller things together chemically into a larger chemical compound. The demo in class was the reaction of hydrogen combining with the oxygen in the air to form water. This reaction had hydrogen gas in a balloon, and a candle was used to both melt the balloon and to provide enough energy to start the reaction. The hydrogen combined with the oxygen in an explosion of fire and sound, and the water formed was instantly vaporized by the heat. Reactions that give off heat are called EXOTHERMIC. This was an extremely fast synthesis that was also an exothermic reaction.

Word Equation: hydrogen plus oxygen yields water

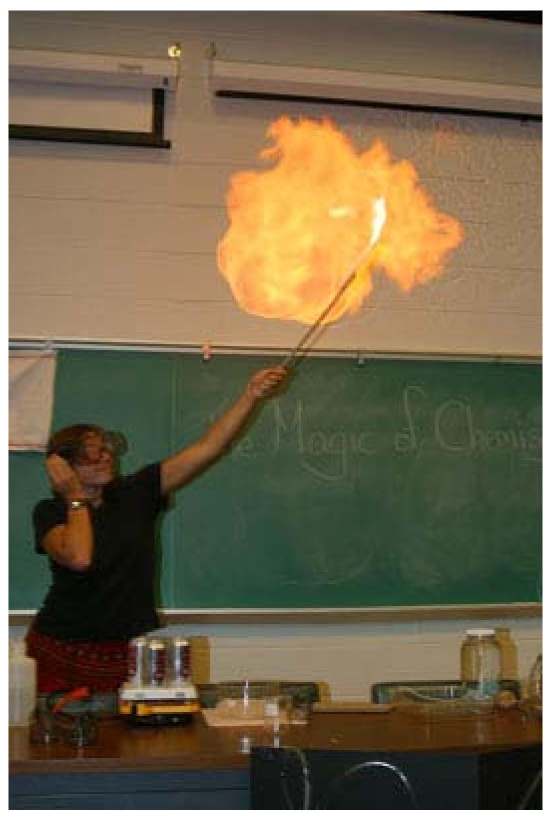
Skeleton Equation: $H_2 + O_2 \text{-->} H_2O$

BALANCED EQUATION: $2H_{2(G)} + O_{2(G)} \text{-->} 2H_2O_{(G)}$

Other synthesis reactions include: iron rusting by combining with oxygen, magnesium oxide forming when magnesium gets hot enough to combine with oxygen in the air, or ammonia forming from hydrogen and nitrogen gases.

Abstractly, this can be represented by: X + Y --> XY

Remember in class to protect your ears, and try not to blink too much or you miss this...



THE DECOMPOSITION REACTION (2/5)

Defined: the reaction that breaks up larger substances into two or more smaller substances. It is the reverse of synthesis. The demo in class was the reaction of hydrogen peroxide breaking down into water and oxygen gas.

This particular reaction was also SO SLOW to watch you could not be sure it was happening. To speed it up the teacher added potassium iodide. That worked as a **catalyst: a substance that speeds up a chemical reaction but does not affect any other part of the reaction.**

This reaction gave off a lot of heat, making it an EXOTHERMIC reaction. Oddly, that same amount of energy would have been given off without the catalyst, just so slowly that the heat would not be noticeable without a very accurate thermometer.

The heat given off is a constant, the catalyst just made it all be given off in a very short period of time. We will learn much more about heats of reactions (ΔH) later in the year.

Word Equation: hydrogen peroxide decomposes into water & oxygen

Skeleton Equation: H_2O_2 --> $H_2O + O_2$

BALANCED EQUATION: $2H_2O_{2(AQ)}$ --> $2H_2O_{(L)} + O_{2(G)}$

The hydrogen peroxide was a 27% solution dissolved into water. PURE hydrogen peroxide could be a LIQUID, but ours was, technically speaking, a solution.

Other decomposition reactions include: ammonia breaking down into hydrogen and nitrogen, copper II carbonate (turquoise powder) breaking down into copper II oxide (black solid) and carbon dioxide (gas).

Abstractly, this can be represented by: AB --> A + B or, XY --> X + Y

THE SINGLE REPLACEMENT REACTION (3/5)

To understand this reaction you need a bit more chemistry background. When most ionic compounds are added to water they can ionize, which means that the cation part and the anion part can separate and these ions literally float around dissolved in the water. They form an aqueous solution.

We will learn more how this happens later in the year. Since these ions are now loose from each other, when a new substance is added into the solution, sometimes this new substance can push one of these ions out of solution and take its place.

This gives the reaction its name: the single replacement reaction. One substance replaces ONE PART of the ionic compound in solution. This only happens with an ionic compound in solution. To further complicate things, depending upon what is in solution and what is added, the reaction can happen or it will not. Lucky for us TABLE J exists, to guide us.

Table J is called the ACTIVITY SERIES. It lists in 2 columns, the activity level or better said: the REACTIVITY LEVEL of a lot of substances. A single replacement reaction has 3 parts, the single substance that gets added into the aqueous solution (which has 2 parts itself). for example:

$$Mg_{(S)} + HCl_{(AQ)} \text{ -->}$$

the 3 parts are the **Mg atom**, the **H cation** and the **Cl anion**.

If we look at Table J, we see that of these 3 parts, 2 of them are only on one side of table J.

(this always happens: 2 of the 3 parts are on one side of the table - in this case on the left).

Locate both Mg and H on the table. Since Mg is HIGHER UP on the table, that means that magnesium has a higher activity level, it would be able to bump out the hydrogen in a single replacement reaction. So,

the skeleton single replacement reaction would be:

$$Mg + HCl \text{ -->} \; MgCl_2 + H_2$$

Metals	Non-Metals
most active	
Li	F_2
Rb	Cl_2
K	Br_2
Cs	I_2
Ba	
Sr	
Ca	
Na	
Mg	
Al	
Ti	
Mn	
Zn	
Cr	
Fe	
Co	
Ni	
Sn	
Pb	
H*	
Cu	
Ag	
Au	
least active	
***H** is a non metal that acts like a metal in SR reactions	

and the balanced chemical reaction would be:

$$Mg_{(S)} + 2HCl_{(AQ)} \text{-->} MgCl_{2(AQ)} + H_{2(G)}$$

Each Mg atom requires 2 molecules of the acid for the reaction to proceed.

NOTE: the table J exists ONLY TO LIST the activity levels. The reaction happens when the new single substance is HIGHER ON THE LIST because it has a higher activity level, not just because it is higher up on some list.

Some single replacement reactions cannot occur, if the added single substance is LOWER on the list, meaning it does not have a high enough activity level.

For example, in class I put my GOLD WEDDING BAND into hydrochloric acid. Since Au is lower than the hydrogen, NO REACTION HAPPENED. The proper form for this is: **$Au_{(S)} + HCl_{(AQ)}$ --> X (no reaction)**

We use Table J to determine whether or not a single replacement reaction will occur as written, or if it will not. We do not need to do every possible reaction since this table will give us the answer.

In few occasions **2 of the 3 parts of the reaction will both be on the RIGHT SIDE OF THE TABLE**. The same "rules" apply, if a single part is higher on the right side of table J it can replace itself into the solution. A "standard" example of this is:

$$Cl_{2(G)} + 2NaBr_{(AQ)} \text{-->} 2NaCl_{(AQ)} + Br_{2(G)}$$

Abstractly, this can be represented by:

A + BC --> AC + B (when 2 of the three are on the LEFT side of Table J)

or,

M + NP --> no reaction

or,

R + ST --> SR + T (when 2 of the 3 are on the RIGHT side of Table J)

THE DOUBLE REPLACEMENT REACTION (4/5)

This reaction is what it sounds to be, a double switch by two different solutions of ionic compounds. The cations and anions are separated from each other in the aqueous solutions as free ions floating around.

When two different solutions of separated ions are combined, often the cations will switch anions in a double switch. This results in two new ionic compounds forming.

In our class we will assume that ANY TIME a double replacement reaction is set up that it will go forward, and we'll use Table F to determine the precipitate evidence of reaction.

Some single replacement reactions are actually NO REACTIONS or "X".
That will not happen in our class with these double replacement reactions.

The original two solutions will be ionized into the water - another way to say that they are dissolve completely. When combined together, and when the cations switch their anions, sometimes the new compounds formed will also be soluble and remain dissolved. Other times these new compounds formed will be insoluble. These insoluble compounds will form precipitates which we will easily be able to see.

The number of potential double replacement reactions is almost endless. Lucky for us that TABLE F exists to help us determine which kinds of ionic compounds will be soluble or insoluble. Using this table can be difficult at first (not unlike tying one's shoes, or learning how to use a swing at the park) but it is remarkably simple once you practice a bit.

An example would be the reaction below:

To use table F use in this reaction: the first compound is aqueous because according to the left side, all halides, which includes chlorides, are soluble except when combined to 3 certain cations of which calcium is not one. Therefore calcium chloride is soluble or an aqueous solution.

The sodium carbonate is also soluble because we find carbonates on the right side where we see they are INSOLUBLE except when combined with GROUP 1 CATIONS which sodium is. It is therefore soluble or an aqueous solution as well.

The word equation is...

calcium chloride + sodium carbonate —-> calcium carbonate + sodium chloride

The balanced chemical reaction is...

$CaCl_{2(AQ)}$ + $Na_2CO_{3(AQ)}$ --> $CaCO_{3(S)}$ --> $2NaCl_{(AQ)}$

The reactants are BOTH aqueous solutions. When the cations switch their anions, the products are **insoluble calcium carbonate**, and **soluble sodium chloride.** The precipitate $CaCO_{3(S)}$ would be EVIDENCE that the reaction happened.

The calcium carbonate is INSOLUBLE because all carbonates are insoluble unless combined to a Group 1 cation or to ammonium ions, which in this case is not happening.

Therefore the $CaCO_3$ is INSOLUBLE or forms a SOLID PRECIPITATE. The sodium chloride is soluble, look at the table to be sure.

If you are careful to look over the table, and READ IT SLOWLY, you can't go wrong with double replacement reactions. Just remember soluble = dissolves into aqueous solution while insoluble = solid or a PRECIPITATE forms.

Abstractly, visualize it this way: AB + XY --> AY + XB
(be sure to trade anions, do not mix up cations/anions with each other)

THE COMBUSTION REACTION (5/5)

This reaction is truly the most basic. **A compound that contains ONLY hydrogen and carbon must combine with oxygen to form ONLY carbon dioxide and water**. It is PRETTY HARD to miss if you memorize that last line. A HYDROCARBON is a compound that has ONLY hydrogen and carbon in it.

Examples include methane (CH_4), octane (C_8H_{18}), and butane (C_4H_{10}). The products must always be carbon dioxide and water. There can be NO OTHER PRODUCTS. This rule makes combustion easy to recognize. Combustion reactions are always rather EXOTHERMIC, they give off lots of heat.

Word Equation: methane plus oxygen yields water and carbon dioxide

Skeleton Equation: $CH_4 + O_2 \text{-->} H_2O + CO_2$

BALANCED EQUATION: $CH_{4(G)} + 2O_{2(G)} \text{-->} 2H_2O_{(G)} + CO_{2(G)}$

Other example reactions include all hydrocarbons combining with oxygen and form water & carbon dioxide, plus lots of heat.

Abstractly, visualize this reaction this way (this X and Y represent a variety of ways that carbon and hydrogen can combine - see three examples above for instance).

$C_xH_y + O_2 \text{-->} H_2O + CO_2$

At right a bunch of friends enjoy a camp fire, an excellent example of a hydrocarbon (the wood) rapidly combining with oxygen in the air, producing carbon dioxide and water (vapor), and excessive exothermic energy is released as light and heat.

These five reactions all are BASIC reactions that will help further our study of matter and how it reacts. There are of course some asterisks out there waiting to surprise us. That is okay and we'll keep an eye out for them. There are several other reactions we will cover later on, such as acid base neutralization reactions, and several nuclear reactions (which do not follow all the same laws, for instance the Law of Conservation of Matter). In nuclear reactions matter is converted into energy ($E=mc^2$). Nuclear reactions are studied in chemistry, but are not part of the conservation of matter, or conservation of energy laws. They are NOT chemical equations by definition, matter and energy are often out of "balance" that a normal chemical reaction or physical change must keep.