1 Reactions

1.1 Balancing Equations

When chemical reactions occur:

- Bonds are broken and new bonds form.
- Energy is produced or absorbed.
- New compounds are formed, or compounds decompose to their elements.
- The Law of Conservation of Mass is obeyed.

Symbols in Equations:

- yield $\rightarrow$
- Sometimes a reaction occurs then stops
- reversible reaction $\leftrightarrow$
- Sometimes the reaction goes back and forth between product and reactant.
- solid or precipitate (s)
- gas (g)
- liquid (l)
- water solution (aq)
- heat Δ

A catalyst is a chemical that speeds up a reaction, but is not actually used up.

Exercise - Put the reaction $Ca(OH)_2$ (s) $\rightarrow$ CaO (s) + H_2O (l) in words. (solid calcium hydroxide yields solid calcium oxide and liquid water)

Balancing Chemical Equations is necessary so that the correct amount of reactants can be determined and the amounts of the products can be predicted.

It also satisfies the law of conservation of mass.

How to balance a chemical reaction:

- Write the equation with the correct formulas and symbols.
- Add coefficients to the formulas to make the number of atoms of each element on both sides of the equation the same. A coefficient is a whole number before a chemical formula.
- You may not add coefficients to the middle of a formula.
- You may not change the subscript of a correctly written formula.

Exercise - Balance FeS + HCl $\rightarrow$ $FeCl_2$ + H_2S (2 in front of HCl)

Exercise - Balance $Zn(OH)_2$ + H_3PO_4 $\rightarrow$ $Zn_3(PO_4)_2$ + H_2O (3 in front of $Zn(OH)_2$, 2 in front of H_3PO_4, 6 in front of H_2O)

Exercise - Write the balanced equation for lithium chlorate decomposing into lithium chloride and oxygen gas. ($2LiClO_3 \rightarrow 2LiCl + 3O_2$)

1.2 Synthesis & Decomposition

Synthesis Reactions - more than one reactant and only one product.

Decomposition Reactions - one reactant and more than one product.

Synthesis Rules

- Reaction between 2 nonmetals produces a common covalent compound.
- Reaction of a metal and a nonmetal produces an ionic compound.
- Reaction of a metal oxide and water produces a metal hydroxide.
- Reaction of a metal oxide with carbon dioxide produces a metal carbonate.
- Reaction of a metal chloride with oxygen produces a metal chlorate.
- Reaction of a nonmetal oxide with water produces an acid in solution.

Exercise - Carbon burns ($C + O_2 \rightarrow CO_2$)

Decomposition Rules

- Decomposition of a binary compound produces two elements.
- Decomposition of a metal carbonate produces a metal oxide and CO_2
- Decomposition of a metal hydroxide produces a metal oxide and water
- Decomposition of a metal chlorate produces a metal chloride and oxygen
- Decomposition of an oxyacid produces a nonmetal oxide and water. The oxidation number of the nonmetal remains the same.

Exercise - Sodium carbonate decomposes when heated ($Na_2CO_3 \rightarrow Na_2O + CO_2$)

Exercise - Calcium chlorate decomposes when heated ($Ca(ClO_3)_2 \rightarrow CaCl_2 + 3O_2$)

1.3 Single Replacement, Double Replacement, & Combustion

Single replacement is when an element replaces another element in a compound.

An element will replace another element in a compound if the lone element is more reactive than the element in the compound.

Single Replacement Rules

- Replacement of a metal by a more reactive metal.
- Replacement of hydrogen in water by a group 1 metal produces a metal hydroxide and H_2
- Replacement of hydrogen in water by a group 2 metal produces a metal oxide and H_2
- Replacement of hydrogen in an acid by a metal more active than H. Metal replaces hydrogen as if it were a metal.
- Replacement of a nonmetal (usually a halogen) in a compound by a more reactive nonmetal.

Exercise - Fluorine + Potassium Bromide ($F_2 + 2KBr \rightarrow 2KF + Br_2$)

Exercise - Copper + Sulfuric Acid ($Cu + H_2SO_4 \rightarrow$ No rxn)

Double replacement reactions occur when elements in two compounds exchange places to make two new compounds.

These reactions occur between ions in aqueous solutions and produce at least one of the following - a precipitate, a gas, or water

If a product is insoluble, it is a precipitate.

Note that hydrogen sulfide is a gas.

H_2CO_3 decomposes to carbon dioxide and water and H_2SO_3 decomposes to sulfur dioxide and water.

Ammonium hydroxide decomposes to form ammonia gas (NH_3) and water.

Exercise - sodium bicarbonate + hydrochloric acid ($NaHCO_3 + HCl \rightarrow NaCl$ (aq) + CO_2 (g) + H_2O (l))

The burning of a hydrocarbon in O_2 to produce heat is combustion.

When hydrocarbons burn in excess oxygen, the products are always carbon dioxide and water.

If there is too little oxygen, carbon monoxide is produced. Carbon monoxide is highly toxic!

1.4 Reaction Rates

Reversible reactions - some reactions continue until the products being to react and form the reactants again.

Equilibrium - the point in a reaction when the rate of the forward reaction is equal to the rate of the reverse reaction.

Reaction rate is how fast a chemical reaction will occur.

Molecular collisions are necessary for two substances to react. Many factors affect how often molecules collide, and therefore affect the reation rate.

There are several factors that affect the speed of a reaction:

- Temperature of reactants
- Concentration of reactants
- Presence of a catalyst or an inhibitor
- Surface area of reactants

Raising the temperature of a substance causes its molecules to move faster. Faster molecules will collide more often, increasing the speed of the reaction. Therefore, higher temperature results in a faster reaction.

Increasing the concentration results in more reactants in a given space, so you will have more collisions per unit time.

A catalyst is a substance that helps molecules come together. It is not used up in a reaction, it just speeds the reaction.

An inhibitor prevents molecules from reacting with each other, thus slowing the reaction rate.

Reactions depend on collisions. The more surface area on which collisions can occur, the faster the reaction.

Some reactions would never happen unless energy is added to the system.

1.5 Redox Reactions

Redox reactions are reactions in which elements' oxidation numbers (charges) change due to moving electrons.

Redox stands for reduction-oxidation reactions. Electrons move from one atom to another or from one ion to another. This means the oxidation numbers of elements change from the reactant to the product side of an equation.

Many types of reactions classify as redox. This isn't a totally separate type of reaction.

Oxidation is loss of electrons and reduction is gain of electrons.

Loss of electrons means the charge goes up and gain of electrons means that the charge goes down.

The element that is oxidized comes from the reactant that is the reducing agent, and the element that is reduced comes from the reactant that is the oxidizing agent.

Exercise - What is being oxidized, reduced, and the reducing agent, and the oxidizing agent in $2Na + Cl_2 \rightarrow 2NaCl$ (oxidized: Na, reduced: Cl, reducing agent: Na, oxidizing agent: Cl_2)

1.6 Net Ionic Equations

A net ionic equation does not show the ions that don't change (i.e do not include the ions that stay aqueous)

Steps for Writing Net Ionic Equations:

1. Write the balanced equation with all states labeled.
2. Split any aqueous ionic or strong acids into ions.
3. Cancel out any ions that appear on both sides of the arrow.

Note that the diatomic elements in aqueous form are no longer diatomic.

Exercise - Write the net ionic equation for a solution of lead(II) nitrate is added to hydrochloric acid. (Pb^{2+}(aq)+$2Cl^{-}$(aq)$\rightarrow$$PbCl_2$(s))