TYPES OF CHEMICAL REACTIONS

To react or not to react? THAT is the question!
Chemical Reactions

Chemical changes are a result of chemical reactions.

All chemical reactions involve a change in substances and a change in energy.

Neither matter or energy is created or destroyed in a chemical reaction---only changed.
Types of Reactions

- There are millions of reactions.
- They fall into 5 general categories.
  - Synthesis
  - Decomposition
  - Single Displacement
  - Double Displacement
  - Combustion
- Given the reactants, we can often predict the products.
#1 Synthesis Reactions

- Synthesis = combine = put together
- Two or more simple substances combine to form a more complex substance.
- The reaction through the equation:
  \[ \text{reactant} + \text{reactant} \rightarrow \text{product} \]
  \[ A + B \rightarrow AB \]
- \[ \text{Ca} + \text{O}_2 \rightarrow \text{CaO} \]
- \[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \]
#1 Synthesis Reactions

- For example, simple hydrogen gas combined with simple oxygen gas can produce a more complex substance—water!

- The chemical equation for this synthesis reaction is:

$$2H_2 + O_2 \rightarrow 2H_2O$$
In the cartoon, the skinny bird (reactant) and the worm (reactant) combine to make one product, a fat bird.
#1 Synthesis Reactions

- metal + oxygen $\rightarrow$ metal oxide
  $$4\text{Fe}_\text{(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Fe}_2\text{O}_3\text{(s)}$$

- nonmetal + oxygen $\rightarrow$ nonmetal oxide
  $$\text{S}_\text{(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_2\text{(g)}$$

- metal oxide + water $\rightarrow$ metallic hydroxide
  $$\text{MgO}_\text{(s)} + \text{H}_2\text{O}_\text{(l)} \rightarrow 2\text{Mg(OH)}_2\text{(s)}$$
#1 Synthesis Reactions

- nonmetallic oxide + water $\rightarrow$ acid
  \[ \text{SO}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(aq) \]

- metal + nonmetal $\rightarrow$ salt
  \[ 2\text{Na}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s) \]
#1 Synthesis Reactions

Rusting of Iron
#2 Decomposition Reactions

- In a decomposition reaction a more complex substance breaks down into its more simple parts.

- One reactant yields 2 or more products. Basically, synthesis and decomposition reactions are opposites.

  reactant $\longrightarrow$ product + product

  $AB \longrightarrow A + B$
#2 Decomposition Reactions

- For example, water can be broken down into hydrogen gas and oxygen gas.

- The chemical equation for this decomposition reaction looks like:

\[
2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2
\]
#2 Decomposition Reactions

Explosions
The explosion of a dynamite is an example of a decomposition reaction.

- When suitably activated, a highly exothermic reaction occurs in which large amounts of gaseous products form.

Nitroglycerin, which can be activated merely by shaking, decomposes as follows:

$$4C_3H_5(NO_3)_3(l) \rightarrow 6N_2(g) + 12CO_2(g) + 10H_2O(g) + O_2(g)$$

#2 Decomposition Reactions
The egg (the reactant), which contained the turtle at one time, now has opened and the turtle (product) and egg shell (product) are now two separate substances.
Metallic carbonates, when heated, form metallic oxides and \( \text{CO}_2 \) gas.

\[
\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g).
\]

Most metallic hydroxides, when heated, decompose into metal oxides and water.

\[
\text{Ca(OH)}_2(s) \rightarrow \text{CaO}(s) + \text{H}_2\text{O}(g).
\]

#2 Decomposition Reactions
#2 Decomposition Reactions

- Some oxides, when heated, decompose.
  \[ 2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g) \]

- Some acids, when heated, decompose into nonmetallic oxides and water.
  \[ \text{H}_2\text{SO}_4(s) \rightarrow \text{H}_2\text{O}(l) + \text{SO}_3(g) \]
#3 Single Displacement

- In a single displacement reaction a single uncombined element replaces another in a compound.
  - Reactants must be an element and a compound.
  - Products will be a different element and a different compound.

- Two reactants yield two products.

  reactant + reactant --------> product + product

  \[ AB + C --------> AC + B \]

- \( \text{Na} + \text{KCl} \rightarrow \text{K} + \text{NaCl} \)
- \( \text{F}_2 + \text{LiCl} \rightarrow \text{LiF} + \text{Cl}_2 \)
#3 Single Displacement

- For example when zinc combines with hydrochloric acid, the zinc replaces hydrogen.

- The chemical equation for this single replacement reaction looks like:

  \[ \text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 \]
#3 Single Replacement

- Metals replace metals (and hydrogen)
  - K + AlN →
  - Zn + HCl →

- Think of water as HOH

- Metals replace one of the H’s, combine with hydroxide.
  - Na + HOH →
Notice, the guy in the orange shirt steals the date of the other guy.

So, a part of one of the reactants trades places and is in a different place among the products.
Replacement of a metal in a compound by a more active metal.

$$\text{Fe} (s) \rightarrow \text{CuSO}_4 (aq) + \text{FeSO}_4 (aq) + \text{Cu} (s)$$

Replacement of hydrogen in water by an active metal.

$$\text{Mg} (s) + \text{H}_2\text{O} (aq) \rightarrow \text{MgO}_4 (aq) + \text{H}_2 (g)$$
#3 Single Displacement

- Replacement of hydrogen in acids by active metals.
  \[ \text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)} \]

- Replacement of nonmetal by a more active nonmetal.
  \[ \text{Cl}_2\text{(g)} + 2\text{NaBr(aq)} \rightarrow 2\text{NaCl(aq)} + \text{Br}_2\text{(g)} \]
#4 Double Displacement

- In a double displacement reaction parts of two compounds switch places to form two new compounds.

- Two reactants yield two products.
  
  reactant + reactant \rightarrow \text{product + product}
  
  AB + CD \rightarrow AC + BD

- \text{NaOH} + \text{FeCl}_3 \rightarrow (\text{the positive ions change places})
- \text{NaOH} + \text{FeCl}_3 \rightarrow \text{Fe}^{3+} (\text{OH})^- + \text{Na}^{+1}\text{Cl}^{-1}
- \text{NaOH} + \text{FeCl}_3 \rightarrow \text{Fe(OH)}_3 + \text{NaCl}
#4 Double Displacement

- For example when silver nitrate combines with sodium chloride, two new compounds—silver chloride and sodium nitrate are formed because the sodium and silver switched places.

- The chemical equation for this double replacement reaction looks like:

  \[ \text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3 \]
Why do you take a tablet when you have an upset stomach?

Calcium carbonate reacts with the hydrochloric acid in your stomach. This is shown in this equation:

\[ \text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{CO}_3 \]
#4 Double Displacement

- Predict the products (assume all of the reactions take place):
  - $\text{CaCl}_2 + \text{NaOH} \rightarrow$
  - $\text{CuCl}_2 + \text{K}_2\text{S} \rightarrow$
  - $\text{KOH} + \text{Fe(NO}_3\text{)}_3 \rightarrow$
  - $(\text{NH}_4\text{)}_2\text{SO}_4 + \text{BaF}_2 \rightarrow$
#4 Double Displacement
#5 Combustion

- **Burning of hydrocarbons**
  - **Hydrocarbon** - A compound composed primarily of C & H (and sometimes O) is reacted with oxygen

- The products for complete combustion will always be CO₂ and H₂O.

- **Examples:**
  - \( C_4H_{10} + O_2 \rightarrow \)
  - \( C_6H_{12}O_6 + O_2 \rightarrow \)
How to recognize which type

- Look at the reactants
  - E = Element
  - C = Compound

- E + E = Combination
- C = Decomposition
- E + C = Single replacement
- C + C = Double replacement
- $C_{\text{N}}H_{\text{N}} + O_2 = \text{Combustion}$
Examples

- $\text{H}_2 + \text{O}_2 \rightarrow$ \textit{Synthesis}
- $\text{H}_2\text{O} \rightarrow$ \textit{Decomposition}
- $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow$ \textit{Single Displacement}
- $\text{HgO} \rightarrow$ \textit{Decomposition}
- $\text{KBr} + \text{Cl}_2 \rightarrow$ \textit{Single Displacement}
- $\text{AgNO}_3 + \text{NaCl} \rightarrow$ \textit{Double Displacement}
- $\text{C}_2\text{H}_6 + \text{O}_2 \rightarrow$ \textit{Combustion}
- $\text{Mg(OH)}_2 + \text{H}_2\text{SO}_3 \rightarrow$ \textit{Double Displacement}