# CHEMICAL EQUATIONS

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

REACTION CONDITIONS - give conditions necessary for chemical reaction to occur. May be:

- $\Delta$ 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

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

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 DENOMINATOR of your fraction.

Use SMALLEST WHOLE NUMBER RATIOS!

# BALANCING

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

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

2 | 4 + 1 = 5

We used a coefficient of 2 1/2 to balance the oxygen atoms, but we can't leave it that way - we want WHOLE NUMBERS. Since the coefficients are part of a RATIO, we can multiply ALL the coefficients by the denominator of our fraction (2, in this case) to get rid of our fractional coefficient!

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$ ✓

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$ ✓

1 - Avoid H (shows up twice on the reactant side), and balance S instead.
2 - Avoid O (shows up in EVERY compound on both sides), and balance Na instead
3 - Balance H, since it should be easier than O (shows up in fewer places)
4 - Now balance O ... (it's already done!)

# IDENTIFYING REACTIONS

You may see one or more of these signs when a chemical reaction occurs

1. - A change in temperature that can't be explained in another way.
2. - Emission of light that can't be explained in another way
3. - The formation of a solid - or PRECIPITATION - in a previously liquid solution. (Not a simple phase change!) or gas formation.
4. - Color change (not simply lightening of color caused by diluting a solution!)

# CLASSIFYING REACTIONS

- It's simpler to talk about different reactions if we can classify them into a small number of classes.

- Most of these reaction classes are reactions that involve TRANSFER OF ELECTRONS from one atom to another. The LAST class or reactions we will discuss does NOT involve electron transfer!

## (1) COMBINATION REACTIONS

- Reactions that involve two or more simple substances COMBINING to form a SINGLE product

- Often involve large energy changes. Sometimes violent!

- Form: $A + B + \ldots \longrightarrow C$

Example:

$$2\,Al(s) + 3\,Br_2(l) \longrightarrow 2\,AlBr_3(s)$$

## (2) DECOMPOSITION REACTIONS

- Reactions where a SINGLE REACTANT breaks apart into several products

- Form: $A \longrightarrow B + C + \ldots$

Example:

$$2\,H_2O_2(l) \longrightarrow 2\,H_2O(l) + O_2(g)$$

* This reaction is NOT a combustion reaction, even though $O_2$ is involved!

* Combustion reactions CONSUME $O_2$, while this reaction PRODUCES $O_2$

# CLASSIFYING REACTIONS

## 3 COMBUSTION REACTIONS

- Reactions of substances with MOLECULAR OXYGEN ($O_2$) to form OXIDES.
- Combustion forms an OXIDE of EACH ELEMENT in the burned substance!

- Form: $AB + O_2 \longrightarrow AO + BO$

Oxide: a compound containing OXYGEN and one other element!

* Combustion of hydrocarbons makes carbon dioxide and water, if enough oxygen is present. In low-oxygen environments, carbon monoxide is made instead!

Examples:

Oxides!

* $C_3H_8(g) + 5O_2(g) \longrightarrow 4H_2O(g) + 3CO_2(g)$

$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

This reaction can also be called a combination! Two reactants form a single product.

# CLASSIFYING REACTIONS

## (4) SINGLE REPLACEMENT REACTIONS

- Reactions where one element REPLACES another element in a compound.
- Can be predicted via an ACTIVITY SERIES (more on that later!)
- Form: $A + BC \longrightarrow AC + B$

"A" and "B" are elements., often metals.

- Easy to spot, since there is an element "by itself" on each side of the equation.

Examples:

$$\overset{0}{Cu}(s) + 2\overset{+1}{Ag}NO_3(aq) \longrightarrow \overset{+2}{Cu}(NO_3)_2(aq) + 2\overset{0}{Ag}(s)$$

$$\overset{0}{Zn}(s) + \overset{+1}{H_2}SO_4(aq) \longrightarrow \overset{+2}{Zn}SO_4(aq) + \overset{0}{H_2}(g)$$

* Single replacement reactions are all examples of ELECTRON TRANSFER or OXIDATION-REDUCTION chemistry!

# CLASSIFYING REACTIONS

## (5) DOUBLE REPLACEMENT REACTIONS

- Also called "exchange" reactions

- The ions in two ionic compounds (one compound may also be an acid) EXCHANGE PARTNERS, forming two new compounds.

- Form: $AB + CD \longrightarrow AD + CB$

"A" and "C" are CATIONS
"B" and "D" are ANIONS

- Can be predicted based on the characteristics of the potential products (More on that later!)

- Occur in AQUEOUS SOLUTION

- Do not involve electron transfer.

Examples:

Precipitation!

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

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