CHEMICAL REACTIONS

Reactants: $Zn + I_2$ ⟶ Product: ZnI_2

Indicators of chemical reactions

- Emission of light or heat

- Production of a gas

- Formation of a precipitate

- Color change

- Emission of odor

PARTS OF A CHEMICAL EQUATION

Chemical equations show the conversion of *reactants* (the molecules shown on the left of the arrow) into *products* (the molecules shown on the right of the arrow).

- A "+" sign separates molecules on the same side
- The arrow is read as "yields"
- States of matter for each species in the reaction are usually written in parentheses after the symbols/formulas
  - solid (s)
  - liquid (l)
  - gas (g)
  - aqueous (aq)

Other Common Symbols Used in Chemical Reactions

Reactants and Products		Reaction Conditions	
Symbol	*Meaning*	*Symbol*	*Meaning*
(*s*) or (*cr*)	solid or crystal	$\longrightarrow$	"produces" or "yields," indicating result of reaction
(*l*)	liquid	$\rightleftharpoons$	reaction in which products can re-form into reactants; final result is a mixture of products and reactants
(*g*)	gas	$\xrightarrow{\Delta}$ or $\xrightarrow{\text{heat}}$	reactants are heated
(*aq*)	in aqueous solution (dissolved in water)	$\xrightarrow{1.0 \times 10^5\ \text{kPa}}$	pressure at which reaction is carried out
$\downarrow$	solid precipitate product forms	$\xrightarrow{0^\circ\text{C}}$	temperature at which reaction is carried out
$\uparrow$	gaseous product forms	$\xrightarrow{\text{Pd}}$	chemical formula of a catalyst added to speed up a reaction
		$\xrightarrow{e^-}$	electrolysis

Chemical Equations

- Because of the principle of the conservation of mass, an *equation must be balanced.*
- It must have the same number of atoms of each element on both sides of the equation.
- When balancing a chemical reaction you may add coefficients in front of the compounds to balance the reaction, but you may not change the subscripts.
- Changing the subscripts changes the compound.

There are four basic steps to balancing a chemical equation.

1. Write the correct formula for the reactants and the products. *DO NOT TRY TO BALANCE IT YET!* You must write the correct formulas first. And most importantly, once you write them correctly *DO NOT CHANGE THE FORMULAS!*
2. Find the number of atoms for each element on the left side. Compare those against the number of the atoms of the same element on the right side.
3. Determine where to place coefficients in front of formulas so that the left side has the same number of atoms as the right side for EACH element in order to balance the equation.
4. Check your answer to see if:
   - The numbers of atoms on both sides of the equation are now balanced.
   - The coefficients are in the lowest possible whole number ratios. (reduced)

Some Helpful Hints

- Take one element at a time, working left to right except for H and O. Save H_2 for next to last, and O_2 until last.
- IF everything balances except for O_2, and there is no way to balance O_2 with a whole number, double all the coefficients and try again. (Because O_2 is diatomic as an element)
- (Shortcut) Polyatomic ions that *appear on both sides of the equation* should be balanced as combined units

Classification of Chemical reactions

1. Synthesis reactions

   occur when two substances (generally **elements**) combine and form a compound

   reactant + reactant → 1 product

   Basically: A + B → AB
   - Example 1: $2H_2 + O_2 \rightarrow 2H_2O$
   - Example 2: $C + O_2 \rightarrow CO_2$

2. Decomposition Reactions

   occur when a compound breaks up into the elements or in a few to simpler compounds

   1 Reactant → Product + Product

   In general: AB → A + B
   - Example 1: $2\,H_2O \rightarrow 2H_2 + O_2$
   - Example 2: $2\,HgO \rightarrow 2Hg + O_2$

Decomposition Exceptions

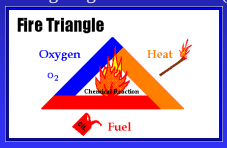
Carbonates, chlorates, and hydroxides are special case decomposition reactions that do not go to the elements.

- Metal Carbonates (CO_3^{2-}) decompose to carbon dioxide and a metal oxide
  - Example: $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$
- Metal Chlorates (ClO_3^-) decompose to oxygen gas and a metal chloride
  - Example: $2KClO_3(s) \xrightarrow[MnO_2(s)]{\Delta} 2KCl(s) + 3O_2(g)$
- Metal Hydroxides (OH^-) decompose to a metal oxide and water
  - Example: $Ca(OH)_2(s) \xrightarrow{\Delta} CaO(s) + H_2O(g)$

Classification of Chemical reactions (continued)

3. Combustion Reactions

- occur when a hydrocarbon reacts with oxygen gas
- This is also called burning!!! In order to burn something you need the 3 things in the "fire triangle":
  1) A Fuel (hydrocarbon)
  2) Oxygen to burn it with
  3) Something to ignite the reaction (spark)



In general: $C_xH_y + O_2 \rightarrow CO_2 + H_2O$

Combustion Reactions cont.

- Products in combustion are ALWAYS carbon dioxide and water. (although incomplete burning does cause some by-products like carbon monoxide)
- Combustion is used to heat homes and run automobiles (octane, as in gasoline, is C_8H_{18})

Classification of Chemical reactions (continued)

4. Single Replacement Reactions

- occur when one *element* replaces another in a *compound*
  - A metal can replace a metal (+) **OR** a nonmetal can replace a nonmetal (-)

element + compound → product + product

- A + BC → AC + B (if A is a metal) **OR**
- A + BC → BA + C (if A is a nonmetal)

(remember the cation always goes first!)

**** When H_2O splits into ions, it splits into H^{+1} and OH^{-1} (not H^{+1} and O^{-2} !!)***

5. Double Replacement Reactions

- occur when a metal replaces a metal in a compound and a nonmetal replaces a nonmetal in a compound (cations switch places)
  - **Compound + compound → product + product**
    AB + CD → AD + CB
  - Involves two ionic compounds or acids (usually in aqueous solution)
  - Products include at least one of the following:
    a) solid (precipitation reaction)
    b) gas
    c) water (acid-base/neutralization reactions)