

HONORS CHAPTER 8

Chemical Equations and Reactions

Chemical Change:

Chemical reaction:

- One or more substances change into one or more new substances

Reactants \rightarrow Products

Describing Chemical Change:

- ❑ **Reactants:** those substances that are reacting or changing
- ❑ **Products:** those substances that are being formed from the reactants

Evidence of a Chemical Change:

1. Evidence of energy as heat and light.
2. Production of a gas.
3. Formation of a precipitate.
4. Color change.

Describing Chemical Change:

- ❑ Chemical equations: using chemical formulas to describe in writing a chemical reaction
- ❑ The arrow separates the formulas of the reactants from the formulas of the products

Describing Chemical Change:

1. The equation must represent known facts.
2. The equation must contain correct formulas for reactants and products.
3. The law of conservation of mass must be satisfied.
 - Coefficients are used to balance equations

Describing Chemical Change:

- ❑ All chemical reactions must follow the law of conservation of mass
- ❑ This means that the number of atoms on each side of the equation must be equal

Describing Chemical Change:

- ❑ In writing a chemical reaction, an arrow is used to separate the reactants from the products
- ❑ The \rightarrow means “yields”, or “reacts to produce”

Types of Equations

□ Word equation:

- Words are used to express the reaction
- Shows just the names of the reactants and products

iron + oxygen → iron (III) oxide

Types of Equations

□ Formula equation:

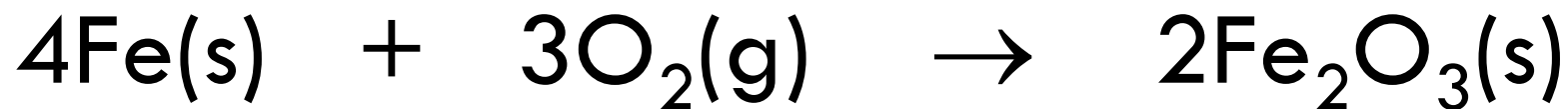
- Does not indicate relative amounts
- Shows just the formulas of the reactants and products



Chemical Equations

Symbols are used to represent the states of substances:

- ▣ solid (s), liquid (l), gas (g) and aqueous (aq)



Symbols Used in Chemical Reactions

- + used to separate two reactants or two products
- “yields” separates reactants from products
- ↔ or ⇌ used in place of the → for reversible rxns
- (s) solid state
- (g) gaseous state or produces gas ↑

Symbols Used in Chemical Reactions

(l) liquid state; only used for water, mercury, and bromine usually

(aq) aqueous solution (made w/ H₂O)

Δ or *heat* written over the \rightarrow to show heat was added

catalyst the actual substance is written over the \rightarrow to show the presence of a catalyst

Chemical Equations

Catalyst:

- ❑ A substance that speeds up the rate of a reaction but is not used up in the reaction
- ❑ The catalyst is written above or below the arrow

Balancing Equations:

- ❑ If there is no indication of the quantity of reactants and products in a equation, it is unbalanced
- ❑ A balanced chemical equation has the same number of atoms of each element on each side of the equation

Balancing Equations:



- ❑ Each side of the equation has the same number of carbon and oxygen atoms
- ❑ The equation is balanced

Balancing Equations:

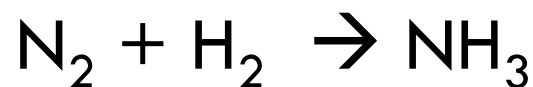
1. First determine the correct formulas for all the reactants and products
(You may include the states of the substances)
2. Write the correct formulas (“skeleton equation”)
3. Count the numbers of each element on each side of the equation
4. If there is a polyatomic ion that appears unchanged on both sides of the equation, treat it as a single unit
5. Balance H and O atoms last

Balancing Equations:

5. Balance the elements one at a time using coefficients. Begin with the elements that appear only once on each side of the equation.
6. Check each atom or polyatomic ion to be sure the equation is balanced.
7. Make sure the coefficients are in the lowest whole number ratio

Balancing Example

Given an unbalanced equation:



$$\text{N} = 2$$

$$\text{H} = 2$$

$$\text{N} = 1$$

$$\text{H} = 3$$

Use coefficients to balance: put a “2” in front of the NH_3 and a “3” in front of H_2



CHAPTER 8.2

Types of Chemical Reactions

Five Types of Reactions

1. **Combination (or synthesis)**
2. **Decomposition**
3. **Single-Replacement**
4. **Double-Replacement**
5. **Combustion**

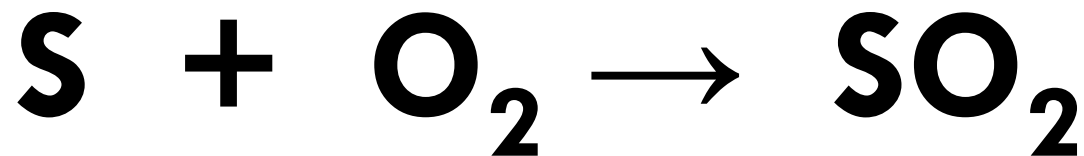
Important Note:

- ❑ Not all reactions fit into one category
- ❑ A reaction may fit equally into two or more categories of reactions

Combination Reaction:

Combination/synthesis (Marriage)

- ❑ Two or more reactants
- ❑ One Product (a compound)



Decomposition

One Reactant Breaks Down into
multiple Products (Divorce)



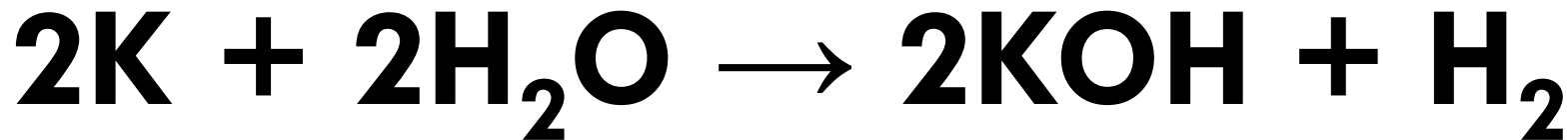
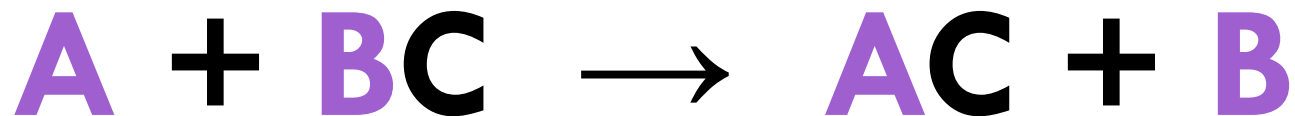
Decomposition Reaction:

- ❑ Products can be combinations of elements or compounds
- ❑ Difficult to predict
- ❑ Most require energy = heat, light or electricity

Single Replacement Reaction:

Atoms of one element replace atoms of a second element

(The Other Woman)



Single Replacement:



In a single replacement there are two reactants and two products.

The element that is displaced must be less active than the element that displaces it.

Activity Series	Symbol	
Lithium	Li	Always
Potassium	K	Replace
Calcium	Ca	Hydrogen
Sodium	Na	
Magnesium	Mg	
Aluminum	Al	Replace
Zinc	Zn	Hydrogen
Iron	Fe	In Acids
Lead	Pb	
Hydrogen	H	
Copper	Cu	
Mercury	Hg	
Silver	Ag	

How to Predict Reactions:



Single Replacement Reaction

- Identify ions of each atom.
- Determine what can replace what (*cation-to-cation OR anion-to-anion*).

Don't let diatomic elements throw you off!

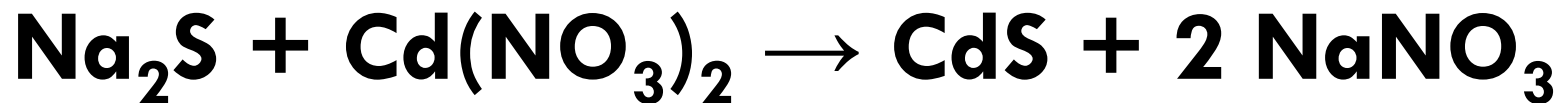
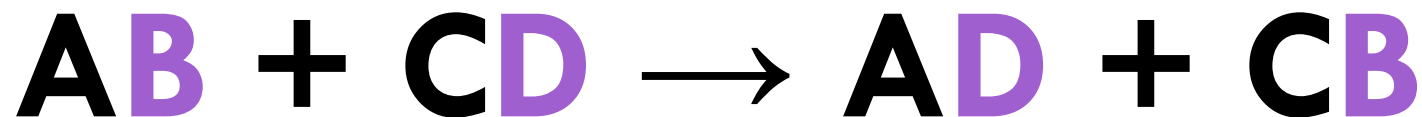
How to Predict Reactions:

Single Replacement Reaction

- ▣ Consult Activity Series Chart! (*only elements higher on the chart can replace an atom in a compound!*)
- ▣ Make new neutral compound and element.
- ▣ Balance equation!

Double-Replacement

Two ionic compounds react by exchanging cations (Wife Swap)



Double Replacement

Generally one of these is true:

1. One product is a precipitate.
2. One product is a gas that bubbles out of mixture
3. One product is a molecular compound such as water

How to Predict Reactions:

AB + CD → (2 aqueous compounds)

Double Replacement Reaction

- Identify ions of each atom.
- Switch the cations by bonding the outside ions together and the inside ions together.

How to Predict Reactions:

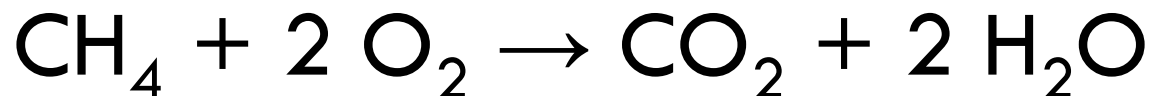
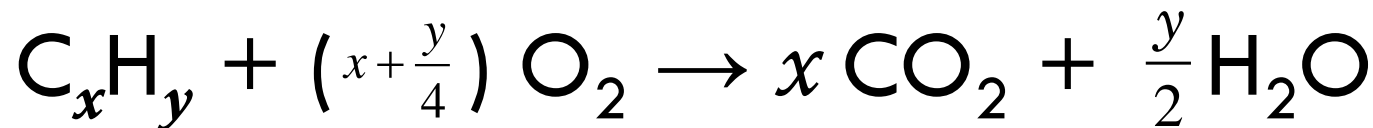
Double Replacement Rxn (cont'd)

- ❑ Make new neutral compounds.
- ❑ Consult Solubility Table and match up new ion pairs.
 - S = soluble, place (aq) after the compound
 - I = insoluble, place ↓ after the compound
- ❑ Balance equation

Combustion

An element or compound reacts with oxygen.
(The Argument)

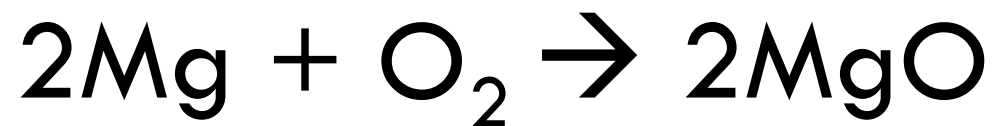
Ex: Combustion of a hydrocarbon



Combustion

Example:

Combustion of an element



Combustion:

- ❑ Element or compound reacting with oxygen.
- ❑ Produces heat and light
- ❑ Product of combustion of an element is the element oxide
- ❑ Products of combustion of hydrocarbon are always carbon dioxide plus water

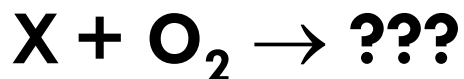
How to Predict Combustion



(hydrocarbon + oxygen)

Combustion Reaction

- Products are always $\text{CO}_2 + \text{H}_2\text{O}$
- Balance equation.



(metal + oxygen)

- ▣ Combustion and/or Combination Reaction
 - Follow rules to make a neutral compound

How to Predict Reactions:

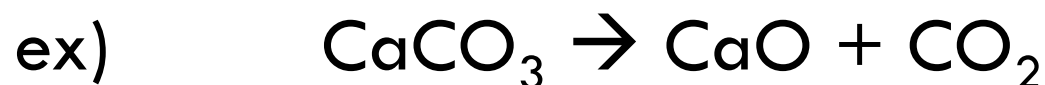
Decomposition Reactions

*** Usually under the presence of heat (Δ) or electrolysis! ***

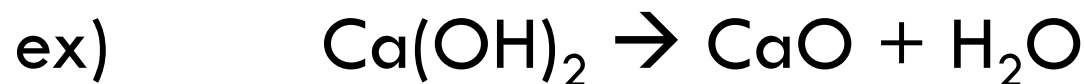
1. Break a binary compound into elements.
2. Be mindful of diatomic elements.
3. Be mindful of “special” reactions.
4. Balance equation.

Decomposition: “Special” reactions

Decomposition of metal carbonates yields the metal oxide plus carbon dioxide

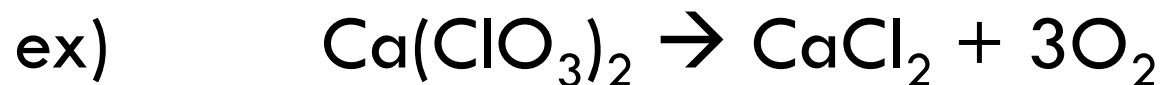


Decomposition of metal hydroxides yields the metal oxides plus water



Decomposition Reactions: “special” reactions

Decomposition of metal chlorates yields the metal chlorides plus oxygen



Decomposition of acids yields the nonmetal oxides plus water

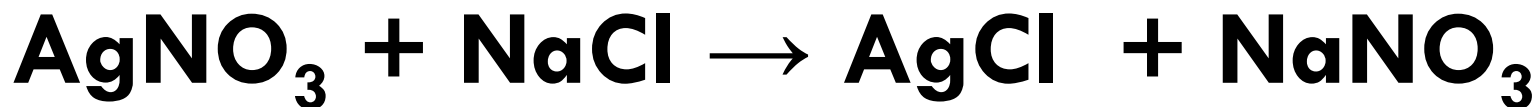
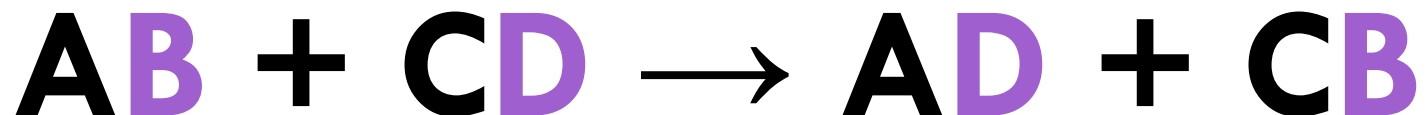


REACTIONS IN AQUEOUS SOLUTION



Double Replacement

Two ionic compounds react by exchanging cations



Double Replacement:

Generally one of these is true:

1. One product is a precipitate.
2. One product is a gas that bubbles out of mixture
3. One product is a molecular compound such as water

Solubility Rules:

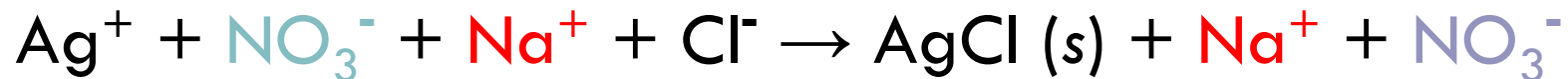
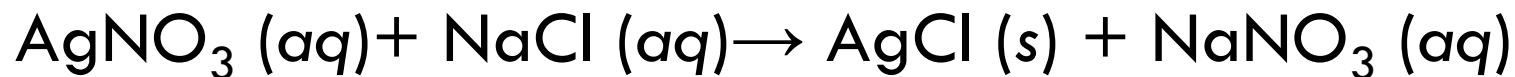
Compounds	Solubility	Exceptions
Salts of alkali metals and ammonia	Soluble	Some lithium compounds
Nitrate salts and chlorate salts	Soluble	Few exceptions
Sulfate salts	Soluble	Compounds of Pb, Ag, Hg, Ba, Sr, and Ca
Chloride salts	Soluble	Compounds of Ag and some compounds of Hg and Pb
Carbonates, phosphates, chromates, sulfides, and hydroxides	Most are insoluble	Compounds of the alkali metals and of ammonia

Aqueous Solutions

- ❑ Many important reactions take place in water
- ❑ Ionic compounds dissociate in aqueous solutions
- ❑ These solutions contain free cations and anions

Complete Ionic Equation

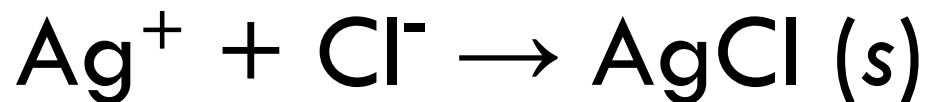
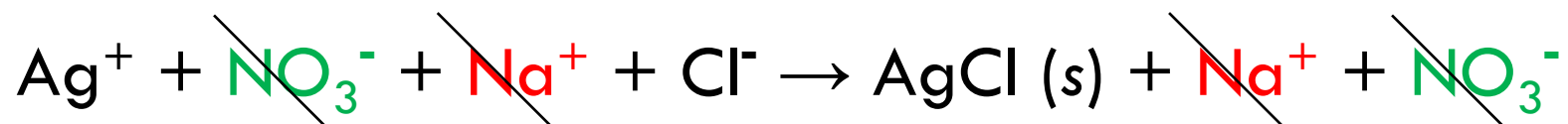
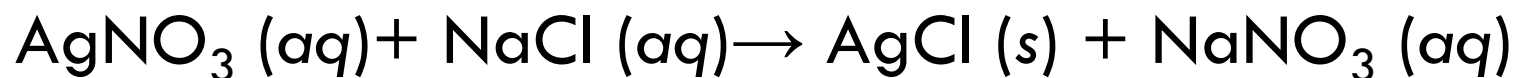
An equation that shows dissolved ionic compounds as their free ions



Complete Ionic Equation

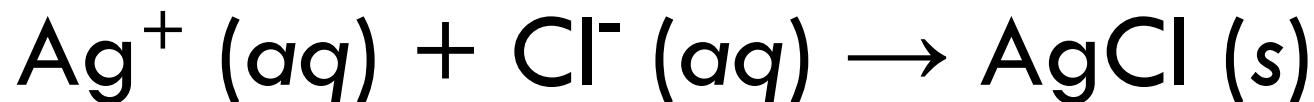
- ❑ The equation can be simplified by eliminating ions that do not participate in the reaction.
- ❑ Ions that appear on both sides of the equation can be cancelled out
- ❑ These ions that are not directly involved in a reaction are called **spectator ions**

Complete Ionic Equation



Net Ionic Equation

The equation that indicates only those particles that actually take part in a reaction is the net ionic equation





So

to summarize.....

Double Replacement:

Generally one of these is true:

1. One product is a precipitate.
2. One product is a gas that bubbles out of mixture
3. One product is a molecular compound such as water