

# HONORS CHAPTER 8

Chemical Equations and Reactions

# Chemical Change:

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Chemical reaction:

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

Reactants  $\rightarrow$  Products

# Describing Chemical Change:

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

# Evidence of a Chemical Change:

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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:

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- ❑ 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:

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- ❑ 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



# Types of Equations

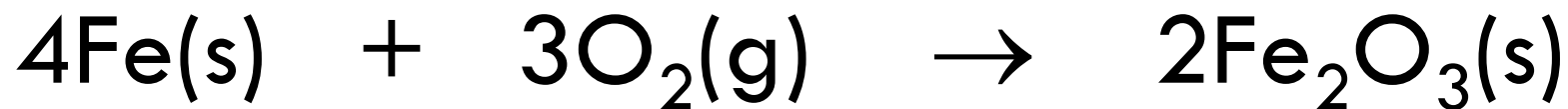
- Skeleton equation:
  - ▣ Does not indicate relative amounts
  - ▣ Shows just the formulas of the reactants and products



# 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/ H<sub>2</sub>O)

$\Delta$  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

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## 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:

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- ❑ 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:

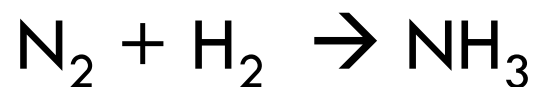
1. First determine the correct formulas for all the reactants and products  
(You may include the states of the substances)
2. Write the correct formulas (“skeleton equation”)
3. Count the numbers of each element on each side of the equation
4. If there is a polyatomic ion that appears unchanged on both 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  $\text{NH}_3$  and a “3” in front of  $\text{H}_2$



# CHAPTER 8.2

Types of Chemical Reactions

# Five Types of Reactions

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

# Important Note:

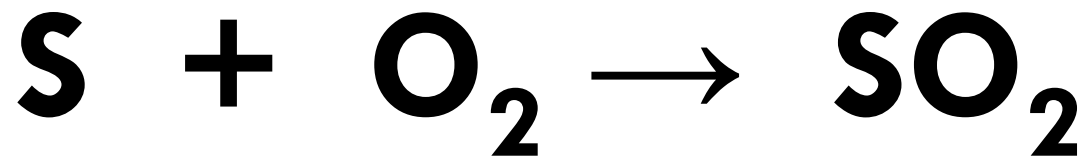
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- ❑ Not all reactions fit into one category
- ❑ A reaction may fit equally into two or more categories of reactions

# Combination Reaction:

## Combination/synthesis (Marriage)

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





# Decomposition

## Decomposition: (Divorce)

One reactant breaks down into multiple products



# Decomposition Reaction:

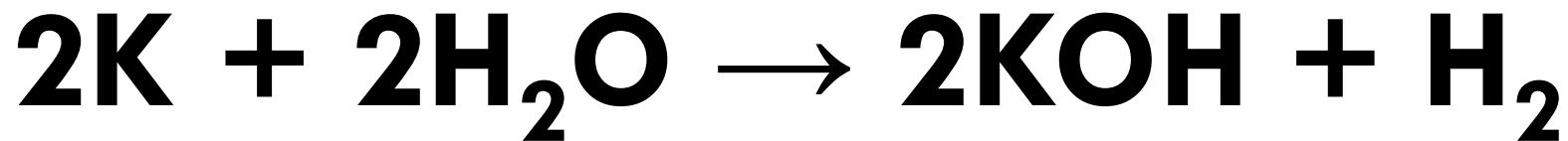
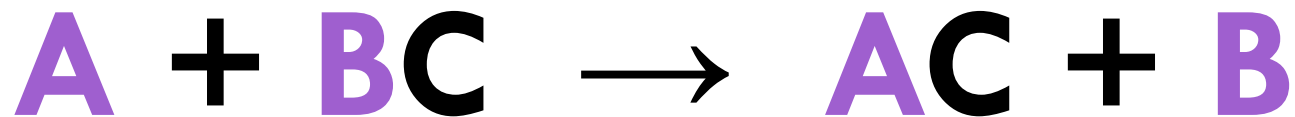
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- ❑ Products can be combinations of elements or compounds
- ❑ Difficult to predict
- ❑ Most require energy = heat, light or electricity

# Single Replacement Reaction:

Atoms of one element replace atoms of a second element in a compound

(The Other Woman/Man)



# Single Replacement (The Other Woman)

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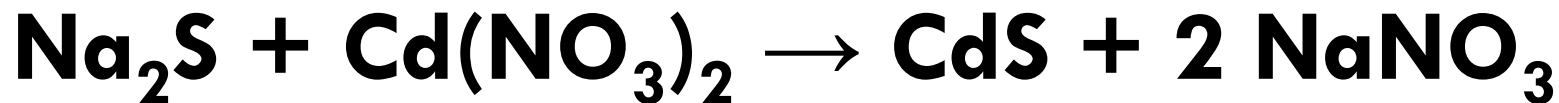
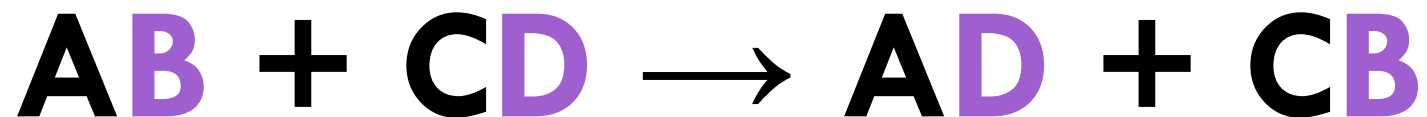
In a single replacement there are **two** reactants and **two** products.

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

<b>Activity Series</b>	<b>Symbol</b>	
<b>Lithium</b>	<b>Li</b>	<b>Always</b>
<b>Potassium</b>	<b>K</b>	<b>Replace</b>
<b>Barium</b>	<b>Ba</b>	<b>Hydrogen</b>
<b>Strontium</b>	<b>Sr</b>	
<b>Calcium</b>	<b>Ca</b>	
<b>Sodium</b>	<b>Na</b>	
<b>Magnesium</b>	<b>Mg</b>	
<b>Aluminum</b>	<b>Al</b>	<b>Replace</b>
<b>Zinc</b>	<b>Zn</b>	<b>Hydrogen</b>
<b>Iron</b>	<b>Fe</b>	<b>In Acids</b>
<b>Nickel</b>	<b>Ni</b>	
<b>Lead</b>	<b>Pb</b>	
<b>Hydrogen</b>	<b>H</b>	
<b>Copper</b>	<b>Cu</b>	
<b>Mercury</b>	<b>Hg</b>	
<b>Silver</b>	<b>Ag</b>	
<b>Gold</b>	<b>Au</b>	

# Double-Replacement (Trading Partners)

Two (ionic) compounds react by exchanging cations



# Double Replacement

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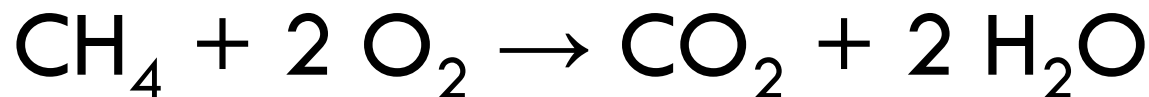
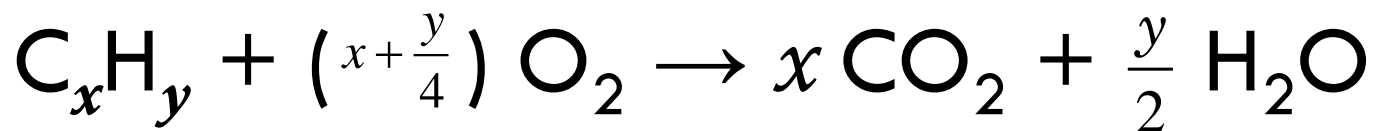
Generally one of these is true:

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

# Combustion (The Argument)

An element or compound reacts with oxygen.  
In a combustion oxygen (elemental) is one of the reactants.

Ex: Combustion of a hydrocarbon



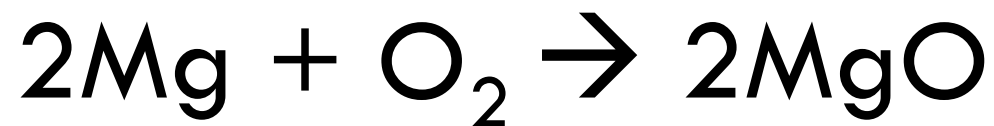


# Combustion

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Example:

Combustion of an element



# Combustion:

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- ❑ 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 PRODUCTS OF REACTIONS



# 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!

<b>Activity Series</b>	<b>Symbol</b>	
<b>Lithium</b>	<b>Li</b>	<b>Always</b>
<b>Potassium</b>	<b>K</b>	<b>Replace</b>
<b>Barium</b>	<b>Ba</b>	<b>Hydrogen</b>
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<b>Copper</b>	<b>Cu</b>	
<b>Mercury</b>	<b>Hg</b>	
<b>Silver</b>	<b>Ag</b>	
<b>Gold</b>	<b>Au</b>	

# 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.

# 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:

## 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

# 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, bromide, and iodide 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

# Combustion:

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- ❑ 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

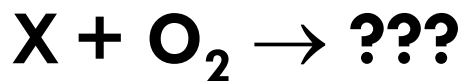
# How to Predict Combustion



(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:

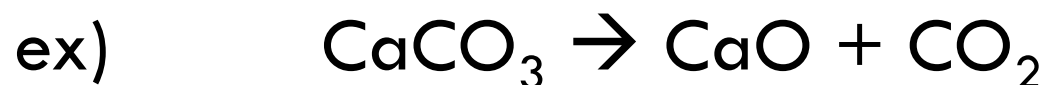
## Decomposition Reactions

**\* Usually under the presence of heat ( $\Delta$ ) or electrolysis! \***

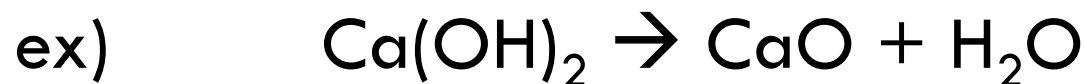
1. Break a binary compound into elements.
2. Be mindful of diatomic elements.
3. Be mindful of “special” reactions.
4. Balance equation.

# Decomposition: “Special” reactions

Decomposition of metal carbonates yields the metal oxide plus carbon dioxide

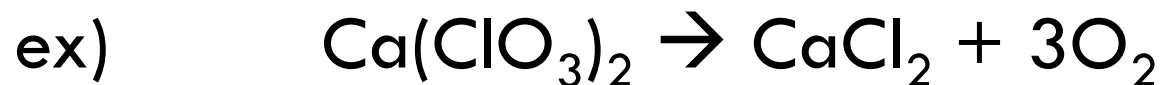


Decomposition of metal hydroxides yields the metal oxides plus water



# Decomposition Reactions: “special” reactions

Decomposition of metal chlorates yields the metal chlorides plus oxygen



Decomposition of acids yields the nonmetal oxides plus water



# How to Predict Equations

**A + B → (2 elements added together)**

## Combination Reaction

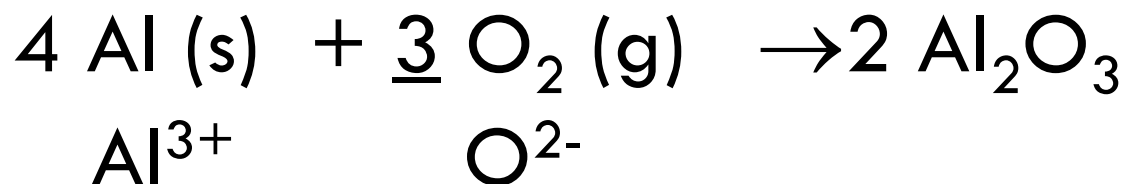
1. Determine charges of each atom (review ion sheet)
  2. Form a neutrally charged product
  3. Balance equation
  4. Be mindful of special reactions
- \*Don't let diatomic elements throw you off!\***



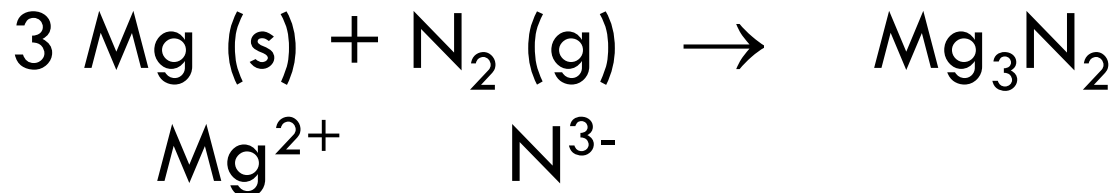
# How to Predict Combination

## Examples

**Synthesis of an element and oxygen to form an oxide**



**Synthesis of a metal and a nonmetal forms an ionic compound**

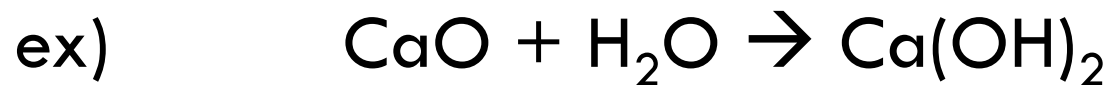


# Combination: “Special” reactions

Combination of metal oxide with carbon dioxide yields the metal carbonate

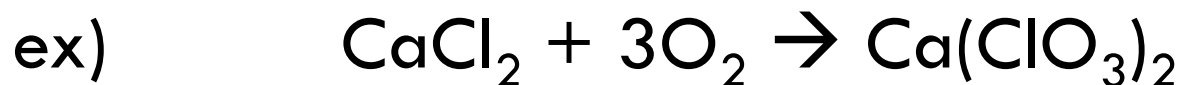


Combination of metal oxide with the water yields the metal hydroxide

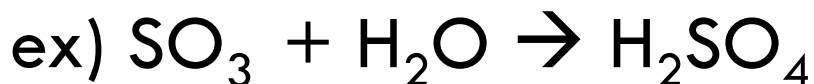
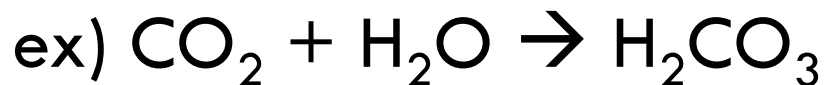


# Decomposition Reactions: “special” reactions

Combination of metal chloride with the oxygen yields the metal chlorate



Combination of a nonmetal oxide with water yields the acid

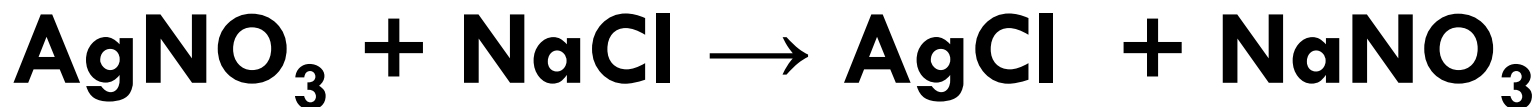
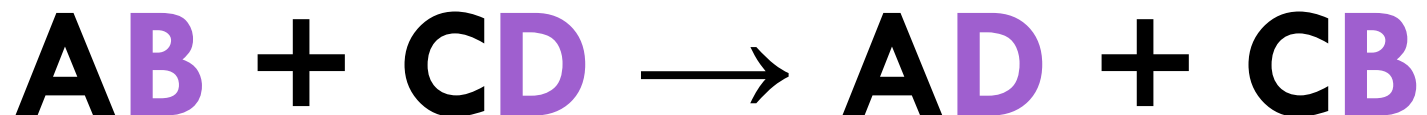


# REACTIONS IN AQUEOUS SOLUTION



# Double Replacement

Two ionic compounds react by exchanging cations



# Double Replacement:

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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

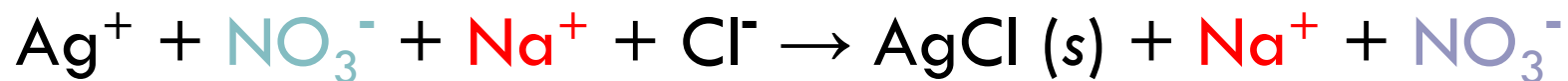
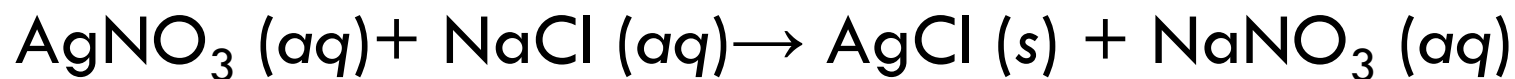
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- ❑ Many important reactions take place in water
- ❑ Ionic compounds dissociate in aqueous solutions
- ❑ These solutions contain free cations and anions



# Complete Ionic Equation

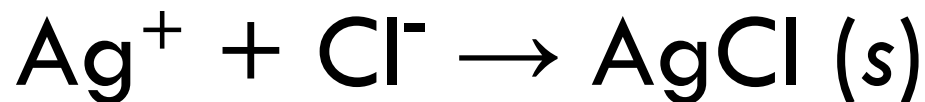
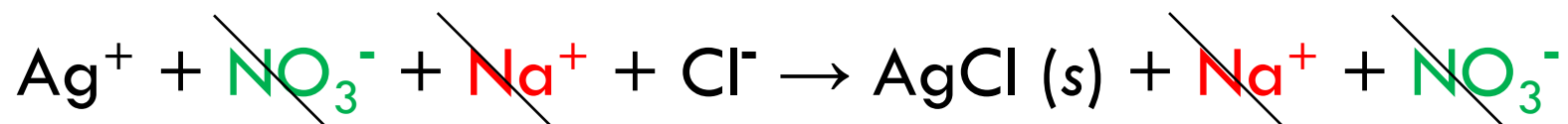
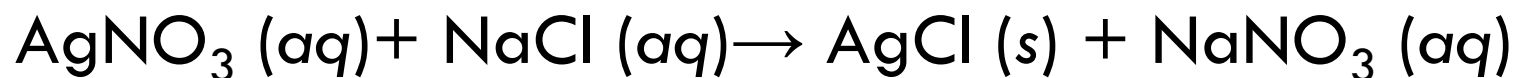
An equation that shows dissolved ionic compounds as their free ions



# Complete Ionic Equation

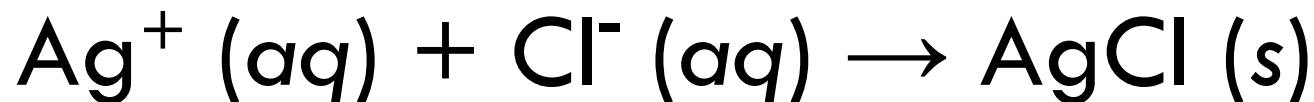
- ❑ The equation can be simplified by eliminating ions that do not participate in the reaction.
- ❑ Ions that appear on both sides of the equation can be cancelled out
- ❑ These ions that are not directly involved in a reaction are called **spectator ions**

# 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:

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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

# CHAPTER 8 REVIEW

Chemical Reactions

# Five Types of Reactions

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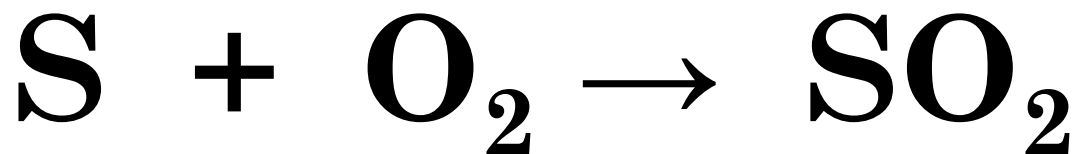
1. Combination (or synthesis)
2. Decomposition
3. Single-Replacement
4. Double-Replacement
5. Combustion



# Combination Reaction:

## Combination or synthesis

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



# How to Predict Synthesis/Combination:

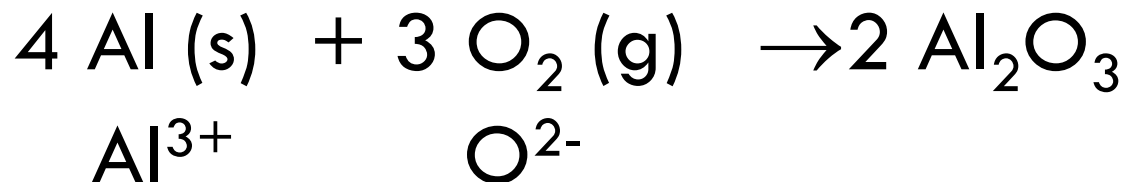
## Synthesis Reactions

1. Combine the elements to form an ionic compound.
2. Be mindful of diatomic elements.
3. Be mindful of “special” reactions.
4. Balance equation.

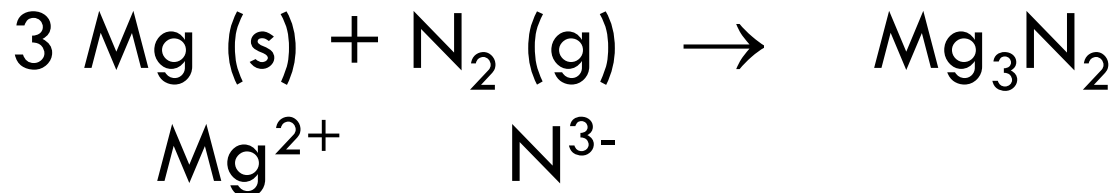
# How to Predict Combination

## Examples

**Synthesis of an element and oxygen to form an oxide**



**Synthesis of a metal and a nonmetal forms an ionic compound**

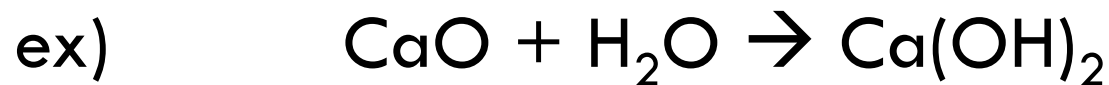


# Combination: “Special” reactions

Combination of metal oxide with carbon dioxide yields the metal carbonate

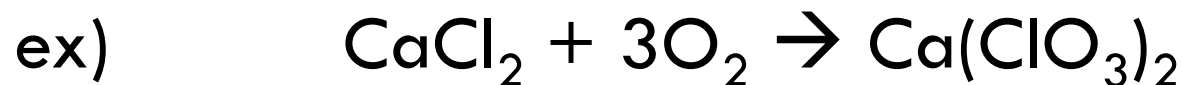


Combination of metal oxide with the water yields the metal hydroxide

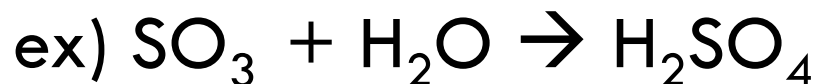
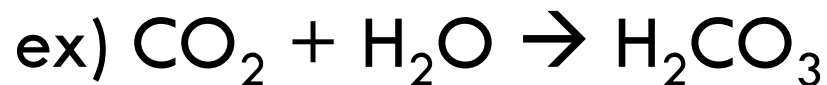


# Decomposition Reactions: “special” reactions

Combination of metal chloride with the oxygen yields the metal chlorate



Combination of a nonmetal oxide with water yields the acid



# How to Predict Decomposition:

## Decomposition Reactions: One reactant

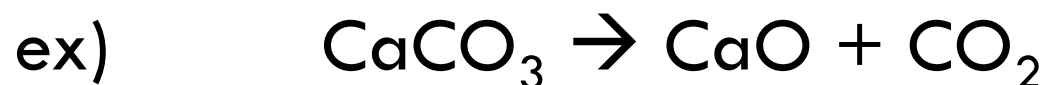
**\*Usually under the presence of heat ( $\Delta$ ) or electrolysis!\***

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

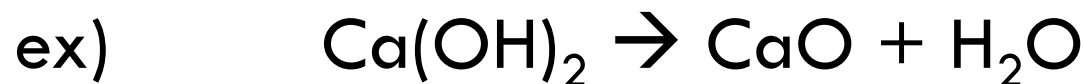


# Decomposition: “Special” reactions

Decomposition of metal carbonates yields the metal oxide plus carbon dioxide

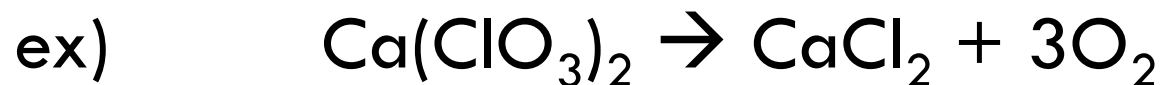


Decomposition of metal hydroxides yields the metal oxides plus water



# Decomposition Reactions: “special” reactions

Decomposition of metal chlorates yields the metal chlorides plus oxygen



Decomposition of acids yields the nonmetal oxides plus water





# How to Predict Single Replacement:

## 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:

1. Is the element a metal or nonmetal?
2. If it is a metal:  
Cationic Single replacement
3. If it is a nonmetal:  
Anionic Single replacement
4. Consult Activity Series/Periodic table
5. Write formula for a neutral compound and an element and balance.

<b>Activity Series</b>	<b>Symbol</b>	
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	

# Double Replacement Reaction:

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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 Double Replacement:

**AB + CD → (2 aqueous compounds)**

1. Identify ions of each atom.
2. Switch the cations by bonding the outside ions together and the inside ions together.
3. Write neutral formulas, check solubility rules, indicate a precipitate “↓”
4. Balance the equation

# Solubility Rules:

Compounds	Solubility	Exceptions
Salts of alkali metals and ammonia	Soluble	None.
Nitrate salts and chlorate salts	Soluble	None.
Sulfate salts	Soluble	Compounds of Pb, Ag, Hg, Ba, Sr, and Ca
Chloride, bromide, and iodide salts	Soluble	Compounds of Ag, Hg, and Pb
Carbonates, phosphates, chromates, sulfides, and hydroxides	Insoluble	Compounds of the alkali metals and of ammonia

# Combustion:

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## **Element or compound reacting with oxygen:**

- ❑ Produces heat and light
- ❑ Product of combustion of an element is the element oxide

## **Hydrocarbon reacting with oxygen:**

- ❑ Products of combustion of hydrocarbon are always carbon dioxide plus water

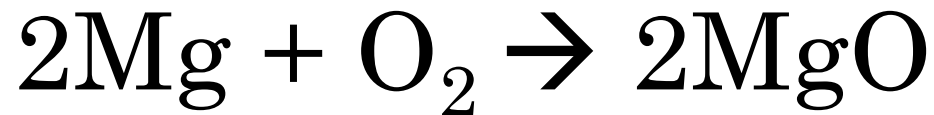
# Combustion

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An element or compound reacts with oxygen.

Example:

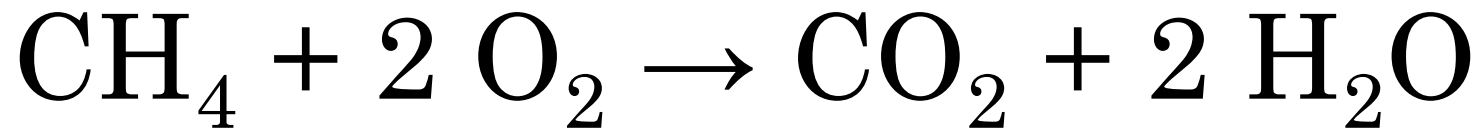
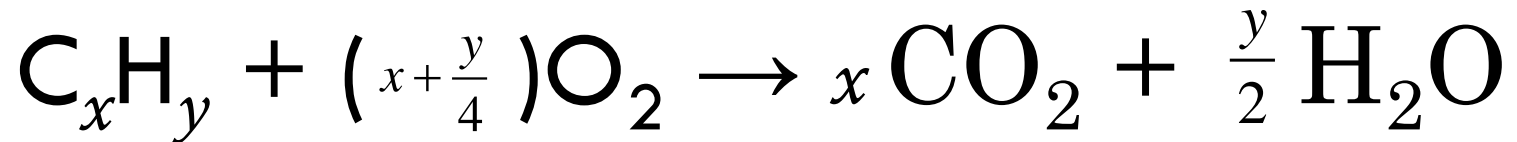
Combustion of an element





# Combustion

## Example: Combustion of a hydrocarbon



# REACTIONS IN AQUEOUS SOLUTION



# Double Replacement:

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If one of the products is a precipitate

1. Write the complete ionic Equation.
2. Cross out any ions that are the same on both sides of the reaction
3. Write a net ionic equation for the formation of the product.