

Types of Chemical Reactions

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CHAPTER 1**Types of Chemical Reactions**

Lesson Objectives

- Define and give general equations for combination, decomposition, single-replacement, and double-replacement reactions.
- Classify a reaction as combination, decomposition, single-replacement, double-replacement, or combustion.
- Use the activity series to correctly predict whether a given reaction will occur.
- Predict the products of simple reactions, given only the reactants.

Vocabulary

- activity series
- combination reaction
- combustion reaction
- decomposition reaction
- double-replacement reaction
- single-replacement reaction

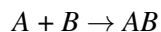
Check Your Understanding**Recalling Prior Knowledge**

- What is the difference between an element and a compound?
- What is the crisscross method, and how does it help one to write correct formulas for ionic compounds?
- What are the steps to balancing a chemical equation?

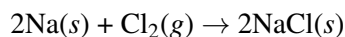
Many chemical reactions can be classified as one of five basic types. Having a thorough understanding of these types of reactions will be useful for predicting the products of an unknown reaction. The five basic types of chemical reactions are combination, decomposition, single-replacement, double-replacement, and combustion. Analyzing the reactants and products of a given reaction will allow you to place it into one of these categories. Some reactions will fit into more than one category.

Combination Reactions

A **combination reaction** is a reaction in which two or more substances combine to form a single new substance. Combination reactions can also be called synthesis reactions. The general form of a combination reaction is:

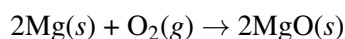


One combination reaction is two elements combining to form a compound. Solid sodium metal reacts with chlorine gas to produce solid sodium chloride.



Notice that in order to write and balance the equation correctly, it is important to remember the seven elements that exist in nature as diatomic molecules (H_2 , N_2 , O_2 , F_2 , Cl_2 , Br_2 , and I_2).

One sort of combination reaction that occurs frequently is the reaction of an element with oxygen to form an oxide. Metals and nonmetals both react readily with oxygen under most conditions. Magnesium reacts rapidly and dramatically when ignited, combining with oxygen from the air to produce a fine powder of magnesium oxide. This reaction can be seen in the following video: <http://www.youtube.com/watch?v=NnFzHt6l4z8> (0:37).

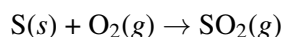


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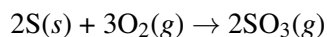
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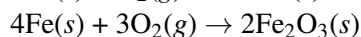
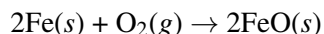
Sulfur reacts with oxygen to form sulfur dioxide.



When nonmetals react with one another, the product is a molecular compound. Often, the nonmetal reactants can combine in different ratios and produce different products. Sulfur can also combine with oxygen to produce sulfur trioxide.



Transition metals are capable of adopting multiple positive charges within their ionic compounds. Therefore, most transition metals are capable of forming different products in a combination reaction. Iron reacts with oxygen to form both iron(II) oxide and iron(III) oxide.



Sample Problem 11.2: Combination Reactions

Potassium is a very reactive alkali metal that must be stored under oil in order to prevent it from reacting with air. Write the balanced chemical equation for the combination reaction of potassium with oxygen.

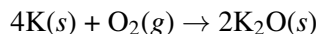
Step 1: Plan the problem.

Make sure formulas of all reactants and products are correct before balancing the equation. Oxygen gas is a diatomic molecule. Potassium oxide is an ionic compound and so its formula is constructed by the crisscross method. Potassium as an ion becomes K^+ , while the oxide ion is O^{2-} .

Step 2: Solve.

The skeleton (unbalanced) equation: $\text{K}(s) + \text{O}_2(g) \rightarrow \text{K}_2\text{O}(s)$

The equation is then easily balanced with coefficients.



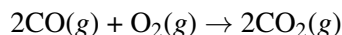
Step 3: Think about your result.

The formulas are correct and the resulting combination reaction is balanced.

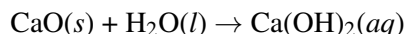
Practice Problems

- Write a balanced equation for the combination reactions.
 - aluminum and oxygen
 - calcium and bromine
- Write a balanced equation showing the formation of copper(II) nitride from its elements.

Combination reactions can also take place when an element reacts with a compound to form a new compound composed of a larger number of atoms. Carbon monoxide reacts with oxygen to form carbon dioxide according to the equation:



Two compounds may also react to form a more complex compound. A very common example is the reactions of oxides with water. Calcium oxide reacts readily with water to produce an aqueous solution of calcium hydroxide.



Sulfur trioxide gas reacts with water to form sulfuric acid. This is an unfortunately common reaction that occurs in the atmosphere in some places where oxides of sulfur are present as pollutants. The acid formed in the reaction falls to the ground as acid rain (**Figure 1.1**).

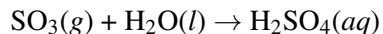


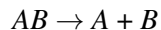
FIGURE 1.1

Acid rain has severe consequences on both nature as well as on man-made objects. (A) Acid rain degrades marble statues like the one on the left. (B) The trees in the forest on the right have been killed by acid rain.

For additional help and examples of combination reactions, also known as synthesis reactions, go to <http://www.ck12.org/Equations/Synthesis.html> .

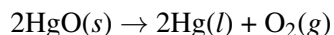
Decomposition Reactions

A **decomposition reaction** is a reaction in which a compound breaks down into two or more simpler substances. The general form of a decomposition reaction is:



Most decomposition reactions require an input of energy in the form of heat, light, or electricity.

Binary compounds are compounds composed of just two elements. The simplest kind of decomposition reaction is when a binary compound decomposes into its elements. Mercury(II) oxide, a red solid, decomposes when heated to produce mercury and oxygen gas.



View a video of the decomposition of mercury(II) oxide at http://www.youtube.com/watch?v=_Y1alDuXm6A (1:12).



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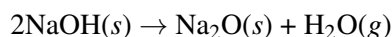
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A reaction is also considered to be a decomposition reaction even when one or more of the products is still a compound. A metal carbonate decomposes into a metal oxide and carbon dioxide gas. For example, calcium carbonate decomposes into calcium oxide and carbon dioxide.



Metal hydroxides decompose on heating to yield metal oxides and water. Sodium hydroxide decomposes to produce sodium oxide and water.



Some unstable acids decompose to produce nonmetal oxides and water. Carbonic acid decomposes easily at room temperature into carbon dioxide and water.



Sample Problem 11.3: Decomposition Reactions

When an electric current is passed through pure water, it decomposes into its elements. Write a balanced equation for the decomposition of water.

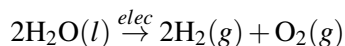
Step 1: Plan the problem.

Water is a binary compound composed of hydrogen and oxygen. The hydrogen and oxygen gases produced in the reaction are both diatomic molecules.

Step 2: Solve.

The skeleton (unbalanced) equation: $\text{H}_2\text{O}(l) \xrightarrow{\text{elec}} \text{H}_2(g) + \text{O}_2(g)$

Note the abbreviation “elec” above the arrow to indicate the passage of an electric current to initiate the reaction. Balance the equation.



Step 3: Think about your result.

The products are elements and the equation is balanced.

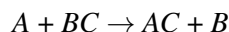
Practice Problem

3. Write balanced equations for the decomposition of the following compounds.
 - (a) strontium phosphide
 - (b) silver carbonate
 - (c) aluminum hydroxide

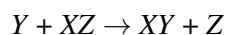
For more information on decomposition reactions, go to <http://www.chemteam.info/Equations/Decomposition.html>

Single-Replacement Reactions

A **single-replacement reaction** is a reaction in which one element replaces a similar element in a compound. The general form of a single-replacement (also called single-displacement) reaction is:



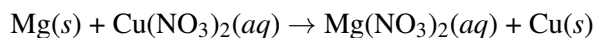
In this general reaction, element A is a metal and replaces element B , also a metal, in the compound. When the element that is doing the replacing is a nonmetal, it must replace another nonmetal in a compound, and the general equation becomes:



Y is a nonmetal and replaces the nonmetal Z in the compound with X .

Metal Replacement

Magnesium is a more reactive metal than copper. When a strip of magnesium metal is placed in an aqueous solution of copper(II) nitrate, it replaces the copper. The products of the reaction are aqueous magnesium nitrate and solid copper metal.



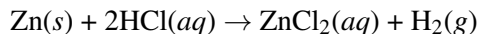
This subcategory of single-replacement reactions is called a metal replacement reaction because it is a metal that is being replaced (copper).

You can view a two part video experiment of a metal replacement occurring over a period of time.

- Part 1 video: <http://www.youtube.com/watch?v=gqGrpd5smtI>
 - The document that goes with part 1 is at http://www.dlt.ncssm.edu/core/Chapter1-Introduction/Chapter1-Labs/Iron_Nail_Observation_Activity.doc .
- Part 2 video: <http://www.youtube.com/watch?v=yWcSzvJ6Kcw>

Hydrogen Replacement

Many metals react easily with acids, and, when they do so, one of the products of the reaction is hydrogen gas. Zinc reacts with hydrochloric acid to produce aqueous zinc chloride and hydrogen (**Figure 1.2**).



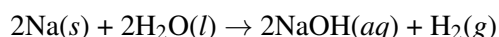
In a hydrogen replacement reaction, the hydrogen in the acid is replaced by an active metal.



FIGURE 1.2

Zinc metal reacts with hydrochloric acid to give off hydrogen gas in a single-replacement reaction.

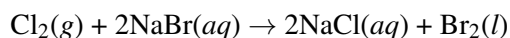
Some metals are so reactive that they are capable of replacing the hydrogen in water. The products of such a reaction are the metal hydroxide and hydrogen gas. All group 1 metals undergo this type of reaction. Sodium reacts vigorously with water to produce aqueous sodium hydroxide and hydrogen (**Figure 1.3**).



View an animation of a metal replacing hydrogen at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/SingleDisp_Reaction-MetalToAcid.html .

Halogen Replacement

The element chlorine reacts with an aqueous solution of sodium bromide to produce aqueous sodium chloride and elemental bromine.



The reactivity of the halogen group (group 17) decreases from top to bottom within the group. Fluorine is the most reactive halogen, while iodine is the least. Since chlorine is above bromine, it is more reactive than bromine and can replace it in a halogen replacement reaction.

You can view a halogen replacement experiment at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/12hexane-1g.htm .

**FIGURE 1.3**

Pictured here is about 3 pounds of sodium metal reacting with water. Sodium metal reacts vigorously when dropped into a container of water, giving off hydrogen gas. A large piece of sodium will often generate so much heat that the hydrogen will ignite.

The Activity Series

Single-replacement reactions only occur when the element that is doing the replacing is more reactive than the element that is being replaced. Therefore, it is useful to have a list of elements in order of their relative reactivities. The **activity series** is a list of elements in decreasing order of their reactivity. Since metals replace other metals, while nonmetals replace other nonmetals, they each have a separate activity series. Listed below (**Table 1.1**) is an activity series of most common metals, and of the halogens.

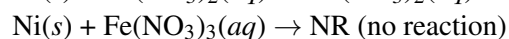
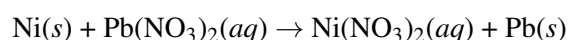
TABLE 1.1: Activity Series

Activity of Metals		Activity of Halogens
Li K Ba Sr Ca Na	React with cold water, replacing hydrogen.	F ₂ Cl ₂ Br ₂ I ₂
Mg Al Zn Cr Fe Cd	React with steam, but not cold water, replacing hydrogen.	
Co Ni Sn Pb	Do not react with water. React with acids, replacing hydrogen.	
H ₂		

TABLE 1.1: (continued)

Activity of Metals		Activity of Halogens
Cu Hg Ag Pt Au	Unreactive with water or acids.	

For a single-replacement reaction, a given element is capable of replacing an element that is below it in the activity series. This can be used to predict if a reaction will occur. Suppose that small pieces of the metal nickel were placed into two separate aqueous solutions: one of iron(III) nitrate and one of lead(II) nitrate. Looking at the activity series, we see that nickel is below iron, but above lead. Therefore, the nickel metal will be capable of replacing the lead in a reaction, but will not be capable of replacing iron.



In the descriptions that accompany the activity series of metals, a given metal is also capable of undergoing the reactions described below that section. For example, lithium will react with cold water, replacing hydrogen. It will also react with steam and with acids, since that requires a lower degree of reactivity.

Sample Problem 11.4: Single-Replacement Reactions

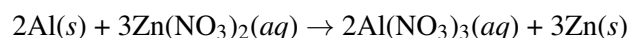
Use the activity series to predict if the following reactions will occur. If not, write NR. If the reaction does occur, write the products of the reaction and balance the equation.

- $\text{Al}(s) + \text{Zn}(\text{NO}_3)_2(aq) \rightarrow$
- $\text{Ag}(s) + \text{HCl}(aq) \rightarrow$

Step 1: Plan the problem.

For 1, compare the placements of aluminum and zinc on the activity series. For 2, compare the placements of silver and hydrogen.

Since aluminum is above zinc, it is capable of replacing it and a reaction will occur. The products of the reaction will be aqueous aluminum nitrate and solid zinc. Take care to write the correct formulas for the products before balancing the equation. Aluminum adopts a 3+ charge in an ionic compound, so the formula for aluminum nitrate is $\text{Al}(\text{NO}_3)_3$. The balanced equation is:



Since silver is below hydrogen, it is not capable of replacing hydrogen in a reaction with an acid.



Step 3: Think about your result.

The equation for 1 is balanced and follows the activity series. Silver, a coinage and jewelry metal, is unreactive toward acids.

Practice Problem

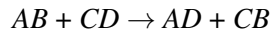
4. Complete and balance the reactions for the following single-replacement reactions. Use the activity series. If no reaction will occur, write NR.
- $\text{Fe}(s) + \text{MgCl}_2(aq) \rightarrow$
 - $\text{F}_2(g) + \text{KI}(aq) \rightarrow$
 - $\text{Sn}(s) + \text{Cu}(\text{NO}_3)_2(aq) \rightarrow$

Watch a video experiment of halogen activity series at http://www.dlt.ncssm.edu/core/Chapter8-Atomic_Str_Part2/bleachoverlay-1g.htm .

For more explanation and examples of single-replacement reactions go to <http://www.chemteam.info/Equations/SingleReplacement.html> .

Double-Replacement Reactions

A **double-replacement reaction** is a reaction in which the positive and negative ions of two ionic compounds exchange places to form two new compounds. The general form of a double-replacement (also called double-displacement) reaction is:

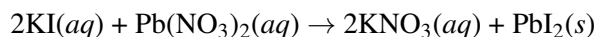


In this reaction, *A* and *C* are positively-charged cations, while *B* and *D* are negatively-charged anions. Double-replacement reactions generally occur between substances in aqueous solution. In order for a reaction to occur, one of the products is usually a solid precipitate, a gas, or a molecular compound such as water.

For more information and examples on double-replacement reactions go to <http://www.chemteam.info/Equations/DoubleReplacement.html> .

Formation of a Precipitate

A precipitate forms in a double-replacement reaction when the cations from one of the reactants combine with the anions from the other reactant to form an insoluble ionic compound. When aqueous solutions of potassium iodide and lead(II) nitrate are mixed, the following reaction occurs.



There are very strong attractive forces that occur between Pb^{2+} and I^- ions and the result is a brilliant yellow precipitate (**Figure 1.4**). The other product of the reaction, potassium nitrate, remains soluble. Rules for predicting the water solubility of ionic compounds and how to apply those rules to reactions are covered in a later chapter.

Watch a video of the reaction between lead(II) nitrate and potassium iodide on the microscopic level at <http://www.youtube.com/watch?v=ncRj5qIoRRg> (0:43).


FIGURE 1.4

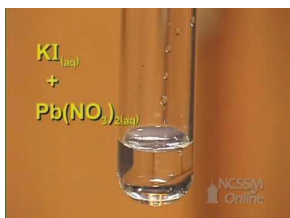
When a few drops of lead(II) nitrate are added to a solution of potassium iodide, a yellow precipitate of lead(II) iodide immediately forms in a double-replacement reaction.


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URL: <http://www.ck12.org/flx/render/embeddedobject/60858>

You can watch the above reaction without a microscope at <http://www.youtube.com/watch?v=X2mB-q2NQXY> (0:38).


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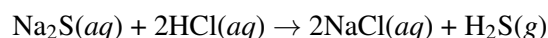
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You can view an animation of a double-replacement precipitation reaction at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/DoubleDisp_Reaction-Precipitation.html .

Formation of a Gas

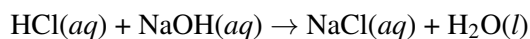
Some double-replacement reactions produce a gaseous product which then bubbles out of the solution and escapes into the air. When solutions of sodium sulfide and hydrochloric acid are mixed, the products of the reaction are aqueous sodium chloride and hydrogen sulfide gas.



Watch a video experiment that shows the production of hydrogen sulfide gas from sodium sulfide and hydrochloric acid at <http://www.youtube.com/watch?v=os8Yr-rindU> .

Formation of a Molecular Compound

Another kind of double-replacement reaction is one that produces a molecular compound as one of its products. Many examples in this category are reactions that produce water. When aqueous hydrochloric acid is reacted with aqueous sodium hydroxide, the products are aqueous sodium chloride and water.



Sample Problem 11.5: Double-Replacement Reactions

Write a complete and balanced chemical equation for the following double-replacement reactions. One product is indicated as a guide.

1. $\text{NaCN}(aq) + \text{HBr}(aq) \rightarrow$ (hydrogen cyanide gas is formed)
2. $(\text{NH}_4)_2\text{SO}_4(aq) + \text{Ba}(\text{NO}_3)_2(aq) \rightarrow$ (a precipitate of barium sulfate forms)

Step 1: Plan the problem.

In 1, the production of a gas drives the reaction. In 2, the production of a precipitate drives the reaction. In both cases, use the ionic charges of both reactants to construct the correct formulas of the products.

Step 2: Solve.

1. The cations of both reactants are 1+ charged ions, while the anions are 1- charged ions. After exchanging partners, the balanced equation is: $\text{NaCN}(aq) + \text{HBr}(aq) \rightarrow \text{NaBr}(aq) + \text{HCN}(g)$
2. Ammonium ion and nitrate ion are 1+ and 1- respectively, while barium and sulfate are 2+ and 2-. This must be taken into account when exchanging partners and writing the new formulas. Then, the equation is balanced. $(\text{NH}_4)_2\text{SO}_4(aq) + \text{Ba}(\text{NO}_3)_2(aq) \rightarrow 2\text{NH}_4\text{NO}_3(aq) + \text{BaSO}_4(s)$

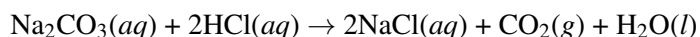
Step 3: Think about your result.

Both are double-replacement reactions. All formulas are correct and the equations are balanced.

Practice Problem

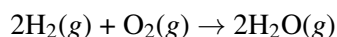
5. Complete and balance the double-replacement reactions.
 - (a) $\text{H}_3\text{PO}_4(aq) + \text{KOH}(aq) \rightarrow$ (water is formed)
 - (b) $\text{AgNO}_3(aq) + \text{CaCl}_2(aq) \rightarrow$ (silver chloride precipitate forms)

Occasionally, a reaction will produce both a gas and a molecular compound. The reaction of a sodium carbonate solution with hydrochloric acid produces aqueous sodium chloride, carbon dioxide gas, and water.



Combustion Reactions

A **combustion reaction** is a reaction in which a substance reacts with oxygen gas, releasing energy in the form of light and heat. Combustion reactions must involve O_2 as one reactant. The combustion of hydrogen gas produces water vapor (**Figure 1.5**).



Notice that this reaction also qualifies as a combination reaction.

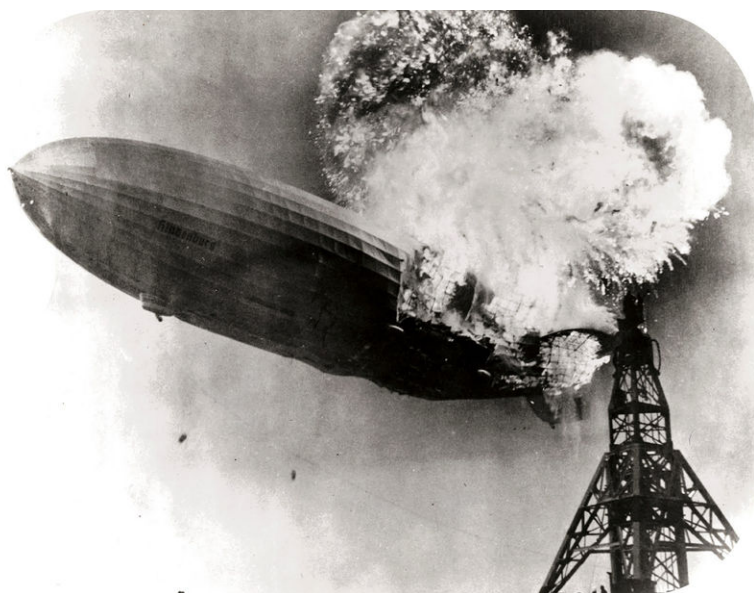
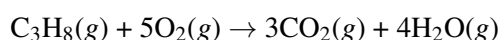


FIGURE 1.5

Hindenburg was a hydrogen-filled airship that suffered an accident upon its attempted landing in New Jersey in 1937. The hydrogen immediately combusted in a huge fireball, destroying the airship and killing 36 people. The chemical reaction was a simple one: hydrogen combining with oxygen to produce water.

Many combustion reactions occur with a hydrocarbon, a compound made up solely of carbon and hydrogen. The products of the combustion of hydrocarbons are carbon dioxide and water. Many hydrocarbons are used as fuel because their combustion releases very large amounts of heat energy. Propane (C_3H_8) is a gaseous hydrocarbon that is commonly used as the fuel source in gas grills.



Practice Problem 11.6: Combustion Reactions

Ethanol can be used as a fuel source in an alcohol lamp. The formula for ethanol is $\text{C}_2\text{H}_5\text{OH}$. Write the balanced equation for the combustion of ethanol.

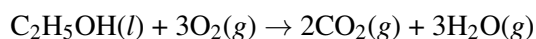
Step 1: Plan the problem.

Ethanol and oxygen are the reactants. As with a hydrocarbon, the products of the combustion of an alcohol are carbon dioxide and water.

Step 2: Solve.

Write the skeleton equation: $\text{C}_2\text{H}_5\text{OH}(\text{l}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

Balance the equation.



Step 3: Think about your result.

Combustion reactions must have oxygen as a reactant. Note that the water that is produced is in the gas rather than the liquid state because of the high temperatures that accompany a combustion reaction.

Practice Problem

6. Write and balance combustion reactions for the following compounds.
- octane (C_8H_{18})
 - sucrose ($C_{12}H_{22}O_{11}$)

For more information and practice on combustion reactions, go to <http://www.chemteam.info/Equations/Combustion.html> .

Lesson Summary

- The five general types of chemical reactions are combination, decomposition, single-replacement, double-replacement, and combustion.
- In a combination reaction, two simple substances combine to form a single product.
- In a decomposition reaction, a compound breaks down into two or more simpler substances.
- In a single-replacement reaction, one element takes the place of another similar element in a compound. Common types of single-replacement reactions include metal replacement, hydrogen replacement, and halogen replacement. The activity series can be used to predict whether a given reaction will occur.
- In a double-replacement reaction, two ionic compounds react by exchanging cation-anion partners. A double-replacement reaction generally produces an ionic precipitate, a gas, or a molecular compound.
- In a combustion reaction, a substance reacts with oxygen gas, giving off energy as light and heat.

Lesson Review Questions**Reviewing Concepts**

1. Write a general reaction for each reaction type below.
 - a. double-replacement
 - b. decomposition
 - c. single-replacement
 - d. combination
2. Which type of reaction generally takes place only between substances in aqueous solution?
3. What do all combustion reactions have in common?
4. Where on an activity series are the most reactive elements located?
5. Classify the following reactions according to the five basic reaction types.
 - a. $Cd(s) + H_2SO_4(aq) \rightarrow CdSO_4(aq) + H_2(g)$
 - b. $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$
 - c. $C_7H_8(l) + 9O_2(g) \rightarrow 7CO_2(g) + 4H_2O(g)$
 - d. $2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(g)$
 - e. $2CoCl_3(aq) + 3Pb(NO_3)_2(aq) \rightarrow 2Co(NO_3)_3(aq) + 3PbCl_2(s)$

Problems

6. Write balanced chemical equations for the following combination reactions.
 - a. $\text{Sr}(s) + \text{S}(s) \rightarrow$
 - b. $\text{Zn}(s) + \text{O}_2(g) \rightarrow$
 - c. $\text{Li}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow$
7. Write balanced chemical equations for the following decomposition reactions.
 - a. $\text{Na}_3\text{N}(s) \xrightarrow{\Delta}$
 - b. $\text{SnCO}_3(s) \xrightarrow{\Delta}$
 - c. $\text{NCl}_3(l) \rightarrow$
 - d. $\text{Mg}(\text{OH})_2(s) \xrightarrow{\Delta}$
8. Use the activity series to write a balanced chemical equation for the following single-replacement reactions. Write NR if no reaction occurs.
 - a. $\text{Cl}_2(g) + \text{NaF}(aq) \rightarrow$
 - b. $\text{Ca}(s) + \text{H}_2\text{O}(l) \rightarrow$
 - c. $\text{Pt}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow$
 - d. $\text{Al}(s) + \text{NiBr}_2(aq) \rightarrow$
9. Write balanced chemical equations for the following double-replacement reactions.
 - a. $\text{Ca}(\text{NO}_3)_2(aq) + \text{K}_3\text{PO}_4(aq) \rightarrow$ (calcium phosphate precipitates)
 - b. $\text{HI}(aq) + \text{Mg}(\text{OH})_2(aq) \rightarrow$
 - c. $\text{FeS}(s) + \text{HCl}(aq) \rightarrow$ (aqueous iron(II) chloride is one product)
 - d. $\text{CuBr}_2(aq) + \text{KOH}(aq) \rightarrow$ (copper(II) hydroxide precipitates)
10. Write balanced equations for the combustion of the following compounds.
 - a. ethyne (C_2H_2)
 - b. acetic acid (CH_3COOH)
 - c. hexane (C_6H_{14})

Further Reading / Supplemental Links

- Reaction Identification Practice, (<http://www.sciencegeek.net/Chemistry/taters/EquationIdentification.htm>)
- MHS Chemistry: Predicting Reaction Products, (<http://dbooth.net/mhs/chem/predictingproducts01.html>)
- You can view several examples of metals reacting with various solutions at <http://www.harpercollege.edu/tm-ps/chm/100/dgodambe/thedisk/series/3perform.htm> . After choosing a metal and a solution, you will be shown a picture of the resulting reaction.

Synthesis reactions:

- Simulation of the synthesis of water: http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/Synthesis.html
- A video of the synthesis reaction that produces magnesium oxide can be found at http://www.youtube.com/watch?v=kx72te_jAfw
- Watch the synthesis of a metal hydroxide at http://www.youtube.com/watch?v=AP79_srafmE
- Watch the synthesis of carbonic acid at <http://www.youtube.com/watch?v=kJC8NHixc9c>
- View the synthesis of calcium oxide at <http://www.youtube.com/watch?v=dszSKIM5rqk>
- View the reaction between copper and chlorine gas at <http://www.youtube.com/watch?v=edLpxdERQZc>

- A video of the combination reaction between chlorine gas and iron can be found at http://www.youtube.com/watch?v=ygLDJKG_QSY
- An animation of a combination reaction between nitrogen gas and oxygen gas can be found at <http://www.dlt.ncssm.edu/core/Chapter6-Stoichiometry/Chapter6-Animations/Stoichiometry-1.html>

Decomposition reactions:

- An animation of the decomposition of a metal hydrogen carbonate can be viewed at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/Decomposition.html
- A video of the decomposition of a metal hydrogen carbonate can be seen at <http://www.youtube.com/watch?v=GPXRY3MPUMY>
- Watch the decomposition of copper(II) oxide at <http://www.youtube.com/watch?v=Ar07zUf52Tc>
- Watch the decomposition of a metal hydroxide at <http://www.youtube.com/watch?v=dFYJ7a7-wIc>
- Watch the decomposition of hydrogen peroxide at <http://www.youtube.com/watch?v=oX5FyaqNx54>
- Watch the decomposition of potassium chlorate at http://www.youtube.com/watch?v=svRIg_kzE68

Metal replacement:

- An animation of a metal replacement reaction can be found at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/SingleDisp_Reaction-MetalToMetal.html
- A video experiment showing what happens at the microscopic level when copper replaces silver in a reaction between copper wire and silver nitrate can be seen at <http://www.youtube.com/watch?v=dVK6B-56MYs>
- A video of the reaction between copper wire and silver nitrate without the use of a microscope can be found at <http://www.youtube.com/watch?v=k8UtR7akNec>

Hydrogen replacement:

- A video experiment of hydrogen replacement by calcium can be seen at http://www.youtube.com/watch?v=hjB96do_fRw
- A video experiment of magnesium metal reacting with hydrochloric acid can be viewed at <http://www.youtube.com/watch?v=OBdgeJFzSec>

Double-replacement reaction:

- Watch an animation of a double-replacement reaction at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/DoubleDisp_Reaction-AcidToBase.html
- View a double-replacement reaction between sodium hydroxide and hydrochloric acid at <http://www.youtube.com/watch?v=HQfXzbZJhgg>

Formation of a precipitate:

- A video experiment in which a precipitate is formed by reacting sodium chloride with silver nitrate can be seen at <http://www.youtube.com/watch?v=eGG3EI4mwok>
- A video of the double-replacement reaction between calcium chloride and sodium phosphate can be viewed at <http://www.youtube.com/watch?v=aFFC6vtI-rY>
- A video of the double-replacement reaction between copper(II) sulfate and sodium sulfide can be viewed at <http://www.youtube.com/watch?v=KkKBDcFfZWo>
- A video of the double-replacement reaction between sodium sulfate and barium chloride can be viewed at <http://www.youtube.com/watch?v=XaMyfjYLhxU>

Formation of a gas:

- When metal carbonates are involved in a double-replacement reaction, the carbonate ion frequently breaks apart after the displacement and forms carbon dioxide. View an animation of this type of reaction at http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/DoubleDisp_Reaction-GasProduction.html .
- Watch a video experiment of a double-replacement reaction between a metal carbonate and an acid at <http://www.youtube.com/watch?v=TJYOxGHNTzg>
- Watch a video experiment of a double-replacement reaction between sodium bicarbonate and hydrochloric acid at <http://www.youtube.com/watch?v=xRfPvDEs2gM>
- Watch a video experiment that shows the production of ammonia gas from ammonium chloride and sodium hydroxide at <http://www.youtube.com/watch?v=LUEakMDNRsM>
- Watch a video experiment that shows the production of sulfurous acid from the double-replacement reaction between sodium sulfite and hydrochloric acid at <http://www.youtube.com/watch?v=BlpjKceHF3g>
- Watch a video experiment in which two gases undergo a double-replacement reaction to produce a solid at <http://www.youtube.com/watch?v=60vtFe42sGs>

Combustion reactions:

- View an in-depth explanation of the combustion reaction that occurs when you strike a match at <http://www.pbs.org/wgbh/nova/cigarette/onfire.html> .
- View an exciting video demonstration that confirms the importance of oxygen in a combustion reaction at http://education.jlab.org/frost/live_candle.html .
- View another video demonstration that confirms the importance of oxygen in a combustion reaction at <http://education.jlab.org/frost/combustion.html> .

Points to Consider

Balanced equations allow chemists to control reactions quantitatively. The coefficients in a balanced equation represent the ideal molar ratio for the reactants in the given reaction.

- How can a balanced chemical equation be used to calculate how much of a certain product will be formed in a reaction or how much of a certain reactant will be needed to perform the reaction?

References

1. (A) Nino Barbieri; (B) User:Nipik/Wikimedia Commons. (A) http://commons.wikimedia.org/wiki/File:Pollution_-_Damaged_by_acid_rain.jpg; (B) http://commons.wikimedia.org/wiki/File:Acid_rain_woods1.JPG . (A) CC BY 2.5; (B) Public Domain
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4. Paige Powers (Flickr:paigggeyy). <http://www.flickr.com/photos/paigggeyy/5533819494/> . CC BY 2.0
5. Courtesy of Gus Pasquerella/US Navy. http://commons.wikimedia.org/wiki/File:Hindenburg_burning.jpg . Public Domain