9-1 The Nature of Chemical Reactions
What are chemical reactions and why do they occur?

- A chemical reaction is a process in which one or more substances are converted into new substances with different physical and chemical properties.
  - Examples: Burning of gasoline, rusting of iron, ripening of bananas, tarnishing of silver.

- Reactions occur to produce a more stable arrangement of electrons in an atom, ion, or molecule.
Chemical Reactions

- All reactions involve two types of substances
  - Reactant – enters into the reaction
  - Product – comes out of the reaction
- Reactants change into products
The reason for reactions

- The arrangement of electrons in an atom determine whether it will bond with other atoms and which atoms it will bond with.
  - Full sets of valance electrons are needed.
  - Heat is often a factor in initiating reactions.
Indication of a Chemical Reaction

- Evolution of heat and light
  - A reaction can release energy as heat or light
  - Ex. Burning magnesium ribbon
  - The evolution of heat and light does not necessarily mean that a chemical reaction has occurred because many physical processes may also release energy.

http://viewpure.com/qSr39UwpELo

http://www.youtube.com/watch?v=meExn7ajUcg
Production of a gas

- Ex. Baking soda + vinegar
- Ex. Zn + 2HCl $\rightarrow$ ZnCl$_2$ + H$_2$

- [viewpure.com](http://viewpure.com/JmzBf3XGksOE)
- [youtube.com](http://www.youtube.com/watch?v=vD3uCRKPc0o)
Formation of a precipitate

- Occurs when a solid forms when two liquids are mixed
  - Ex. $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl} + \text{NaNO}_3(\text{aq})$

- [Viewpure](http://viewpure.com/DITY2rXYU-I)
- [YouTube Video](http://www.youtube.com/watch?v=DITY2rXYU-I)
9-2 Chemical Equations
Characteristics of Chemical Equations

- The equation must represent known facts
  - Show reactants and products
- The equation must contain the correct formulas for the reactants and products
  - Be sure to remember what elements are diatomic
- The law of conservation of mass is satisfied
  - Atoms are neither created nor destroyed in a chemical reaction
  - Remember to only balance with coefficients
Word Equations

- An equation in which the reactants and products are represented using words.
  - Zinc + Hydrochloric Acid $\rightarrow$ Zinc Chloride + Hydrogen
  - Do not give quantities of reactants and products

- The “plus” sign means reacts with, and the arrow means yields or produces

- Once you know the word equation, substitute the correct formulas
Formula Equations

- Represents the reactants and products in the equation with the chemical symbols and formulas.

\[ \text{Zn}(s) + 2\text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2(g) \]

- Be sure to include the state of matter if known
- Be sure to balance
Example

- Word Eq: calcium + oxygen → calcium oxide
- Formula Eq: \( \text{Ca} + \text{O}_2 \rightarrow \text{CaO} \)
- Balanced: \( 2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO} \)
Example

- magnesium + nitrogen $\rightarrow$ magnesium nitride
- Formula Eq: $\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$
- Balanced: $3\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$
Sample Problem

- Write the balanced equation for the following reaction: silver (I) nitrate reacts with copper to form copper(II) nitrate and silver

- AgNO$_3$ + Cu $\rightarrow$ Cu(NO$_3$)$_2$ + Ag
  - Notice this is not balanced yet

- 2AgNO$_3$ + Cu $\rightarrow$ Cu(NO$_3$)$_2$ + 2Ag
Balancing Chemical Equations (read pgs. 284-287)

1. Identify the names of the reactants and the products, and write the word equation
2. Write the formula equation by substituting correct formulas for the names of the reactants and products.
3. Balance the formula equation according to the law of conservation of mass

- Balance different types of atoms one at a time
- First balance atoms of elements that are combined and that appear only once on each side of the equation.
- Balance Polyatomic ions that appear on both sides of the equation as single units.
- Balance H atoms and O atoms after atoms of all other elements have been balanced.
Steps 4 and 5

4) Count atoms to be sure the equation is balanced

5) If you are unable to balance the equation, check to make sure the formulas are correct. This is the most common mistake
Example

- Ca + O\textsubscript{2} \rightarrow CaO
  - Start with calcium it is balanced
  - Go to oxygen next - need two on the right side
- Ca + O\textsubscript{2} \rightarrow 2CaO
  - Now oxygen is balanced but Ca is not
  - Balance the oxygen
- 2Ca + O\textsubscript{2} \rightarrow 2CaO
  - Remember only change coefficients
Write a complete chemical equation

- Write a balanced equation for the reaction in which iron(II) chloride reacts with sodium phosphate to produce sodium chloride and iron(II) phosphate

  - Unbalanced:
    - $\text{FeCl}_2 + \text{Na}_3\text{PO}_4 \rightarrow \text{NaCl} + \text{Fe}_3(\text{PO}_4)_2$

  - Balanced:
    - $3\text{FeCl}_2 + 2\text{Na}_3\text{PO}_4 \rightarrow 6\text{NaCl} + \text{Fe}_3(\text{PO}_4)_2$
Sample:

- Write a balanced equation for the reaction which aluminum reacts with oxygen to produce aluminum oxide.

- Unbalanced:
  - $\text{Al} + \text{O}_2 \rightarrow \text{Al}_2\text{O}_3$

- Balanced
  - $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$
Significance of a Chemical Equation

- The coefficients of a chemical reaction indicate relative, not absolute, amounts of reactants and products.
  - Reduce all coefficients

- The relative masses of the reactants and products of a chemical reaction can be determined from the reaction’s coefficients
  - Represent moles – we will do this in later chapters
There is some information that a chemical equation does not give

- Does not give an indication of whether a reaction will actually occur
- A chemical equation can be written for a reaction that may not take place.
- Does not give information about the speed of a reaction
- Does not tell about bonding changes during the reaction
9-3 Classifying Chemical Reactions
5 main types of reactions

- Direct Combination (synthesis)
- Decomposition Reaction
- Single Replacement
- Double Replacement
- Combustion
Direct Combination

- 2 or more substances reacting together to form a single product

\[ A + X \rightarrow AX \]

Examples

- \[ 2Na + Cl_2 \rightarrow 2NaCl \]
- \[ CO_2 + H_2O \rightarrow H_2CO_3 \]
- \[ 8 Fe + S_8 \rightarrow 8 FeS \]
Decomposition Reaction

- Single substance broken down into 2 or more smaller substances
- \[ AX \rightarrow A + X \]
- Energy is often added in order to decompose
  - Binary compound breaks down into its elements
  - Some reactions require heat
  - Electrolysis – decomposition of a substance by an electric current.
    - \[ 2\text{H}_2\text{O}(l) \rightarrow \text{O}_2(g) + 2\text{H}_2(g) \]
Single Displacement Reaction
(Replacement Reaction)

- 1 element replaces another in a compound
- \[ A + BX \rightarrow B + AX \]
- Example:
  - \[ \text{Al(s)} + \text{Pb(NO}_3\text{)}_2(\text{aq}) \rightarrow \text{Pb(s)} + \text{Al(NO}_3\text{)}_3(\text{aq}) \]
  - \[ \text{Fe(s)} + \text{HCl(aq)} \rightarrow \text{FeCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

- Note these are not balanced
Double Displacement Reaction

- 2 atoms or ions replace each other
- $AX + BY \rightarrow AY + BX$

Examples:

- $\text{BaBr}_2(\text{aq}) + \text{K}_2\text{SO}_4(\text{aq}) \rightarrow \text{KBr}(\text{aq}) + \text{BaSO}_4(\text{s})$
- $\text{FeS}(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{H}_2\text{S}(\text{g}) + \text{FeCl}_2(\text{aq})$
- $\text{Ca(OH)}_2(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$

- Note: these are not balanced
Combustion Reaction

- $O_2$ often involved in reaction
- Often produces a flame
- Hydrocarbons often involved
- $H_2O + CO_2$ often produced
  - $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$
Practice identifying the following

- AgNO\(_3\) + HCl $\rightarrow$ AgCl + HNO\(_3\)
  - Double Displacement

- Cu + AgNO\(_3\) $\rightarrow$ CuNO\(_3\) + Ag
  - Single Displacement

- Pb(OH)\(_2\) + H\(_2\)SO\(_4\) $\rightarrow$ PbSO\(_4\) + 2H\(_2\)O
  - Acid Base

- C\(_2\)H\(_4\) + 3O\(_2\) $\rightarrow$ 2CO\(_2\) + 2H\(_2\)O
  - Combustion Reaction