Chapter 8

Chemical Equations and Rxns

8.1

Describing Chemical rxns

Objectives

- **List** three observations that suggest that a chemical reaction has taken place.
- **List** three requirements for a correctly written chemical equation.
- **Write** a word equation and a formula equation for a given chemical reaction.
- **Balance** a formula equation by inspection.

Chemical Rxns

- A *chemical reaction* is the process by which one or more substances are changed into one or more different substances.
- In any chemical reaction, the original substances are known as the *reactants* and the resulting substances are known as the *products*.
- According to the law of conservation of mass, the total mass of reactants must equal the total mass of products for any given chemical reaction

Chem rxn

- Evidence of a chemical reaction (most of the time)
  - Change in color
  - Odor, gas, or bubbles may form.
  - NRG is released as heat or light
    - Temp change
  - Precipitate (ppt) is formed
    - **Ppt** is a solid that is produced as a result in a chemical rxn

Chemical Equation

- A **chemical equation** represents, with symbols and formulas, the identities and relative molecular or molar amounts of the reactants and products in a chemical reaction.
- Ex.

  H_2 (g) + O_2 (g) → H_2O (g)

Representing Chemical Reactions

- Chemists use statements called equations to represent chemical reactions.

Reactants are the starting substances.
Products are the substances formed in the reaction.
This table summarizes the symbols used in chemical equations.

Symbol	Purpose
+	Separates 2 or more reactant or products
→	Separate products and reactants
Double arrow	Reversible rxn
(s)	Solid State
(l)	Liquid State
(g)	Gas State
(aq)	Aqueous State

Representing Chemical Reactions

- In word equations,

aluminum (s) + bromine (l) → aluminum bromide (s)

reads as "solid aluminum and liquid bromine react to produce solid aluminum bromide".

- Skeleton equations use symbols and formulas to represent the reactants and products.

$$Al(s) + Br(l) \rightarrow AlBr_3(s)$$

Diatomics

- They start on 7
- There are 7
- They look like a 7… and H

- DON'T forget these
  - They are diatomics when by THEMSELVES and in the GAS state

Example

- H_2 (g) + O_2 (g) → H_2O (g)
- H_2 and O_2 are diatomics because they are…
  - By themselves
  - In the gas state (not Br or I)

- H_2O are NOT diatomics because they are NOT..
  - By themselves (i.e. in a cmpd)

Formula Equation

- A **formula equation** represents the reactants and products of a chemical reaction by their symbols or formulas
  - Ex. Hydrogen gas and oxygen gas react to produce dihydrogen monoxide gas (this is a word equation)
  - Ex. H_2 (g) + O_2 (g) → H_2O (g)

Balancing Chemical Reactions

- A coefficient in a chemical equation is the number written in front of a reactant or product, describing the lowest <u>whole-number</u> ratio of the amounts of all the reactants and products.
- The coefficients are in red

  Al (s) + Br_2 (g) --> $AlBr_3$ (s)

  2 Al (s) + 3 Br_2 (g) --> 2 $AlBr_3$ (s)

Question???

$Al (s) + Br_2 \rightarrow AlBr_3$

Why is it Br_2 and not just Br?

Why is the product $AlBr_3$ and not just AlBr?

How to Balance a Chem Equation

- Write the skeletal equation
  - Hydrogen gas and oxygen gas react to produce dihydrogen monoxide gas
  - **H_2 (g) + O_2 (g)** → H_2O (g)
- Count the atoms on the reactant side
  - 2 Hydrogen and 2 Oxygen

What did that mean??

- This is where you **MUST** remember the
  - Diatomics (H, N, O, F, Cl, Br, I)
  - The correct chemical symbols for elements
  - The correct chemical formula for a molecule or compound
  - Put the reactants on one side and the products on the other

How to Balance a Chem Equation

- Count the atoms on the products side
  - H_2 (g) + O_2 (g) → **H_2O (g)**
  - 2 hydrogens and 1 oxygen
- Change the coefficients to make both sides equal each other
  - **2** H_2 (g) + O_2 (g) →**2** H_2O (g)
  - 2 of each on both sides!

What did that mean??

- This is where you **MUST** remember the
  - Diatomics (H, N, O, F, Cl, Br, I)
  - The correct chemical symbols for elements
  - The correct chemical formula for a molecule or compound
  - Put the reactants on one side and the products on the other

- Reduce coefficents
  - If possible (usually not)
- Double check work
  - ALWAYS do this!

What does that mean???

- This is where you…
  - Reduce your coefficients
    - 2 r + 2 t --> 4 rt
    - Reduces to r + t --> 2 rt
  - Double check, it is the only way to make sure you did it correctly
- <u>This is usually a trial and error process</u>

One thing to remember…

Subscripts can

NOT

be added or subtracted

Practice

- Liquid water decomposes into hydrogen gas and oxygen gas
- Solid sodium oxide reacts with liquid iron (III) sulfate to produce solid iron (III) oxide and liquid sodium sulfate.
- Lithium nitride reacts with oxygen gas to produce lithium oxide and nitrogen gas (HARD)

Practice

- Page 254
  - 1a
  - 2a
  - 3 (nitrogen gas)

Why is a chem equation important?

- They indicate the relative amount of reactants and products

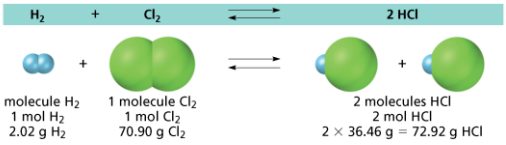
- $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$
- There are…
  - 2 molecules of hydrogen
  - 1 molecule of oxygen
  - 2 molecules of water

Why is a chem equation important?

- The relative masses can be determined
- $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$
  - i.e. convert moles to grams
    - Hydrogen = 4.04 g
    - Oxygen = 32 g
    - Water = 36.04 g

Why is a chem equation important?

- The reverse rxn for a chem equation has the same relative amount of substances as the forward rxn
  - **Reversible rxn** is a chemical rxn where the product re-form the reactant
    - It goes in reverse while going forward!



What a chem equation does NOT do

- An equation gives no indication of whether a reaction will actually occur.
- Chemical equations give no information about the speed at which reactions occur.
- Equations do not give any information about how the bonding between atoms or ions changes during the reaction.

Hydrogen and oxygen gases react to form liquid water

1. H (g) + O (g) --> H_2O (l)
2. 2 H (g) + O (g) --> H_2O (l)
3. H_2 (g) + O_2 (g) --> 2 H_2O (l)
4. 2 H_2 (g) + O_2 (g) --> 2 H_2O (l)
5. None of the above

You can change coefficients when writing a chemical equation.

1. True
2. False

Which of the following is balanced properly?

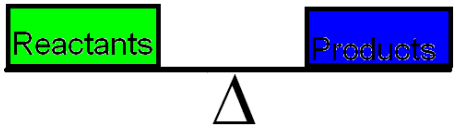
1. Cl_2 + 2 H --> 2 HCl
2. 4 H_2O --> 4 H_2 + 2 O_2
3. 2 SO_2 + O_2 --> 2 SO_3
4. Na + Cl --> NaCl
5. All of the above
6. None of the above

Which of the following is balanced properly?

1. $NaCl_2$ --> Na + Cl_2
2. H_2 + O_2 --> H_2O
3. 2 Al + 2 Br_2 --> 2 $AlBr_3$
4. NaOH --> Na + 2 OH
5. All of the above
6. None of the above

Homework

- Page 260
  - 2, 5
- Word to formula and vise versa worksheet



8.2

Types of Chemical Rxns

Which of the following is balanced properly?

1. $NaCl_2$ --> Na + Cl_2
2. 2 H_2 + O_2 --> 2 H_2O
3. 2 Al + 2 Br_2 --> 2 $AlBr_3$
4. NaOH --> Na + 2 OH
5. All of the above
6. None of the above

Which is balanced properly?

1. Na (s) + Cl (g) --> NaCl (s)
2. 2 Na (s) + 2 Cl (g) --> 2 NaCl (s)
3. Both
4. Neither

Objectives

- **Define** and **give** general equations for synthesis, decomposition, single-displacement, and double-displacement reactions.
- **Classify** a reaction as a synthesis, decomposition, single-displacement, double-displacement, or combustion reaction.
- **List** three kinds of synthesis reactions and six kinds of decomposition reactions.

Objectives (Cont)

- **List** four kinds of single-displacement reactions and three kinds of double-displacement reactions.
- **Predict** the products of simple reactions given the reactants.

Rxn Types

- 5 rxn types
  - Synthesis
  - Decomposition
  - Single Displacement (replacement)
  - Double Displacement (replacement)
  - Combustion

Synthesis

- In a **synthesis reaction,** also known as a composition reaction, two or more substances combine to form a new compound
- General Equation

  $A + X \rightarrow AX$
- A and X can be elements or compounds.
- AX is a compound

Synthesis Reaction

- A synthesis reaction can be:
  - 2 elements forming 1 compound
  - 1 element and 1 compound forming 1 compound
  - 2 compound forming 1 compound

$$A + X \text{ --> } AX$$

Rxns with O and S

- Almost all metals react with oxygen to form *oxides*
- Example

  $2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)$

- Group 1 and 2 metal react with sulfur to produce *sulfides*

  $16Rb(s) + S_8(s) \rightarrow 8Rb_2S(s)$

  $8Ba(s) + S_8(s) \rightarrow 8BaS(s)$

Active Metals

- Active metals are highly reactive
- These metals react with water to produce metal hydroxides

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

Synthesis Practice

- Rxn between…
  - H and O
  - Li and O
  - BeO and water
  - Aluminum oxide and water

Decomposition Rxns

- In a **decomposition reaction,** a single compound undergoes a reaction that produces two or more simpler substances.
- These are the <u>opposite</u> of synthesis rxns
- General Equation

$$AX \rightarrow A + X$$

Decmop (cont)

- The decomposition of a substance by an electric current is called **electrolysis.**
- Example

$$2H_2O\ (l) \xrightarrow{\text{electricity}} 2H_2\ (g) + O_2\ (g)$$

- Example (when heated)

$$2HgO(s) \xrightarrow{\Delta} 2\ Hg\ (l) + O_2\ (g)$$

Special Decomp rxns

- Decomp of Metal Carbonates
  - Produces metal oxide and carbon dioxide

$$CaCO_3\ (s) \xrightarrow{\Delta} CaO\ (s) + CO_2\ (g)$$

- Decmop of Metal Hydroxides
  - Produce metal oxide and water (except G1)

$$Ca(OH)_2\ (s) \xrightarrow{\Delta} CaO\ (s) + H_2O\ (g)$$

Special Decomp rxns

- Decmop of Metal Chlorates
  - Produce metal chloride and oxygen

$$2KClO_3\,(s) \xrightarrow[MgO_2\,(s)]{\Delta} 2KCl\,(s) + 3O_2\,(g)$$

Decomp Practice

- NaOH
- Water
- Li_2CO_3
- $Ca(ClO_3)_2$

Single-Displacment Rxn

- In a **single-displacement reaction,** also known as a replacement reaction, one element replaces a similar element in a compound.
- Most of these rxns happen in aqueous solutions
- General Equation

$A + BX \rightarrow AX + B$

$Y + BX \rightarrow BY + X$

Special SR Rxns

- Active metals (G1) in water
  - Produce metal hydroxide and hydrogen

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

- Less active metals in water (steam)
  - Produce metal oxide and hydrogen

$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

Replacement Reactions

- In replacement reactions, non-metals replace non-metals and metals replace metals

Which will switch?

$CaBr_2 + Cl_2$ -->

$KCl + Al$ -->

$K + NaCl$ -->

$F_2 + MgI_2$ -->

$MgO + Ca$ -->

Double Displacement Rxns

- In **double-displacement reactions,** the ions of two compounds exchange places in an aqueous solution to form two new compounds.
- One of the following are usually formed
  - Bubbles (gas)
  - Ppt
  - Water (hard to see this one)
- The other cmpd is usually soluble and stay in the solution

DD Rxns

- General equation
- AX + BY → AY + BX
- Example (ppt formation)

$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

- Where is the ppt?

Replacement Reactions

- Either you can look at it as the METALS switch places OR the NON-METALS switch places
- Again, the **metals** switch with each other or the **non-metals** switch with each other

A switches with B or X switches with Y

DD Rxns

- Gas formation

$FeS(s) + 2HCl(aq) \rightarrow H_2S(g) + FeCl_2(aq)$

- Water formation

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

DD Practice

- $CaO + Li_3P \rightarrow$
- $Fe(OH)_2 + Li_3P \rightarrow$

Combustion

- In a **combustion reaction,** a substance combines with oxygen, releasing a large amount of energy in the form of light and heat.
- Example (with H)

  $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

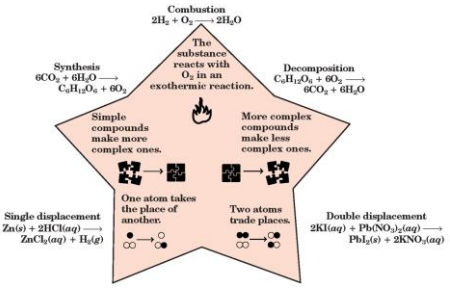
- Example (Propane)

  $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g$

Determining Rxn Type

- Synthesis =
- Decomp =
- SR =
- DD =
- Combustion =

Determining Rxn Type



Which of the following is a single replacement rxn?

1. $2\ H_2\ + O_2$ --> $2\ H_2O$
2. 2NaCl --> 2Na + Cl_2
3. Al + 3ZnCl --> 3 Zn + $AlCl_3$
4. NaCl + $AgNO_3$ --> $NaNO_3$ + AgCl
5. More than 1
6. None of the above

Which of the following is a synthesis rxn?

1. $2\ H_2\ + O_2$ --> $2\ H_2O$
2. 2NaCl --> 2Na + Cl_2
3. Al + 3ZnCl --> 3 Zn + $AlCl_3$
4. NaCl + $AgNO_3$ --> $NaNO_3$ + AgCl
5. More than 1
6. None of the above

A precipitate is a…

1. Solid
2. Liquid
3. Gas
4. More than 1
5. None of the above

Assignment

- 8.2 Worksheet
- 8.2 Practice Problem
- Page 270
  - 1-4

Activity Series of the Elements

8.3

Objectives

- Explain the significance of an activity series.
- Use an activity series to predict whether a given reaction will occur and what the products will be.

Activity Series of the Elements

- "Activity" is used when discussing an elements ability to react
  - More reactive = higher activity
- An **activity series** is a list of elements organized according to the ease with which the elements undergo certain chemical reactions.
  - For metals, greater activity means a greater ease of *loss* of electrons, to form positive ions.
  - For nonmetals, greater activity means a greater ease of *gain* of electrons, to form negative ions.

Replacement Reactions

- A metal will not always replace a metal in a compound dissolved in water because of differing reactivities.
- An activity series can be used to predict if reactions will occur.
- Activity Series Handout
  - Second Ca→ Na

Replacement Reactions

- If the element is higher on the activity series, it will replace the lower element
  - Ex. Zn **will** replace Cu
    Mg will **not** replace K
- Some other rules also apply
  - See Activity Series
- The Halogens are also on the Series list

Replacement Reactions

- In replacement reactions, non-metals replace non-metals and metals replace metals

Which will switch?

$CaBr_2 + Cl_2$ -->

KCl + Al -->

K + NaCl -->

$F_2 + MgI_2$ -->

MgO + Ca -->

Single Replacement Reactions

1. Will the reaction occur?
   * Look at the Activity Series
2. Write out the skeleton equation.
3. Balance the equation.

Assignment

- Activity Series Wkst
- Page 273
  - 1-3