Unit 6 - Chemical Reactions

1. Parts of a Chemical Reaction
2. Indicators of a Chemical Reaction
3. Enthalpy
4. Balancing Chemical Equations
5. Word Equations
6. Classifying Chemical Reactions
7. Predicting Products

1. Parts of Chemical Reactions

- Can you think of any chemical reactions that occur naturally?
- Photosynthesis
- Respiration
- Corrosion
- Acid Rain
- Fermentation
- Combustion

How to read a chemical equation

$$\underset{\text{reactants}}{2\,H_2(g) + O_2(g)} \rightarrow \underset{\text{products}}{2\,H_2O(g)}$$

- Reactants are on the left and products are on the right
- Subscripts tell how many atoms of each type of element are in the substance
- Coefficients show how many particles of each type of substance are needed for the reaction to take place
- "→" reaction taking place
- "+" is used to separate reactant (and product) substances from each other

Subscripts: $H_2O = H_2O_1$

A water molecule is made up of two hydrogens and one oxygen

Coefficients: $3H_2O$

There are three water molecules

Abbreviations of State

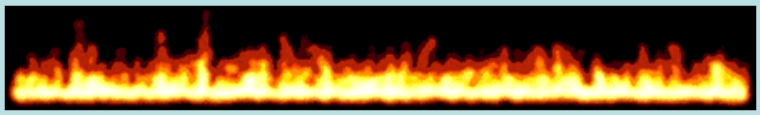
- (g) gas
- (l) liquid
- (s) solid
- (aq) aqueous – a substance dissolved in water

2. Indicators of Chemical Rxns

- evolution of a gas
- $Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$
- change in colour
- $FeCl_{3(aq)} + 3KSCN_{(aq)} \longrightarrow Fe(SCN)_{3(aq)} + 3KCl_{(aq)}$
- formation of a solid
- $Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \longrightarrow PbI_{2(s)} + 2KNO_{3(aq)}$
- odour
- $FeS_{(s)} + 2HCl_{(aq)} \longrightarrow H_2S_{(g)} + FeCl_{2(aq)}$
- temperature change in the surroundings
- $NH_4SCN + Ba(OH)_2 + \text{energy} \longrightarrow$
- $NH_3 + H_2O + Ba(SCN)_2$

14 KMnO4 + 4 C3H5(OH)3 --> 7 K2CO3 + 7 Mn2O3 + 5 CO2 + 16 H2O + HEAT

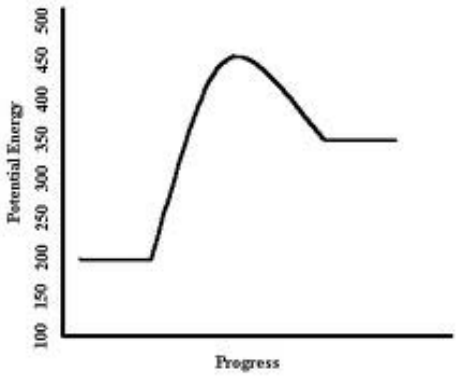
3. Enthalpy



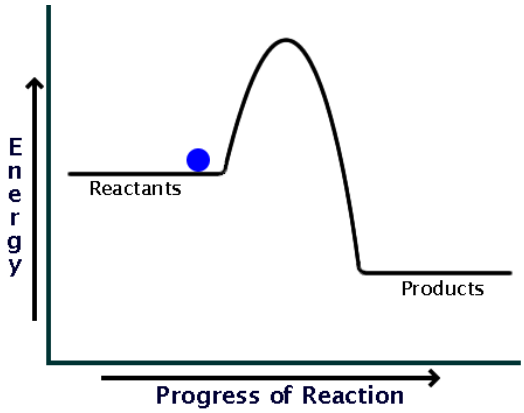
Energy Changes in Reactions

- When a chemical reaction occurs, energy (in the form of heat) must be absorbed in order for reactant bonds to break
- Once reactant bonds are broken, product bonds form and energy is released
- 2 outcomes:
- The amount absorbed is more than the amount released = heat is needed for reaction
- The amount released is more than the amount absorbed = heat is given off in the reaction

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibcsl_1/int/bonds/0911.html



Energy needed (absorbed) for this reaction -called an ENDOTHERMIC reaction



Energy released for this reaction -called an EXOTHERMIC reaction

Enthalpy (heat of reaction) H

- The change in Enthalpy (ΔH) is the energy difference between the reactants and the products, found by
- Product Energy – Reactant Energy
- **For an Endothermic reaction**:
- product energy - reactant energy = positive #, so ΔH is positive
- **For an Exothermic reaction**:
- product energy - reactant energy = negative #, so ΔH is a negative

Endothermic Reaction

- Endothermic reaction-a reaction in which heat is absorbed
- The products are higher in energy than the reactants

- $2NH_4SCN_{(s)} + Ba(OH)_{2(s)} \rightarrow Ba(SCN)_{2(aq)} + 2H_2O + 2NH_{3(l)}$
- Is heat a product or a reactant (Was the reaction warmer before or after the reaction?)

- $heat + 2NH_4SCN_{(s)} + Ba(OH)_{2(s)} \rightarrow Ba(SCN)_{2(aq)} + 2H_2O + 2NH_{3(l)}$

Exothermic Reaction

- Exothermic reaction-a reaction in which heat is released
- The products are lower in energy than the reactants
- $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$
- http://www.youtube.com/watch?v=OFG4Yr7lQzw
- 
- Is heat a product or a reactant (Was the reaction warmer before or after the reaction?)
- $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)} + \text{heat}$

Summary

- There are two ways to show an endothermic reaction in a chemical equation:
- $2N_2 + O_2 + 58kJ \Longrightarrow 2N_2O$

- $2N_2 + O_2 \Longrightarrow 2N_2O$
  $\Delta H = +58kJ$

- There are two ways to show an exothermic reaction in a chemical equation:

1. $CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O + 102kJ$

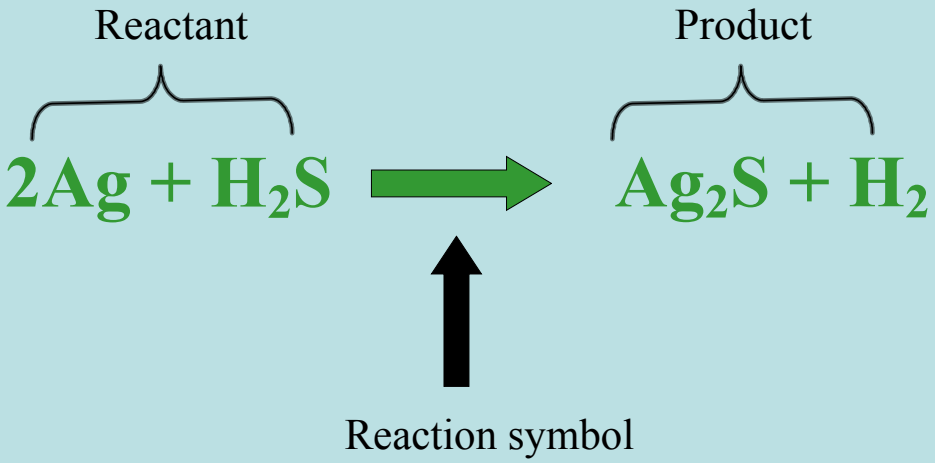
2. $CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O$
   $\Delta H = -102kJ$

http://www.kentchemistry.com/links/Energy/HeatConversions.htm

HOMEWORK:
Hebden p.121-122 #70-80

4. Balancing Chemical Equations

Parts of an Equation:



Reactant

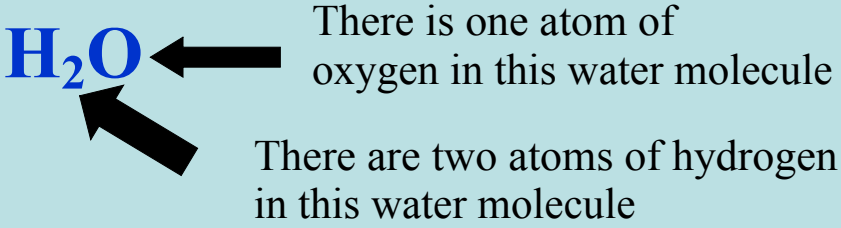
- The chemical(s) you start with before the reaction.

Product

- The new chemical(s) formed by the reaction.

Subscript

- In a chemical equation, the number that shows how many atoms of an element are in a specific molecule.



Coefficient

- In a chemical equation, the number that shows how many molecules there are of this chemical.

$3\ H_2O$

There are three molecules of water

A balanced chemical equation has the same number of atoms on both sides of the equation.

$4Al + 3O_2 \rightarrow 2Al_2O_3$

4 Aluminum
6 Oxygen

4 Aluminum
6 Oxygen

Balancing Rules

- Matter can never be created nor destroyed.
- A *subscript* can *never* be added, removed or changed.
- You may change *only* the *coefficients* in the equation.
- You must end up with the same *number and type of atoms* on the reactant and product sides of the equation.
- Generally, balance main elements first, then try hydrogens, then try oxygens

** Balancing Demo

$$H_2 + O_2 \rightarrow H_2O$$

	Reactants	Products
Hydrogen		
Oxygen		

You try! – use a tally if needed!

$$C + O_2 \rightarrow CO_2$$

$$Fe + O_2 \rightarrow Fe$$

$$N_2O \rightarrow N_2 + O_2$$

$$Fe + O_2 \rightarrow Fe_2O_3$$

You try! – use a tally if needed!

$1C + 1O_2 \rightarrow 1\ CO_2$

Already balanced! Write in "1's" or write the word "Balanced"

$2\ Fe + O_2 \rightarrow 2\ Fe$

$2N_2O \rightarrow 2N_2 + O_2$

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Balance this…

$C_4H_{10} + O_2 \Longrightarrow CO_2 + H_2O$

$C_4H_{10} + O_2 \quad 4CO_2 + H_2O$

$C_4H_{10} + O_2 \quad 4CO_2 + 5H_2O$

$C_4H_{10} + 6.5O_2 \quad 4CO_2 + 5H_2O$

But we can't have a decimal coefficient so multiply by 2

$2C_4H_{10} + 13O_2 \quad 8CO_2 + 10H_2O$

Polyatomic Ions

- If you have the same polyatomic ion on both sides of the equation, balance the whole polyatomic rather than each element in the polyatomic….see below

$Na_2SO_4 + Al(NO_3)_3 \Rightarrow NaNO_3 + Al_2(SO_4)_3$

$3Na_2SO_4 + Al(NO_3)_3 \Rightarrow NaNO_3 + Al_2(SO_4)_3$

$3Na_2SO_4 + Al(NO_3)_3 \Rightarrow 6NaNO_3 + Al_2(SO_4)_3$

$3Na_2SO_4 + 2Al(NO_3)_3 \Rightarrow 6NaNO_3 + Al_2(SO_4)_3$

PRACTICE PROBLEMS
BALANCING CHEMICAL EQUATIONS

Balance the following chemical equations. The answers are found on the next slide.

1. __$Na_2SO_4(aq)$ + __$BaCl_2(aq)$ → __$BaSO_4(s)$ + __$NaCl(aq)$

2. __$Al(s)$ + __$H_2SO_4(aq)$ →__$Al_2(SO_4)_3(aq)$ + __$H_2(g)$

3. __$NO_2(g)$ + __$H_2O(l)$ + __$O_2(g)$ → __$HNO_3(aq)$

4. __$Al(s)$ + __$HCl(aq)$ → __$AlCl_3(aq)$ + __$H_2(g)$

5. __$C_3H_8(g)$ + __$O_2(g)$ → __$CO_2(g)$ + __$H_2O(g)$

BALANCING CHEMICAL EQUATIONS

Answers

1. __$Na_2SO_4(aq)$ +__$BaCl_2(aq)$ → _$BaSO_4(s)$ + _2_$NaCl(aq)$

2. _2_$Al(s)$ + _3_$H_2SO_4(aq)$ → __$Al_2(SO_4)_3(aq)$ + _3_$H_2(g)$

3. _4_$NO_2(g)$ + _2_$H_2O(l)$ + __$O_2(g)$ → _4_$HNO_3(aq)$

4. _2_$Al(s)$ + _6_$HCl(aq)$ → _2_$AlCl_3(aq)$ + _3_$H_2(g)$

5. __$C_3H_8(g)$ + _5_$O_2(g)$ → _3_$CO_2(g)$ + _4_$H_2O(g)$

HOMEWORK:

Balancing Chemical Equations I Worksheet

5. Word Equations

- we must be able to build balanced formula equations from word equations
- hints: keep in mind that seven elements naturally occur as diatomic molecules:
- H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2
- acids can be found on the back of periodic table
- ammonia is the common name for NH_3
- yields is another word for produces

Example

hydrogen and nitrogen yields ammonia

$$H_2 + N_2 \longrightarrow NH_3$$

Now balance:

$$\mathbf{3}H_2 + N_2 \longrightarrow \mathbf{2}NH_3$$

Another…

aluminum sulphate + phosphoric acid yields aluminum phosphate + sulfuric acid

$$Al_2(SO_4)_3 + H_3PO_4 \Longrightarrow AlPO_4 + H_2SO_4$$

Balance…

$$Al_2(SO_4)_3 + 2H_3PO_4 \Longrightarrow 2AlPO_4 + 3H_2SO_4$$

HOMEWORK:

Balancing Chemical Equations II Worksheet

6. Classifying Chemical Reactions

http://www.youtube.com/watch?v=tE4668aarck

Classifying Types of Chemical Reactions

Reaction type	General form
synthesis (or combination)	$A + B \rightarrow AB$
decomposition	$AB \rightarrow A + B$
single replacement	$AB + C \rightarrow CB + A$
double replacement	$AB + CD \rightarrow CB + AD$
acid–base neutralization	$H\text{-}X + B\text{-}OH \rightarrow BX + HOH$
combustion (of hydrocarbons)	$C_xH_y + O_2 \rightarrow CO_2 + H_2O$

Six types of chemical reactions.

- Classified according to patterns of reactants & products
- Study pattern to predict products

- **Synthesis** – combining 2 (or more) substances into 1
  - can start with elements or compounds
  - follow rules for writing formulas for product

http://www.youtube.com/watch?v=Ftw7a5ccubs

E.g. $2Na + Cl_2 \rightarrow 2NaCl$

http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/Synthesis.html

2. **Decomposition** – 1 substance breaking down into 2 (or more)
   - products are elements or simpler compounds

E.g. $2H_2O \rightarrow 2H_2 + O_2$

- **Single Replacement** – element reacts with compound
  - single element replaces one element in compound
  - metal replaces metal, non-metal replaces non-metal

e.g. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$

http://www.dlt.ncssm.edu/core/Chapter5-Moles-Molarity-Reaction_Types/Chapter5-Animations/SingleDisp_Reaction-MetalToMetal.html

- **Double Replacement** – 2 compounds switch partners
  - 2 elements replace each other
  - new compounds will be ionic (+ ion/-ion)
  - follow formula writing rules

e.g. $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

- **Acid-Base Neutralization**
  (special kind of Double Replacement)
  H^+ from acid and OH^- from base neutralize to form H_2O

Acid + Base → Salt + Water

e.g. **H**Br + Li**OH** → LiBr + **HOH**
(H_2O)

- **Combustion** - burning of hydrocarbons
  - ***always*** requires oxygen gas
  - products are ***always*** CO_2 and H_2O

e.g. CH_4 + $2O_2$ → CO_2 + $2H_2O$

HOMEWORK:

Classifying Reactions Worksheet

http://www.kentchemistry.com/links/Math/TypreofChemicalRxns.htm

5 videos below

7. Predicting Products of Chemical Reactions

- We have many tools in our tool belt.
- We can: make formulas from names
- balance equations
- give reaction types for different reactions
- Now we'll use these tools to build reactions and predict the products!

Predict the products:

$Ca(OH)_2 + Al_2(SO_4)_3 \longrightarrow$?

Step 1: Determine the reaction type using only the reactants.
i.e. Is this synthesis, decomposition, single replacement, double replacement, neutralization, combustion?

The reactants are both compounds, but there is no acid present, therefore the type is…..

DOUBLE REPLACEMENT!

Step 2: Build the products using ion charges

$$Ca(OH)_2 + Al_2(SO_4)_3 \longrightarrow CaSO_4 + Al(OH)_3$$

Step 3: Balance the equation

$$3Ca(OH)_2 + Al_2(SO_4)_3 \longrightarrow 3CaSO_4 + 2Al(OH)_3$$

Try these…(use the 3 steps)

- $2H_2 + O_2 \Longrightarrow$
- $2NaCl \Longrightarrow$
- $2C_2H_2 + 5O_2 \Longrightarrow$
- $H_2SO_4 + 2NaOH \Longrightarrow$

Try these...(use the 3 steps)

- $2H_2 + O_2 \Longrightarrow 2H_2O$
- $2NaCl \Longrightarrow 2Na + Cl_2$
- $2C_2H_2 + 5O_2 \Longrightarrow 4CO_2 + 2H_2O$
- $H_2SO_4 + 2NaOH \Longrightarrow 2H_2O + Na_2SO_4$

Predicting Single Replacement

- If you have reactants composed of a single element reacting with a compound, you most likely have a single replacement reaction
- There are two outcomes to a single replacement reaction:
- The reaction proceeds as you would predict
- The reaction will not occur

- Some elements are more reactive than others
- If a more reactive element is replacing a less reactive element in a compound, the reaction **WILL** proceed
- If a less reactive element is attempting to replace a more reactive element in a compound, the reaction **WILL NOT** occur
- We have a reactivity list called an ACTIVITY SERIES

Activity Series

Metals

- Lithium - most active
- Potassium
- Calcium
- Sodium
- Magnesium
- Aluminum
- Zinc
- Chromium
- Iron
- Nickel
- Tin
- Lead
- Hydrogen
- Copper
- Silver
- Mercury
- Platinum
- Gold - least active

Nonmetals

- Fluorine
- Chlorine
- Bromine
- Iodine

An element higher on the list will replace an element lower on the list in a single replacement reaction. NOTE: separate lists for metals & non-metals

- $Al + NiCl_2 \Longrightarrow$
- $Pb + LiBr \Longrightarrow$
- $F_2 + CaCl_2 \Longrightarrow$

$Br_2 + AlCl_3 \Longrightarrow$

Try these...

- $2Al + 3NiCl_2 \Longrightarrow 2AlCl_3 + 3Ni$
- $Pb + LiBr \Longrightarrow$ no rxn

$F_2 + CaCl_2 \Longrightarrow Cl_2 + CaF_2$

$Br_2 + AlCl_3 \Longrightarrow$ no rxn

HOMEWORK:

1. Classifying & Predicting Worksheet
2. Activity Series Worksheet