EXAM III Material

PART 1 SOLUTION CHEMISTRY

I. Solutions are homogeneous mixtures of two or more substances

II. Components of a solution:

A solution is a mixture of a ___________ that gets dissolved and a ___________ that does the dissolving

Solute particles
Ions, atoms or small molecules with a diameter less than 1 nm or .000000001m
Solute particles are evenly dispersed in the solvent

Suspensions are mixtures similar to solutions but the particles are not considered dissolved, they are dispersed. The dispersed particles are larger than 1nm in size and can be large molecules or clumped together ions.

III, Properities of a solution:

A. Solutions are homogeneous and variable in composition.

B. Solutions may be colored or colorless but are usually transparent.

C. The solute can be molecular or ionic and is <u>dissolved</u> in the solvent.

Examples of solutions

Solute	Solvent solid	Liquid	gas
Solid			
Liquid			
Gas			

III. Solubility:

The amount of solute that dissolves in a given amount of solvent at a given T^{o} and Pressure

A. In: $\frac{\text{g solute}}{\text{100 g solvent}}$

B. Past solubility → Additional solute will not dissolve
ex.

C. Concentration of solutions

1) Dilute solutions contain a relatively small amount of solute.

2) Concentrated solutions contain a relatively large amount of solute.

D. Solubility terms for **solids** as the solute

1) Unsaturated solutions: A solution that contains less solute than it's solubility limit

2) Saturated solutions: A solution that contains the maximum amount of solute.

3) Supersaturated Solution - A solution that has been prepared to hold more solute than its solubility limit

4) Saturated, Unsaturated, or supersaturated?

E. Solubility terms for **liquids** as the solute

1) Miscible - 2 liquids that form a solution in all proportions

2) Immiscible - 2 liquids that do not form a solution

3) Partially miscible - 2 liquids that forms a solution in limited proportions

F. Factors that Effect Dissolving Rate

1) Particle size
Smaller crystals will have a larger surface to volume ratio. Therefore, smaller crystals will dissolve faster due to the increased solute-solvent contact.

2) Temperature

Solids

At higher temperatures solvent molecules possses more kinetic energy (more movement). At higher temperatures solvent molecules will hit the crystal surfaces with more force and frequency.

3) Stirring/Agitation

Stirring/Agitation increases the solute - solvent contact.

G. Factors that Effect Solubility

1) Temperature

In general, the solubility of solids increases with increasing temperature

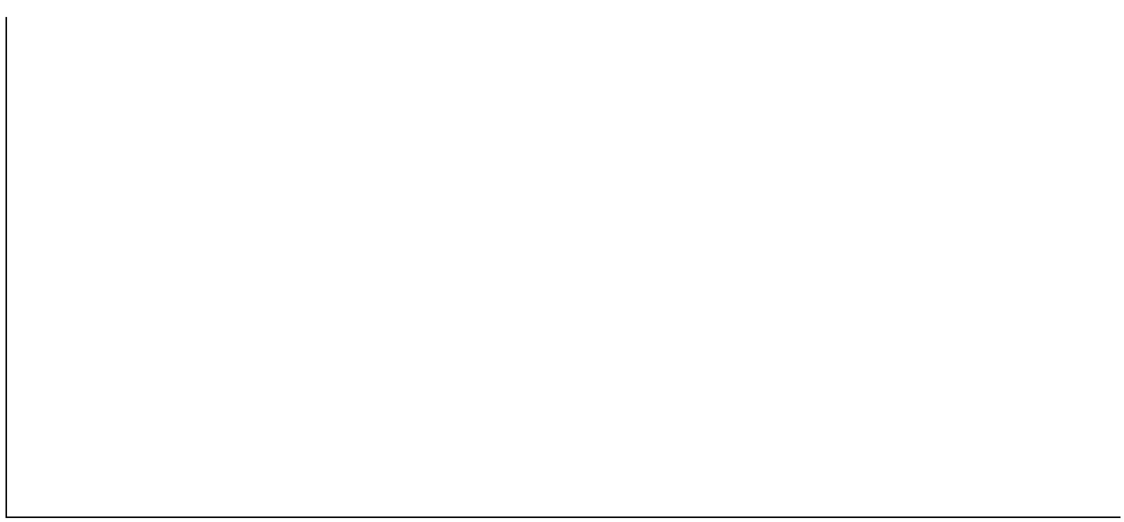
The solubility of gases decreases with increasing temperature

2) Pressure (gases)

The solubility of gases increases with increasing pressure.

3) Nature of the Solute/Solvent

H. Solubility curves



IV. Solution Formation

A. Molecular polarity (background)

1. Background

2. Electronegativity- The measure of the attractive force that an atom of an element has for its shared electrons.

3. Bond Polarity

4. Molecular polarity - net polarity of molecules
    a. Draw individual bond polarities, using relative electronegativity trends
    b. Find the net molecular polarity-using vector analysis by inspection.
    c. If there is a net polarity-the molecule is polar and has a **DIPOLE**!

B. Intramolecular (particle) forcesReview

The attractive forces within a molecule

C. Intermolecular (particle) forces Review

The attractive forces between molecules/paricles.

Types

1. Dipole-Dipole interaction:

Dipole - dipole interactions are electrostatic attractions between polar molecules

2. Hydrogen bonds:

A hydrogen bond is a relatively strong dipole-dipole attractive force between a hydrogen atom and a pair of nonbonding electrons on a F,O, or N atom

3. London forces

London forces are very weak electrostatic forces of attraction between molecules with "temporary" dipoles.

D. Solution Formation

Rule of thumb: Like dissolves like

Dissolved Ions

E. Solubility and the nature of the solvent and solute

"Like" dissolves "like"

1. Polar or ionic substances are more soluble in polar solvents

2. Nonpolar substances are more soluble in nonpolar solvents

SOLUBILITY RULES FOR IONIC COMPOUNDS

Ion contained in the Compound	Solubility	Exceptions
Group IA	soluble	
NH_4^+	soluble	
$C_2H_3O_2^-$	soluble	
NO_3^-	soluble	
Cl^-, Br^-, and I^-	soluble	Ag^+, Pb^{2+}, Hg_2^{2+}
SO_4^{2-}	soluble	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
CO_3^{2-}, PO_4^{3-}, CrO_4^{2-}	insoluble	group IA and NH_4^+
S^{2-}	insoluble	group IA, IIA, and NH_4^+
OH^-	insoluble	group IA, Ca^{2+}, Ba^{2+}, Sr^{2+}

STRONG BASES	
LiOH	CsOH
KOH	$Sr(OH)_2$
RbOH	$Ba(OH)_2$
NaOH	All of these are
$Ca(OH)_2$	soluble

STRONG ACIDS	
HNO_3	HCl
$HClO_4$	HBr
H_2SO_4	HI
	All of these are soluble

Soluble or insoluble?

Solute	Soluble	Insoluble
Na_2S		
FeS		
LiOH		
$C_6H_{12}O_6$ (polar)		
K_2CrO_4		
HCl		
$PbSO_4$		
$PbCO_3$		
AgCl		
$Mn(OH)_3$		
CH_2Cl_2 (nonpolar)		

V. Concentrations

A. Percent solute

1. % by weight

2. % by volume

3. Wt-Vol %

What is the %concentration (m/m)   if 25 grams of NaCl are dissolved in 125 grams of water?

Find the % concentration (m/v) of $FeCl_2$ solution that contains 25 grams of the solute dissolved in enough water to make 400ml of solution.

How many grams of sucrose are dissolved in 250 gram solution that has a concentration of 42% (m/m) sucrose?

How many ml of alcohol are needed to make 125 ml of a 6.0 % (v/v) solution of alcohol in water

B. Molarity = $\frac{\text{moles solute}}{\text{Liters solution}}$

Problem: What is the molar concentration of a solution that has 10.3 g of sodium bromide in 251 mL of solution?

Solution Concentration Problems

1. How many grams of NaCl is in 51 ml of a 2.0 M solution

3. What is the volume of a solution if 311 g KBr are used to make a 5.4 M KBr solution?

Part 2 ACIDS/BASES/SALTS & ELECTROLYTES

I. ACIDS AND BASES

A. Acidic Characteristics

1. Tart/Sour taste
2. Produces color changes with indicators
3. Will react with and neutralize a base to form water
4. Will react with certain metals with H_2 as a product

B. Basic Characteristics → Ionic Compounds that contains OH-

1. Bitter taste
2. Slippery feeling
3. Produces color changes with indicatiors
4. Will neutralize an acid to form water
5. Will form a precipitate (ppt) with certain cations

C. Definitions of Acids and Bases

Arrhenius Acid → A substance that INCREASES the concentration of H^+ in water
ex.

Arrehenius base → A substance that INCREASES the concentration of OH^- in water
ex.

D. Acid-Base reaction

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

E. Salts- A salt is produced in an acid-base reaction.

$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O$

Acid + Base → Salt + H_2O

How to recognize:
A salt is an ionic compound that does not contain OH^- and is not a metal oxide

HCl(aq)	NaBr	$Zn(C_2H_3O_2)_2$	KOH
$Sn(OH)_2$	HClO(aq)	$HC_6H_6O_2$(aq)	$AgHSO_4$

F. Strength of Acids and Bases

Strong Acids

$HCl + H_2O \rightarrow$

Weak Acids

$HC_2H_3O_2 + H_2O \rightarrow$

Strong Bases

$NaOH + H_2O \rightarrow$

Weak Bases

$NH_3 + H_2O \rightarrow$

STRONG BASES

LiOH	NaOH
KOH	RbOH
CsOH	$Sr(OH)_2$
$Ba(OH)_2$	$Ca(OH)_2$

STRONG ACIDS

HNO_3	H_2SO_4
$HClO_4$	HCl
HBr	HI

G. Autoionization of water

Experiments have shown that a very small percentage of water will undergo the following ionization to produce ions:

$$H_2O + H_2O \rightarrow H_3O^+ + OH^-$$

Experimentally, it was determined that the product between the molar concentraions of the hydronium ion and hydroxide ion is a constant:

$$[H_3O^+] \times [OH^-] = 10^{-14}$$ ← ion product for water (constant)

or $[H^+] \times [OH^-] = 10^{-14}$ as an abbreviation

Therefore, **in pure water**, $[H_3O^+] = [OH^-] = 10^{-7}$

$[H^+] = .0000001 = 1 \times 10^{-7}$

$[OH^-] =$

Problems:

1. What is the hydrogen (hydronium) ion concentration when $[OH^-] = 1 \times 10^{-3}$M?

2. What is the hydrogen (hydronium) ion concentration when HCl = .0001

3. What is the hydroxide ion concentration in a 0.010 M HCl solution?

H. The pH scale

Hydrogen ion concentrations, $[H^+]$ and hydroxide ion concentrations, $[OH^-]$ are usually very small numbers.....$[H^+] = 2 \times 10^{-1}$M and $[H^+] = 1 \times 10^{-11}$M for example. The pH scale was developed to handle these very small numbers over a wide range.
(2×10^{-1} is 20 **trillion** times larger than 1×10^{-11}!)

$$pH = -\log [H_3O^+]$$

$$\text{and } pOH = -\log [OH^-]$$

Problems:

1. What is the pH when $[H^+] = 10^{-3}$M?

2. What is the what is the pH of a 0.001 M HCl solution?

3. What is the pH of a 1.00×10^{-2} M NaOH solution?

Acidic, Basic, and Neutral solutions:

$[H_3O^+]$	$[OH^-]$	pH	pOH	acidic/basic/neutral
10^0	10^{-14}	0		
10^{-1}	10^{-13}	1		
10^{-2}	10^{-12}	2		
10^{-3}	10^{-11}	3		
10^{-4}	10^{-10}	4		
10^{-5}	10^{-9}	5		
10^{-6}	10^{-8}	6		
10^{-7}	10^{-7}	7		
10^{-8}	10^{-6}	8		
10^{-9}	10^{-5}	9		
10^{-10}	10^{-4}	10		
10^{-11}	10^{-3}	11		
10^{-12}	10^{-2}	12		
10^{-13}	10^{-1}	13		
10^{-14}	10^{-0}	14		

Problem: Basic, acidic or neutral solutions?

1. 2×10^{-10} M $[H^+]$
2. $[H^+] = 2 \times 10^{-10}$
3. $[OH^-] = 6 \times 10^{-5}$
4. pH = 12

What is the pH of 0.010M HCl?

What is the pH of 0.00010M HNO_3?

What is the pH of 0.010M HF

What has a higher pH 0.010M HCl or 0.010M HF?

What is the pH of 0.010M KOH?

What is the pH of 0.00010M NaOH?

What is the pH of 0.010M NH_3 (NH_4OH)

What has a higher pH 0.010M NH_3 or 0.010M KOH?

Neutralization

Neutralization happens when an acid reacts completely with a base

Acid + Base → Salt + Water

$$HCl + NaOH \rightarrow NaCl + H_2O$$

$$HNO_3 + LiOH \rightarrow$$

Another definition of acids

Brönsted-Lowry theory

Acids are compounds that can donate a proton (H^+)
Bases are compounds that can accept a proton (H^+)

Buffers

A type of solution that resists change in pH. A solution that is capable of reacting with either added acid or added base to maintain the original pH.

Buffers have 2 parts

1. A solute that can react with added OH^- (hydroxide) ions
2. A solute that can react with added H^+/H_3O^+ (Hydrogen/hydronium) ions

These solute particles are usually a weak acid and a salt of a weak acid or a weak base and the salt of a weak base. A salt of a weak acid contains the anion of a weak acid. HF is a weak acid so a salt of that weak acid could be NaF or KF etc. The salt of a weak base like NH_3 could be NH_4Cl or NH_4NO_3.

Examples

1. Acetic acid and sodium acetate $HC_2H_3O_2$ + Na $C_2H_3O_2$ in water

Solute particles present in the solution:

When a strong acid, like HCl, is added:

When a strong base, like NaOH, is added:

2. Ammonia and ammonium chloride NH_3 (NH_4OH)+ NH_4Cl in water
Solute particles present in the solution:

When a strong acid, like HCl, is added:

When a strong base, like NaOH, is added:

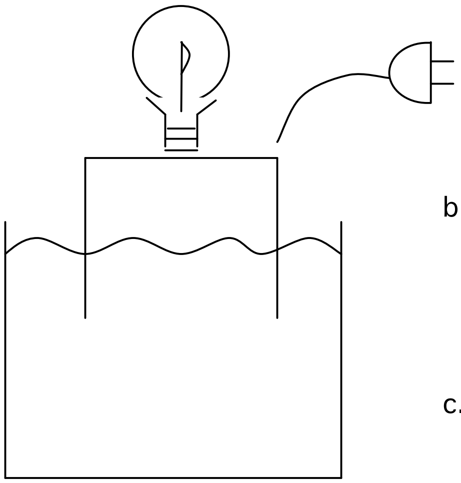
II. ELECTROLYTES- A substance that is a conductor of electricity in water

A. Experimental background:

Movement of ions in solution

B. Strong, Weak, and Nonelectrolytes

1. **Strong Electrolytes:** a.



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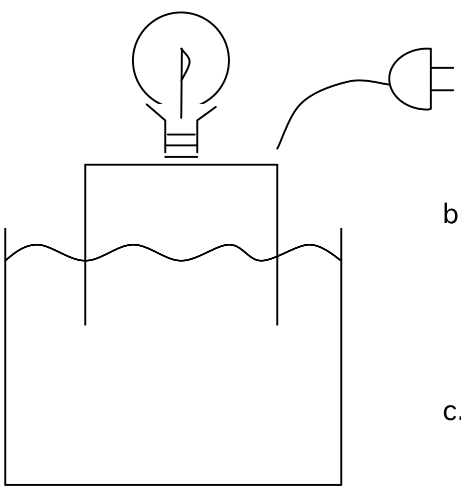
c. Substances which are strong electrolytes:

(1) Soluble ionic compounds

(2) Strong Acids

(3) Strong Bases

2. **Weak Electrolytes:** a.



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c. Substances which are weak electrolytes:

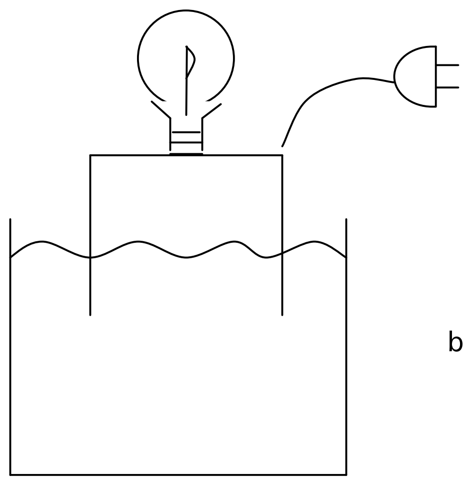
(1) Weak Acids

(2) Weak Soluble Bases

*(3) Slightly soluble ionic compounds

*Do not need to know at this time

3. Nonelectrolytes: a.



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c. Substances which are nonelectrolytes:

(1) Insoluble ionic compounds

(2) Soluble substances that only exists as molecules in water

III. SOLUTION INVENTORIES (PREDOMINANT SPECIES)

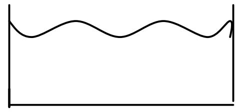
The most abundant particle(s) in aqueous solutions

Key:
1. Know solubility rules
2. Know strong and weak acids and bases
3. Know intermolecular attractions

ACIDS	BASES	IONIC COMPOUNDS	MOLECULAR COMPOUNDS

PARTICLE | Solution Inventory/ Most abundant particle(s)

KCl →



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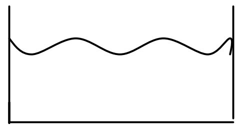
$Ba(C_2H_3O_2)$ →



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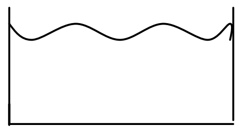
HCl →



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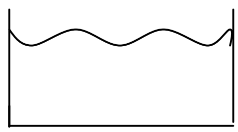
Ag_2CO_3 →



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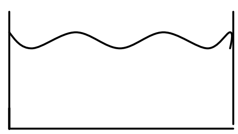
HclO →



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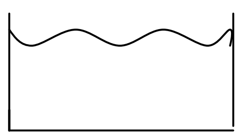
Ammonia →



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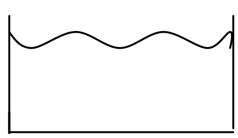
$Fe(OH)_3$ →



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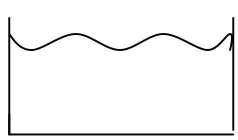
$C_6H_{12}O_6$ (polar) →



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PART 3 CHEMICAL REACTIONS

A chemical reaction occurs when there is a change in chemical composition.

Symbols of chemical equations:

$C_6H_{12}O_6$ + O_2 → CO_2 + H_2O

Balancing equations

$BaCO_3$ →

Al + H_2SO_4 -→

I. Evidence of a reaction- One of the following would be observed:

a. A precipitate is formed or dissolved

b. A change of color

c. Effervescence occurs (gas formation)

d. Energy in the form of heat, light, or electricity is released

II. Types of Chemical Reactions → Know and complete

A. Composition/Combination Reactions - One product is formed:

1. Metal + Nonmetal —combines to form→ an Ionic compound
ex.

2. Metal Oxide + H_2O —combines to form→ a Base
ex.

3. Nonmetal Oxide + H_2O —combines to form→ an Acid
ex.

B. Decomposition- A single reactant will form two or more products

1. Carbonates (CO_3^{2-}) $\xrightarrow{\text{decomposes}}$ to oxides and $CO_2(g)$

Ex.

2. Sulfites (SO_3^{2-}) $\xrightarrow{\text{decomposes}}$ to oxides and sulfur dioxide gas

Ex.

3. Binary Ionic Compounds $\xrightarrow{\text{decomposes}}$ to Metal + Nonmetal

4. More complex compounds can decompose

C. Combustion Reactions involves organic compounds:

General Form: $(C_xH_yO_z) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

D. Single Replacement Reactions

TYPES:

Active metal Replacing hydrogen in water or acid

Type 1: Metal + H_2O (HOH) $\rightarrow$ Base + $H_2(g)$

Type 2: Metal + Acid $\rightarrow$ Salt + $H_2(g)$

Active metal replacing another less active metal

Type 3: $\text{Metal}_1 + \text{Salt}_1 \rightarrow \text{Metal}_2 + \text{Salt}_2$

Halogen replacing less active halogen

Type 4. $\text{Nonmetal}_1 + \text{Salt}_1 \rightarrow \text{Nonmetal}_2 + \text{Salt}_2$

PREDICITING if the Single displacement reaction will occur
USING:

1. Activity table for metals-for Single displacement types 1-->3
    a. Which metals reacts with H_2O
    b. Which metals reacts with hot H_2O, steam
    c. Which metals reacts with acids
    d. Which metals are more reactive
2. Activity series for halogens for single displacement type 4

ACTIVITY SERIES FOR COMMON METALS

MOST ACTIVE

Reacts with acids	Metal	Reacts with water
	K	
	Na	Reacts with $H_2O(l)$
	Ca	
	Mg	
	Al	
Reacts with Acids to liberate hydrogen gas	Mn	Reacts with $H_2O(g)$, (Steam)
	Zn	
	Cr	
	Fe	
	Ni	
	Sn	
	Pb	
	H	
	Cu	
	Hg	
*Do not react with Acids to liberate hydrogen gas	Ag	
	Pt	
	Au	

LEAST ACTIVE

*Note: Other types of rxns may occur with acids but will not produce H_2 gas-you are not responsible to know these 'other' types

E. Double Replacement

1. In an double displacement (ion exchange) reaction, the positive end and negative end of compounds "change partners" to form new products:

a. Precipitate
*Note: A ppt **must** form for the rxn to occur. (if it doesn't...Then NR!)

b. Less Ionized Substance.(Molecule formation)
(1) Gas

(2) Neutralization

(3) A weak acid is formed

Summary of Reaction Types

III. Balancing Chemical Equations

A. Conservation of Mass → Matter cannot be created or destroyed.

B. Balancing

Object: Each side of the equation must have the same number of atoms of each element.

Hint: Work Systematically

BALANCING EQUATIONS

HOW TO:

1. Correct formulas for reactants and products must be written, for example,

$NaCl_2$ → WRONG!!

2. Physical states must be included.

Keys: 1. Know the physical states of the elements

(g) (l) (s) (aq)

2. Know solubility rules

3. Balancing equations

a) Count and compare the number of atoms of each element on both sides of the equation.

b) Balance each element individually by placing whole numbers in front of the chemical formula

c) Check all elements after each individual element is balanced to see, whether or not in balancing one element, others have become imbalanced.

d) Hydrogen, nitrogen, oxygen plus the halogens are diatomic and **must** be written as such.

H_2, O_2, N_2, Cl_2, Br_2, I_2, F_2

IV. Predicting, Writing and Balancing Chemical equations

A. Items to be included:

Correct prediction of products using and knowing:

a. Reaction types
b. Activity table
c. Electron affinity
d. Solubility rules
e. Correct Chemical Formulas
f. Diatomic elements
g. Physical states

***NOTE: IONIC COMPOUNDS IN AIR ARE SOLIDS*

Examples

What is the type of reaction?

Is it balanced?

1. $Mg (s) + 2H_2O (g) \rightarrow Mg(OH)_2 + H_{2(g)}$

2. $NaF(aq) + HNO_3(aq) \rightarrow HF(aq) + Na\ NO_3(aq)$

3. $Ca(s) + 2HNO_3(aq) \rightarrow H_2 + Ca(NO_3)_2$

4. $Cu(s) + O_2(g) \rightarrow CuO (s)$

5. $Zn(s) + 2\ HCl(aq) \rightarrow H_{2\ (g)} + ZnCl_{2\ (aq)}$

6. $13O_2 (g) + C_4H_{10} \rightarrow 4CO_{2\ (g)} + 5H_2O\ (g)$

7. $Cl_2 + KI(aq) \rightarrow I_2 + KCl (aq)$

8. $2HCl + Ca(OH)_2 \rightarrow H_2O + CaCl_2\ (aq)$

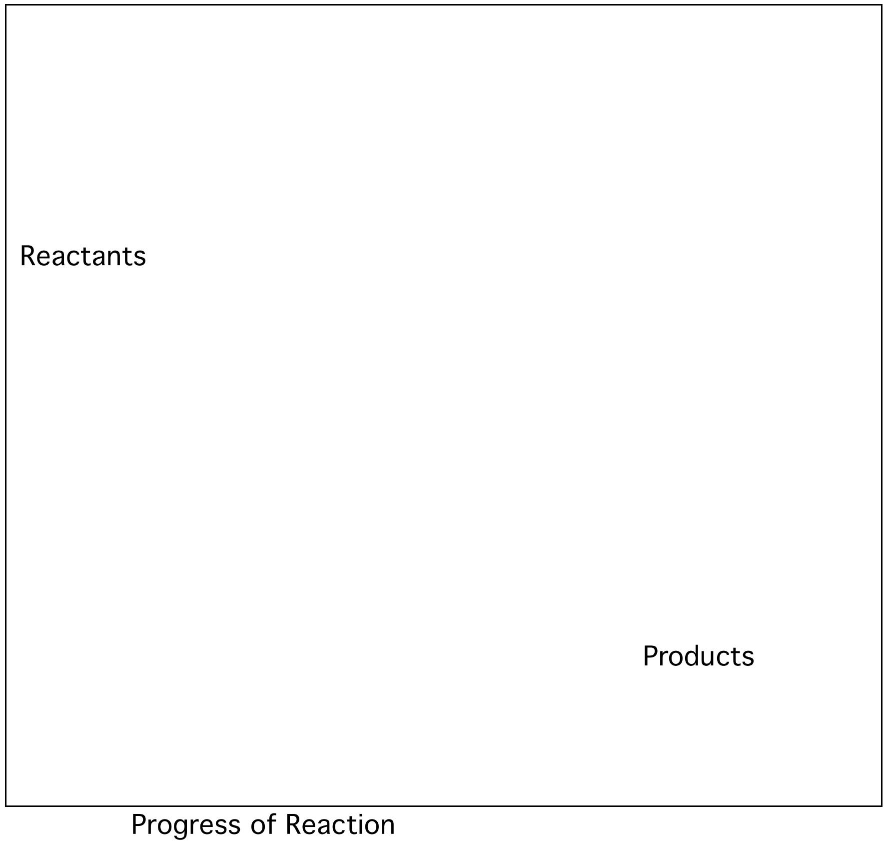
9. $H_2(g) + O_2(g) \rightarrow H_2O$

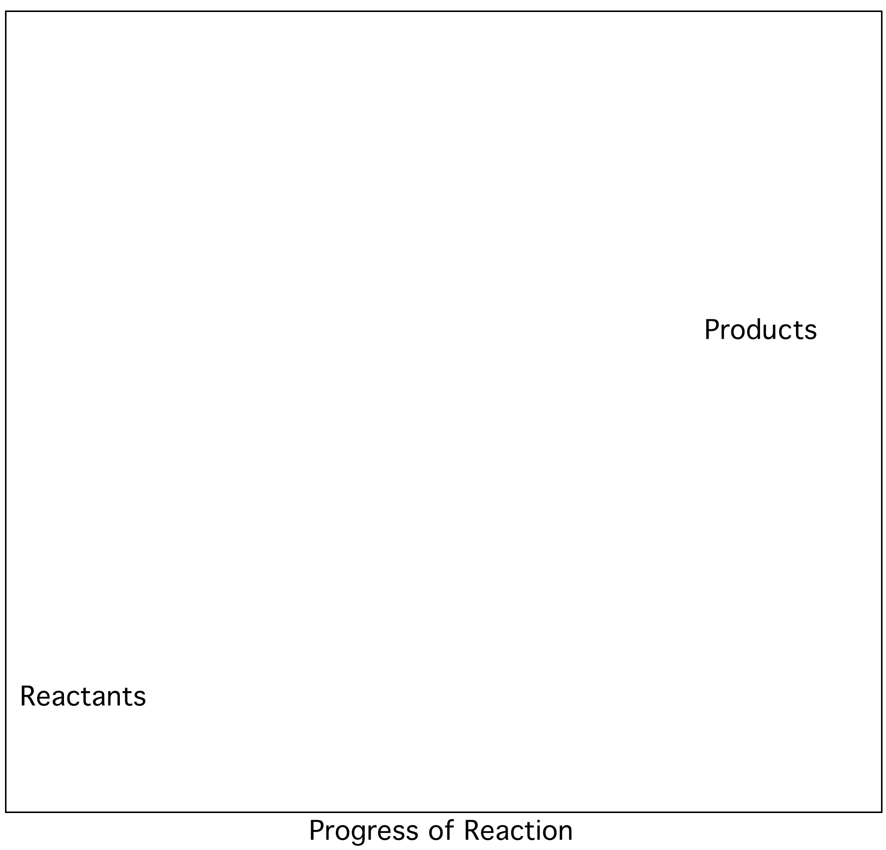
V. Reaction Rate

For a reaction to occur between two particles (atoms, ions or molecules) 3 things must happen

1. Particles must collide
2. Particles must collide with the right amount of energy
3. Particles must collide in the right direction or orientation

Energy Diagrams





Four factors affect how fast a reaction will occur. All of these affect the number of collisions

1. Size of reacting particles

2. Concentration

3. Temperature

4. Catalyst

Chemical Equilibrium

If a reaction (system) reaches "dynamic equilibrium" then:

The rate of the forward reaction is equal to the **rate** of the reverse reaction. The reaction goes forward and backward at the same rate.

The concentration of the reactants remains constant and the concentration of the products stays constant even though the concentrations of products and reactants are not the same.

In the reaction below

$HF + H_2O \rightleftharpoons H_3O^+ + F^-$

The forward reaction

$HF + H_2O \longrightarrow H_3O^+ + F^-$

Is happening at the same rate as

The reverse reaction

$H_3O^+ + F^- \longrightarrow HF + H_2O$

Two ways to disturb the equilibrium:

Changing concentration

Changing the temperature