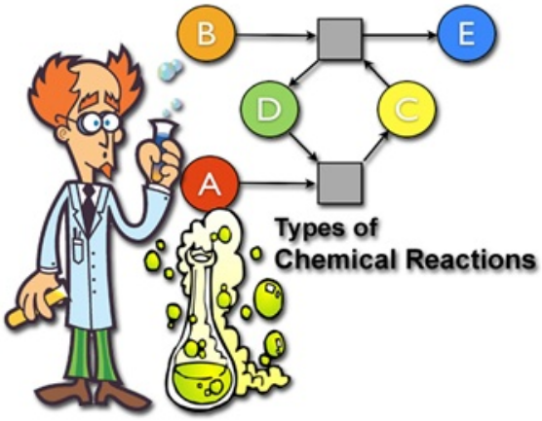
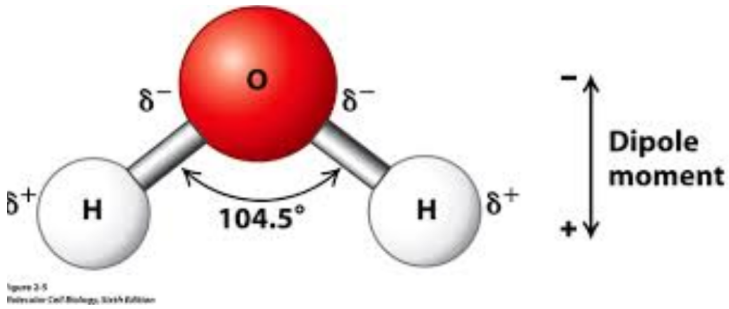
Ch 4 Reactions and Solution Chemistry:

- Solutions - concentrations and types
- Chemical Reactions
    - Precipitate Rxns
    - Acid/Base Rxns
    - Other types of Rxns



H_2O - The Common Solvent:



- Type of bonds?

- Types of compounds it can dissolve?

- How does it dissolve or dissociate?

https://www.youtube.com/watch?v=EBfGcTAJF4o

Solubility:

- Quantitative amount (measured in X g solute/100 g H_2O) of solute that will dissolve in solvent

Solute:

Solvent:

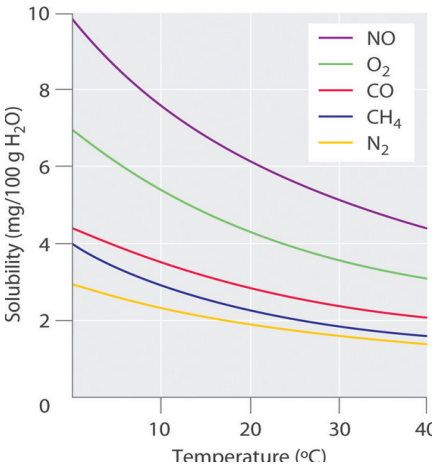
Trends in solubility:

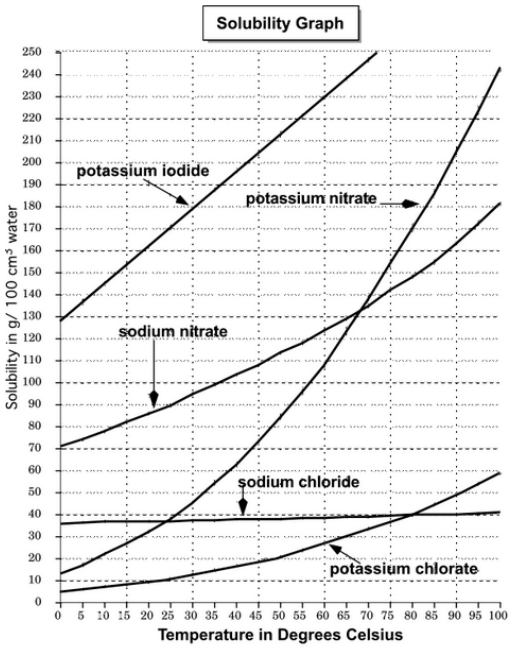
- Solids:

Generally an ↑ in temp = ↑ in amt. of solute soluble in 100 g H_2O

- Gases:

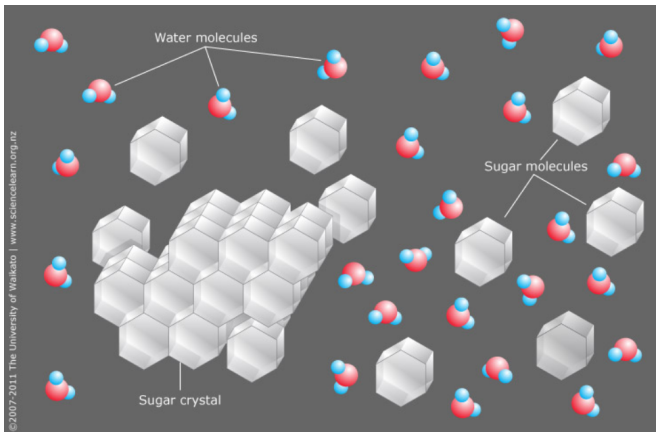
Opposite is true: ↑ temp = ↓ in amount of gas solubility in solvent

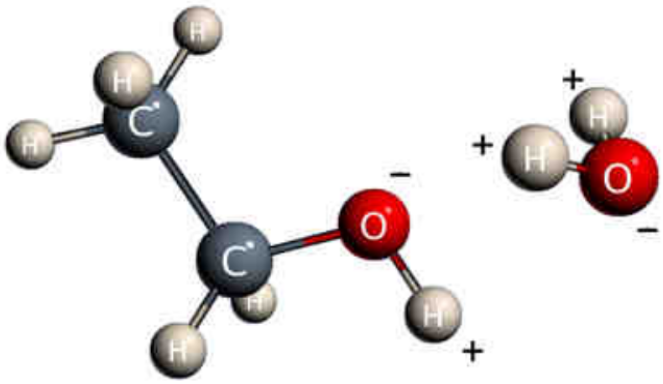




H_2O also dissolves non-ionic substances:

- Breaks them into molecules by attraction to waters S- and S+ sides
    - this applies to molecular substances like sugar and alcohols
- **Does not** Dissociate them into ions or atoms
    - Only breaks a mass clump of molecules into individual molecules





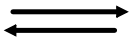
Strong vs Weak Electrolytes:

Strong electrolyte - 100% of compound ionizes when placed in water

Ex: Strong acids, strong bases, soluble salts

Weak electrolyte - a small degree of ionization occurs when placed in water

Ex: Weak acids, weak bases, insoluble salts



Non-electrolyte - no dissociation into ions occurs, but compound dissolves into individual molecules

Ex: Sugars, alcohols

Writing dissociation equations for compounds:

- Decide if compound is an acid, base, or salt
- Decide if it is strong or weak (this tells you what arrow to use)
- Dissociate the compound, balancing each side. Show the ions as charged
- If it is a polyprotic acid, be sure to dissociate the H^+ in steps

Dissociation review/practice:

$Ca(OH)_2$

$Mg(NO_3)_2$

Oxalic acid

Determining the concentration of solutions:

Molarity = $\frac{\text{moles solute}}{\text{Liters of solution}}$
(M)

% concentration = $\frac{\text{g solute}}{\text{g total solution}}$ * 100

molality = $\frac{\text{moles solute}}{\text{kg solvent}}$
(m)

Dilution equation: $M_1V_1=M_2V_2$

1 = initial conditions

2 = final conditions

Difference in V_1 to V_2 is due to ?

Moles of solute stays CONSTANT between change of volumes!

Practice with concentration math:

#1: Determine Molarity if 11.5 g of NaOH is used to make a 1.50 L solution.

#2: If a solution of NaCl has a density of 1.25 g/mL and a % by mass concentration of 16.0%, Determine its Molarity.

#3: You need to make a 0.10 M solution of H_2SO_4. How much stock solution should you use to make 2.00 L of you dilute solution if the stock solution is 16 M.

#4: Typical blood serum is 0.14 M NaCl. What volume of blood contains 1.0 mg of NaCl.

More concentration practice:

Introduction of ICE box method

Ex 1: Calculate the molarity of each ion present in solution if you dissolve 8.00 g of $Fe(ClO_4)_3$ into 1.50 L of total solution.

Ex: Calculate the moles of Na^{+1} ions present in a solution of 1.25 M Na_2SO_4 solution.

Reactions that involve solutions:

- Metathesis (double replacement)
    - liquid, gas or precipitate = products possible
- Acid-Base (neutralization)
    - salt and H_2O are your products
- Reduction - oxidation (redox)
    - involves a transfer of e- and reduction of 1 compound, oxidation of other

Metathesis reactions:

- pretend cations switch places, thus showing possible products

- think of solubility rules and ID states of products - (s) for insoluble or slightly soluble compoiunds

- ppt is indicated with ↓

- other possible products are:

NH_3 and H_2O (due to NH_4OH being formed)

CO_2 and H_2O (due to H_2CO_3 being formed)

Predict the following: Draw the ions/compounds in beakers as the reaction progresses.

Ex: Potassium nitrate + Barium chloride

Ex: Sodium sulfate + lead (II) nitrate

Ex: Potassium hydroxide + Iron (III) nitrate

Net ionic equations:

Use of solubility rules and understanding of strong vs weak electrolytes to show what is happening in a reaction

Compounds that totally ionize ($\longrightarrow$):

Compounds that have little/partial ionization ($\rightleftharpoons$):

Rules of follow in net ionic equations:

1.) Only dissociate the compounds that totally ionize, leave others together

2.) Show charges of ions and elements

-what is the charge on an element?

3.) Balance all ions/compounds in the equation

4.) Determine the net ionic equation and spectator ions after completing the overall ionic equation

Practice with net ionic equations:

Ex 1: $KCl + AgNO_3$

Ex 2: $KOH + Fe(NO_3)_3$

Ex 3: $Na + H_2O \text{ ------> } NaOH_{(aq)} + H_2$

Ex 4: Potassium hydroxide solution is poured into acetic acid

Stoichiometry of solutions:

- Focus on who the product is

- Need moles, use Molarity

- Use stoichiometry rules we know - may need to use ICE box if asked about concentrations of ions also

Ex: Find the mass of NaCl needed to ppt out all Ag+ ion from $AgNO_3$ with a molarity of 0.100 M and a volume of 1.50 Liters

Ex 2: Aqueous solutions of sodium sulfate and lead (II) nitrate are mixed. Calculate the mass of product formed from 1.25 L of 0.0500 M lead (II) nitrate and 2.00 L of 0.0250 M sodium sulfate.

Acid - Base Reactions:

- **Arrhenius Theory:**

  Acids - produce H^+ ions

  Bases - produce OH^- ions

- **Bronsted - Lowry Theory:**

  Acids - H^+ donor

  Bases - H^+ acceptor

Neutralization reaction - acid + base ---> salt + H_2O

Practice stoichiometry of acid-base reactions:

Steps for stoichiometry of acid base reactions:

1.) Write the reaction, balance, and determine the net ionic equation

Special note about net ionic equations of acid/base: If a weak acid is reacting with a strong base, a 100% reaction occurs even though the acid was weak

2.) Stoichiometry math

3.) Convert grams, volume, molarity if needed

Ex: What volume of 0.100 M HCl is needed to neutralize 25.0 mL if 0.350 M $Ca(OH)_2$?

Ex 2: In an experiment, 28.0 mL of 0.250 M HNO_3 and 53.0 mL of 0.320 M KOH are mixed. What concentration of H+ and OH- ions are in excess after the reaction?

Titrations of acids and bases:

Titration- delivering a measurable volume of a known concentration solution to an unknown concentration solution

Equivalence point - pt in titration when mole of titrant has 100% reacted with analyte

Endpoint - pt in titration when indicators color changes

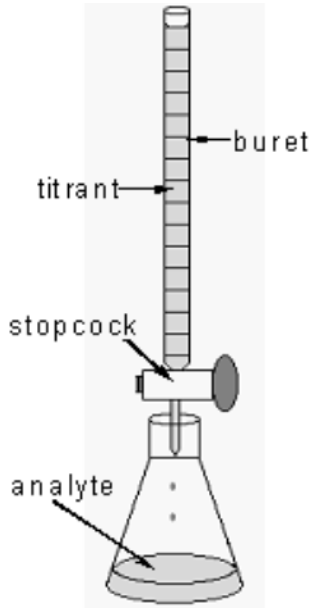
-(this ideally should coincide with the equivalence point - if you chose the correct indicator)

Titrant - solution in buret

- measure amount you use at end

Analyte - solution in flask

- measured the amount at the beginning



Steps to follow as you do a titration and its math:

1.) Know the balanced reaction of titrant + analyte

2.) Pick proper indicator

3.) Careful, slow.... stop as soon as that 1 single drop changes the color permanently

4.) Know the exact moles or volume of analyte you used

Ex: 1.3009 g of KHP ($KHC_8H_4O_4$) is dissolved in approximately 50.0 mL of H_2O. The titration used 41.20 mL of the titrant (NaOH). Determine the M of NaOH.

Ex: A chemist analyzed effluent water from an industrial process known to contain CCl_4 and benzoic acid ($HC_7H_5O_2$), a weak acid that has one acid proton per molecule. A sample of this effluent weighing 0.3518 g was shaken with water, and the resulting aqueous solution required 10.59 mL of 0.1546 M NaOH to neutralize. Calculate the mass percent of $HC_7H_5O_2$ in the original sample.

Oxidation-Reduction reactions:

-Reactions where 1 or more e- are transferred

-Covalent and ionic compounds can undergo Redox reaction

- How to know if REDOX rxn occurred = if the oxidation #s of atoms changed

How to determine oxidation # of atoms:

1.) An unbonded atom = 0

2.) Monatomic ions = its normal charge due to its group

3.) If atoms are in a polyatomic ion or compound:

a.) Fluorine present = it has priority = it is -1

b.) Oxygen is normally -2

c.) Hydrogen = +1

d.) The summed charges of the atoms needs to = total charge of ion or compound

Practice:

Find the oxidation #s on each of the atoms:

CO_2 SF_6 NO_3^{-1}

Fractional oxidation charges may occur... that is ok (WE are the ones that assign e- a home)

ex: Fe_3O_4

Details about Redox reactions:

Electrons are transferred to:

1.) form ions

2.) rearrange atoms

Oxidation = increase in oxidation state (become more +)

Reduction = decrease in oxidation state (become more -)

OIL RIG

Oxidizing agent (OA) - electron acceptor (gets reduced)

Reducing agent (RA) - electron donor (gets oxidized)

Examples: ID who is oxidized, who is reduced, and ID OA and RA

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

The following reactions take place as chemists take galena (PbS), a lead conaining ore, to its elemental state.

$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$

$PbO + CO \rightarrow Pb + CO_2$

Balancing Redox Reactions:

(FOR EASIER REDOX REACTIONS)

Steps:

1.) Assign oxidation #s to all atoms

2.) e- lost must = e- gained

Show the e- lost and gained with tie lines

3.) Use coefficients to = e- lost/gained

4.) Add states (s, l, g, aq)

5.) Balance the rest of the equation

Example:

$Cu_{(s)} + Ag^{+}_{(aq)} \text{ ----> } Ag_{(s)} + Cu^{+2}_{(aq)}$

$H^{+} + Cl^{-} + Sn + NO_3^{-1} \text{ ----> } SnCl^{-2}_6 + NO_2 + H_2O$

$PbO + NH_3 \text{ ----> } N_2 + H_2O + Pb$

Gravimetric analysis:

- Use of precipitation reaction to measure product made

- Through stoichiometry - determines amount of a certain ion in solution

Example:
An ore sample is to be analyzed for sulfur. As part of the procedure, the ore is dissolved, and the sulfur is converted to sulfate ion (SO_4^{-2}). Barium nitrate is added which causes the sulfate to precipitate out. The original sample had a mass of 3.187 g. The dried product is 2.005 g. What is the percent of original Sulfur in the ore?

Example: The thallium (present in Tl_2SO_4) in a 9.486 g pesticide sample was precipitated as thallium (I) iodide. Calculate the mass percent of Tl_2SO_4 in the sample if 0.1824 g of thallium (I) iodide was recovered.

Determination of Concentration of ions in solution:

A) Determine the amount of moles of each reactant ion (Molarity --> moles and ICEBOX)

B) Use stoichiometry to calculate Limiting and excess reactant

C) Complete LR to ER stoich to find the moles of ER needed

- Then subtract from given amount of ER ion to find moles of ER left over

D) After you know the moles of each ion, use molarity formula to find [ ] Conc.

Ex: Determine the molarity of Fe^{+3} ions and SO_4^{-2} ions in a solution prepared by dissolving 48.05 g of Iron (III) sulfate in enough water to make a total volume solution of 800. mL.

Ex: You react 35.0 mL of 2.00 M Sodium carbonate solution with 25.0 mL of 1.50M Calcium chloride solution. Determine the mass of product expected. Then find the concentration of all ions in the filtrate solution.

REDOX practice:

Determine the oxidation #s, who is reduced, who is oxidized, OA and RA for the following problems. Then balance and ID # e- transferred and if they are gained or lost.

Ex:

$H_2 + O_2 \rightarrow H_2O$

$Zn_{(s)} + Cu^{+2} \rightarrow Zn^{+2} + Cu_{(s)}$

$2MnO_4^-{}_{(aq)} + 16H^+{}_{(aq)} + 5C_2O_4^{2-}{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 10CO_2 + 8H_2O$

Single Replacement Reaction Review:

Element + Compound (aq) ---> Element + Compound (aq)

Cation replaces cation
Anion replaces anion

Activity series - stronger element can replace weaker element

Ex: Ca + $Fe(NO_3)_3$

Ex: Chlorine gas is bubbled into a solution of hydrobromic acid

Ex: Copper is added to a solution of zinc chloride.