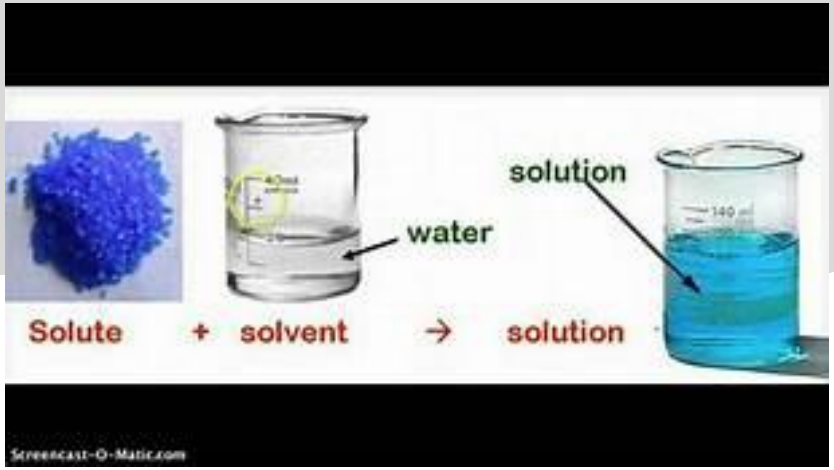
AP Chemistry Unit 2

Reactions and Solutions

Terms



Solute - what gets dissolved

Solvent - what does the dissolving

Solution - the mix of the solute and solvent

Solubility - does the solute dissolve? If so, how well?

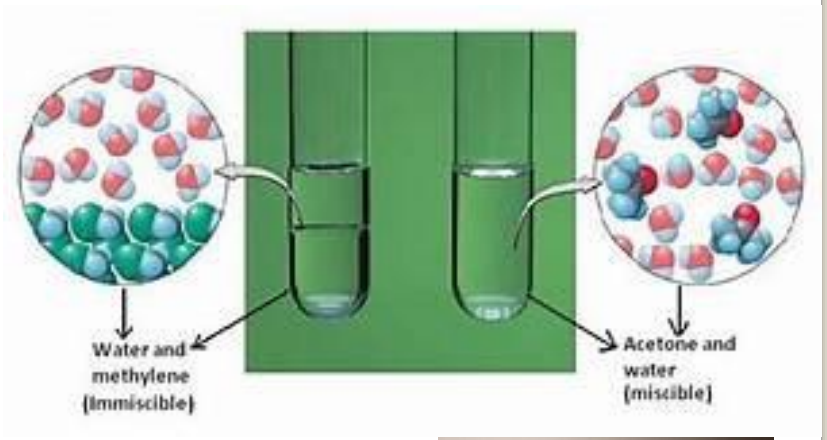
Molar solubility - how many moles dissolve in 1L of solvent

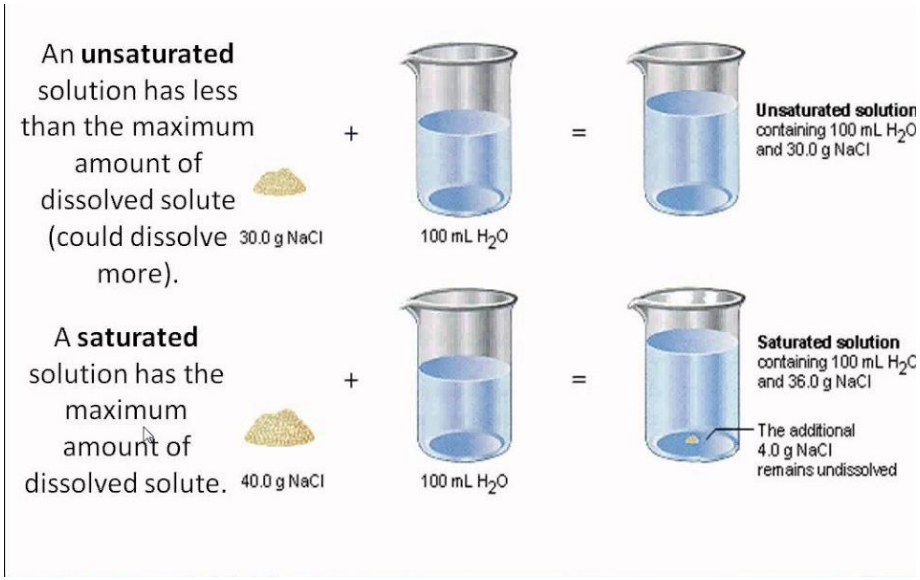
Terms

Saturated vs. unsaturated solution

Super-saturated

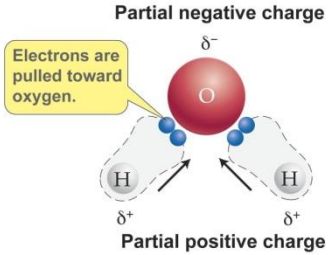
Miscible vs. immiscible





Does a Saturated Soln need ppt on bottom?

How to look at solubility



• **Polar** - Covalent bonds (electrons "shared") but one atom "hogs" the electrons, making one end behave a little negative, while the other end is little "bare" of electrons and behaves a little positive.

- **Polar solvents** dissolve ionic compounds (think NaCl and water) very well
- Polar solvents also dissolve other polar compounds well

• **Nonpolar** - "evenly shared electrons" - there's no real "temporary charge" on the molecule.

- Think about oil - what will get dissolved in oily solvents?

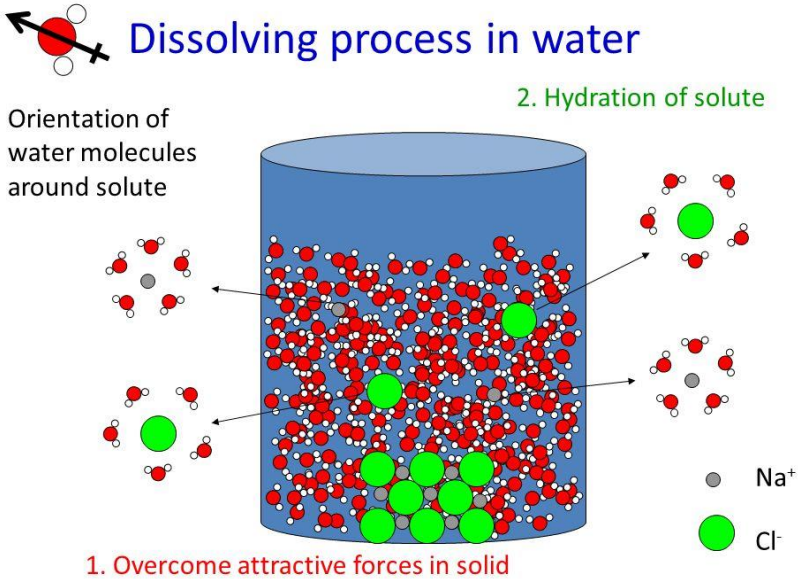
• Some molecules have a property of both - and you will see mixed results.
• In order to be soluble, solvent and solute have to have **IMF**s (intermolecular forces) that can allow for productive and meaningful interactions (forces that align). If they are not, the solute with not be very soluble in the solvent.

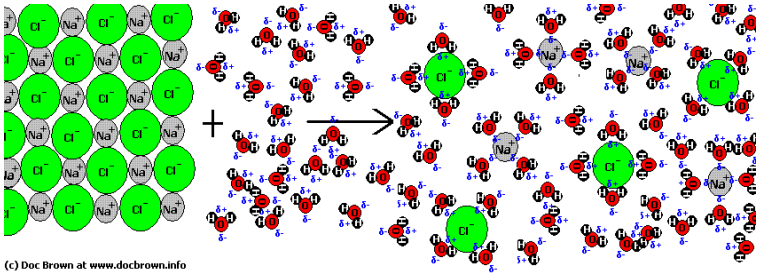
Common Polar Solvents	Common Nonpolar Solvents
Water (H_2O)	Hexane (C_6H_{14})
Acetone (CH_3COCH_3)	Diethyl ether ($CH_3CH_2OCH_2CH_3$) *
Methanol (CH_3OH)	Methylbenzene (toluene) (C_7H_8)
Ethanol (CH_3CH_2OH)	Carbon tetrachloride (CCl_4)

*Diethyl ether has a small dipole moment and can be considered intermediate between polar and nonpolar.

1. Describe the orientation of the polar water molecules in relationship to the Na^+ and Cl^- Ions.

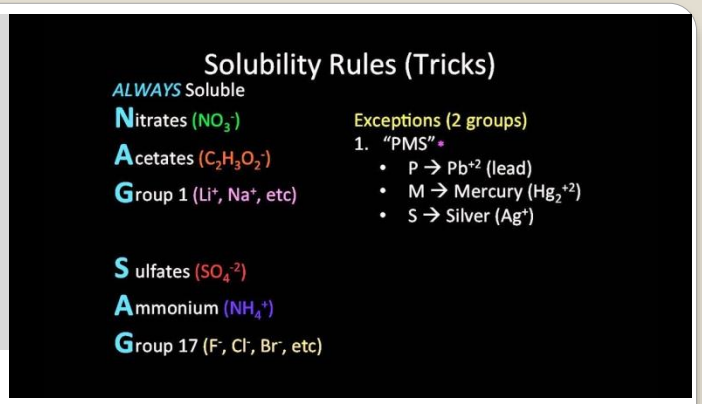
2. Draw a molecular-level representation of a saturated and unsaturated solution of a mixture of NaCl and water





YouTube- water dissolve

Solubility Rules



When working with water solutions, it is helpful to have a few rules concerning which substances are soluble, and which will form precipitates. The more common **solubility rules** are listed below: (**quizlet on website)**

1. All common salts of the Group IA(Li, Na, K, etc) elements and the ammonium ion (NH_4^+)are soluble.

2. All common acetates, nitrates, chlorates, perchlorate and hydrogen carbonates are soluble.

3. All binary compounds of Group VIIA elements(other than F) with metals are soluble, <u>except</u> those of silver, mercury (I), and lead.

4. All sulfates are soluble <u>except</u> those of barium, strontium, lead, calcium, silver, and mercury (I).

5. Most hydroxide salts are insoluble. $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$ are slightly soluble. Hydroxide salts of transition metals and Al^{3+} are insoluble. Thus, $Fe(OH)_3$, $Al(OH)_3$, $Co(OH)_2$ are not soluble.

6. Most ionic compounds NOT listed above are insoluble . . . on the AP Test. Examples include: chromates, carbonates, sulfides, phosphates.

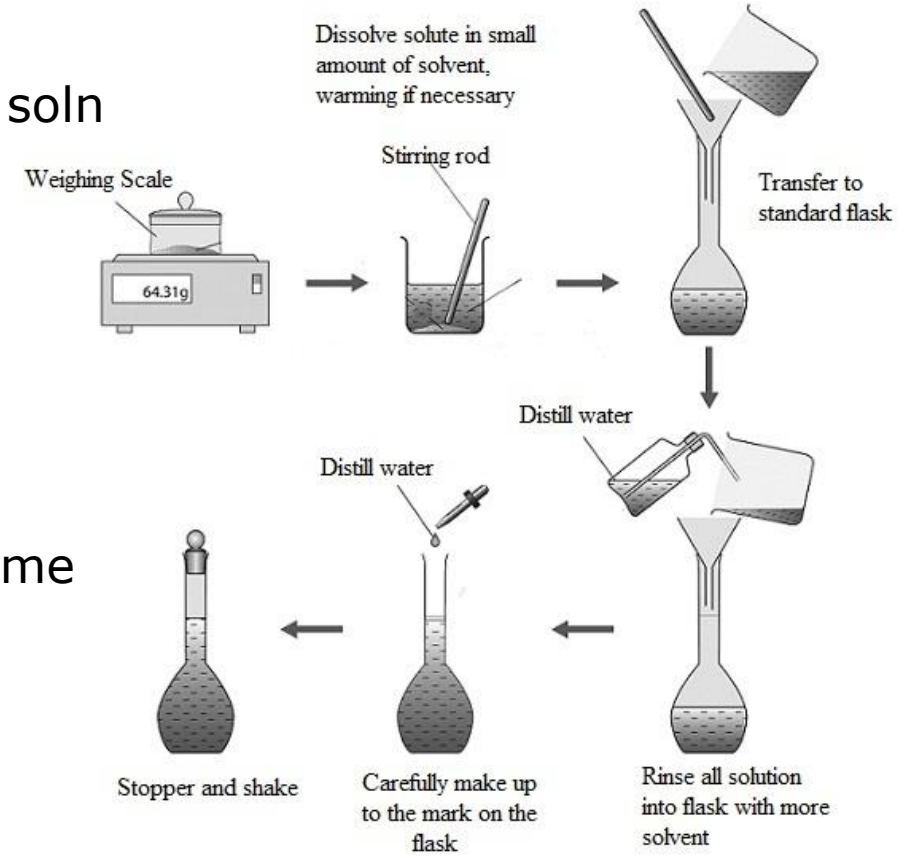
Steps to making Solution

Molarity = Moles solute / Liters of soln

- pay attention to your units.
  - Don't divide by mL

Dilution formula: $M_1V_1 = M_2V_2$

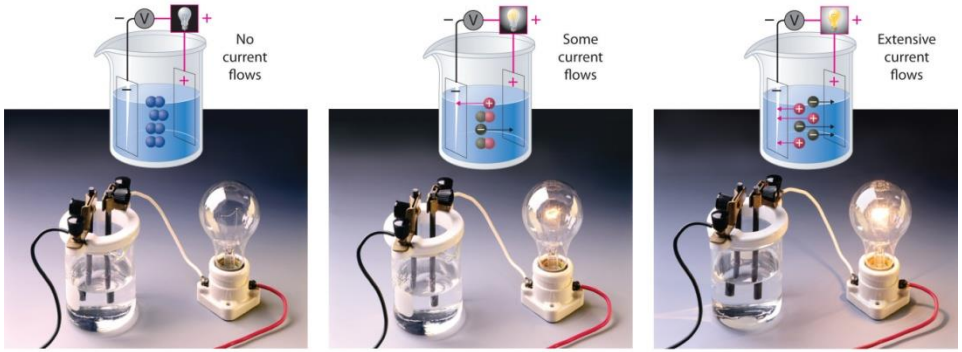
- You don't have to convert into liters, just make sure your volume units match.



Strong vs Weak Electrolytes

A useful property for characterizing a solution is
Electrical Conductivity

- Reminder a soln is a homogeneous mixture
- Pure water is not an electrical conductor



(a) Nonelectrolyte (b) Weak electrolyte (c) Strong electrolyte

Strong vs. Weak Electrolytes

Strong Electrolytes:

- Exist in solution completely (or nearly completely) as ions
- Essentially all soluble ionic compounds & some molecular (some acids) fall into this category

Weak Electrolytes:

- Exist in solution almost entirely as molecules (a small fraction may be ions)
- Molecular compounds fall into this category

Be able to draw out a diagram of Strong vs Weak Electrolytes!!

Strong vs Weak Electrolytes

Strong Acids = Strong Electrolytes

Strong Base = Strong Electrolytes

Non-electrolytes means no ions. Think covalent compounds in solution.

You need to know the strong Bases and 6 strong acids!!

Quiz each other

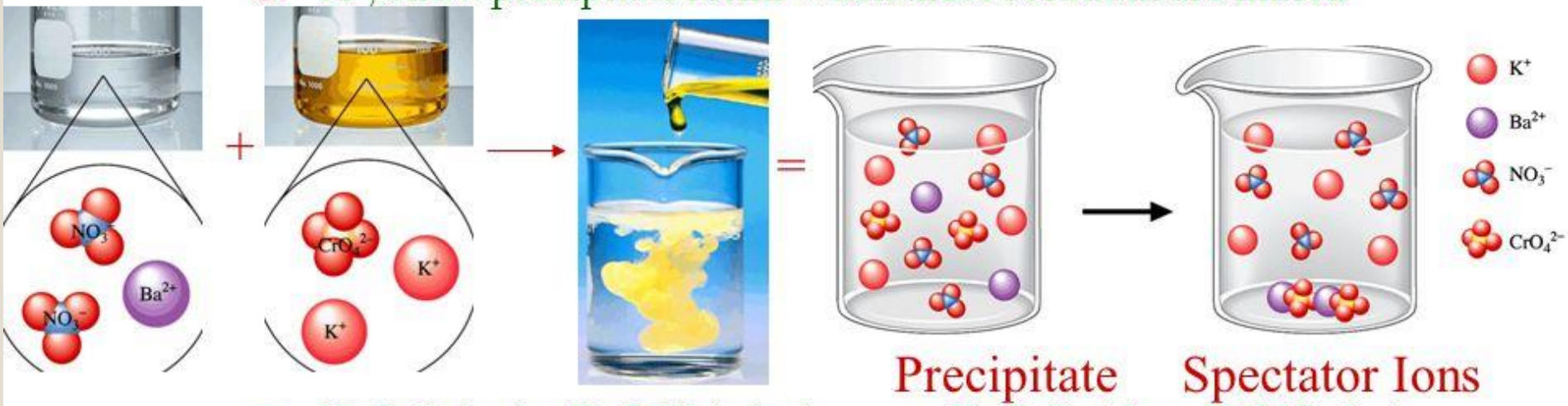
Strong Bases
Group I Metals + OH Group II Metals + OH (except Beryllium) Ex. NaOH, $Mg(OH)_2$, LiOH, $Ca(OH)_2$

6 Strong Acids	
$HClO_4$	perchloric acid
HCl	hydrochloric acid
HBr	hydrobromic acid
HI	hydroiodic acid
HNO_3	nitric acid
H_2SO_4	sulfuric acid

Precipitation Reactions

A. Definitions

1. When two solutions are mixed and a solid forms
2. **Precipitate** = solid that forms from a precipitation reaction
3. $K_2CrO_4(aq) + Ba(NO_3)_2(aq) \rightarrow 2K^+(aq) + CrO_4^{2-}(aq) + Ba^{2+}(aq) + 2NO_3^-(aq)$
   a. K_2CrO_4 and $Ba(NO_3)_2$ are both soluble (all dissolve in water)
   b. A yellow precipitate forms when these solutions are mixed



   c. $K_2CrO_4(aq) + Ba(NO_3)_2(aq)$ -----> $BaCrO_4(s) + 2KNO_3(aq)$
4. $AgNO_3(aq) + KCl(aq)$ ------> $AgCl(s) + KNO_3(aq)$

Types of Chemical Rxns

Reaction type	Explanation	General formula
Combination	Two or more compounds combine to form one compound.	$A + B \rightarrow AB$
Decomposition	The opposite of a combination reaction – a complex molecule breaks down to make simpler ones.	$AB \rightarrow A + B$
Precipitation	Two solutions of soluble salts are mixed, resulting in an insoluble solid (precipitate) forming.	A + soluble salt B → precipitate + soluble salt C
Neutralisation	An acid and a base reaction with each other. Generally, the product of this reaction is a salt and water.	acid + salt → salt + water
Combustion	Oxygen combines with a compound to form carbon dioxide and water. These reactions are exothermic, meaning they give off heat.	$A + O_2 \rightarrow H_2O + CO_2$
Displacement	One element trades places with another element in the compound.	$C_xH_y + O_2 \text{ -> } CO_2 + H_20$

Net Ionic equations

Total and Net Ionic Equations

Balanced formula equation:

$$2\ KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow PbI_{2(s)} + 2\ KNO_{3(aq)}$$

Total ionic equation. Rewrite the equation so that all dissolved compounds (*aq*) (see solubility chart) are separated into their constituent ions:

$$2\ K^+_{(aq)} + 2\ I^-_{(aq)} + Pb^{2+}_{(aq)} + 2\ NO_3^-{}_{(aq)} \rightarrow PbI_{2(s)} + 2\ K^+_{(aq)} + 2\ NO_3^-{}_{(aq)}$$

Spectator ions are those that appear on both sides of the equation and as such do not participate in the reaction. In the above example, the spectator ions are $2\ K^+_{(aq)}$ and $2\ NO_3^-{}_{(aq)}$.

Net ionic equation:

Spectator ions cancel, and are ***not*** included in the net ionic equation:

$$Pb^{2+}_{(aq)} + 2\ I^-_{(aq)} \rightarrow PbI_{2(s)}$$

Find another double Replacement RXN, and write out the complete and net ionic eqn

Redox Reactions (oxidation-reduction)

Redox reactions — reactions in which there's a simultaneous transfer of electrons from one chemical species to another — are really composed of two different reactions: ***oxidation*** (a loss of electrons) and ***reduction*** (a gain of electrons).

- The electrons that are lost in the oxidation reaction are the same electrons that are gained in the reduction reaction.
  - These two reactions are commonly called **half-reactions**;
  - the overall reaction is called a **redox** (*red*uction/*ox*idation) reaction.

- Redox reactions happen with D-block metals.
  - They have more than one possible charge (Copper I, II)

- Reactions of this type are quite common in ***electrochemical reactions***, reactions that produce or use electricity.

Redox Reactions History

When Ores are processed to obtain metals, the mass of the metal is always less than the mass of the original ore as impurities are removed by physical and chemical means.

- The pure metal was a **REDUCTION** of the ore

If a pure metal tarnishes or rusts, often by rxn with oxygen, the mass increases, and the process was called **OXIDATION**

Writing half-reactions

$MnO_4^- + I^- \rightarrow Mn^{2+} + I_2$

LEO says **GER**
Loss of Electron is Oxidation
Gain of Electron is Reduction

Reduction half rxn: $\overset{+7}{MnO_4^-} \rightarrow \overset{+2}{Mn^{2+}}$

Mn is 7+ on the reactant side: it is 2+ on the product side = it has GAINED electrons and is therefore REDUCED. (GER)

Oxidation half rxn: $\overset{-1}{I^-} \rightarrow \overset{0}{I_2}$

Iodine is negative on the reactant side and is NEUTRAL on the product side =it LOST an electron and is oxidized.

Balancing a Redox Rxns

1. Separate the whole thing into half reaction (one for oxidation; one for reduction) LEO goes GER
2. Balance all elements except besides H and O
3. Balance Oxygen by adding H_2O
4. Balance hydrogen by adding H+
5. Balance the electrons by adding e^- (These are your Balanced ½ Rxn)
6. Multiply each half reaction so the electrons cancel
7. Add the half-reactions, and cancel identical species
8. Check that the elements and charges balanced

If you are doing this in an acidic solution, you are finished!

If you are doing this in a basic solution,

9. add to both sides of eqn OH- to cancel the H+ (this will add OH- to one side of the equation and make water on the other that will result in more cancelling)
10. Check to see if BALANCED AGAIN!!!