

## **Some Basic Terminology of Solutions**

### **solution**

homogeneous mixture, most often with one component a liquid

### **solute**

solution component, usually in smaller proportion, dissolved in the liquid component; solutes may be solids, liquids, or gases.

### **solvent**

liquid component of a solution, into which the solute is dissolved

### **solubility**

maximum amount of solute per volume of solvent or solution that can be dissolved at a certain temperature

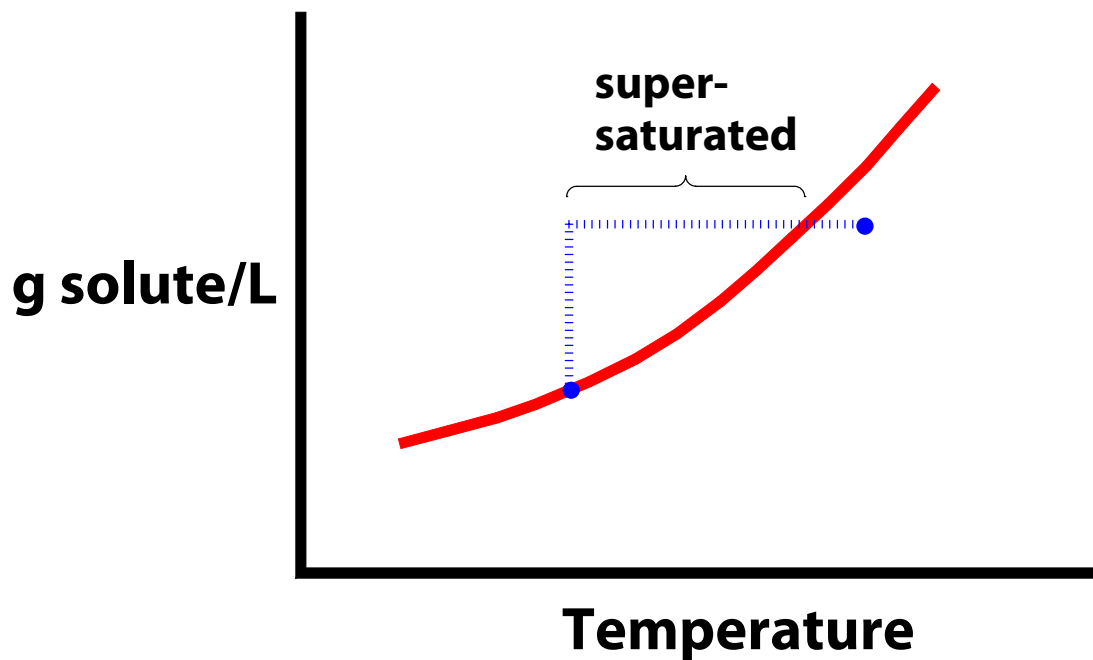
### **saturated solution**

solution with solute concentration at the solubility limit

# Solubility Limits and Supersaturated Solutions

## supersaturated solution

solution with a solute concentration that exceeds the normal limit for the temperature



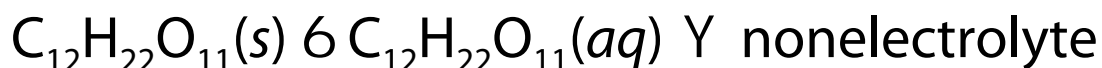
## Electrolytes and Nonelectrolytes

- A solute that increases the electrical conductivity when added to a solvent is an **electrolyte**.
- A solute that does not change the electrical conductivity when added to a solvent is a **nonelectrolyte**.
- Electrolyte solutions conduct electricity by the movement of cations and anions in the solution.

ion formation:



no ion formation:

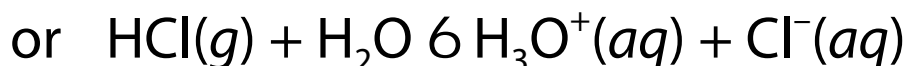
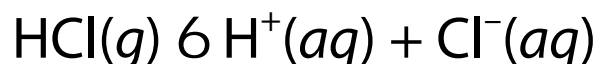
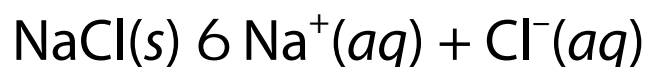


- Solid ionic compounds are non-conductors of electricity, because the ions in them are not free to move off their positions in the crystal structure.

## Strong Electrolytes vs. Weak Electrolytes

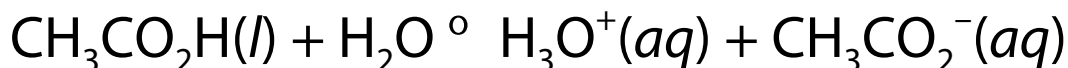
- Strong electrolytes break up virtually completely into ions in solution, producing only ions in solution.

Strong electrolytes:



- Weak electrolytes are molecular substances that break up partially when dissolved to give a mixture of ions and undissociated molecules in solution.

Weak electrolytes:



## Soluble or Insoluble?

- A solute is **soluble** if an appreciable amount of it can be dissolved in a given amount of solvent.
- A solute is **insoluble** if very little of it can be dissolved in a given amount of solvent.
- The distinction between soluble and insoluble is imprecise, but the following guidelines give a rough division:

If the maximum solubility is ...	the solute can be considered to be ...
$>0.10$ mol/L soln	soluble
$<0.01$ mol/L soln	insoluble
$0.01 - 0.10$ mol/L soln	sparingly soluble

# General Rules for Water Solubility of Simple Ionic Compounds

## Soluble Compounds

1. All nitrates and acetates.
2. All compounds with alkali-metal ( $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , etc.) and ammonium ( $\text{NH}_4^+$ ) cations.
3. The halides  $\text{Cl}^-$ ,  $\text{Br}^-$ , and  $\text{I}^-$ , *except* those of  $\text{Pb}^{2+}$ ,  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$ , which are insoluble.
4. Sulfates, *except* those of  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Pb}^{2+}$ , and  $\text{Hg}_2^{2+}$ , which are insoluble. ( $\text{CaSO}_4$  is slightly soluble.)

## Insoluble Compounds

1. Carbonates and phosphates, *except* those with alkali-metal and ammonium cations, which are soluble.
2. Hydroxides, *except* those with alkali-metal cations, which are soluble, and  $\text{Ca}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$ , and  $\text{Ba}(\text{OH})_2$ , which are sparingly soluble.
3. Sulfides, *except* those with alkali-metal, calcium, and ammonium cations, which are soluble.

## Metathetical Reactions

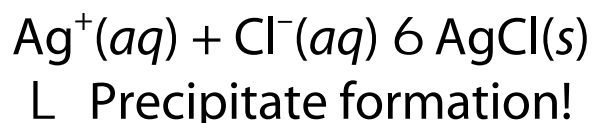
- A **metathetical reaction** (also called **double displacement** or **exchange**) occurs when two ionic compounds exchange ions resulting in a product.



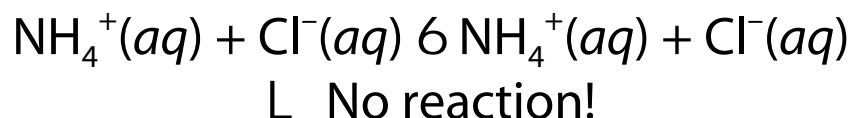
- A metathetical reaction yields a product when the new cation-anion pairings result in any of the following:
1. An insoluble compound (a **precipitate**)
  2. A **neutralization**
  3. A **gas** or other **molecular species**

## Precipitate Formation

- When a cation-anion combination is created in solution that would result in an **insoluble ionic compound** (as determined by the Rules of Solubility) a **precipitate** will form.

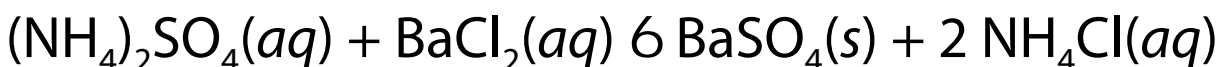


- When a cation-anion combination is created in solution that would result in a **soluble ionic compound** (as determined by the Rules of Solubility) no net reaction occurs from the combination.

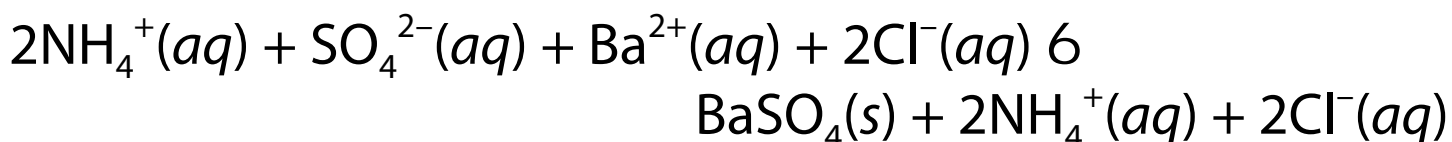


## Three Ways of Writing a Metathesis Reaction

### Molecular equation:

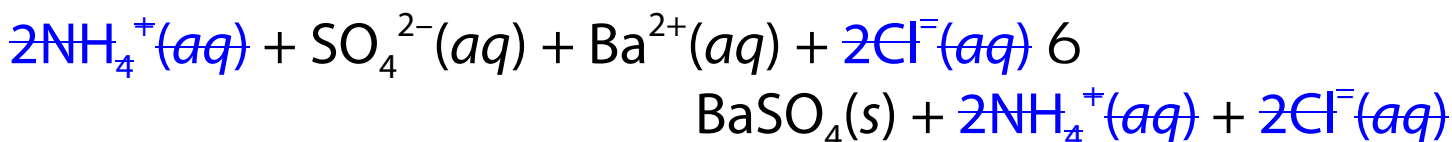


### Ionic equation:

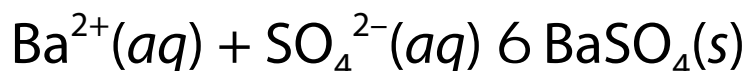


### Net ionic equation:

Remove spectator ions



to obtain net ionic equation



- Spectator ions must be in exactly the same form and number on both sides of the ionic equation.