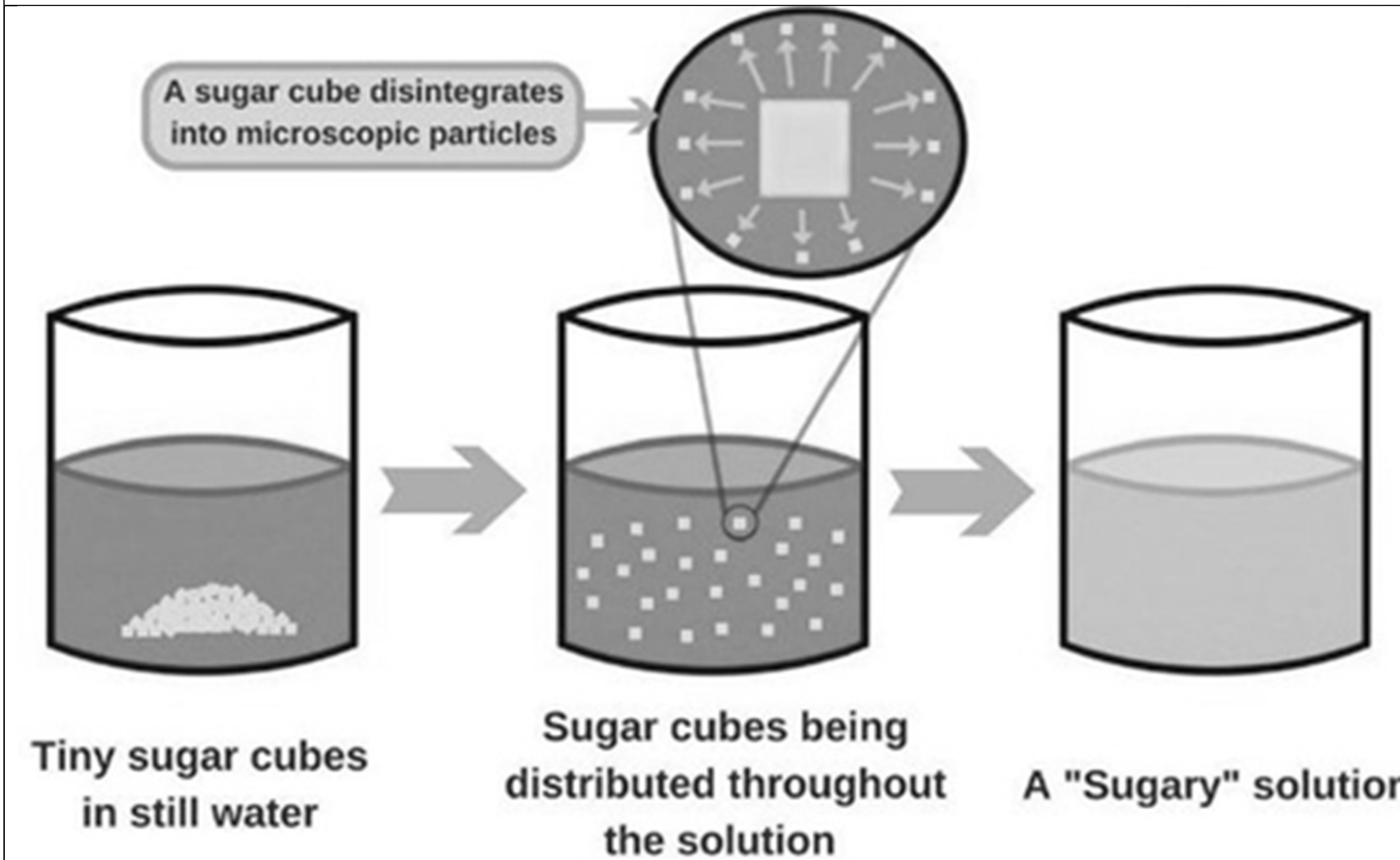
Solutions Pack—Arbuiso Chem



Solutions are mixtures. They can be homogeneous (like salty water) or they can be heterogeneous (like chocolate milk that has settled). They usually are aqueous, but they can be dissolved in other liquids. They can also be gases or solids.

Solutions are concentrated or dilute; or you can measure their exact strength. Solutions can be made from scratch using the molarity formula, or you can dilute some of what you have in stock, called the stock solution) using the dilution formula.

You can measure the concentration of solutions in molarity, or in parts per million, or even in parts per billion if you like to do a lot of math.

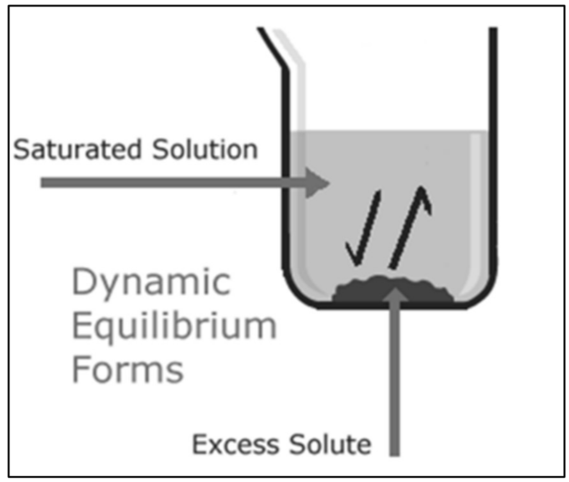
Normal solutions are measured in molarity, but when solutions are really dilute PPM works better. Either formula would work and show a solution strength, but the point is to get numbers we can grasp.
If a solution is 11.4 PPM, the molarity might be a small decimal like 0.000456 molar.
11.4 is easier on the brain than decimals like that one!

Solutions BASICS

In this section of chemistry we'll be examining solutions, how they form, how to measure their strength, their properties, and how to dilute them exactly to get new solutions of lesser concentration and volume. We'll study about the 3 Colligative Properties of water, all affected by how much solute is dissolved into the water. Finally, we will do some math, the concept of parts per million for very un-concentrated solutions.

Solutions are homogeneous mixtures containing a solute in a solvent. We most often think of them as wet, with water as the solvent. Other liquids can be solutes as well. Gases can mix homogeneously which makes a gas solution, and we could even melt metals or other solids and stir them together. When they cool, they are solid solutions (like steel). For now, we'll stick to aqueous solutions.

Solutions can be saturated, these are holding as much solute in the solvent as possible. At some point there is just no more room in the solvent and added solute cannot dissolve, so it falls to the bottom of the container. Although a saturated solution is "maxed out", solute continues to dissolve into solution while other solute falls out of solution – a **dynamic equilibrium** is formed.



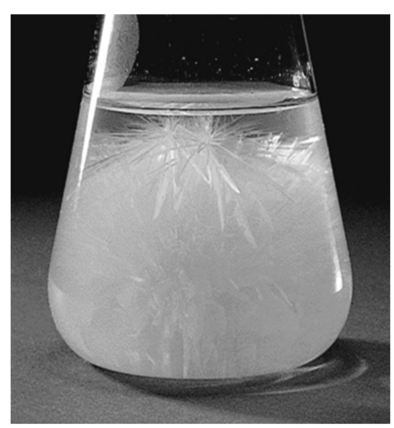
The rate of dissolving = the rate of precipitation. The solution is full up, but it's constantly changing while the amount of dissolved solute remains constant.

An **unsaturated solution** has room to hold more solute. It's not full up yet, it can dissolve more solute.

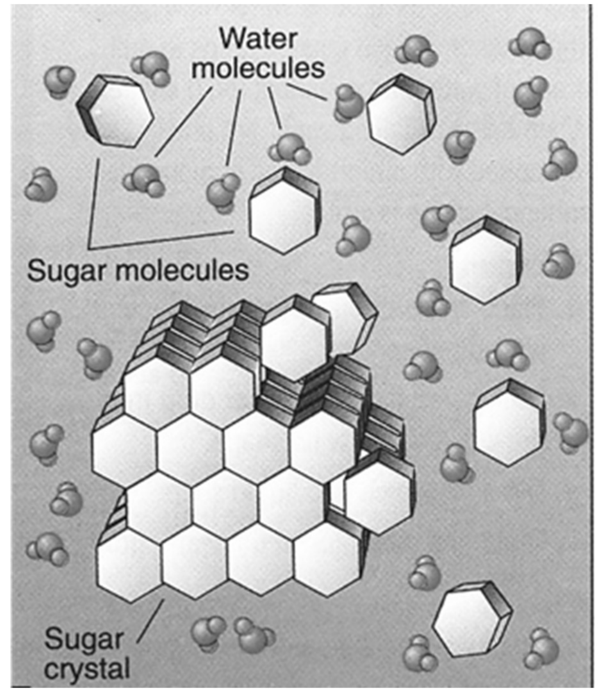
A **supersaturated solution** is one that is more highly concentrated than is normally possible under given conditions of temperature of the solution. They way to make one is to start hot. Most often, a hotter solution holds more solute than a cooler one can. Some solutes can get "tricked" into staying in solution as you cool the hot saturated solution down. The cooler solutions now have more solute in them then can fit if one started with a colder solvent.

All the solute stays aqueous, until ALL AT ONCE the solute can collapse into a solid, like this beaker. If you add a "seed" crystal of solute to a super saturated solution, ions will begin to lock onto the "seed" crystal, and then all the excess ions solidify at once. This photo shows the crystallization of excess solute after the seeding. There are 2 examples of this in our class, table sugar can supersaturate and so can the salt sodium acetate (found in reusable hand warmers).

When these (ionic) bonds form, energy is released.



Formation of Solutions…

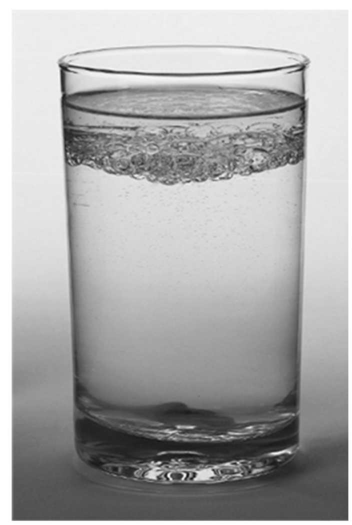


When a crystal of sugar (or other polar compound) is put into the polar solvent water, the crystal is "attacked" by the water molecules. The water molecules surround the sugar molecules, carrying them off molecules of the crystal into solution.

Of course, molecules are too small to see, so the visible crystal is soon invisible to the eye as it's broken into billions of molecules too small to see. At some point the solvent cannot hold a single molecule more, so as more sugar dissolves, some other sugar molecules will precipitate out of solution at the same rate.

<u>Like dissolves like</u> is our solution mantra; polar solvents such as water can only dissolve polar molecular compounds, or most ionic compounds.

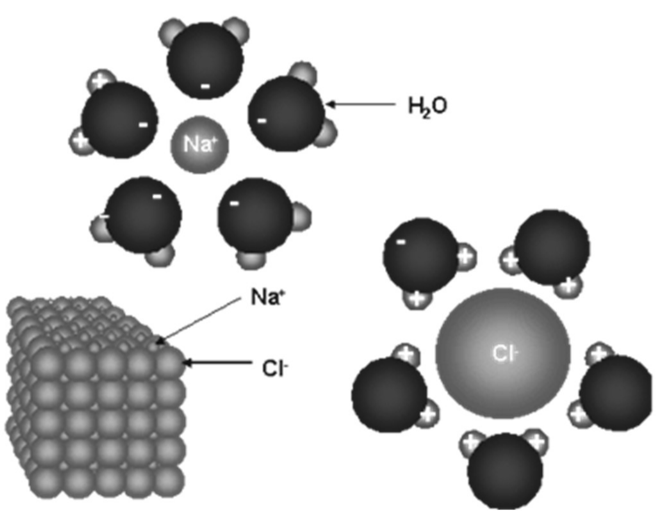
Non-polar compounds cannot mix with polar solvents.



On the right is oil sitting atop water. The polar water cannot mix with the nonpolar oil. The oil floats because it's less dense. It doesn't mix because: <u>Like Dissolves Like</u> is always true. Polar water can't dissolve NONPOLAR oil.

When ionic compounds are put into a polar solvent like water, they (usually) are dissociated or ionized into ions. The water molecules surround them as shown below. Solubility exceptions exist on table F!

In the picture below, note how the positive hydrogen side of the water molecules surround the negative chloride anions. The oxygen, with their negative charge, surround the positive sodium cations. The solvent will dissolve solute until saturated, then the dynamic equilibrium will form.



Remember what an electrolyte is? It's a solution that can conduct electricity.

Solutions with ions dissolved can conduct electricity, but solutions with dissolved molecules like sugar cannot conduct. The more ions, the better the conduction.

The less ions, the weaker the conduction.

Acids are special chemical compounds in aqueous solutions that appear to be molecular compounds like sugar (no metals), which they are, but they do form ions (we'll learn about acids and bases soon enough).

The CONCENTRATION of solutions.

One of the coolest concepts in chemistry is MOLARITY, the measure of how concentrated a solution is. Molarity can best be described as the molar concentration of a solution, expressed as the number of moles of solute/ liter of solution.

The formula is:

$$\text{Molarity} = \frac{\text{number of moles of solute}}{\text{Liters of solution}}$$

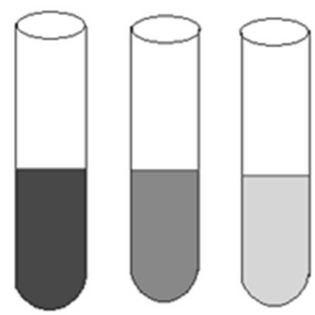
The formula is set up as moles divided by LITERS of solution, but a solution of any volume can be made, and its CONCENTRATION will be measured using this formula.

For example…
A 1.0 Molar aqueous solution of HCl could be made by putting 1.0 moles HCl into 1.0 Liters of H_2O.

Or the same strength or concentration solution could be made with 0.25 moles HCl and 250 mL water.

A near infinite number of combinations of moles to volume exist to make the same concentration.

These three tubes represent 3 different solutions of the SAME compound, but at different concentrations. The darkest one, on the left, would have the HIGHEST MOLARITY with the greatest concentration.
The lightest colored solution at right has the LOWEST MOLARITY with the lowest least concentration.



THINKING PROBLEM:
What is the concentration of an aqueous solution of KCl containing 370 grams KCl dissolved into 2.5 liters water? Using the formula above for molarity, we figure this way…

$\text{Molarity} = \frac{\text{\# moles KCl}}{\text{liters of solution}}$	$\frac{370\text{ g KCl}}{1} \times \frac{1\text{ mole KCl}}{74\text{ grams KCl}} = 5.0\text{ moles KCl}$	$M = \frac{5.0\text{ moles KCl}}{2.5\text{ Liters}}$ M = 2.0 molar solution

Making a solution from Scratch.

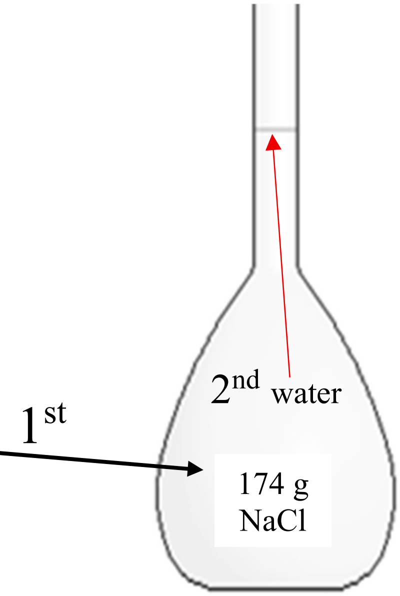
How do you prepare a 1.00 M of $NaCl_{(AQ)}$ solution of 3.00 Liters in volume?

Start with the molarity formula, putting in the data you have, solving for moles of solute (here that's the NaCl).

$$\text{Molarity} = \frac{\#\text{moles solute}}{\text{liters of solution}}$$

$$\frac{1.00\text{ M}}{1} = \frac{\#\text{ moles NaCl}}{3.00\text{ Liters}} = 3.00\text{ moles NaCl}$$

$$\frac{3.00\text{ moles NaCl}}{1} \times \frac{58\text{ grams NaCl}}{1\text{ moles NaCl}} = 174\text{ g NaCl}$$



To make this solution, FIRST put in the 174 grams of solute, then, FILL UP TO THE 3.00 Liter mark on the volumetric flask. The 3.00 Liters includes the SOLUTE PLUS THE WATER.

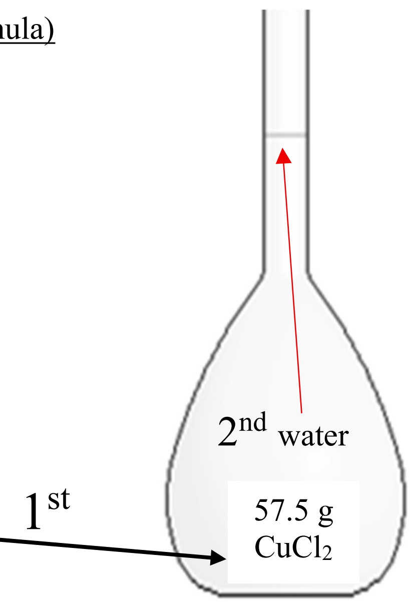
NOTE: do not think for one moment that you can put 174 grams of salt into 3.00 Liters of water! That salt has a small volume, it's not zero. Adding salt to the 3.00 liters of water would give you a slightly larger volume, just enough to be WRONG!

How do you make 245 mL of 1.75 M $CuCl_{2(AQ)}$? (start with molarity formula)

$$\text{Molarity} = \frac{\#\text{moles solute}}{\text{liters of solution}}$$

$$\frac{1.75\text{ M}}{1} = \frac{\#\text{ moles }CuCl_2}{0.245\text{ Liters}} = 0.429\text{ moles }CuCl_2$$

$$\frac{3.00\text{ moles }CuCl_2}{1} \times \frac{134\text{ grams }CuCl_2}{1\text{ moles }CuCl_2} = 57.5\text{ g }CuCl_2$$



To make this solution, FIRST put in the 57.5 grams of solute, then, FILL UP TO THE 245 mL mark on the volumetric flask. The 245 mL includes the SOLUTE PLUS THE WATER.

The Molar Dilution Formula

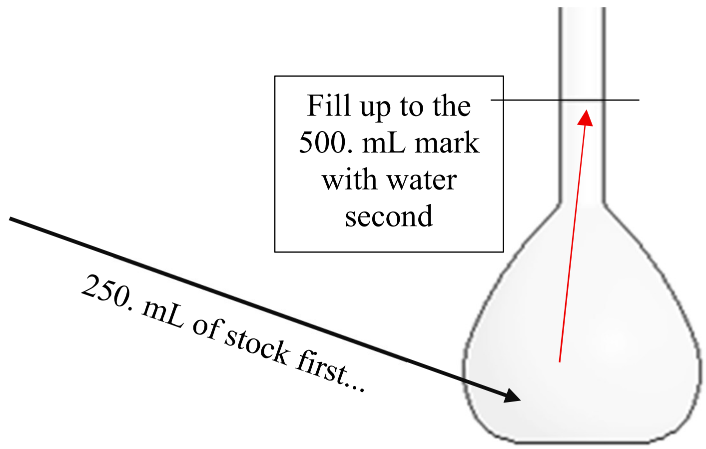
Another formula that we can use is called the dilution formula. We can start out with a concentrated stock solution that we know the molarity of and use it to make a new solution with a new volume and concentration that we want.

The Molar Dilution formula is: $M_1V_1 = M_2V_2$

(Molarity of the stock)x(unknown volume we need) = (Molarity of new solution)x(Volume of new solution)

For example, assume you have a lot of a concentrated $CuSO_{4(AQ)}$, of 2.00 Molar strength. How would you mix a 500. mL $CuSO_4$ solution of only 1.00 Molarity?

$$M_1V_1 = M_2V_2$$
$$(2.00\text{ M})\ (V_1) = (1.00\text{ M})(500.\text{ mL})$$
$$V_1 = 250.\text{ mL stock solution}$$

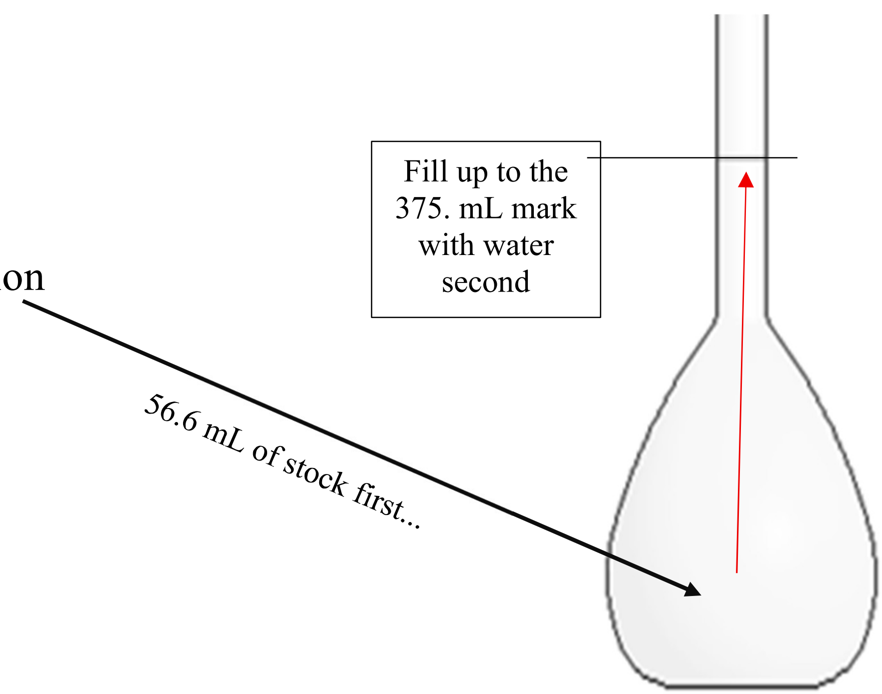


To make this new solution, start with exactly 250. mL of the stronger, stock solution, then add enough water to dilute it and fill up the beaker to 500. mL solution.

Example2

How do you prepare a 375. mL saltwater solution of 0.755 M concentration with a stock $NaCl_{(AQ)}$ of 5.00 M?

$$M_1V_1 = M_2V_2$$
$$(5.00\text{ M})\ (V_1) = (0.755\text{ M})(375\text{ mL})$$
$$V_1 = \frac{(0.755\text{ M})(375\text{ mL})}{5.00\text{ M}}$$
$$V_1 = 56.6\text{ mL of stock solution}$$



Colligative Properties of Solutions

These are physical properties that can change depending upon how much solute is dissolved into 1 liter of the solution. They are boiling point, freezing point, & vapor pressure. These change when solute dissolves.
In high school we will ONLY look at aqueous solutions, and we will always use one liter solution sizes (to keep the math simple). The more particles are dissolved in a solution, the greater these properties change.

Before we do math, let's review what actually happens when compounds dissolve into water.
Molecular compounds, like sugar, dissolve into water, but they do not form ions. They are not ionic. When soluble ionic compounds dissolve, the compound ionizes, or it dissociates into ions.

$C_6H_{12}O_6$	$C_6H_{12}O_{6(S)} \rightarrow C_6H_{12}O_{6(AQ)}$	1 mole $C_6H_{12}O_6 \rightarrow$ 1 mole of molecules
NaCl	$NaCl_{(S)} \rightarrow Na^{+1}_{(AQ)} + Cl^{-1}_{(AQ)}$	1 mole NaCl → 2 moles of ions
$CaCl_2$	$CaCl_2 \rightarrow Ca^{+2}_{(AQ)} + Cl^{-1}_{(AQ)} + Cl^{-1}_{(AQ)}$	1 mole $CaCl_2$ → 3 moles of ions
$AlCl_3$	$AlCl_3 \rightarrow Al^{+3}_{(AQ)} + Cl^{-1}_{(AQ)} + Cl^{-1}_{(AQ)} + Cl^{-1}_{(AQ)}$	1 mole $AlCl_3$ → 4 moles of ions
AgCl	AgCl → no moles of ions, it's insoluble!	1 mole AgCl = zero particles.

1 mole of substance does not always equal one mole of particles.

BOILING POINT ELEVATION

The water boils when it can overcome both the air pressure pressing down on the surface, and the internal hydrogen bonding holding the molecules together. At standard pressure water boils at 373 Kelvin. When polar molecules or ions are dissolved into the water, the water molecules are ALSO attracted to the particles. This creates MORE INTERNAL ATTRACTION, which means it will take more energy to make the water boil into a gas – a higher BP.

The boiling point elevation for water is 0.50 K per mole of particles per liter of solution.
For every mole of particles, the boiling point goes up by 0.50 Kelvin or 0.50 °C

FREEZING POINT DEPRESSION

The freezing point is also affected by dissolved particles. The difference is that the freezing point requires colder temperatures to freeze around the molecules that are "in the way" of the water locking together in that hexagon rings. Water freezes when the hydrogen bonding is strong enough to do this with the ions or molecules getting in their way.

The freezing point depression for water is 1.86 K per mole of particles per liter of solution.
For every mole of particles dissolved, the freezing point goes down by 1.86 Kelvin or 1.86 °C.

Example 1. What is the boiling point of a 1.0 Molar NaCl solution of one liter? (forms 2 moles of ions)

Start boiling point	Boiling point elevation	New boiling point
373 K	+ (2 x 0.50 K) =	373 + 1 = 374 K

Here we INCREASE THE boiling point, ADD the BP elevation to the normal BP of 373 Kelvin.

Example 2. What is the boiling point of a 1.0 Molar $CaCl_2$ solution of one liter? (forms 3 moles of ions)

Start boiling point	Boiling point elevation	New boiling point
373 K	+ (3 x 0.50 K) =	373 + 1.5 = 374.5 K

Three moles of ions in a one-liter solution has a bigger effect on the BP.

Example 3. What is the boiling point of a 2.0 Molar $CaCl_2$ solution of one liter? (forms 6 moles of ions)

Start boiling point	Boiling point elevation	New boiling point
373 K	+ (6 x 0.50 K) =	373 + 3 = 376 K

This solute has a 6 fold impact on the BP, since 2 moles of this compound produces 6 moles of ions.

Example 4. What is the boiling point of a 4.0 Molar $AlCl_3$ solution of one liter? (16 moles of ions, wow)

Start boiling point	Boiling point elevation	New boiling point
373 K	+ (16 x 0.50 K) =	373 + 8 = 381 K

Each mole of aluminum chloride forms 4 moles of ions. 4 moles of $AlCl_3$ produces 16 moles of ions!

Example 5. What is the boiling point of a 2.5 Molar $CaBr_2$ solution of one liter? (see below)		
Start boiling point	Boiling point elevation	New boiling point
373 K	+ (7.5 x 0.50 K) =	373 + 3.75 = 386.75 K
Each mole of calcium bromide forms 3 moles of ions. Here the solution contains 2.5 moles of calcium chloride, each forms 3 moles of ions, so 2.5 X 3 = 7.5 moles of ions		

FREEZING POINT DEPRESSION

The water molecules wish to freeze normally at 273 Kelvin. The water forms six-molecule rings, locking into place when their hydrogen bonding is stronger than the kinetic energy provided by the temperature. At 273 K the hydrogen bonding is strong enough to lock the water into the grid-like lattice we call ice.

When the water has ions dissolved into it, or polar molecules dissolved into it, the water molecules can't lock together until they get colder than usual. They need to be able to "freeze out" these particles; that requires lower kinetic energy or a lower temperature.

Each mole of particles in one liter of solution drops the freezing point by 1.86 Kelvin or 1.86°C.

Example 6. What is the freezing point of a 1.0 Molar NaCl solution of one liter?		
Start freezing point	Freezing point depression	New boiling point
273 K	– (2 x 1.86 K) =	273 – 3.72 = 269.28 K
Here the one mole of NaCl provides 2 moles of ions, so the FP is depressed by 2 times the 1.86 K.		

Example 7. What is the freezing point of a 2.0 Molar $CaCl_2$ solution of one liter?		
Start freezing point	Freezing point depression	New boiling point
273 K	– (6 x 1.86 K) =	273 – 11.16 = 261.84 K
Each mole of $CaCl_2$ forms 3 moles of ions. With 2 moles forming 3 ions each there is a 6 fold impact.		

Example 8. What is the freezing point of a 4.0 Molar $AlCl_3$ solution of one liter?		
Start freezing point	Freezing point depression	New boiling point
273 K	– (16 x 1.86 K) =	273 – 29.76 = 243.24 K
Each mole of $AlCl_3$ forms 4 moles of ions. With 4 moles, that's 4 x 4 = 16 moles of particles in solution.		

THINK #1:
Why would people do better with calcium chloride than sodium chloride on their sidewalks in winter?
NaCl ionizes into TWO IONS, while the $CaCl_2$ ionizes into THREE IONS.
More moles of ions means that the sidewalk water would not freeze until a LOWER temperature, making them ice free, and safer, to a lower temperature.

THINK #2:
If we add one mole of sugar, 1 mole of sodium chloride or 1 mole of calcium chloride, which solution ends up with the highest boiling point?

One mole of sugar molecules (1 mole of particles) raises the boiling point of one liter of water to 373.5 K.

One mole of NaCl ionizes into 2 moles of ions, raising the boiling point to 374 K.

One mole of $CaCl_2$ ionizes into 3 moles of ions, raising the boiling point of one liter of water to 374.5 K.

THINK #3:
Why would there be different Vapor Pressure with different numbers of particles dissolved into solutions?
This occurs for the same reason as the change in boiling point — the water sticks together well due to the many hydrogen bonds. With the addition of extra charged (or polar) particles, there are MORE attractions that have to be overcome to evaporate those water molecules into the gas phase. Vapor pressure is also affected by particles in solutions, but we won't do any math with this in high school.

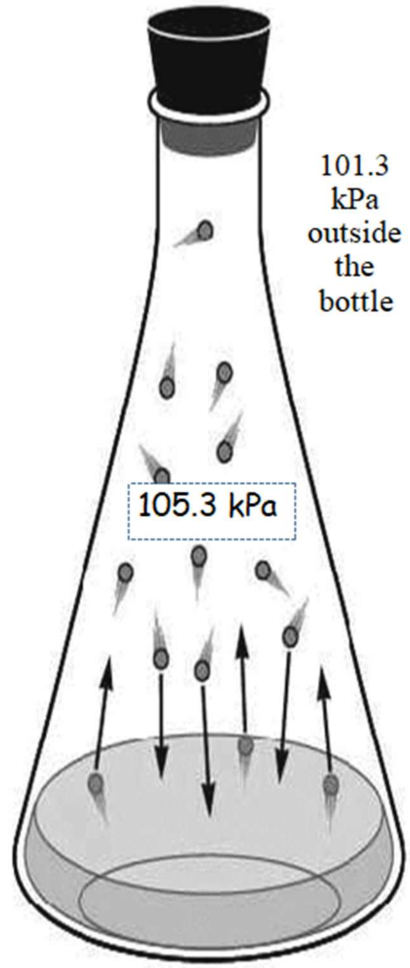
In a sealed system, molecules of the liquid will evaporate into the space above the surface of the liquid.
How much evaporation is determined by the attractiveness of the particles to each other which keeps them liquid, also by the temperature (the more Kinetic Energy means more evaporating), and how many particles are dissolved into the liquid. The more particles that are dissolved, the more attractive the liquid is to itself; the less evaporation = lower vapor pressure.

Let's imagine a NaCl solution. The salt ions are now present, and although the water molecules have plenty of hydrogen bonds to each other, they also have attraction to these ions. This makes evaporation more difficult.

VAPOR PRESSURE ADJUSTMENT

The vapor pressure is shown in table H on the reference tables.
The vapor pressure is THE EXTRA PRESSURE ADDED TO A CLOSED SYSTEM BY THE EVAPORATION OF A LIQUID.

Room temperature water (25°C) has a vapor pressure of about 4 kPa. That means inside that bottle at right, if the starting air pressure inside the bottle was 101.3 kPa (normal), the water evaporating will add to it by about +4 kPa. That makes the pressure in the bottle about 105.3 kPa.



Water doesn't evaporate well because of all the hydrogen bonding it has. That means water has low vapor pressure. Adding any solute to water only increases the internal attraction, making it harder to evaporate.

In our class we will only know that any solute in water decreases the vapor pressure (makes it evaporate less well).

More concentrated aqueous solutions have lower vapor pressure compared to dilute aqueous solutions.

There is NO MATH for the vapor pressure in high school.

We will attempt to make relative decisions as to which solutions have the highest vapor pressure.

Which of the following aqueous solutions will have the highest and lowest vapor pressures?

A. 3.00 molar $Al(NO_3)_{3(AQ)}$
B. 5.00 molar $NaCl_{(AQ)}$
C. 8.00 molar $C_6H_{12}O_{6(AQ)}$
D. 15.0 molar $SrSO_{4(AQ)}$

$Al(NO_3)_3$ will ionize into 4 moles of particles, a 3.00 M solution form 3.00 X 4 = 12 moles of ions in solution

NaCl will ionize into 2 moles of particles, a 5.00 M solution form 5.00 X 2 = 10 moles of ions in solution

$C_6H_{12}O_6$ won't ionize, an 8.00 M solution forms 8.00 X 1 = 8 moles of polar molecules in solution

$SrSO_4$ will NOT ionize, it's ionic, but according to table F, it is insoluble. No particles = no impact on V.P.

$SrSO_{4(S)}$ has the highest vapor pressure (same as water's).
The lowest VP will be with the solution with the MOST particles dissolved into solution, which is $Al(NO_3)_{3(AQ)}$

PARTS PER MILLION

Some solutions are so very dilute that the molarity becomes a super small decimal that our brains can't make easy sense of. For example, when you add just 1.0 moles of NaCl into a swimming pool sized 43,000 Liter solution, the molarity works this way:

Another way to measure concentration is called PPM or parts per million. Some concentrations are so small that molarity is too small to grasp easily, so this other expression is used.

Any concentration can be measured in molarity or parts per million, but sometimes certain units make things easier. If you measured the distance from your house to the Empire State building in inches, that would be hard to understand. Inches are so small, the number of inches would be so big, it's the wrong unit to use, but it's possible.

If you wanted to measure the mass of an ant, you would not want it in tons. The decimal would be so small that it would be hard to understand, but not incorrect, just dopey.

Parts per million (PPM) is for very low concentrations, molarity for "normal" concentrations.

> Example: What is the molarity of a solution containing 58 grams NaCl in 43,000 liters of water?
> (a teaspoon of salt in a backyard pool)

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{Liters of solution}} \qquad \text{Molarity} = \frac{\text{1 mole NaCl}}{\text{43,000 Liters}}$$

M = 0.0000233 M

or it's
233 ten millionths Molar NaCl

which is silly small, and a silly unit.

> Example: What is the concentration of a solution containing 58 grams NaCl in 43,000 liters of water expressed in parts per million (PPM)? (the same teaspoon of salt in a backyard pool)
>
> (each liter = 1000 mL or 1000 grams)

$$\text{PPM} = \frac{\text{58 g NaCl}}{\text{43,000,000 g } H_2O} \times 1{,}000{,}000 = 1.35 \text{ Parts per million}$$

(an equivalent strength but a more normal number to deal with)

> Example: If there is 0.125 grams of mercury dissolved into 101. liters of sea water, concentration in PPM?

$$\text{PPM} = \frac{\text{0.125 g Hg}}{\text{101,000 g } H_2O} \times 1{,}000{,}000 = 1.24 \text{ PPM}$$

Example: What is the concentration of a solution in PPM, if 0.02 grams Na_3PO_4 is dissolved into 1000 grams water? A. 20 PPM B. 2 PPM C. 0.2 PPM D. 0.02 PPM

$$PPM = \frac{0.02\ g}{1{,}000\ g\ H_2O} \times 1{,}000{,}000 = 20\ PPM \quad \text{(choice A)}$$

Bits and Pieces

To make a proper solution, of perfect volume, there is only one way to proceed. First get a special flask with a line that shows exactly a particular volume (often 1.00 L). Put the solute in first. Then fill with pure water up to the line. This is the ONLY WAY to make a perfect solution. You can't just add solute into the solvent, it will affect the volume (in a small but measurable way).

When an ionic compound (NaCl, KCl, etc.) is dissolved into water it forms an ionic solution. It has free ions floating in the water. This is a homogeneous mixture. The more ions in solution, the better electrical conduction that occurs, which is a stronger electrolyte. With fewer ions means a lesser electrical conduction, or a weaker electrolyte.

If you melt an ionic compound like $NaCl_{(L)}$ or $CuBr_{(L)}$ it will be super-duper hot. It will also be able to conduct electricity because the ions are loose, almost like in an aqueous solution. This is weird, it would be way too hot to handle in most colleges or in high school, but it would conduct.

Ionic compounds that do not ionize in water are NOT electrolytes, but they can conduct electricity is their liquid or melted states.

Electrolytes are solutions with ions in them (soluble ionic compounds), and they can conduct electricity. Electrolytes are always able to conduct electricity. The more ions in solution, the better the electricity flows.

Ionic compounds in the solid form CANNOT conduct electricity because there are no loose ions, and no loose electrons (as with metals and metallic bonds). Solid ionic compounds are called electrolytes only if they are soluble in water. Electrolytes can be solutions that conduct, or (strangely enough) solids that would form soluble ionic solutions. Insoluble ionic compounds like AgCl, or molecular compounds are never electrolytes, and cannot conduct electricity.

SOLUTIONS NOTES Objective: Describing what solutions are, how they form, & how are they're strength is measured.	
1	A solution is a
2	The dissolves into the
3	If you put sugar into coffee, the sugar is the while the coffee is the
4	When a solution holds the maximum amount of solute it is a ______________________________ solution.
5	If there is less than the maximum amount of solute in the solution it is
6	6. Compare a 10°C sugar solution to a 90°C sugar solution. At 10°C you can fit _______ g sugar into solution. At 90°C you can fit _______ g sugar into solution.
7	It's hard to see here, but the NaCl solubility increases just a tiny bit (___________________________) in a100 mL solution, a small increase.
8	Most solutions you think about will be aqueous which means dissolved in
9	Solutions can also be gases like ___________, or solid ________________________ like brass or cast iron
Demo one: Which dissolves faster, chunks of solute or powdered solute?	
Demo two: Which dissolves faster, Alka-Seltzer in cold water, or hot water?	
Demo three: Which dissolves faster, cube of sugar with stirring or without stirring?	
10	SMALLER PARTICLES = MORE SURFACE AREA
11	HOTTER TEMP = HIGHER KE = MORE MOTION
12	AGITATION = HIGHER KE = MORE MOTION

14	The rate of solvation increases with		
	More	Higher	and More

How much solute will dissolve into a solution? It depends first on

15	
16	
17	

18	Draw structural diagrams of H_2O and CO_2	
19	What sort of molecules are these?	
20	The only way to make carbon dioxide dissolve into water, to make seltzer is…	

21. There are several ways to measure how strong a solution is in chemistry.

Qualitatively we can say things like

Or we could use "better" words like

With numbers and units,
in a quantitative measure, we will use

22	Molarity is the expression of concentration of a solution as measured by the number of moles of solute in a liter of solution.	M =
23	What is the concentration of a $NaNO_3$ solution containing 4.50 moles of solute in 1220 mL volume?	
24	SAY:	
	WRITE:	
	THINK:	
25	What is the concentration of a 1650 mL salty water solution containing 125 g NaCl?	
Convert grams of NaCl into moles first.		
Then convert mL into liters.		
Write the molarity formula, do the math		

26	If you add 43.5 g NaCl to water to form a 648 mL solution, what is its concentration?
Convert to moles first	
Convert to liters next	
SAY WRITE THINK	

27	You put 111g KCl solid into a volumetric flask. You fill the flask to 250. mL, what is the molarity of this solution? (draw)

28	You put 74.0 g KCl solid into a flask, fill to 1600. mL. What is the molarity of this solution?

SAY

WRITE

THINK

29	Calculate the molarity of 750. mL $LiBr_{(AQ)}$ that has 215 g LiBr solute

30	How many grams of $NaNO_3$ are in a 100 mL aqueous solution that is saturated at 10°C?
31	How many grams of $NaNO_3$ fit into 325 mL of water at 10°C? (write temp, $NaNO_3$ over WATER)
32	What is the MOLARITY of this solution of 260. g $NaNO_3$ in 325 mL?

33. Solution Vocabulary you have to memorize	
	the stuff dissolved into the solvent of a solution, the salt of salty water
	the part of the solution that the solute is dissolved into, the water of salty water.
	when a solution is holding the maximum solute at a particular temperature.
	when a solution is holding LESS THAN the maximum amount of solute at a particular temperature.
	the solubility guidelines for 10 compounds over all liquid water temps.
	the measured concentration of a solution in moles/Liter units.
	$M = \frac{\text{moles of solute}}{\text{liters of solution}}$
	MOLES of solute per LITER - not grams or mL!

34	Calculate the molarity of a solution containing 259 g $KBr_{(AQ)}$ with total volume of 750. mL (the molar mass KBr = 119 g/mole)
35	How many grams of sodium chloride are in a 100 mL aqueous solution that is saturated at 90°C?
36	How many grams of sodium chloride are in an 885 mL aqueous solution that is saturated at 90°C? Do this as shown, no variations allowed.
37	What's the molarity of this saturated solution of $NaCl_{(AQ)}$? *Convert 354 grams of NaCl into moles first.*
38	If you had two SATURATED $NaCl_{(AQ)}$ - one 100 mL, another of 885 mL… WOULD THEY BE THE SAME? Same molarity? Same ability to conduct electricity? 

39 How many grams of NaCl are required to form a 2.50 L of 0.900 M $NaCl_{(AQ)}$? *(use a formula)*

40	How many grams of KOH required to make a 1.20 M solution of $KOH_{(AQ)}$ of 2.00 Liters?

How can we prepare this 2.00 Liter solution of $KOH_{(AQ)}$ with 1.20 M concentration?

The wrong way is to get 2.00 Liters and add 134 g of KOH into it.

The KOH would increase the volume over 2.00 liters.

41 How can we prepare a 1.20 M solution of $KOH_{(AQ)}$ of 2.00 Liters?

42 How would you mix up 2.65 liters of 2.50 M $KNO_{3(AQ)}$ from scratch?

If you have some strong 2.50 M $KNO_{3(AQ)}$ solution in the stock room,
how would you use it make 1.00 Liter of 1.15 M $KNO_{3(AQ)}$?

Take out your reference table, back page, and add this dilution formula to the concentration box.

Concentration	For mixing solutions from scratch, or measuring solution concentration. **Molarity** = $\frac{\textbf{Moles of solute}}{\textbf{Liters of solution}}$	For mixing up a new solution from a stock solution you have on-hand $M_1V_1 = M_2V_2$

43 The DILUTION FORMULA is:

The symbols mean:

M_1 = Molarity of the original stock solution

V_1 = Volume of the original stock solution (unknown)

M_2 = Molarity of the new solution you want to make

V_2 = is Volume of new solution that you want to make

44 Using a 2.50M $KNO_{3(AQ)}$ how would you make 1.00 Liter of 1.15 M $KNO_{3(AQ)}$?

45	How do you prepare a 200. mL $NaCl_{(AQ)}$ solution of 1.00 molarity from a stock solution of 5.50 M? 
46	Hydrochloric acid solution comes to the school very concentrated – at 12.0 M! Using this stock, how do you to make up 2.00 L of 2.25 M HCl solution? *start with a formula*

Use words to tell how to make this solution, no diagram here.

No Writing, think about this, you put 1502 grams NaCl into a swimming pool of 312,000 liters of water. What is the molarity of this solution? (the answer is stupidly small to make a point)

$$\frac{1502 \text{ g NaCl}}{1} \times \frac{1 \text{ mole NaCl}}{58 \text{ g NaCl}} = 25.9 \text{ moles salt}$$

$$M = \frac{\text{moles solute}}{\text{liters solution}} \quad \frac{25.9 \text{ moles}}{312{,}000 \text{ Liters}}$$

M = 0.0000830 Molar $NaCl_{(AQ)}$

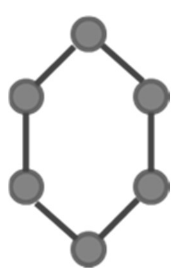
830 ten millionths Molar!! Sort of a stupid.

It's true, but the number is way too small to "make any sense" to us.

47	PPM stands for:
48	Write the formula, from back page of the reference tables PPM =
49	You put 1502 grams NaCl into a swimming pool of 312,000 liters of water. What is the molarity of this solution? What's the concentration of this in PPM? *use the formula*

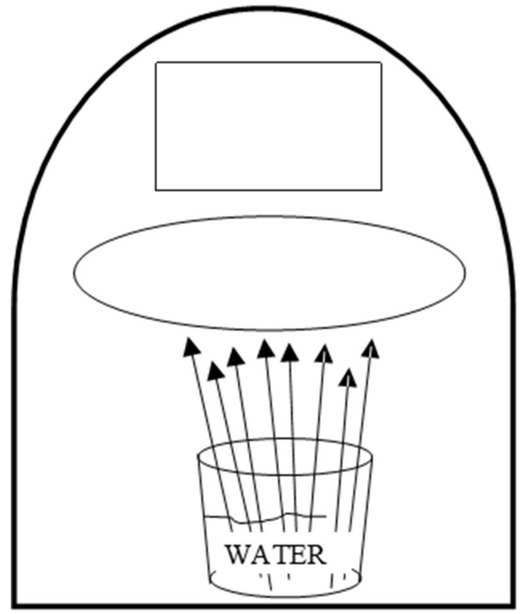
Sometimes low concentration environmental **poisons** are measured this way.

MOLARITY & PPM are mathematically interchangeable, just try to use "normal" numbers.

50	There are 3 properties of called the colligative properties.
51	The 3 colligative properties of water are:
52	The reason for these properties is
53	For water to boil, energy must break the _______________________________________ bonds.
54	If solute like NaCl ions are dissolved into water, the hydrogen bonds still need to break, but now, the water must also overcome the polar attractions to the _______________________________ too.
55	Water has a BP of __________________. Salty water will have a _____________________ BP.
56	For water to freeze, the molecules must make those neat little 6-molecule rings to solidify. The molecules are hydrogen bonded to each other. Draw an ion getting in the way of six molecules of water to form an ice ring. 

When solute is dissolved into the water, these particles literally get in the way of the hydrogen bonding.
Water can't freeze at a normal 273 must it has to be colder for the ions to be pushed aside as ice forms.

The more solute (polar molecules like sugar, or ions) the colder the water must be to freeze.



57	Vapor pressure is (like a bell jar).
58	Water has a ___________________________________ vapor pressure.
59	What is the vapor pressure of water at 25 centigrade?
60	Why does water have LOW VAPOR PRESSURE?
61	What impact would polar molecules, or ions, (solute) have on vapor pressure?
62	At 25 C, what are vapor pressures for water and propanone? Why?

63	The boiling point ELEVATION for water is
64	The freezing point DEPRESSION for water is

65. Formula	When the ionic compounds go into water, this is what they turn into
1.0 M $NaCl_{(S)}$	1 mole Na^{+1} and 1 mole Cl^{-1} = 2 moles ions
2.0 M $NaCl_{(S)}$	__ moles Na^{+1} and _ _ moles Cl^{-1} = __ moles ions
3.0 M $NaCl_{(S)}$	__ moles Na^{+1} and __ moles Cl^{-1} = _ _ moles ions
2.0 M $CaCl_{2(S)}$	__ moles Ca^{+2} and __ moles Cl^{-1} = __ moles ions
3.0 M $CaCl_{2(S)}$	__ moles Ca^{+2} and __ moles Cl^{-1} = __ moles ions

66. Formula	Numbers of moles of particles*
2.50 M $NaCl_{(AQ)}$	mole Na^{+1} & mole Cl^{-1} = moles ions
1.25 M $NaCl_{(AQ)}$	moles Na^{+1} & moles Cl^{-1} = moles ions
1.75 M $NaCl_{(AQ)}$	moles Na^{+1} & moles Cl^{-1} = moles ions
2.25 M $CaCl_{2(AQ)}$	moles Ca^{+2} & moles Cl^{-1} = moles ions
3.0 M $Al(OH)_{3(AQ)}$	mole Al^{+3} & moles OH^{-1} = moles ions
1.0 M $NH_{3(AQ)}$	mole of MOLECULES
2.50 M $C_{12}H_{22}O_{11(AQ)}$	moles of MOLECULES
1.0 M AgCl	***

67	Calculate the temperature that a 1.00 liter, 2.00 M $NaCl_{(AQ)}$ solution will boil in Kelvin.
68	Calculate the Kelvin BP of a 1.00 Liter, 3.00 M $CaCl_{2(AQ)}$.
69	Calculate the temperature that a 1.00 liter, 2.00 M $NaCl_{(AQ)}$ solution will freeze in Kelvin.
70	Calculate the FP in Kelvin of a 1.00 Liter, 3.00 M $CaCl_{2(AQ)}$.

71 What is the parts per million concentration of a solution containing 98.0 grams of lithium chromate (Li_2CrO_4) that is dissolved into a swimming pool of 57,800 liters?

72. Aqueous solution	Moles of particles/liter	Vapor pressure rank
1.00 M NaCl		
1.00 M $CaCl_2$		
1.00 M NBr_3		
1.00 M $Al(NO_3)_3$		

The dissociation of ionic compounds into water. Count the ions!

73. Compound	Formula	Dissolves into water	And forms these ions
Sodium carbonate		water →→→	
Ammonium sulfide		water →→→	
Aluminum nitrate		water →→→	
Lead (IV) acetate		water →→→	
Silver chloride		water →→→	

74 What is the freezing point of a 1.00 liter solution of 1.00 M Tin (IV) nitrate?

75	In a solution labeled 2.46 M $KCl_{(AQ)}$ that is exactly 2.00 Liters in volume, how many grams of KCl are in this solution?
76	*According to an article in the New England Journal of Medicine, mercury toxicity begins at 0.100 PPM.* If someone dropped 125 grams of $Hg_{(L)}$ into the school pool, that is 102,900 liters, would the mercury level be low enough to be safe, or over the limit of safety?
77	What is the molarity of a solution if 278 g KCl is dissolved into a solution of 5000. mL total volume?
78	How do you prepare 100.0 mL 0.850 M $NaOH_{(AQ)}$ if you start with a stock solution of 6.40 M? 

79	You dissolve 2.25 moles of KBr into water forming a 1.00 liter solution. What is this solution's BP and FP?
80	If you have a 2.40 M HCl stock solution, how do you make a 50.0 mL of 3.00 M HCl solution from it? *A diagram might help you think through this math.* 

81 Three ions are shown below. Draw in 3 water molecules oriented to <u>each of these ions</u>