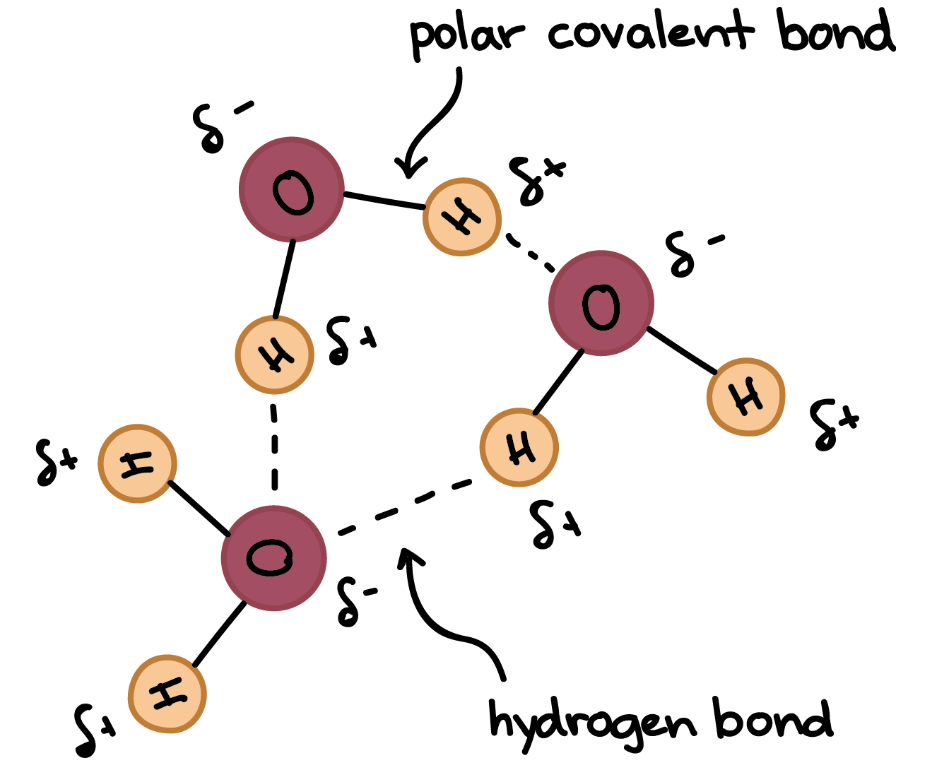
The Properties of Water



Water’s \_\_\_\_\_\_\_ gives it the ability to form \_\_\_\_\_\_\_ bonds and thereby giving water many unique and special properties.

\_\_\_\_\_\_\_ Bonds

* Water is a \_\_\_\_\_\_\_ molecule and therefore, is attracted to other water molecules (\_\_\_\_\_\_\_ interactions).
* The \_\_\_\_\_\_\_ end of one water molecule attracts the \_\_\_\_\_\_\_ end of another water molecule.
* Hydrogen bonds arise when a hydrogen atom (\_\_\_\_\_\_\_) is covalently bonded to a highly \_\_\_\_\_\_\_ larger atom.

Hydrogen bonding produces many of water’s properties:

* Water's \_\_\_\_\_\_\_ and \_\_\_\_\_\_\_ points are higher than expected.
* Water exhibits strong \_\_\_\_\_\_\_ \_\_\_\_\_\_\_ and capillary action due to \_\_\_\_\_\_\_ & \_\_\_\_\_\_\_.
* Water’s \_\_\_\_\_\_\_ \_\_\_\_\_\_\_ is second highest of all liquids. As a result, it can store large amounts of \_\_\_\_\_\_\_ energy. This allows it to moderate climate.
* Water is the one of the few substances whose \_\_\_\_\_\_\_ state is \_\_\_\_\_\_\_ dense than its liquid state. Ice is less dense than liquid water because when water reaches 4 ⁰C, it \_\_\_\_\_\_\_.

High Boiling & Melting Point of Water

\_\_\_\_\_\_\_ (covalent) compounds of low molecular mass are usually \_\_\_\_\_\_\_ or \_\_\_\_\_\_\_ with low boiling points at normal atmospheric pressure.

Water has a molar mass of 18.0 g/mol, but it has a \_\_\_\_\_\_\_ boiling point of 100˚C. Ammonia (NH3) has a molar mass of 17.0 g/mol and boils at about –33˚C. Look at the graph for a comparison. This is due to \_\_\_\_\_\_\_ bonding.

\_\_\_\_\_\_\_ Tension

* + The property of the surface of a liquid that allows it to resist an external force.
  + Strong \_\_\_\_\_\_\_ forces produce higher surface tension (\_\_\_\_\_\_\_ bonding).

Adhesion & Cohesion produce Surface Tension

\_\_\_\_\_\_\_ 🡪 attraction of molecules of \_\_\_\_\_\_\_ substances

* + - \_\_\_\_\_\_\_ in glass tubes
    - capillary action

\_\_\_\_\_\_\_ 🡪 attraction of molecules \_\_\_\_\_\_\_ a substance (e.g. formation of droplets)

Specific Heat

* Resistance to \_\_\_\_\_\_\_ in \_\_\_\_\_\_\_
* Higher specific heat means a substance can \_\_\_\_\_\_\_ more heat or release more heat depending on temperature.
* \_\_\_\_\_\_\_ bonds increase the amount of energy required for the average \_\_\_\_\_\_\_ (temperature) to change.
* \_\_\_\_\_\_\_ change in temperature
* Water takes a long \_\_\_\_\_\_\_ to heat up and a long time to cool down.
* Water’s high specific heat produces \_\_\_\_\_\_\_ climates in places with a lot of water : warmer winters and cooler summers.

\_\_\_\_\_\_\_ of Ice

* As water temperature drops below \_\_˚C, it no longer behaves like a typical liquid, but \_\_\_\_\_\_\_. Ice at 0˚C, has about a 10% lower density than water at 0˚C.
* 99% of chemical substances are \_\_\_\_\_\_\_ dense as \_\_\_\_\_\_\_.
* Ice is \_\_\_\_\_\_\_ dense. Ice is one of only a few solids that \_\_\_\_\_\_\_ in its own liquid due to \_\_\_\_\_\_\_ bonding.

Solutions

Solutions are \_\_\_\_\_\_\_ mixtures of two or more \_\_\_\_\_\_\_ substances (elements and/or compounds).

* A solution is made of a \_\_\_\_\_\_\_ (*the substance being* \_\_\_\_\_\_\_) and a \_\_\_\_\_\_\_ *(the substance* \_\_\_\_\_\_\_ *the dissolving*).
* Air, a solution composed of 78% nitrogen and 21% oxygen. \_\_\_\_\_\_\_: O2 \_\_\_\_\_\_\_: N2
* In a solution, the solvent is present in a \_\_\_\_\_\_\_ amount. In a solution, the \_\_\_\_\_\_\_ dissolves in a \_\_\_\_\_\_\_.

Water is considered a \_\_\_\_\_\_\_ solvent for \_\_\_\_\_\_\_ (no C-H bonds) substances, meaning that it dissolves \_\_\_\_\_\_\_ non-organic matter ... due to \_\_\_\_\_\_\_.

How Does a Solution Form?

The \_\_\_\_\_\_\_ attraction between \_\_\_\_\_\_\_ and \_\_\_\_\_\_\_ particles become \_\_\_\_\_\_\_ than the attraction between solute particles themselves or between solvent particles themselves.

\_\_\_\_\_\_\_ (dissolution)

* As a solution forms, the \_\_\_\_\_\_\_ pulls solute particles apart at the \_\_\_\_\_\_\_ of the solute. This dissolving process is called \_\_\_\_\_\_\_. Then, water \_\_\_\_\_\_\_ the “broken apart” particles. This process is called \_\_\_\_\_\_\_.
* Involves a \_\_\_\_\_\_\_ Change 🡪 You can get back the original solute by evaporating the solvent. In other words, NO new substance is produced.
* \_\_\_\_\_\_\_ particles are “pulled apart” by the \_\_\_\_\_\_\_. NON ionic molecules break apart from each other remaining whole molecules.
* \_\_\_\_\_\_\_ is a form of dissolving in which \_\_\_\_\_\_\_ compounds break apart into its \_\_\_\_\_\_\_.

Solutions & Energy Changes

Solvent particles engage undissolved solute particles at their surface and \_\_\_\_\_\_\_ them. This is always \_\_\_\_\_\_\_ … \_\_\_\_\_\_\_ *some heat/energy to be added*).

The solvent particles surround the solute particles (\_\_\_\_\_\_\_), forming solute / solvent interactions & is always \_\_\_\_\_\_\_ … \_\_\_\_\_\_\_ *heat/energy into the solution).*

In a solution, the solute is dispersed \_\_\_\_\_\_\_ throughout the solvent. Therefore, we say it is \_\_\_\_\_\_\_.

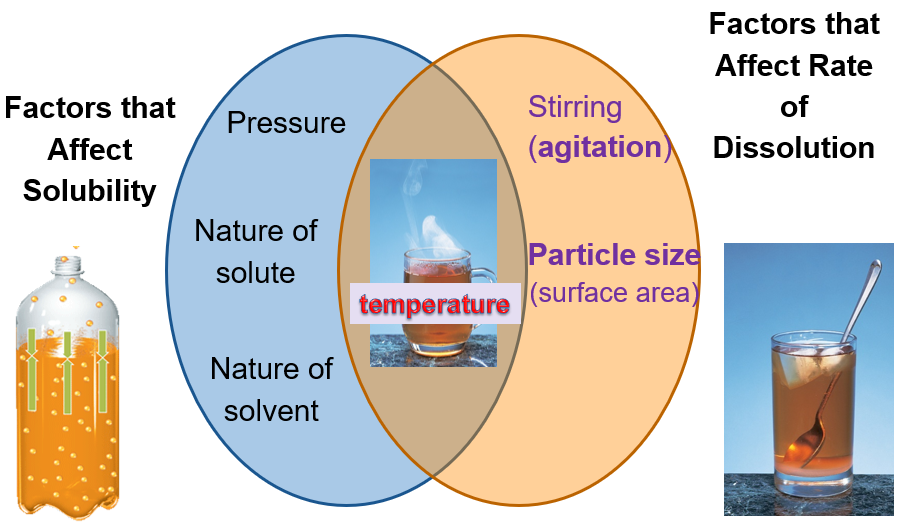
Solutes: Electrolytes & Nonelectrolytes

* An \_\_\_\_\_\_\_ is a compound that conducts an electric current when it is in an aqueous solution or in the molten state.
* All \_\_\_\_\_\_\_ compounds are electrolytes because they \_\_\_\_\_\_\_ into ions when aqueous or molten.
* A \_\_\_\_\_\_\_ is a compound that does \_\_\_\_ conduct an electric current when it is in an aqueous solution, but its non-dissociated particles are surrounded by the solvent.

Nonelectrolyte 🡪 Dissolving particles are not \_\_\_\_\_\_\_ (Example: glucose).

\_\_\_\_\_\_\_ 🡪 Dissolving particles are \_\_\_\_\_\_\_ & \_\_\_\_\_\_\_ to move (e.g. Na+Cl-).

Factors Affecting Solubility & Rate of Dissolving



\_\_\_\_\_\_\_ Law: Solubility & Pressure

* The solubility (*S*) of a gas in a liquid is \_\_\_\_\_\_\_ proportional to the pressure (*P*) of the gas above the liquid at a given temperature.
* As the pressure of the gas above the liquid \_\_\_\_\_\_\_, the solubility of the gas \_\_\_\_\_\_\_.
* As the \_\_\_\_\_\_\_ of the gas decreases, the \_\_\_\_\_\_\_ of the gas decreases.
* Carbonated beverages contain large amounts of carbon dioxide (CO2 (g)) dissolved in water.
* The drinks are bottled under a high pressure of CO2 gas, which \_\_\_\_\_\_\_ solubility of the gas in solution.
* When the container is opened, the \_\_\_\_\_\_\_ of CO2 above the liquid decreases.
* Immediately, bubbles of CO2 form in the liquid & \_\_\_\_\_\_\_ from the bottle [Solubility \_\_\_\_\_\_\_].

\_\_\_\_\_\_\_ CANS

* The "head space" of the aerosol can is filled with highly \_\_\_\_\_\_\_ gas \_\_\_\_\_\_\_ in the product. When the nozzle is depressed, the pressure \_\_\_\_\_\_\_ so solubility of the gas also \_\_\_\_\_\_\_ and sprays out.

\_\_\_\_\_\_\_ Divers & the “Bends”

* The air scuba divers breathe is ~78% nitrogen. As one dives deeper pressure \_\_\_\_\_\_\_, meaning the solubility of nitrogen \_\_\_\_\_\_\_. \_\_\_\_\_\_\_ causes pressure to decrease, making nitrogen \_\_\_\_\_\_\_ soluble (i.e. “boils out”). If the divers surface too quickly, nitrogen bubbles just as in carbonated soda pop (the Bends). Helium is added to oxygen tanks, reducing this affect.

Solubility

The \_\_\_\_\_\_\_ amount of a \_\_\_\_\_\_\_ that can be \_\_\_\_\_\_\_ in a solvent is called that substance’s solubility. Solubility also describes the \_\_\_\_\_\_\_ of solutions by using three terms:

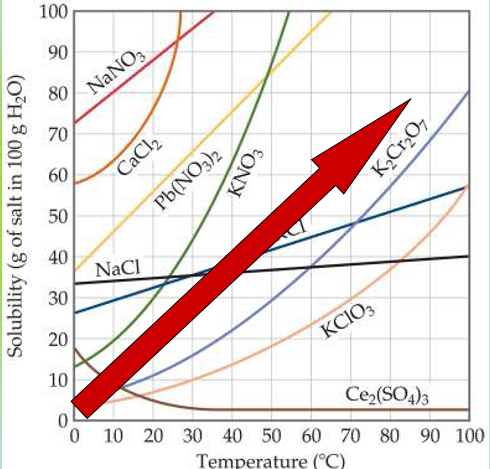
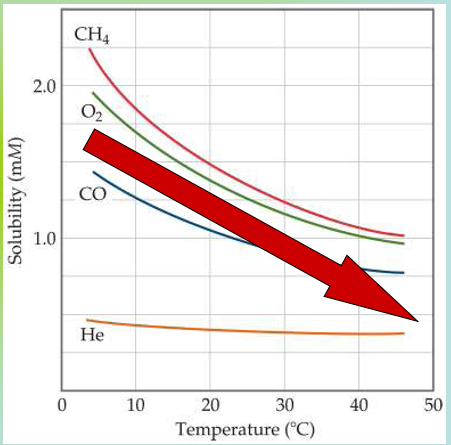
\_\_\_\_\_\_\_, \_\_\_\_\_\_\_, & \_\_\_\_\_\_\_ Solutions.

\_\_\_\_\_\_\_ solution 🡪 the concentration of solute is \_\_\_\_\_\_\_ than the maximum concentration the solvent can dissolve at a given temperature.

\_\_\_\_\_\_\_ solution 🡪 the concentration of solute is \_\_\_\_\_\_\_ to the maximum concentration the solvent can dissolve at a given temperature. Notice particles have settled out in solution.

\_\_\_\_\_\_\_ solution 🡪 the concentration of solute is \_\_\_\_\_\_\_ than the maximum concentration the solvent was expected to dissolve at a given temperature. No particles have settled out.

\_\_\_\_\_\_\_ a Super Saturated Solution 🡪 These solutions are \_\_\_\_\_\_\_; crystallization can usually be stimulated by adding a “\_\_\_\_\_\_\_ crystal” or scratching the side of the flask or \_\_\_\_\_\_\_.

Solubility of \_\_\_\_\_\_\_ exhibits a \_\_\_\_\_\_\_ relationship with temperature.

Generally, the solubility of \_\_\_\_\_\_\_ solutes in liquid solvents \_\_\_\_\_\_\_ with increasing temperature.

Label the graphs as “solids” or “gases” 🡪

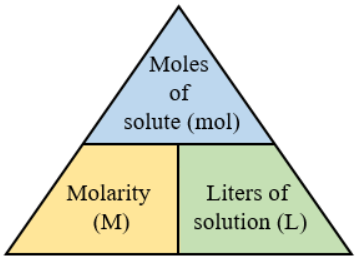
16B

Solute Concentration is helpful to know in order to describe solutions and is an important “real life” variable.

Molarity

The number of moles of solute in 1 liter of solution.

This term is the most used when describing \_\_\_\_\_\_\_ (symbolized by “\_\_\_”) in a general chemistry lab.

M =

Moles =

L =

Volume of a liquid is more easily measured than mass, therefore, laboratory reagents are usually made up of a specific \_\_\_\_\_\_\_ to give us a standard.

Molarity Calculations

What is the molarity of a solution that contains 25 g of HCl in 150. mL of solution? (The molar mass of HCl is 36.45 g/mol.)

What should you find first? \_\_\_\_\_\_\_

What set up is correct to find moles? \_\_\_\_\_\_\_ x 1 mol HCl / 36.45 g HCl

What set up is correct to find liters? \_\_\_\_\_\_\_ x 1 L / 1000 ml

How would you prepare 25 liters of 0.10 M BaCl2 solution, starting with solid BaCl2?

\_\_\_\_\_\_\_ = # \_\_\_\_\_\_\_ of solute / # \_\_\_\_\_\_\_ of solution

Find moles   \_\_\_\_\_\_\_ = \_\_\_\_\_\_\_ / \_\_\_\_\_\_\_ OR X moles = 0.1 M x 25 L

X = \_\_\_\_\_\_\_ BaCl2

Convert Moles to Grams GFM of BaCl2 = 137.3 + (2)(35.5) = \_\_\_\_\_\_\_ g / mole

2.5 moles x \_\_\_\_\_\_\_ / 1 mole = \_\_\_\_\_\_\_

*Place the* \_\_\_\_\_\_\_  *BaCl2 in an appropriate container and add sufficient water to give a final* \_\_\_\_\_\_\_ *of* \_\_\_\_\_\_\_*.*

Using Concentrated Solutions (\_\_\_\_\_)

(\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) = (Molarity) (Volume)

solution 1 solution 2

Usually one starts with a \_\_\_\_\_\_\_ concentrated solution and \_\_\_\_\_\_\_ it with water to obtain the desired volume. This is more convenient than using molarity or moles.

Making Dilutions

How would you prepare 100. ml (V1) of a 2.00 M HCl (M1) solution, starting with concentrated hydrochloric acid (12.0 M) (M2)?

\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_

Find Volume

V2 = M1V1 / M2 V2 = (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) / (\_\_\_\_\_\_\_) X = \_\_\_\_\_\_\_ = 0.0167 L

Make the Dilution:

Place \_\_\_\_\_\_\_ of 12.0 M HCl in the container (flask) & add enough water to get a FINAL \_\_\_\_\_\_\_ of \_\_\_\_\_\_\_.

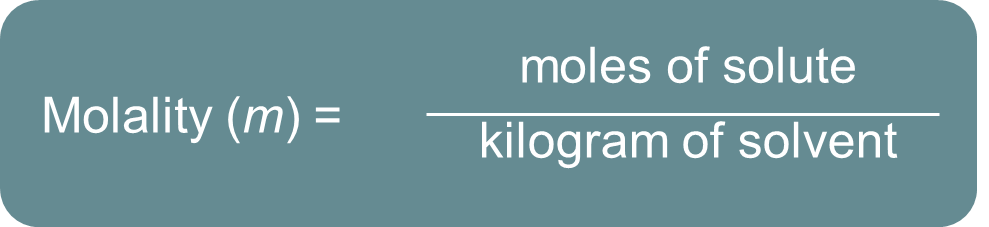
Colligative Properties of Solutions

\_\_\_\_\_\_\_ properties of solutions are properties that depend upon the \_\_\_\_\_\_\_ of \_\_\_\_\_\_\_ molecules or ions, but not upon the identity of the solute.

Colligative properties include: \_\_\_\_\_\_\_ Point \_\_\_\_\_\_\_, \_\_\_\_\_\_\_ Point \_\_\_\_\_\_\_, Vapor Pressure Lowering, Osmotic Pressure.

Since colligative properties deal with the \_\_\_\_\_\_\_ of particles in a solution, we need to learn a new way to calculate concentration.

\_\_\_\_\_\_\_ (*\_\_\_*) 🡪 the number of moles of solute dissolved in 1 kilogram (1000 grams) of solvent. Molality is also known as molal concentration and is calculated by:



Calculating Molality

What is the molality (m) of a solution obtained by dissolving 45.0 grams of glucose (C6H12O6) in 2000. grams of water?

\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_ of solute / \_\_\_\_\_\_\_ of solvent

Find moles

GMM of C6H12O6 = (6 x 12.0 g/mol) + (12 x 1.00 g/mol) + (6 x 16.0 g/mol) = \_\_\_ g / mole

45.0 g x 1 mole / 180 g = \_\_\_\_ moles

Find molality

2000. g x 1 kg/1000 g = 2.00 kg

m = \_\_\_\_\_\_\_ moles / \_\_\_\_\_\_\_ kg = \_\_\_\_ m

Boiling Point \_\_\_\_\_\_\_

* The change in boiling point is proportional to the \_\_\_\_\_\_\_ of the solution:

∆\_\_b = Kb x \_\_\_

where Kb is the molal boiling point elevation constant, a property of the solvent.

* Boiling Point Elevation 🡪 A 1 \_\_\_\_\_\_\_ solution of water will \_\_\_\_\_\_\_ at \_\_\_\_\_\_\_ C rather than 100.00 C.

Freezing Point \_\_\_\_\_\_\_

* The change in freezing point can be found similarly: ∆\_\_f = Kf x \_\_\_ where Kf is the molal freezing point depression constant of the solvent.
* A 1 \_\_\_\_\_\_\_ solution of water will \_\_\_\_\_\_\_ at \_\_\_\_\_\_\_ C rather than 0 C.

Colligative Properties of Electrolytes

* \_\_\_\_\_\_\_ are ionic compounds that dissociate to form \_\_\_\_\_\_\_ in solution and therefore, can conduct \_\_\_\_\_\_\_.
* \_\_\_\_\_\_\_ is a \_\_\_-electrolyte and has \_\_\_ ions in solution.
  + 1 \_\_ of sugar 🡪 \_\_ mol particles
* Salt is an electrolyte and has \_\_\_\_\_\_\_ in solution. 1 \_\_\_ of salt 🡪 \_\_ mol ions.
* Since colligative properties *(vapor pressure, boiling point elevation, freezing point depression)* depend on the \_\_\_\_\_\_\_ of particles \_\_\_\_\_\_\_, solutions of electrolytes (which dissociate in solution) should show \_\_\_\_\_\_\_ changes than those of non-electrolytes.
* Notice the difference in moles produced when 3 moles of each substances is made into solutions of equal volume.



* Glucose produces \_\_\_ moles of solute in solution (no ions)
* NaCl produces \_\_\_ moles of solute in solution (TWICE as much)

… NaCl (aq) 🡪 Na+ + Cl- \_\_\_ moles of ions / NaCl (aq)

* CaCl2 produces \_\_\_ moles of solute in solution (3 times as much)

… CaCl2(aq) 🡪 Ca+2 + 2Cl- \_\_\_ moles of ions / CaCl2 (aq)

Calculating fp depression & bp elevation

Find the boiling point elevation and the freezing point depression of Nickel II Bromide (electrolyte) if 0.121 mol are dissolved in 224 grams of water (0.224 kg).

Find molality [*m = mol solute/Kg solvent*]

M = \_\_\_\_ moles / \_\_\_\_ kg = \_\_\_\_ m

Find molality of particles (ions)

NiBr2 (aq) 🡪 Ni+2 + \_\_\_\_ Br-1 = \_\_\_\_ moles of ions x \_\_\_\_ m = \_\_\_\_\_\_\_ m

Calculate fp depression and bp elevation

∆Tf = kf x \_\_\_\_ ∆Tb = kb x \_\_\_\_

= (\_\_\_\_ C)( \_\_\_\_ m) = (\_\_\_\_ C)( \_\_\_\_ m)

= \_\_\_\_ C + \_\_\_\_ C = \_\_\_\_ C + \_\_\_\_ C

Fp = \_\_\_\_ C Bp = \_\_\_\_ C