

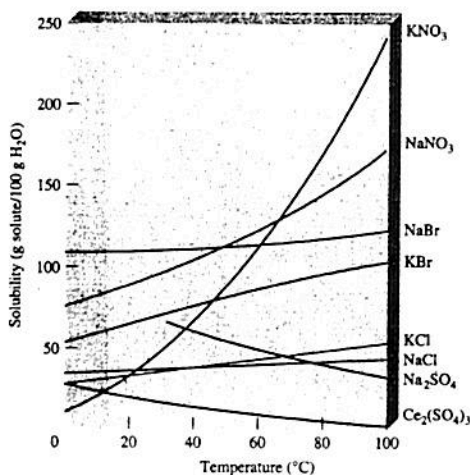
NOTES #41

Colligative Properties/Solutions II Ap Chemistry

A. EFFECT OF TEMP ON SOLUBILITY:

General rule - The solubilities of most liquids and solids **INCREASES** with increasing temperatures. Whereas the solubilities of gases **DECREASES** with increasing temperatures.

1. Solid Solubility and Temperature (at constant pressure):



a. Observations about solids and solubility by looking at the graph.

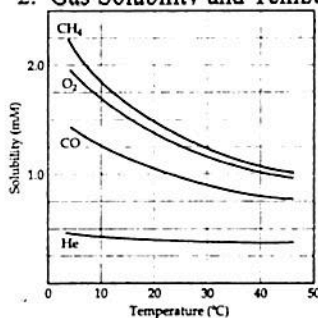
b. In general, the effect of temperature on solubility is best determined experimentally.

c. **FRACTIONAL CRYSTALLIZATION** - the separation of a mixture of substances into pure components on the basis of their differing solubilities.

EX: If you had 90 g of KNO₃ that is contaminated with 10 g of NaCl, you could purify the KNO₃ sample by dissolving the mixture in 100 mL of water at 60°C and cooling the solution to 0°C. Why? Looking at the solubility curves for NaCl and KNO₃, what would happen at 0°C???

Ex: Under what conditions does fractional crystallization work best?

2. Gas Solubility and Temperature (at constant pressure):



a. **THERMAL POLLUTION** - In the US, about 100,000 billion gallons of water are used for industrial cooling (mostly in electric and nuclear power production). The heated water, which can't dissolve as much oxygen, is then returned to rivers and lakes. Very harmful to aquatic life.

B. EFFECT OF PRESSURE ON SOLUBILITY OF GASES:

* For all practical purposes, external pressure does not influence solubility of liquids and solids, but **DOES** greatly affect the solubility of gases.

1. The relationship between gas solubility and pressure is given by **HENRY'S LAW** - the solubility of a gas in a liquid is directly proportional to the partial pressure of that gas over the solution.

$$c \propto P \quad \text{or} \quad c = kP$$

c = molar concentration (mol/liter) of dissolved gas

P = pressure (atm) of the gas over the soln

k = constant for a given gas at a given temp

** _____ P ; _____ conc of gas dissolved

2. How can Henry's Law be understood in terms of Kinetic Molecular Theory?

The amount of gas that will dissolve in a solvent depends on how frequently the gas molecules collide with the liquid surface and become trapped by the condensed phase. The more gaseous particles you have, the _____ collisions you have, the _____ gas molecules dissolving in solution.

EX: A can of coke, before the lid is put in on, is pressurized with a mixture of air and CO₂. Explain how Henry's law can explain the fact that pop fizzed when opened.

Crash Course in Colligative Properties:

Colligative Properties:

Properties of solutions that depend upon the ratio of the number of solute particles to the number of solvent molecules in a solution, and not on the type of chemical species present.

Examples of colligative particles:

- If you placed 10 glucose molecules in water you would get an aqueous solution of glucose that does not conduct electricity. The lack of conductivity suggests that the glucose did not dissociate and the ten glucose molecules provide ten colligative parts to the solution.
- If you placed 10 formula units of NaCl in water you would get an aqueous solution of NaCl that does conduct electricity. This conductivity suggests that the NaCl did dissociate and the ten NaCl units provided twenty colligative parts to the solution. $\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$
- If you placed 10 formula units of MgCl_2 in water you would get an aqueous solution of MgCl_2 that does conduct electricity. This conductivity suggests that the MgCl_2 did dissociate and the ten MgCl_2 units provided thirty colligative parts to the solution. $\text{MgCl}_2 \rightarrow \text{Mg}^{2+} + 2\text{Cl}^-$

THE MORE COLLIGATIVE PARTS A SOLUTION HAS THE MORE COLLIGATIVE PROPERTIES THE SOLUTION WILL DISPLAY.

Volatility: A volatile chemical is one that will evaporate. It will exert a vapor pressure as it evaporates and its evaporation rate will be directly proportional to its vapor pressure. EX: water, alcohols, ethers, acetone, hexane

Non-Volatile: A chemical that does not evaporate. EX: oils, salts, waxes, sugars, pitch

There are five colligative properties:

1. Vapor Pressure Lowering
2. Vapor Pressure Elevation
3. Freezing Point Depression
4. Boiling Point Elevation
5. Osmotic Pressure

*Vapor Pressure Lowering: By adding a non-volatile chemical to a volatile one, the resultant solution will take on the non-volatile properties. This new solution will evaporate much slower as the interacting chemicals at the surface of the liquid are not 100% solvent (water).

Vapor Pressure Elevation: By adding a volatile substance to a lesser volatile substance, the combined vapor pressure will be higher than the lesser component. The resulting solution will evaporate faster and it will separate when heated (distillation).

Freezing Point Depression: By adding *any* solute to water, the solute serves to disrupt the formation of solid water by interfering with the hexagonal crystal system of ice. The ice will still freeze at much colder temps but it will form smaller crystals. You have seen these solutions and their slushy nature (think slushy drinks and the nasty salty slime next to the road after it has been salted).

*Boiling Point Elevation: This colligative property coincides with vapor pressure lowering. If a non-volatile solute is added to the solvent, the vapor pressure will be lower. The definition of the normal boiling point is when the vapor pressure of the solution meets or exceeds that of the atmospheric pressure. If the non-volatile solute lowers the vapor pressure, an increase in the temperature will be required to get the vapor pressure to match that of the atmospheric pressure. This will occur at an elevated temperature.

Osmotic Pressure: Osmosis is the movement of water through a semi-permeable membrane from high to low concentration. Example: a cell placed in distilled water will pull in water and swell up because the cell contains salts (minerals). The water will travel from where the water content is high (outside of the cell) to where it is low (inside the cell). Osmotic pressure is the pressure required to reverse the process (move water from low concentration to high). With reverse osmosis water purification systems, the osmotic pressure is applied to the semi-permeable membrane, pushing pure water out of the salty water.