Colligative Properties

Colligative properties

- There are properties of a solution that don't depend on the identify of a solute, only the concentration of the solute.
- The Van't Hoff factor (i) is commonly used in these equations because ionic compounds have their concentration increased by a factor of how many ions it dissociates into.

Vapor Pressure

- Vapor pressure lowering is another colligative property.
- Vapor pressure, the amount of a liquid that will evaporate above a liquid, will be lower if anything is dissolved in it.
- If you have a mixture of two volatile liquids, the one with a higher normal vapor pressure will evaporate at a higher rate.

Raoult's Law

- Raoult's law is an equation to determine the vapor pressure above a solution
- $P_A = P°_A \chi_A i$
- P_A is the observed vapor pressure above the solution
- $P°_A$ is the normal vapor pressure of the solvent
- χ_A is the mole fraction of the solution
- i is the Van't Hoff Factor

Problem

- A pure sample of benzene has a vapor pressure of 10.0 kPa, and a pure sample of toluene has a vapor pressure of 2.9 kPa at a certain temperature. Calculate the vapor pressure of each, and the total vapor pressure in a mixture that is .70 mol benzene and .30 mol toluene.
- -Both have a Van't Hoff factor of 1 since neither are ionic.

Answer

- Benzene
- $P_A = P°_A \chi_A$
- $P_{benzene}$ = 10.0 kPa (.70) = 7.0 kPa
- Toluene
- $P_A = P°_A \chi_A$
- $P_{toluene}$ = 2.9 kPa (.30) = .87 kPa
- Total vapor pressure
- P = 7.0 kPa + .87 kPa = 7.9 kPa

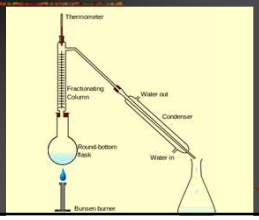
Important to note

- The previous solution was 70% benzene, however the vapors above the solution were 89% benzene (7.0 kPa / 7.9 kPa).
- This can be used to make it easier to separate the mixture.

Fractional distallation

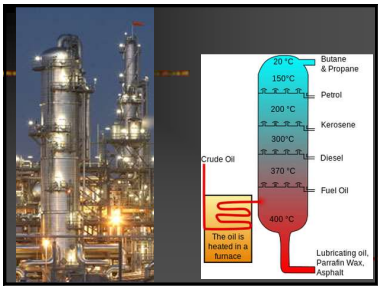
- Fractional distillation makes use of vapor pressure lowering.
- Fractional distillation is used to separate petroleum or crude oil.
- Petroleum is a mixture of volatile liquids.
- The vapors above will be much more pure than the solution because the most volatile will lower the amount of other substances that can evaporate

Fractional Distillation



Fractional distillation

- There is a large column on top of a standard distillation set up, that is meant to distill the vapors. As they get further from the flame, the temperature decreases, so at each level different things may condense out.
- In the case of the distillation of crude oil, the tower is hundreds of feet high.



Change in vapor pressure

- Sometimes, it useful to look at the change in vapor pressure for substance. In which case you would use the normal vapor pressure for the substance and mole fraction of the solute.
- $\Delta P_A = P^o_A \chi_B$

Osmosis

- Diffusion of a solvent across a semipermeable membrane.
- A semipermeable membrane is a substance with pores small enough to allow solvent particles through, but not solute particles.
- Examples of a semipermeable membrane would be an animal bladder or cellophane.
- The solvent will move to equalize the pressure on either side of the membrane.

Osmotic Pressure

- Osmotic pressure is a colligative property of a solution, it is the pressure that must be applied to a solution to stop osmosis.
- π = iMRT
- π osmotic pressure
- i Van't Hoff factor
- M concentration in molarity
- R Ideal gas constant
- T temperature

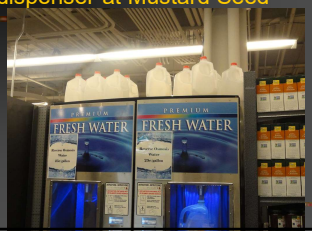
Osmosis is important to living things

- A cell is an aqueous solution surrounding by a semipermeable membrane. The surrounding solution must have an osmotic pressure close to that of the cell, otherwise water will enter or leave the cell.
- This could cause the cell to shrivel up or burst.

Reverse Osmosis

- Reverse osmosis is used to purify water.
- A pump is used to pressurize a solution on one side of a semipermeable membrane.
- The pressure is greater than that of the osmotic pressure. This forces the solvent across the membrane.
- This is one method of desalinating (removing salt) water supplies.

Reverse Osmosis water dispenser at Mustard Seed

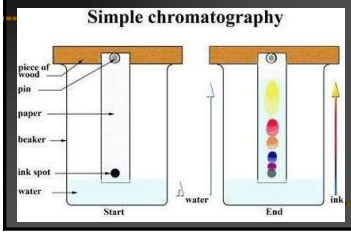


Chromatography

- Separating a solution by *capillary action*
- ~the attraction of a liquid to the surface of a solid, why water "climbs up things"
- For a simple chromatography place ink on chromatography paper and place the paper in a solvent with the ink above the water line.
- The solvent will "climb up" and separate the ink

Chromatography

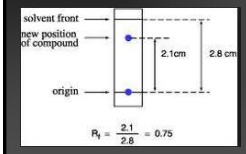
- In chromatography, a **mobile phase** carries something through a **stationary phase**.
- If different constituents have move at different speeds the material will be separated
- In simple paper chromatography the water is the mobile phase, the paper is the stationary phase.



R_f Factor

- R_f value is determined by taking the ratio of distance the substance has traveled compared to the distance the solvent has traveled.
- This R_f factor is compared to a known sample and used to identify unknowns.

R_f factor



Other types of chromatography

- Gas chromatography
- TLC, thin layer chromatography
- Column Chromatography
- HPLC, high performance liquid chromatography