Colligative Properties

Colligative Properties

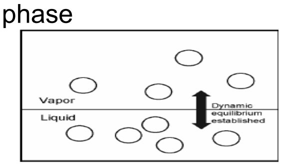
- ______________ – physical properties of solutions that are affected only by the number of particles NOT the identity of the solute
- They include:
  1. Vapor Pressure ____________
  2. Boiling Point ____________
  3. Freezing Point ____________
  4. Osmotic Pressure
- In all of these we will be comparing a pure substance to a mixture

Non-Electrolyte solutions

- ______________ - solution is one where the solute particles do not dissociate to any degree when then are dissolved in the solvent
- This is usually in a covalent compound

Vapor Pressure Lowering

- ______________– the pressure exerted in a closed container by liquid particles that have escaped to the surface and entered the gas phase



Vapor Pressure Lowering

- Changes related to lowering of vapor pressure are governed by Raoult's law, and fall into two categories.
  - Those where the solute is non-volatile
  - those where the solution has two volatile components.

Raoult's law

- **The presence of a nonvolatile solute lowers the vapor pressure of the solvent.**
- $\mathbf{VP_{solution} = X_{solvent} P_{solvent}}$
- $VP_{solution}$ = VP of the solution
- $X_{solvent}$ = mole fraction of the solvent
- $P_{solvent}$ = VP of the pure solvent

Example

- At a given temperature water has a vapor pressure of 22.80 mmHg. Calculate the vapor pressure above a solution of 90.40 g of sucrose ($C_{12}H_{22}O_{11}$) in 350.0 mL of water, assuming the water to have a density of 1.000 g/mL.

Another example

- 23.00 g of an unknown substance was added to 120.0 g of water. The vapor pressure above the solution was found to be 21.34 mmHg. Given that the vapor pressure of pure water at this temperature is 22.96 mmHg, calculate the Molar Mass of the unknown.

Another Example

A solution with two volatile components

- Modified Raoult's law
- $VP_T = X_A P_A + X_B P_B$

Example

- At 20.0 ^oC the vapor pressures of methanol (CH_3OH)and ethanol (C_2H_5OH) are 95.0 and 45.0 mmHg respectively. An ideal solution contains 16.1 g of methanol and 92.1 g of ethanol. Calculate the vapor pressure.

Boiling Point Elevation

- ____________ - point at which enough energy has been added to overcome the intermolecular forces that hold the solute in the solution.

Boiling Point Elevation

- The boiling point of a mixture is higher that the boiling point of a pure substance
- The difference in boiling points can be calculated by the equation:
- $\Delta T_b = K_b \, m \, (i)$

Boiling Point Elevation

- $\Delta T_b = K_b \, m \, (i)$
- ΔT_b = change in boiling point (boiling point elevation)
- K_b = Boiling point elevation constant (will always get form chart)
- m = molality
- i = van't Hoff factor = number of particles that the molecule breaks into

K_b

- K_b will always be given to you in the chart along with the solution's boiling point

TABLE 13.4 Molal Boiling-Point-Elevation and Freezing-Point-Depression Constants

Solvent	Normal Boiling Point (°C)	K_b (°C/m)	Normal Freezing Point (°C)	K_f (°C/m)
Water, H_2O	100.0	0.52	0.0	1.86
Benzene, C_6H_6	80.1	2.53	5.5	5.12
Ethanol, C_2H_5OH	78.4	1.22	–114.6	1.99
Carbon tetrachloride, CCl_4	76.8	5.02	–22.3	29.8
Chloroform, $CHCl_3$	61.2	3.63	–63.5	4.68

molality (m)

- **molality** = moles solute / kg solvent
- What is the molality of a solution with 4.5 g of NaCl dissolved in 100.0 g of H_2O?

van’t Hoff Factor (i)

- See if the compound is ionic or molecular.

van’t Hoff Factor (i)

- For example
- What will be the ion factor in the following compounds
- $C_6H_{12}O_6$
- NaCl
- $CaCl_2$
- Na_3PO_4

Freezing Point Depression

- ______________ - point where enough energy has been removed from the solution to slow the molecules down and increase intermolecular forces so the solution becomes a solid

Freezing Point Depression

- The freezing point of a mixture is lower that the freezing point of a pure substance
- The difference in freezing points can be calculated by the equation:
- $\Delta T_f = K_f\, m$ (i)

Freezing Point Depression

- $\Delta T_f = K_f\, m\ (i)$
- ΔT_f = change in freezing point (freezing point depression)
- K_f = Freezing point depression constant (will always get form chart)
- m = molality
- i = number of particles that the molecule breaks into

K_f

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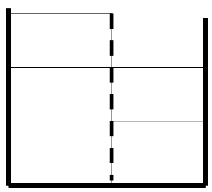
Calculations with BPE & FPD

- What are the boiling points and freezing points of a 0.029 m aqueous solution of NaCl?

BP & FP

- What are the boiling point & freezing point of a 0.050 m solution of a non-electrolyte in ethanol?

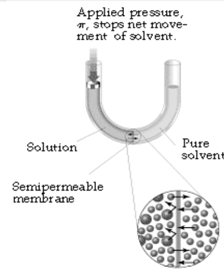
What is Osmosis?



- Suppose a salt solution and water are separated by a semipereable membrane
- Water will move through the membrane from into the salt solution to equalize the concentrations on each side of the membrane.
- This is osmosis

Osmotic Pressure

- **The minimum pressure that stops the osmosis is equal to the osmotic pressure of the solution**



Osmotic Pressure Calculations

- π = MRT
- π = osmotic pressure
- M = molarity
- R = 0.0821
- T = Temperature