Chem 103 lecture 1c

Henry's Law

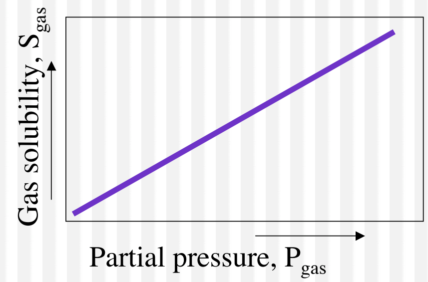
Review colligative properties

Osmotic pressure

15.5 Henry's Law

Solubility of a gas increases as its partial pressure increases

Henry's Law: $S_{gas} = k_H P_{gas}$



Henry's Law in action

Can you think of everyday examples involving Henry's Law?

Soda bottle - very high P_{CO2} results in high $[CO_2]$ in drink.

When bottle is suddenly opened, P_{CO2} drops. It's suddenly supersaturated and thus unstable. CO_2 bubbles form to leave solution until $[CO_2]$ reaches new, lower solubility.

4 common colligative properties

4 common colligative properties are:

1) Vapor pressure **lowering**
2) Boiling point **elevation**
3) Freezing point **depression**
4) **Osmotic pressure**

Boiling point *elevation*

Boiling point (BP) of solns is higher than that of the pure solvent. $\Delta T_b = i\, k_b m$. where k_b is BP elevation constant and m is the molality of the solution. i = van't Hoff factor (to account for electrolytes' ions); for water: k_b = 0.512 °C-kg/mol.

How would you explain this phenomenon?
Explanation: Boiling occurs when vapor P = atmospheric P. Presence of solute lowers vapor P of solvent because it *dilutes* the solvent.

Boiling Pt (T_b) elevation example

Example: Say we have a 3.00 m KNO_3 solution. What is its new boiling point, T_b?
Solution:
Recall: $\Delta T_b = i\, k_b\, m$ where i =2 since $KNO_3 \rightarrow K^+ + NO_3^-$
ΔT_b =(2) (0.512 °C-kg/mol)(3.00 mol ples /kg)=3.07°C
So the $T_b = T_b° + \Delta T_b$ = 100°C + 3.07°C =103.07°C

Note that you **add** ΔT_b to the normal boiling point, $T_b°$

Freezing point depression

Similar to boiling point elevation:

$$\mathbf{\Delta T_f = i\, k_f\, m}$$

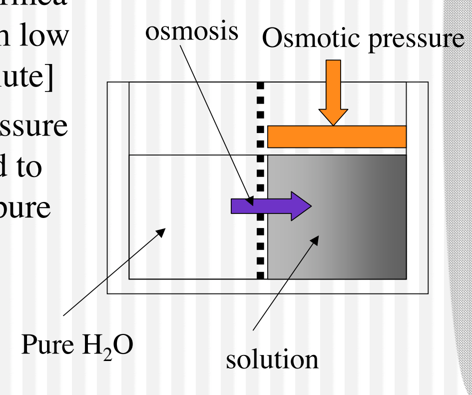
where k_f = 1.86°C kg/mol for water

Salt water freezes at a lower temperature than pure water! (Once the water freezes into ice the ice is pure water.)

In icy road conditions, $CaCl_2$ salt is often added to the ice causing it to melt. Explain why.

Osmotic Pressure

- Osmosis=movement of solvent thru semipermeable membrane; from low [solute] **to** high [solute]
- Osmotic pressure: pressure that must be applied to stop osmosis from pure solvent.



Osmotic Pressure reason…

Reason for osmosis (and other colligative properties) is due to increase in entropy (S) when going from a *pure solvent* to a *solution*. That is, there's more disorder in a solution.

The semipermeable membrane prevents solute molecules from passing through the pores

The only way to form a solution is for the pure solvent to diffuse through the membrane to become a solution.

Osmotic pressure problem

The equation is: $\pi = cRTi$ where c = moles/L (molarity)

(can be derived from pV=nRT => p =(n/V)RT)

Example. A solution prepared by adding 50. g of solute to make 1.0 L solution at 300 K has π = .821 atm. What is the MW of the solute (assuming it is a nonelectrolyte)?

$$\pi = cRTi = \frac{g_{solute}/MW_{solute}}{V_{solution}} RTi$$

$$\text{or,}\quad MW = \frac{g_{solute}}{\pi V_{solution}} RTi$$

$$MW = \frac{50.g}{(.821 atm)(1.0L)} (0.0821 \frac{atm-L}{mol-K})(300K)(1)$$

$$MW = 1.50x10^3 g/mol$$

Red blood cells and π

Red blood cells (RBC's) are "semipermeable bags", which must maintain the same concentration within and without, or else! (i.e. solution surrounding it must be *isotonic*)

Water leaves cell: crenation

If solution is more concentrated (*hypertonic*) than the internal concentration, what happens?

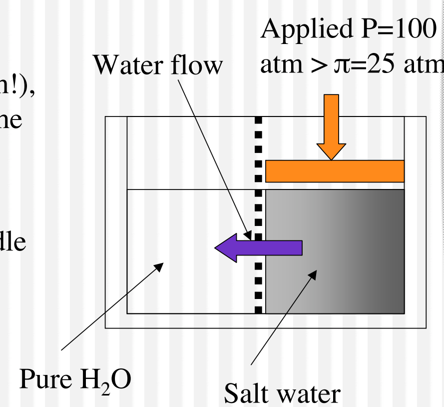
If solution is less concentrated (*hypotonic*) than the internal concentration, what happens?

Water enters cell:hemolysis

Reverse osmosis: desalination

If the applied pressure is high enough (and the membrane robust enough!), it is possible to reverse the flow of solvent).

Example: desalination plants - common in middle east, Florida,…



Colloids

Colloid = dispersed phase (large molecs, 2-2000nm) + continuous phase (solvent)

=often scatter light (Tyndall effect)

Examples:

Aerosols (liquid or solids and gas) like fog, clouds

Foam (gas in liquid) like whipped cream

Emulsion (liquids in liquid) like milk

Gels (solids in liquids) like butter

Surfactants

Surfactants = molecules with hydrophobic and hydrophillic parts

e.g. sodium stearate: Na^+ $^-O\text{-}C(=O)\text{-}(CH_2)_{16}\text{-}CH_3$

Soaps are made by saponification reaction of triglycerides

Triglycerides + 3 NaOH ---> Na(fatty acid) + glycerine

Soaps + grease + water = an emulsion…

Municipal water treatment

Only 3% of all the planet's water is fresh water.

Only 0.008% is found in reservoirs, rivers, lakes

0.77% of water is ground water

Water treatment:

Water intake --> coarse screen --> settling tanks --> sand filter

→aeration --> Cl or O_3 addition --> storage tank --> consumer.

Water hardness: high concentration of Ca^{2+}, Mg^{2+}, Fe^{2+}, or Mn^{2+}