Volatile Solutes

i.e. solubility of gases in liquids

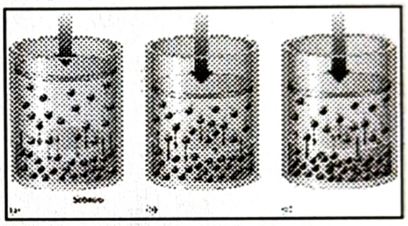
Henry's Law- The amount of a gas dissolved in solution is directly proportional to the pressure of the gas above the solution.

Holds for dilute solutions in which the solute does not dissociate or react with the solvent.

$S = k_H P$

Henry's Law Constant

Solubility



Henry's Law Example

The solubility of N_2 in water is 8.21 x 10^{-4} mol/L at 0°C when the N_2 pressure above water is 0.790 atm.

Calculate the solubility of N_2 in water at 0°C when the N_2 pressure above water is 1.10 atm.

$8.21 \times 10^{-4} = k_H \cdot 0.79$

$k_H = 1.04 \times 10^{-3}$ mol/L atm

$S = 1.04 \times 10^{-3} (1.1) = 1.14 \times 10^{-3}$ M

Colligative Properties

Solution properties that depend on the number of solute particles in solution (not the identity).

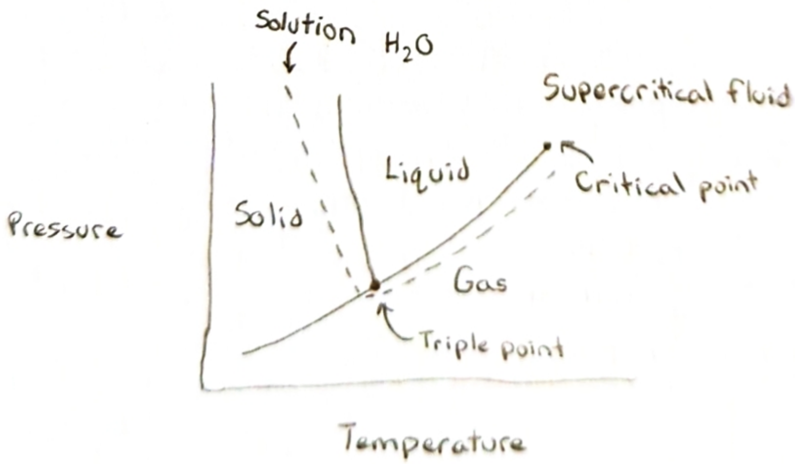
Boiling-point elevation:
A solution boils at a higher temperature than the pure solvent

Freezing-point depression:
A solution freezes at a lower temperature than the pure solvent

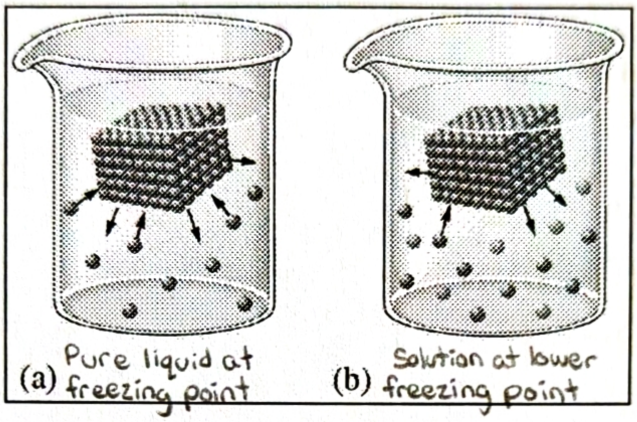
Vapor pressure lowering:
Vapor pressure of a solution is less than that of the pure solvent

Osmotic pressure:

Phase Diagrams



Freezing-Point Depression



ΔT = freezing point of pure liquid - freezing point of solution

k_f = molal freezing point depression constant, solvent dependent (°C kg/mol)

m = molality (mol/kg)

i = van't Hoff factor, number of particles

Boiling Point Elevation

Boiling Point: Temperature at which the vapor pressure of a liquid equals atmospheric pressure

A nonvolatile solute elevates the boiling point of a pure solvent.

$\Delta T = i k_b m$

ΔT = boiling point of solution - boiling point of pure liquid

k_b = molal boiling point elevation constant, solvent dependent

Pure liquid at boiling point

Solution at higher boiling point

Antifreeze is an aqueous solution of ethylene glycol ($C_2H_6O_2$, 62.07 g/mol). Determine the freezing point of an antifreeze solution that is 40 % ethylene glycol by mass. K_f = 1.86 °C kg/mol for H_2O

100 g solution → 60 g solvent, 40g solute

$\Delta T = i k_f m$

$$m = \frac{\frac{40\,g}{62.07\,g/mol}}{0.06\,kg} = 10.7$$

$\Delta T = 1.86(10.7)(1) = 20.0$

$0.0 - 20.0 = -20°C$

Calculate the boiling point of a 25% by mass aqueous NaCl (58.55 g/mol) solution. K_b = 0.51 °C kg/mol for H_2O

75 g solvent, 25 g solute

$$m = \frac{\frac{25\,g}{58.55\,g/mol}}{0.075\,kg} = 5.7$$

$\Delta T = 0.51(5.7)(2) = 5.8$

$100.0 + 5.8 = 105.8°C$