Today Jan 15 Sections 12.5 - 12.7

Tuesday 1/16 tutoring with Ali in epply 107 7:00-8:30

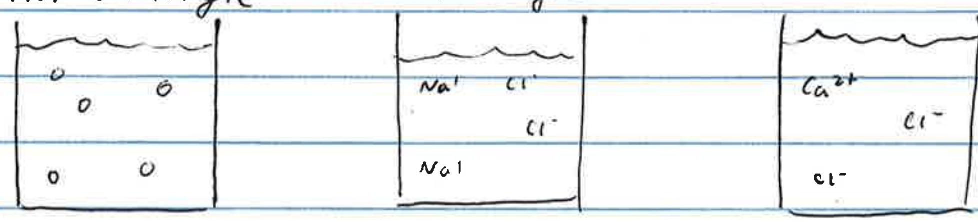
Wednesday 1/17 Section 12.4 and 12.8 and catch up

Friday 1/19 start chapter 13

Colligative properties

· properties of solutions that depend on the amount of particles in solution

non-electrolyte — electrolyte — $CaCl_2(aq)$



1 mol $CaCl_2$ ≙ 3 mol particles

o $C_{12}H_{22}O_{11}$

1 mol NaCl ≙ 2 mol particles

Van't Hoff factor, i

$i = 1$ for non-electrolyte

$i = 2$ for 1:1 electrolytes ex: $NaCl$, KBr, NH_4NO_3

$i = 3$ for 1:2 or 2:1 electrolytes ex: $CaCl_2$, Na_2SO_4

$HX + H_2O \rightleftharpoons H_3O^+ + X^-$

95% — 5%

$i = 1$ — $i = 2$

$i = 1.05$ (i does not have to be a whole number)

· for very concentrated solutions i can be less than 2 or 3 (tight ion pairs)

Colligative properties

1. Vapor pressure lowering
2. Freezing point lowering
3. Boiling point raising
4. Osmotic pressure

Vapor pressure lowering (Raoult's law)

$P_{sol'n} = P_{solvent} * X_{solvent}$

Given the vapor pressure of water is 23.76 mmHg at 25°C. If 17.0 g $C_6H_{12}O_6$ (glucose), MM = 180 g/mol is dissolved in 80.0 g H_2O, what is P_{soln}? Glucose is a non-volatile, non-electrolyte.

$P_{sol'n} = P_{H_2O} \times X_{H_2O}$

$= 23.76 \text{ mmHg} \times 0.979$

$= \boxed{23.27 \text{ mmHg}}$

$X_{H_2O} = \frac{n_{H_2O}}{n_{H_2O} + n_{C_6H_{12}O_6}}$

$n_{H_2O} = 4.44 \text{ mol}$

$n_{glc} = 0.0944 \text{ mol}$

$X_{H_2O} = \frac{4.44 \text{ mol}}{4.44 \text{ mol} + 0.0944 \text{ mol}} = 0.979$

The more solute that is added the more the vapor pressure decreases

· Suppose 35.0 g NaCl ($i = 2$) were dissolved in H_2O at 25°C. What is the $P_{sol'n}$?

$n_{NaCl} = 0.598 \text{ mol}$

$n_{H_2O} = 5.56 \text{ mol}$

$P_{sol'n} = P_{H_2O} \times X_{H_2O}$

$X_{H_2O} = \frac{n_{H_2O}}{n_{H_2O} + n_{NaCl} \times i}$

$X_{H_2O} = \frac{5.66}{5.66 + (0.698 \times 2)}$

$P_{soln} = 23.76 \text{ mmHg} \times 0.823$

$P_{soln} = 19.55 \text{ mmHg}$

$X_{H_2O} = 0.823$

· Vapor pressure involving a volatile solute (and volatile solvent)

cyclohexane, C_6H_{12} MM = 84 g/mol higher BP P_{vap} = 122 mmHg

cyclopentane, C_5H_{10} MM = 70 g/mol higher vapor pressure P_{vap} = 385 mmHg (at 30°C)

P_{soln} = ~~X~~ $\underbrace{P_A \times X_A}_{cyclopentane} + \underbrace{P_B \times X_B}_{cyclohexane}$

What is P_{soln} made of 4.7 mol cyclohexane and 1.3 mol cyclopentane?

$X_{cyclopentane} = \frac{1.3}{1.3 + 4.7} = 0.217$

$X_{cyclohexane} = 1 - 0.217 = 0.783$

$P_{soln} = 0.217 \times 365\,mmHg + 0.783 \times 122\,mmHg$

$P_{soln} = 179\,mmHg$

· Continuing with the cyclopentane, cyclohexane problem, at 30°C, what is the composition of a solution that has a vapor pressure of 200 mmHg?

$P_{soln} = P_{cyclopentane} \times X_{cyclopentane} + P_{cyclohexane} \times X_{cyclohexane}$

$200\,mmHg = 385\,mmHg \times X_{cyclopentane} + 122\,mmHg \times (1 - X_{cyclopentane})$

$X_{cyclopentane} = 0.297$

Freezing point lowering

ΔT_f = how much the freezing point is lowered = $K \times m \times i$

(deg) ← either °C or K

K: constant for each solvent p. 470

m: molality $\left(\frac{mol\ solute}{kg\ solvent}\right)$

i: Van't Hoff

questions that could be asked:

what is the change in temperature (ΔT)

What is the actual temperature ($T_{freezing} - \Delta T$)

non-electrolyte

What is T_{fp}^{soln} if 22.4 g urea, $CO(NH_2)_2$ MM = 60 g/mol are dissolved in 50 g H_2O? Given K_f (H_2O) = 1.86 deg/molal

$$\Delta T_f = K_f \times m \times i$$

$$m_{urea} = \frac{0.37 \text{ mol urea}}{.050 \text{ kg } H_2O} = 7.47 \text{ molal}$$

$$\Delta T_f = 1.86 \frac{deg}{molal} \times 7.47 \text{ molal} \times 1 = 13.9 \text{ deg}$$

$$T_{fp}^{H_2O} = 0°C$$

$$T_{fp}^{sol'n} = 0°C - 13.9°C = \boxed{-13.9°C}$$

- Suppose 4.845 g of an unknown non-electrolyte ($i = 1$) was dissolved in 25.0 g H_2O and the solution froze at −4.3°C. What is the molar mass of the unknown?

$$MM = \frac{m_{unk}}{n_{unk}} = \frac{4.845 g}{0.0578 mol} = \boxed{84.3 g/mol}$$

84.3 g/mol

$$\Delta T_f = 4.3 \text{ deg} = 1.86 \frac{deg}{molal} \times \frac{n_{unk}}{0.025 \text{ kg}} \times 1$$

$$n_{unk} = 0.0578 \text{ mol}$$