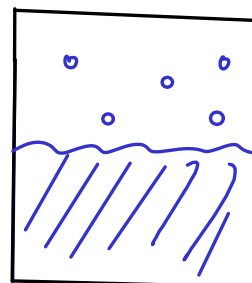


VAPOR PRESSURE LOWERING

- Described by RAOULT'S LAW



P_A = partial pressure of the VAPOR of solvent molecules.

$$P_A = P_A^* \times X_A$$

mole fraction of component A

vapor pressure of pure component A (depends on temperature)

partial pressure of component A in a solution

... but component "A" above is actually the SOLVENT. If we want to describe this as a colligative property, we want to express Raoult's law in terms of the SOLUTE! Assuming a two-component mixture, we get...

$$\Delta P = P_A^* \times X_B$$

mole fraction of component B (the SOLUTE in a two-component mixture)

Vapor pressure lowering. This is the DECREASE in the vapor pressure of the solvent due to the presence of solute.

BOILING POINT ELEVATION

- Since the vapor pressure is lowered by the presence of a solute, AND since boiling occurs when the vapor pressure of a liquid equals the external pressure - solutes also cause BOILING POINT ELEVATION.
- The equation for boiling point elevation looks almost exactly like the equation for the freezing point depression, and is used in almost the same way.

$$\Delta T_b = K_b \times C_m$$

ΔT_b — Boiling point elevation: The amount the boiling temperature is RAISED by the solute.

K_b — Boiling point elevation constant (for SOLVENT)

C_m — concentration of solute (molality)

(Find constant values on p619 OpenStax Table 11.2)

What is the boiling point of a solution that contains 2.817 g of molecular sulfur (S_8) dissolved in 100.0 grams of acetic acid?

$$T_b = 118.1^\circ\text{C}$$

$$K_b = 3.07^\circ\text{C}/m$$

(Values from p619 OpenStax Table 11.2)

$$\Delta T_b = \underbrace{K_b}_{3.07^\circ\text{C}/m} \times C_m \left[\frac{\text{mol } S_8}{\text{kg } H_2O} \right]$$

We'll start by calculating the moles of sulfur. Use FORMULA WEIGHT.

$$S_8: \frac{8 \times 32.07}{256.56 \text{ g } S_8} = \text{mol } S_8 \quad \left| \quad 2.817 \text{ g } S_8 \times \frac{\text{mol } S_8}{256.56 \text{ g } S_8} = 0.0109798877 \text{ mol } S_8$$

Next, divide moles sulfur over kilograms of acetic acid to get C_m ...

$$\frac{0.0109798877 \text{ mol } S_8}{0.1000 \text{ kg } H_2O} = 0.1097988775 \text{ m } S_8$$

↑ from problem statement - 100.0 g = 0.1000 kg

Find DELTA T_b

$$\Delta T_b = (3.07^\circ\text{C}/m) (0.1097988775 \text{ m } S_8) = 0.3370825538^\circ\text{C}$$

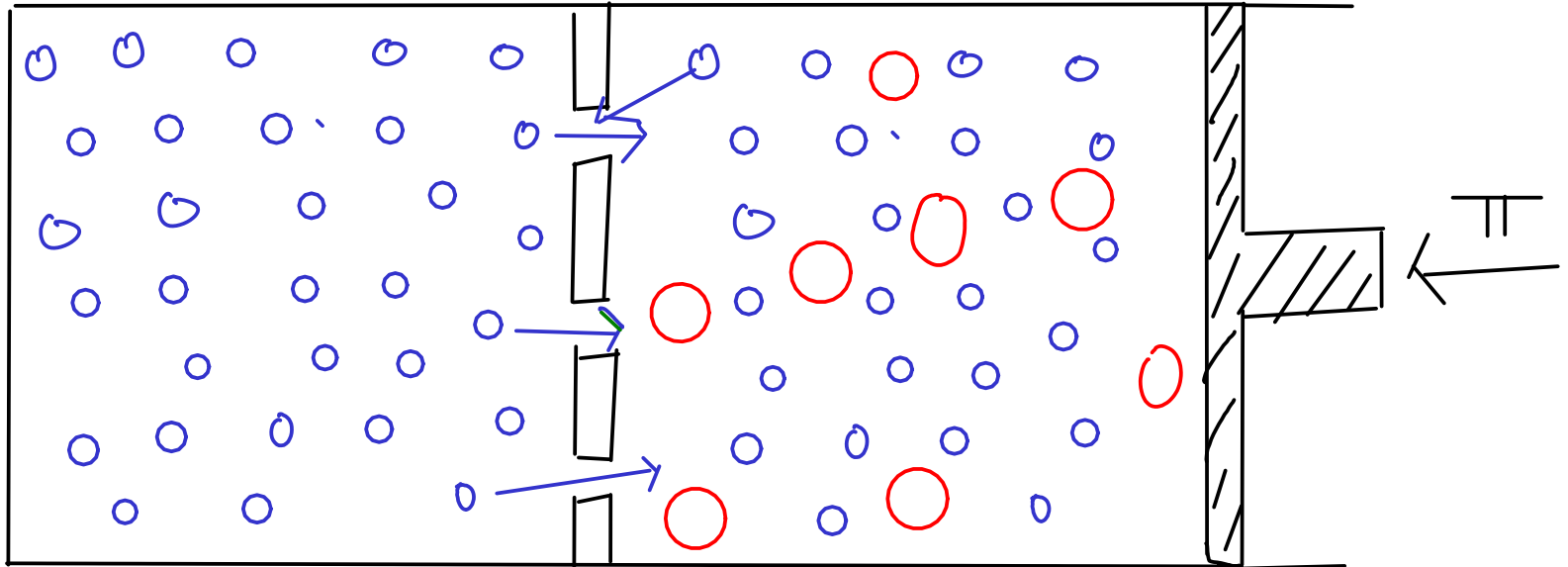
Find the new boiling point by adding DELTA T_b to the original T_b ...

$$T_{b, \text{solution}} = 118.1^\circ\text{C} + 0.3370825538^\circ\text{C} = \boxed{118.4^\circ\text{C}}$$

OSMOTIC PRESSURE

permits flow of solvent, but not solute particles

- OSMOSIS: the flow of solvent molecules through a SEMIPERMEABLE membrane to equalize concentration of solute on each side of the membrane.



The rate of solvent migration towards the RIGHT is greater than that towards the LEFT.

If you apply enough pressure to the piston, osmosis will not occur. This pressure is called the OSMOTIC PRESSURE

$$\Pi = M \times R \times T$$

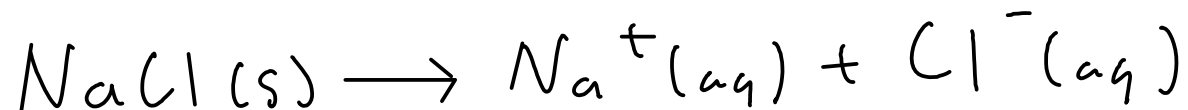
temperature

ideal gas constant

molar concentration of solute

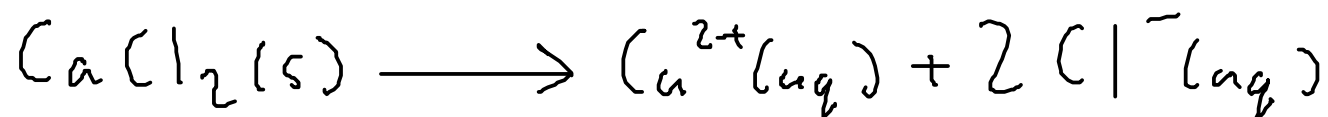
IONIC COMPOUNDS and colligative properties

- Ionic compounds DISSOCIATE in water into their component ions. Each ion formed can act as a solute and influence the colligative properties!



2 ions!

... so the concentration of IONS here is TWICE the nominal NaCl concentration.



3 ions!

... so the concentration of IONS here is THREE TIMES the nominal calcium chloride concentration.

- Ions interact with each other in solution, so unless an ionic solution is DILUTE, the effective concentrations of ions in solution will be less than expected. A more advanced theory (Debye-Huckel) covers this, but we'll assume that our solutions are dilute enough so that we can use the concentration of the ions in solution to determine the colligative properties!

If you are at an altitude high enough for the boiling point of water to be 95.00 C, what amount of sodium chloride would you need to add to 1.000 kg of water to raise the boiling point to 100.00 C?

$$K_b = 0.512 \text{ } ^\circ\text{C}/m$$

$$\text{NaCl: } 58.443 \text{ g/mol}$$

$$\Delta T_b = K_b \times C_m \quad C_m = \frac{\text{mol ions}}{\text{kg H}_2\text{O}}$$

$\underbrace{\Delta T_b}_{100^\circ\text{C} - 95^\circ\text{C} = 5.00^\circ\text{C}}$
 $\underbrace{K_b}_{0.512^\circ\text{C}/m}$

<-- NaCl is ionic, and breaks apart into several ions in solution

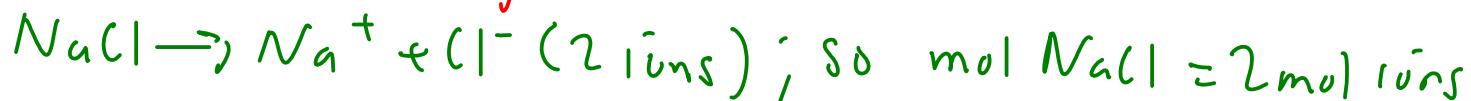
First, find C_m

$$5.00^\circ\text{C} = (0.512^\circ\text{C}/m) C_m$$

$$C_m = 9.765625 \text{ mol ions}$$

Now, find MOLES of ions

$$1.000 \text{ kg H}_2\text{O} \times \frac{9.765625 \text{ mol ions}}{\text{kg H}_2\text{O}} = 9.765625 \text{ mol ions}$$



$$9.765625 \text{ mol ions} \times \frac{\text{mol NaCl}}{2 \text{ mol ions}} = 4.8828125 \text{ mol NaCl}$$

Now find grams NaCl...

$$4.8828125 \text{ mol NaCl} \times \frac{58.443 \text{ g NaCl}}{\text{mol NaCl}} = 285 \text{ g NaCl}$$