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?

$$T_b = 118.5°C \qquad K_b = 3.08°C/m$$

$$\Delta T_b = K_b \times C_m \qquad \Bigg| \qquad C_m = \frac{mol\ S_8}{kg\ HC_2H_3O_2}$$

$$\underset{3.08°C/m}{}$$

First, we will determine Cm by calculating the moles of sulfur (mass/mole conversion) and calculating the kg of acetic acid (just a unit conversion).

$$S_8: \quad 8 \times 32.07 = 256.56\ g/mol$$

$$2.817\ g\ S_8 \times \frac{mol\ S_8}{256.56\ g\ S_8} = 0.01097988877\ mol\ S_8$$

$$100.0\ g\ HC_2H_3O_2 \times \frac{kg}{10^3\ g} = 0.1000\ kg\ HC_2H_3O_2$$

$$C_m = \frac{0.01097988877\ mol\ S_8}{0.1000\ kg\ HC_2H_3O_2} = 0.1097988775\ m\ S_8$$

$$\Delta T_b = (3.08°C/m)(0.1097988775\ m) = 0.338°C$$

$$T_{b,new} = 118.5°C + 0.338°C = \boxed{118.8°C}$$

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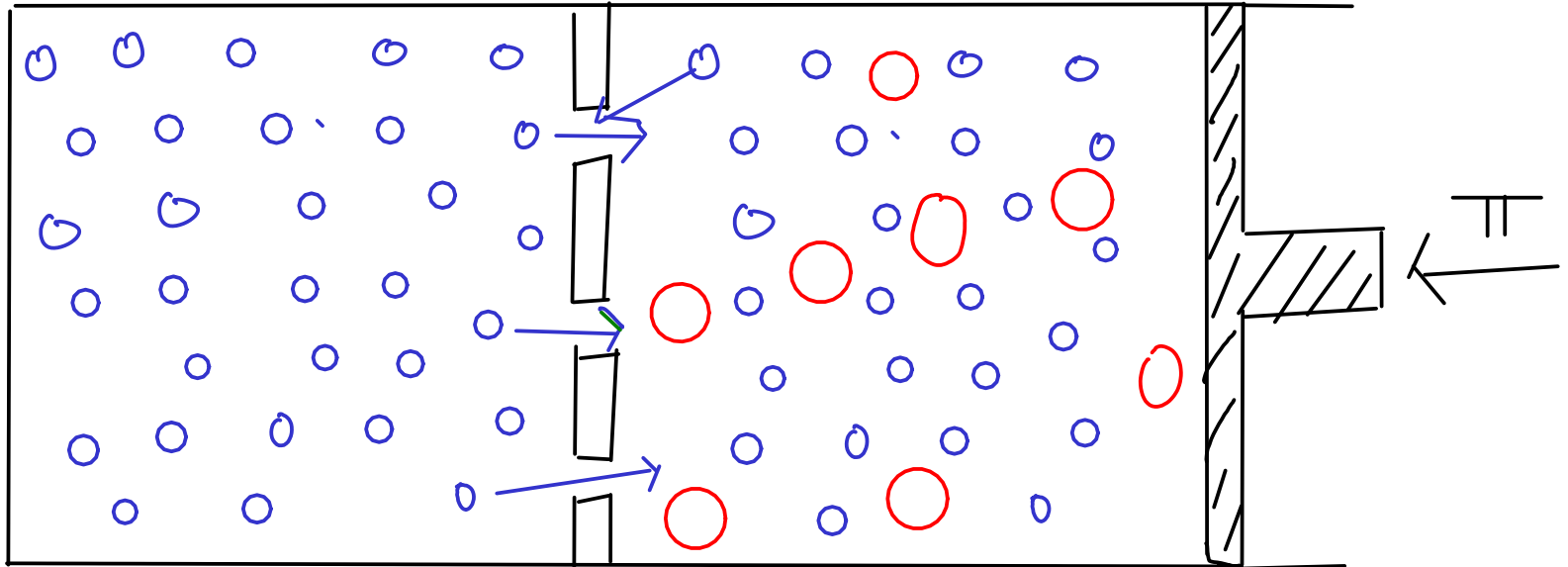
The rate of solvent migration towards the RIGHT is greater than that towards the LEFT.

If you apply enough pressure to the piston, osmosis will not occur. This pressure is called the OSMOTIC PRESSURE
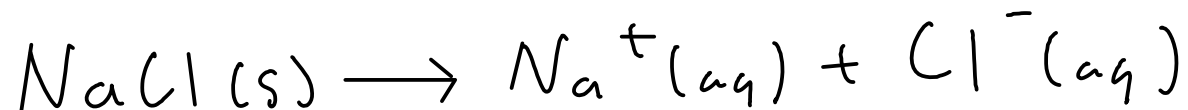
$$\pi = M \times R \times T$$

temperature

ideal gas constant
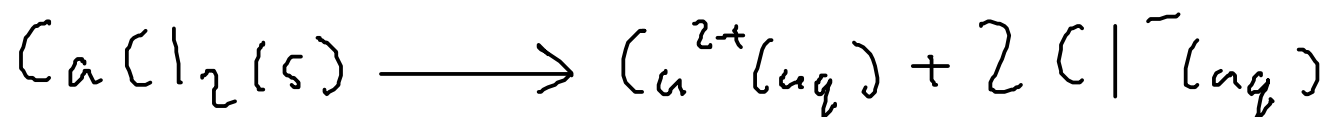
molar concentration of solute

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!

$$NaCl\,(s) \longrightarrow Na^+\,(aq) + Cl^-\,(aq)$$

2 ions!

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

$$CaCl_2\,(s) \longrightarrow Ca^{2+}\,(aq) + 2\,Cl^-\,(aq)$$

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?

$$K_b = 0.512 \, ^\circ C/m \qquad NaCl: 58.443 \, g/mol$$

$$\Delta T_b = K_b \times C_m \qquad C_m = \frac{mol\ ions}{Kg\ H_2O}$$

$$\underbrace{}_{100.00^\circ C - 95.00^\circ C = 5.00^\circ C} \underbrace{}_{0.512 ^\circ C/m} \qquad \overset{\curvearrowright}{1.000\,kg}$$

First. we'll calculate Cm, and then we'll use Cm to find out how many moles of IONS we need to dissolve. Since the moles of ions come from the NaCl, we can then calculate the amount of NaCl required.

$$5.00^\circ C = (0.512 ^\circ C/m) \times C_m \qquad 9.765625\,m = \frac{mol\ ions}{1.000\,kg\,H_2O}$$

$$9.765625\,m\ ions = C_m \qquad 9.765625\,mol = mol\ ions$$

$$NaCl \longrightarrow Na^+ + Cl^- \ (2\,mol\ ions),\ So\ mol\ NaCl = 2\,mol\ ions$$

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

Finally, convert to grams...

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

KINETICS

- the study of the RATE of chemical reactions. Or, the study of the factors affecting how fast chemical reactions proceed.

DEFINING RATE

- RATE is defined as the change in the molar (M) concentration of a reactant or product over time. Usually, rate is defined in terms of one of the REACTANTS

$$A + B \longrightarrow C$$

...Let's look at a simple combination

$$Rate = \frac{-\Delta [A]}{\Delta t}$$

$[A]$ = "molar concentration of substance "A".

Square brackets ( ) are used to denote MOLAR concentration
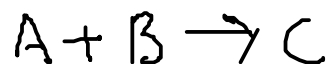
change in time

$$Rate = \frac{\Delta [C]}{\Delta t}$$

Negative sign because we define the rate as a POSITIVE number, and (A) will decrease over time!

You could ALSO define the rate in terms of the disappearance of B or the appearance of C over time! Our choice of A was arbitrary,

THE RATE LAW

- We express the rate of reaction using an equation called the RATE LAW.

$$A + B \rightarrow C$$

$$Rate = -\frac{\Delta[A]}{\Delta t} = k \times [A]^p \times [B]^q$$

This is the RATE CONSTANT. It depends on TEMPERATURE, but does not depend on the CONCENTRATION of any reactant or product.

"p" and "q" are called REACTION ORDERS. They indicate the effect a particular reactant or catalyst has on the rate of a reaction. Reaction orders may be positive, zero (in which case the substance has NO effect on rate) and negative (in which case the substance actually slows the reaction down).

- Rate laws depend on CONCENTRATION of reactants. Since the concentrations of reactants CHANGE throughout the course of the reaction, so does the rate!

- RATE CONSTANTS and REACTION ORDERS are determined experimentally. If you do experiment 13 (the iodine clock reaction), you will see how this can be done in the lab via the INITIAL RATES METHOD.

Initial rates method:

- To determine the rate constant and reaction orders in a reaction, it's possible to monitor the rate of a reaction starting from time zero to a short time later where the concentrations of the reactants haven't changed much. In other words, we look at the INITIAL RATE.

- To determine the rate constant and orders, we need to perform several experiments - one for each order to determine and one baseline experiment to determine the rate constant.

Example:

$$A + B \rightarrow C + D$$

$$Rate = k\,[A]^{q}\,[B]^{r}$$
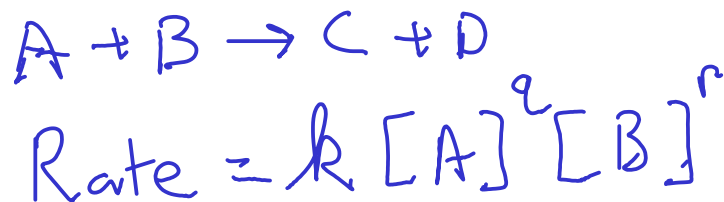
... we want to find the rate constant 'k', and the orders 'q' and 'r'.

Trial	$[A]$	$[B]$	Rate $\dfrac{-\Delta[A]}{s}$	
1	0.156	0.180		Baseline experiment
2	0.300	0.156		Double (A) to find 'q'
3	0.150	0.300		Double (B) to find 'r'

Trial	[A]	[B]	Rate $\dfrac{-\Delta [A]}{s}$
1	0.150	0.150	0.0016875
2	0.300	0.150	0.0033750
3	0.150	0.300	0.0067500

Rate doubles

Rate quadruples

The rate law is:

$$Rate = k[A]^q [B]^r$$

... so how do we use the data above to find out the values of 'k', 'q', and 'r'?

We observe that in the second trial ((A) doubled), the rate has doubled!

$$(2 * [A])^q = 2 * Rate \; ; \; q = 1$$

We observe that in the third trial ((B) doubled), the rate has quadrupled.

$$(2 * [B])^r = 4 * Rate \; ; \; r = 2$$

$$Rate = k[A][B]^2$$