Colligative Properties of Electrolyte Solutions

Recall

“Several important properties of solutions depend on the number of solute particles in solution and not on the nature of the solute particles”

Substances that produce ions give a greater concentration of “particles”than expressed by the molar concentration of the solute.

Electrolyte Solutions

Elevation in boiling point

$$\Delta T_{bp} = iK_{bp}\, m_{solute}$$

Depression in freezing point

$$\Delta T_{fp} = iK_{fp}\, m_{solute}$$

Where i is the number of particles formed from each molecule of solute (called the van’t Hoff factor)

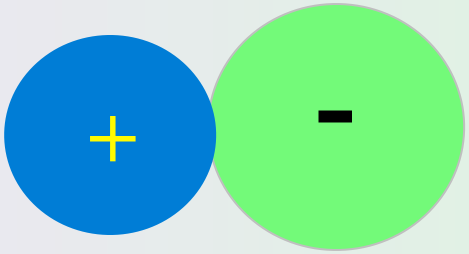
Van’t Hoff Factors

Electrolyte (0.05 m)	*i* (measured)	*i* (calculated)
HCl	1.9	2.0
NaCl	1.9	2.0
$MgSO_4$	1.3	2.0
$MgCl_2$	2.7	3.0
$FeCl_3$	3.4	4.0

Ion Pairing

a theoretically explanation for the difference between a calculated van't Hoff factor and the actual value

at a given instant a small percentage of cations and anions in a solution are paired thus counting as a single particle



Freezing point depression

What is the freezing point of a solution of 250 g of $CaCl_2$ (which is a strong electrolyte) in 1.0 kg of water? (K_f for H_2O = 1.86 ° kg/mol

$$\Delta T = i\, K_f\, m_{solute}$$

i $CaCl_2$ = 3

$$m = 250.0\ \text{g CaCl}_2 \times \frac{1\ \text{mol CaCl}_2}{111.0\ \text{g CaCl}_2} \times \frac{1}{1\ \text{kg H}_2\text{O}} = \frac{2.25\ \text{mol CaCl}_2}{1\ \text{kg}}$$

$$\Delta T = 3 \times \frac{2.25\ \text{mol CaCl}_2}{1\ \text{kg}} \times \frac{1.86\ \text{kg}}{\text{mol}} = 12.5^\circ$$

0° C - 12.5° = -12.5 ° C