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)

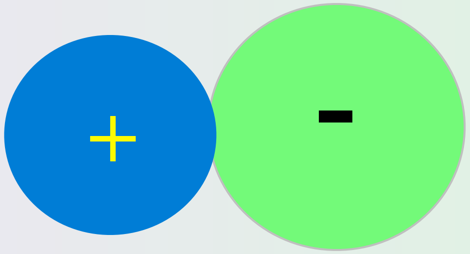
Van’t Hoff Factors

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

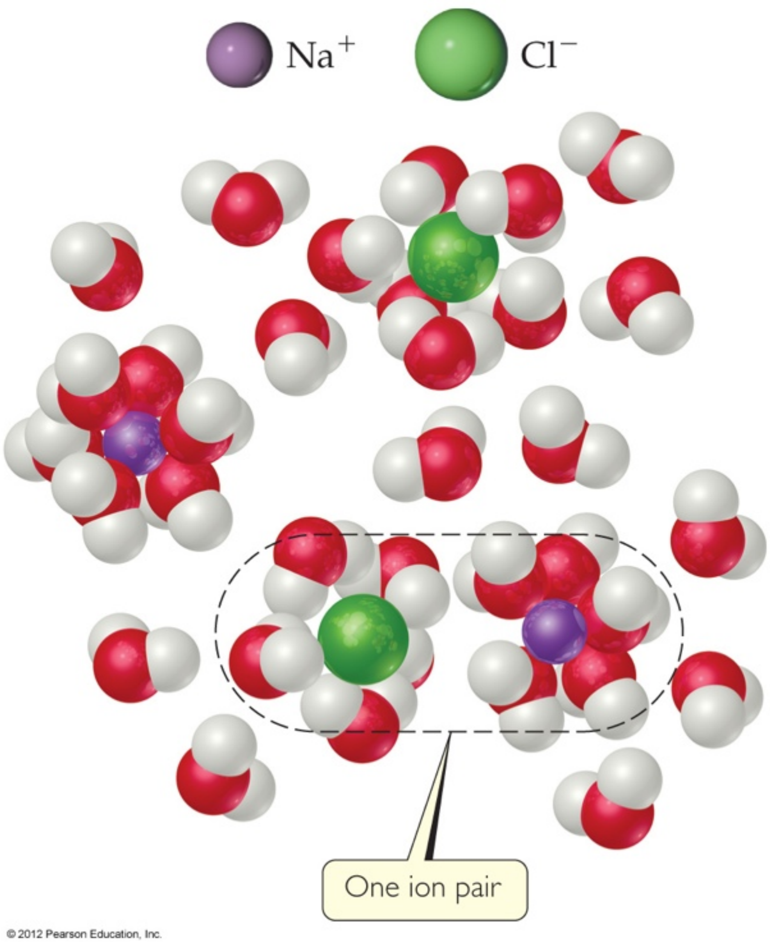
Ion Pairing

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



van’t Hoff Factor



One mole of NaCl in water does not really give rise to two moles of ions.

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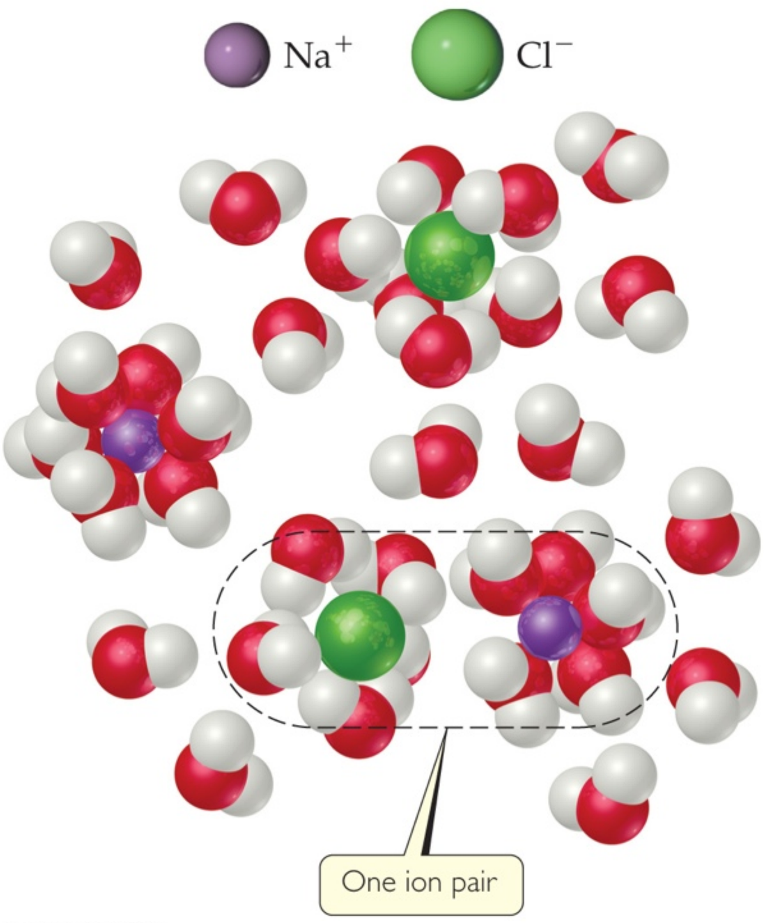
van’t Hoff Factor



Some Na^+ and Cl^- reassociate for a short time, so the true concentration of particles is somewhat less than two times the concentration of NaCl.

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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

$$m = 250.0 \text{ g } CaCl_2 \times \frac{1 \text{ mol } CaCl_2}{111.0 \text{ g } CaCl_2} \times \frac{1}{1 \text{ kg } H_2O} = \frac{2.25 \text{ mol } CaCl_2}{1 \text{ kg}}$$

$$\Delta T = 3 \times \frac{2.25 \text{ mol } CaCl_2}{1 \text{ kg}} \times \frac{1.86 \text{ kg}}{\text{mol}} = 12.5^\circ$$

0° C - 12.5° = -12.5 ° C

Colloids

Suspensions of particles larger than individual ions or molecules, but too small to be settled out by gravity, are called **colloids**.

TABLE 13.5 • Types of Colloids

Phase of Colloid	Dispersing (solvent-like) Substance	Dispersed (solute-like) Substance	Colloid Type	Example
Gas	Gas	Gas	—	None (all are solutions)
Gas	Gas	Liquid	Aerosol	Fog
Gas	Gas	Solid	Aerosol	Smoke
Liquid	Liquid	Gas	Foam	Whipped cream
Liquid	Liquid	Liquid	Emulsion	Milk
Liquid	Liquid	Solid	Sol	Paint
Solid	Solid	Gas	Solid foam	Marshmallow
Solid	Solid	Liquid	Solid emulsion	Butter
Solid	Solid	Solid	Solid sol	Ruby glass

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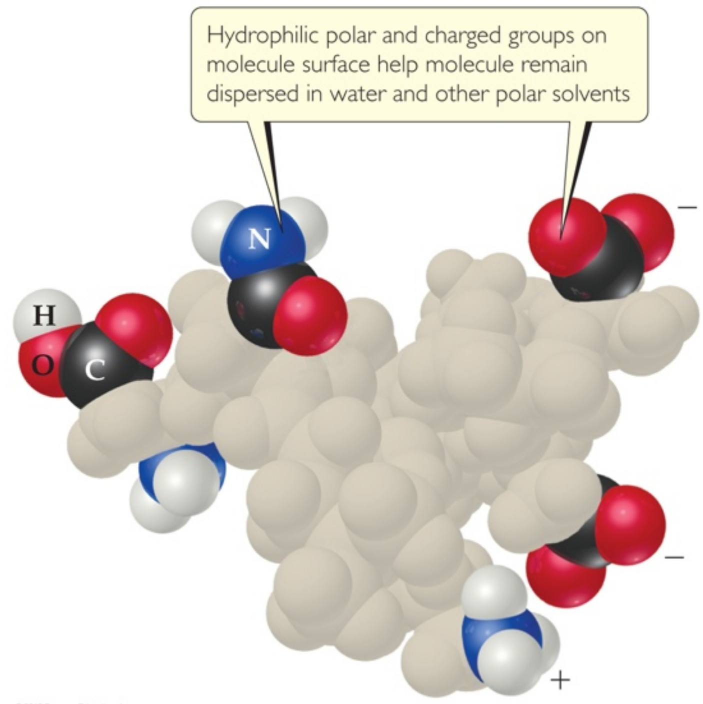
Colloids in Biological Systems

Some molecules have a polar, **hydrophilic** (*water-loving*) end and a nonpolar, **hydrophobic** (*water-hating*) end.



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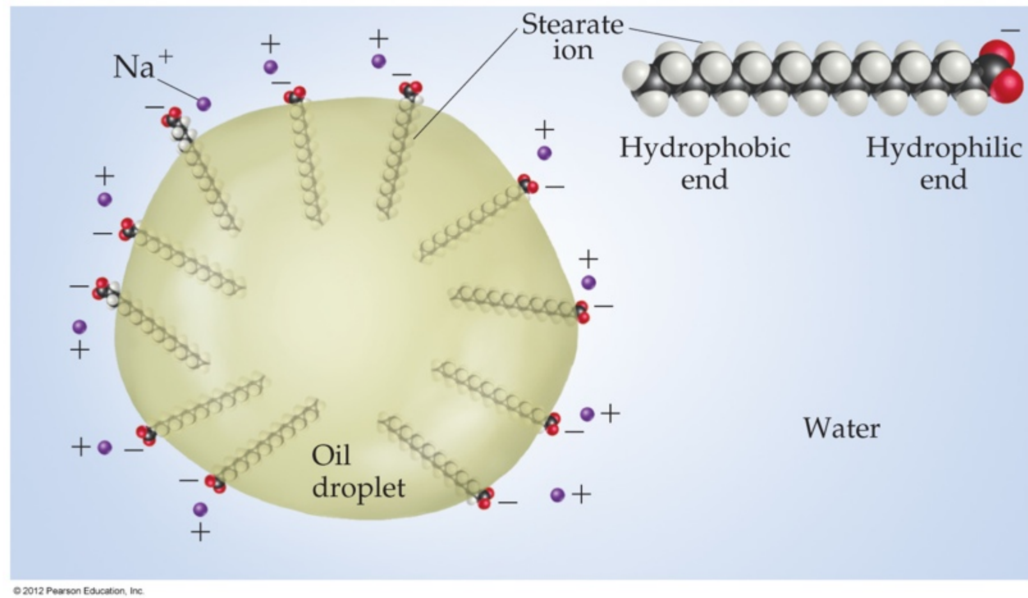
Colloids in Biological Systems

These molecules can aid in the emulsification of fats and oils in aqueous solutions.



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