Colligative Properties of Solutions

Honors Chemistry

How do you get from this…

…to this?

Add an ionic compound!

Colligative Properties

- Properties that depend only on the number of solute particles and not on their identity.

Some Colligative Properties are:

- Boiling point elevation
- Freezing Point depression

metal + nonmetal 2 nonmetals

Ionic vs Molecular Solutes

(covalent)

- Ionic solutes produce two or more ion particles in solution.
- They affect the colligative properties proportionately more than molecular solutes (that do not ionize).
- The effect is proportional to the **number of particles of the solute in the solution.**

How many particles do each of the following give upon solvation?

I • $NaCl \rightarrow Na^{1+} + Cl^{1-}$ (2 particles)

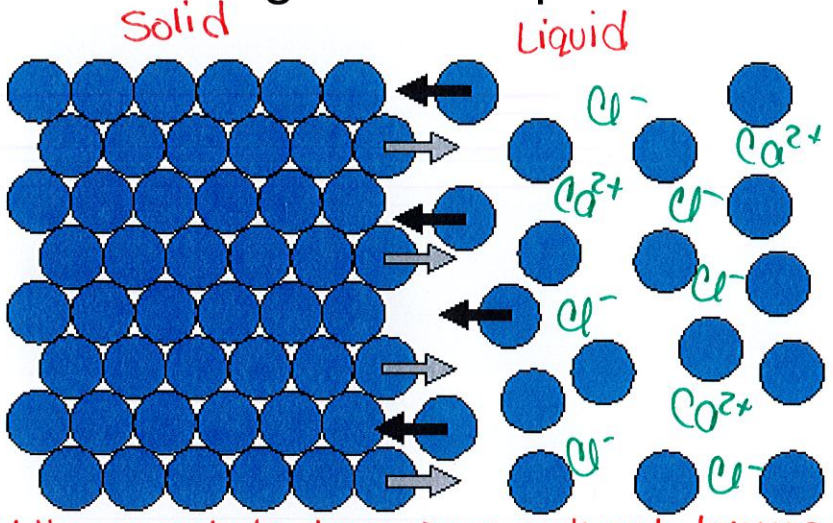
I • $CaCl_2 \rightarrow Ca^{2+} + 2Cl^{1-}$ (3 particles)

C • Glucose (1 particle)

$C_6H_{12}O_6$

(no ions

Freezing Point Depression



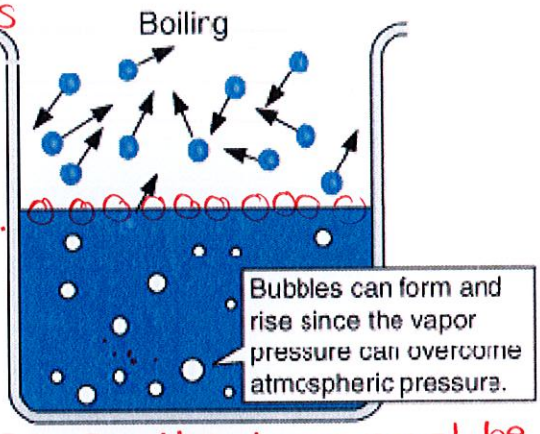
Adding a solute to a pure solvent lowers the freezing point of the solution. The solute interferes with a crystal (solid) forming. In order to get the crystal to form, the temp. must be made even lower to force crystallization.

Example

- Salt is added to melt ice by reducing the freezing point of water.

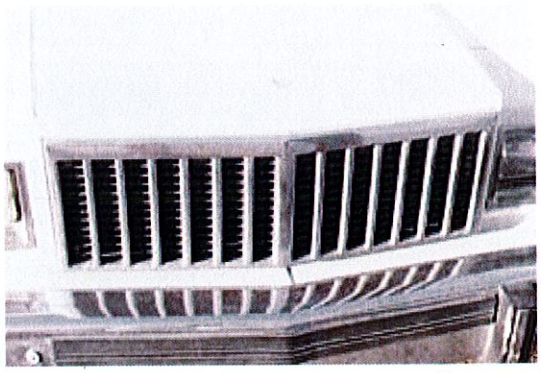
Boiling Point Elevation

In order to boil, solvent particles have to gain enough kinetic energy to break their IMFs & escape as a gas. When a solute is added, they "block" the solvent from escaping as a gas. So the temp. must be increased, raising the boiling pt., giving the solvent molecules enough energy to push past the solute & escape.



Example

- Addition of ethylene glycol $C_2H_6O_2$ (antifreeze) to car radiators.



Freezing Pt. Depressed

$$\Delta T_F = m \cdot i \cdot K_f$$

- ΔT_F: change in freezing pt.
- m: molality
- i: # particles in solution
- K_f: freezing pt constant

Boiling Pt Elevated

$$\Delta T_b = m \cdot i \cdot K_b$$

- ΔT_b: change in boiling pt.
- m: molality
- i: # particles in solution
- K_b: boiling pt constants

Na_2SO_4 or VF_6

$2Na^+ + SO_4^{2-}$

3 particles

$V^{6+} + 6F^{1-}$

7 particles

CO_2 or $(NH_4)_3P$

covalent

1 particle

$3NH_4^{+1} + P^{3-}$

4 particles

Acids & Bases

· Definitions

Arrhenius acids
- substances that release H^{1+} ions in solution

Ex) $HCl_{(aq)} \rightarrow H^{1+}_{(aq)} + Cl^{1-}_{(aq)}$

Ex) $H_2SO_{4(aq)} \rightarrow H^{1+}_{(aq)} + HSO_4^{1-}_{(aq)}$

$HSO_4^{1-}{}_{(aq)} \rightarrow H^{1+}_{(aq)} + SO_4^{2-}_{(aq)}$

* Acids lose one H^{1+} ion at a time

Arrhenius bases
- substances that release OH^{1-} ions in solution

Ex) $KOH_{(aq)} \rightarrow K^{1+}_{(aq)} + OH^{1-}_{(aq)}$

Ex) $Al(OH)_{3(aq)} \rightarrow Al^{3+}_{(aq)} + 3OH^{1-}_{(aq)}$

* Base lose all OH^{1-} ions at once.

Bronsted-Lowry Acids
- substances that donate H^{1+} ions in solution.

- All acids have a conjugate base - what is left over after the acid loses an H^{1+} ion.

Bronsted-Lowry Bases
- substances that accept H^{1+} ions in solution

- All bases have a conjugate acid - what the base becomes when it accepts an H^{1+} ion

Examples

(1) $\underset{A}{HSO_4^{1-}{}_{(aq)}} + \underset{B}{F^{1-}_{(aq)}} \rightarrow \underset{CB}{SO_4^{2-}{}_{(aq)}} + \underset{CA}{HF_{(aq)}}$

(2) $\underset{B}{NH_{3(aq)}} + \underset{A}{H_2O_{(aq)}} \rightarrow \underset{CA}{NH_4^{1+}{}_{(aq)}} + \underset{CB}{OH^{1-}_{(aq)}}$

(3) $\underset{A}{HNO_{3(aq)}} + \underset{B}{H_2O_{(aq)}} \rightarrow \underset{CB}{NO_3^{1-}{}_{(aq)}} + \underset{CA}{H_3O^{1+}_{(aq)}}$

amphoteric - substances that can act as an acid or a base