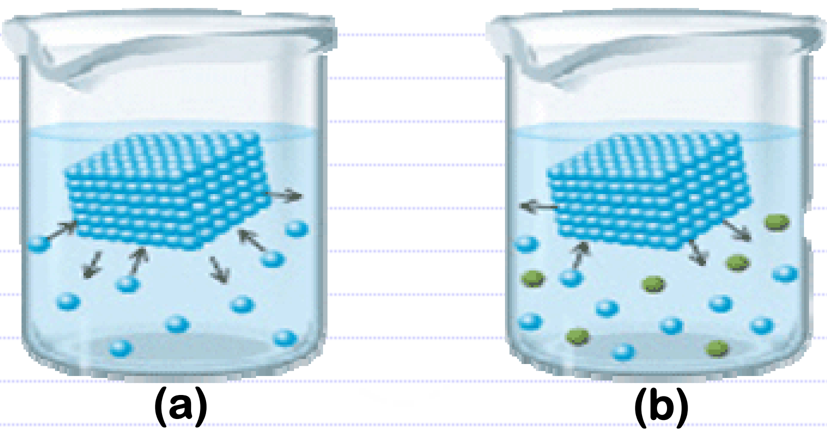
13.4 Colligative Properties

Vapor Pressure Lowering – Freezing Point Depression

$$\Delta T_{fp} = i \times K_{fp} \times m_{solute}$$



ΔT_{fp} : Change in freezing point.

K_{fp} : Freezing point depression constant for the solute.

m_{solute} : Molality of the solute.

i : van't Hoff factor. For a nonelectrolyte, $i = 1$.

13.4 Colligative Properties

Vapor Pressure Lowering – van't Hoff Factor?

In our disscussion of Raoult's law we have stuck with non volatile liquids (nonelectrolytes) that dissolve in water.

What if we used soluble ionic compounds?

$$1M\ NaCl(aq) = 1M\ Na^+ + 1M\ Cl^- \quad : \quad i = 2$$

$$1M\ CaCl_2(aq) = 1M\ Ca^{2+} + 2M\ Cl^- \quad : \quad i = 3$$

What about using a weak acid?

$$1M\ HCN(aq) \rightleftharpoons ?M\ H^+ + ?M\ CN^- \quad : \quad i > 0 \text{ but } < 2$$

13.4 Colligative Properties

Vapor Pressure Lowering – van't Hoff Factor?

Which of the following solutions would have the **highest boiling point**?

a)	0.19m NH_4NO_3	$NH_4^+ + NO_3^-$:	$i = 2$	$2 \times 0.19 = 0.38$
b)	0.18m KCH_3COO	$K^+ + CH_3COO^-$:	$i = 2$	$2 \times 0.18 = 0.36$
c)	0.21m NaCl	$Na^+ + Cl^-$:	$i = 2$	$2 \times 0.21 = 0.42$
d) ✓	0.44m Glucose (nonelectrolyte)	:	$i = 1$	$1 \times 0.44 = 0.44$ ✓

13.4 Colligative Properties

Vapor Pressure Lowering – van't Hoff Factor?

Which of the following solutions would have the **lowest freezing point**?

a) 0.15m CuI_2 — $Cu^{2+} + 2I^-$: $i = 3$ — $3 \times 0.15 = 0.45$

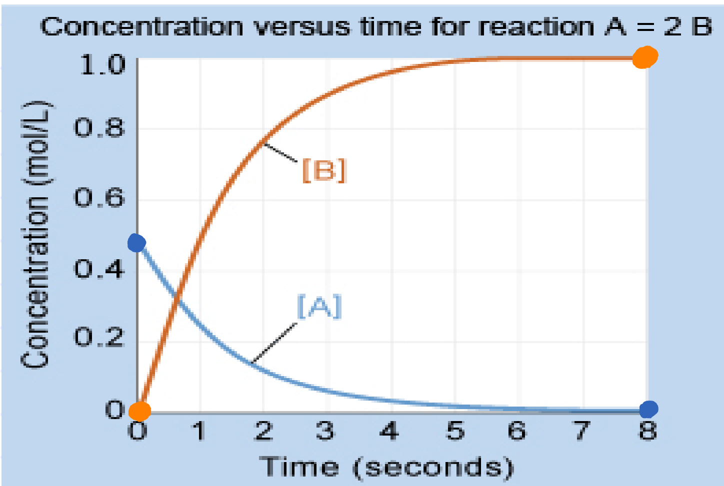
b) ✓ 0.17m $Zn(CH_3COO)_2$ — $Zn^{2+} + 2CH_3COO^-$: $i = 3$ — $3 \times 0.17 = 0.51$ ✓

c) 0.14m CoI_2 — $Co^{2+} + 2I^-$: $i = 3$ — $3 \times 0.14 = 0.42$

d) 0.47m Urea (nonelectrolyte) : $i = 1$ — $1 \times 0.47 = 0.47$

14.2 Expressing the Rate of a Reaction

Average Rate and Reaction Stoichiometry



A = 2B

Timed from 0 to 8 seconds

$$\text{Rate} = \frac{\Delta[B]}{\Delta t} = \frac{[B]_8 - [B]_0}{t_8 - t_0} = \text{Rate of Formation of B}$$

$$\text{Rate} = \frac{\Delta[A]}{\Delta t} = \frac{[A]_8 - [A_0]}{t_8 - t_0} = \text{Rate of Dissapearance of A}$$

For B:

$$\text{Rate} = \frac{1M - 0M}{8s - 0s} = 0.125\ M.s^{-1}$$

For A:

$$\text{Rate} = \frac{0M - 0.5M}{8s - 0s} = -0.0625\ M.s^{-1}$$

No surprise, A = 2B, that the average rate of formation of B is twice the average rate of Dissapearance of A.