Colligative Properties

Concentration Units

Molarity (M):

Moles solute divided by the volume (L) of solution

Unit: mol/L

Percent by mass

Grams solute divided by the amount of solution (in grams) multiplied by 100%

Unitless: mass units cancel out

ppm: part per million ($1g/1x10^6g$)

Molality (*m*)

Denominator is kg solvent, not solution!

Removes temperature dependence as it is mass based

Unit: mol/Kg $_{solvent}$

Solutions Of Electrolytes

Colligative properties:

Physical properties of solutions that depend on the *number* of solute particles present but *not* on the identity of solute.

Boiling Point, Freezing Point, Osmotic Pressure

van't Hoff factor, *i*

Used to modify the equations for colligative properties

For nonelectrolytic solutions, $i = 1$.

For a solution of electrolytes, *i* is equal to the number of ions a substance dissociates into in solution.

For NaCl, $i = 2$ and for $Pb(NO_3)_2$, $i = 3$

Boiling Point Elevation

Vapor pressure above a solution is always less than vapor pressure above pure solvent.

1. Higher temperature needed for vapor pressure to hit 1 atm.
2. Boiling point of solution higher than boiling point of pure solvent

3. Boiling Point Elevation

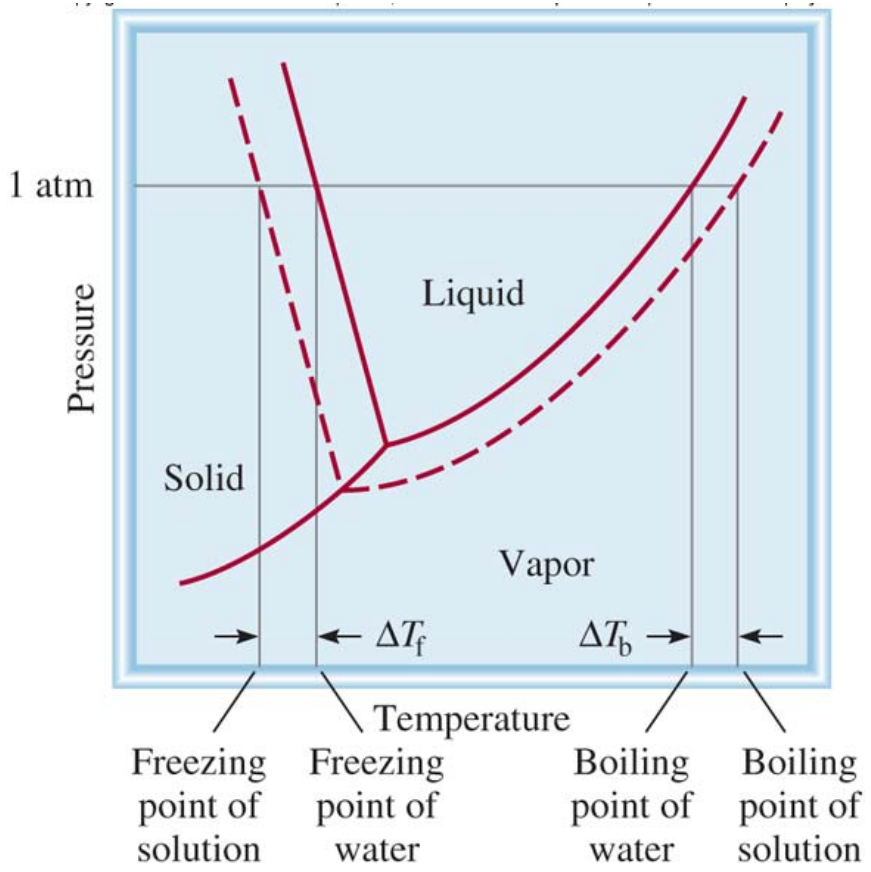
   Depends on:

   Type of solvent

   # of solute particles

$\Delta T_b = iK_b m \quad \Delta T_b = T_b - T°_b$

m = solute molality



Freezing Point Depression

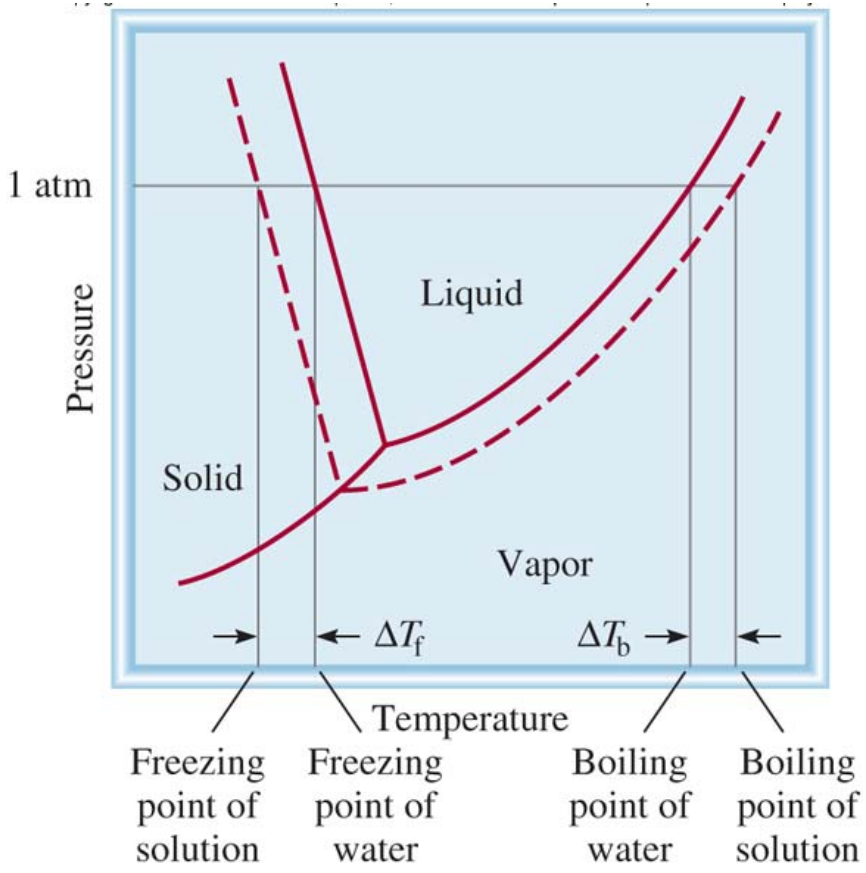
The solution freezes at a lower temperature than if pure.

Depends on solvent & # of solute particles

$\Delta T_f = iK_f m \quad \Delta T_f = T°_f - T_f$

Only the pure solvent freezes out

Broad range for melting points.



Constants

TABLE 13.2 Molal Boiling-Point Elevation and Freezing-Point Depression Constants of Several Common Liquids

Solvent	Normal Freezing Point (°C)*	K_f (°C/*m*)	Normal Boiling Point (°C)*	K_b (°C/*m*)
Water	0	1.86	100	0.52
Benzene	5.5	5.12	80.1	2.53
Ethanol	−117.3	1.99	78.4	1.22
Acetic acid	16.6	3.90	117.9	2.93
Cyclohexane	6.6	20.0	80.7	2.79

Recitation Questions

A 14.00% by mass acetic acid solution has a density of 1.020 g/mL. What is its molarity?

A 14.00% by mass acetic acid solution has a density of 1.020 g/mL. What is its molality?

If water is the solvent, what is the mole fraction of acetic acid in the 14.00% CH_3COOH solution

For cyclohexane, K_f= 20.0°C/m and T°_f = 6.55°C. A solution of 2.366g solute in 82.10g cyclohexane freezes at 2.65°C. Determine the molar mass of the solute.