Molality

- Molality is said molal and is represented by a lower case m
- molality= mol solute/ kg of solvent

Chart

Table of concentration measures

Frequently used standards of concentration			
Measurement	Notation	Generic formula	Typical units
Molarity	M	$\left(\frac{\text{moles solute}}{\text{liters solution}}\right)$	mol/L (or M)
Mass percentage	wt%	$\left(\frac{\text{grams solute} \times 100}{\text{grams solution}}\right)$	%
Molality	*m*	$\left(\frac{\text{moles solute}}{\text{kilograms solvent}}\right)$	mol/kg (or m**)
Mole fraction	χ (chi)	$\left(\frac{\text{moles solute}}{\text{moles solution}}\right)$	(decimal)

Boiling point elevation = $BP_{normal} + \Delta T$
Where $\Delta T = K_b (m)i$

Freezing Point Depression = $FP_{normal} - \Delta T$
Where $\Delta T = K_f (m)i$

Dilution equation
MV = MV

Problem

- 2.1 kg of sodium chloride is dissolved in 45 kg of water. What is the molality of the solution?

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- 2.1 kg of sodium chloride is dissolved in 45 kg of water. What is the molality of the solution?
- 2100 g x 1 mol / 58.44 g = 35.93 mol NaCl
- m = 35.93…mol / 45 kg
- = .80 m

Convert

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- Convert 1.2 M HNO_3 to molality if the density of the solution is 1.12 g/mL.
- 1.2 M = 1.2 mol HNO_3 /1 L solution
- 1.2 mol x 63.018 g / 1 mol = 75.6216 g HNO_3
- 1 L of solution = 1000 mL x 1.12 g/1mL = 1120 g of solution
- 1120 g of solution – 75.6216 = 1044.3784 g of water
- m = 1.2 mol HNO_3 / 1.0443784 kg
- = 1.1 m

Colligative Properties

- ~properties that depend only on the solute's concentration rather than what the solute is
- All solutions will freeze at a lower temperature and boil at a higher temperature.
- *Boiling point elevation* and *freezing point depression* are colligative properties

Where it is used

- Road salt goes into solution with snow, ice and water on the roads and lowers the freezing point.
- Water below the freezing point will not freeze and runs off the road

Boiling Water

- Students often assume that all boiling water is exactly at 100.0^o C.
- That is normally not the case because of two factors; the air pressure, and anything dissolved in the water.
- Anything dissolved in the water will always raise the boiling point.

Calculations for phase change points

- ΔT = change in temperature
- Boiling point elevation = $BP_{normal} + \Delta T$
- Where $\Delta T = K_b$ (m)i
- Freezing Point Depression = $FP_{normal} - \Delta T$
- Where $\Delta T = K_f$ (m)i
- K_b is the ebulliscopic constant
- K_f is the cyroscopic constant
- m is the molality of the solution
- i is the Van't Hoff factor

Van't Hoff Factor (i)

- Colligative properties means it doesn't matter what the solute is.
- Some things when dissolved dissociate (ionic compounds), which, if you don't care what the solute is technically would increase the molality.
- $NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$
- Sodium chloride dissociates into 2 things
- So it's Van't Hoff factor is 2
- $C_6H_{12}O_{6(s)} \rightarrow C_6H_{12}O_{6\,(aq)}$
- Glucose is a covalent compound that doesn't dissociate, so it's Van't Hoff factor is 1

Freezing Point Depression and Boiling Point Elevation

Solvent	Formula	Melting Point (°C)	Boiling Point (°C)	K_f(°C/m)	K_b(°C/m)
Water	H_2O	0.000	100.000	1.858	0.512
Acetic acid	$HC_2H_3O_2$	16.60	118.5	3.90	3.08
Benzene	C_6H_6	5.455	80.2	5.12	2.53
Chloroform	CH_2O	-63.5	61.3	4.68	3.63
Carbon disulfide	CS_2	-112	46.3	3.8	2.34
Cyclohexane	C_6H_{12}	6.55	80.74	20.0	2.79
Ethanol	C_2H_5OH	-114.6	78.3	1.99	1.07

Bottom of Chart

Boiling point elevation = $BP_{normal} + \Delta T$
Where $\Delta T = K_b$ (m)i

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Dilution equation
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Boiling point problem

- Determine the boiling point of a 2.8 m solution of **water** with aluminum chloride ($AlCl_3$) dissolved in it.

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- K_b = .512 °C/m
- i =(Van't Hoff) $AlCl_3 \rightarrow Al^{3+} + 3\ Cl^-$ = 4
- $\Delta T = K_b$ (m) i
- ΔT = .512 °C/m (2.8 m) 4= 5.7
- BP_{water} = 100.00 + 1.7 = 105.7° C

Another Boiling point problem

- Determine the boiling point of a 1.7 m potassium nitrate (KNO_3) aqueous solution.

Another Boiling point problem

- Determine the boiling point of a 1.7 m potassium nitrate (KNO_3) aqueous solution.
- K_b = .512 °C/m
- i =(Van't Hoff) $KNO_3 \rightarrow K^+ + NO_3^-$ = 2
- $\Delta T = K_b$ (m) i
- ΔT = .512 °C/m (1.7 m) 2= 1.7
- BP_{water} = 100.00 + 1.7 = 101.7° C

Freezing point problem

- Determine the freezing point of a 2.1 m solution of water with calcium chloride ($CaCl_2$) dissolved in it.

Freezing point problem

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- (Van't Hoff) $CaCl_2 \rightarrow Ca^{2+} + 2\ Cl^-$ i = 3
- $\Delta T = K_f\,(m)i$
- ΔT = 1.858 °C/m (2.1 m) 3= 12
- FP_{water} = 0.00 – 11.7 = -12° C

Salt the road

- Determine the freezing point of a 21 kg sample of water with 1.1 kg of calcium chloride ($CaCl_2$) dissolved in it.

Salt the road

- Determine the freezing point of a 21 kg sample of water with 1.1 kg of calcium chloride ($CaCl_2$) dissolved in it.
- 1100 g $CaCl_2$ x 1 mol / 110.98 g = 9.911 mol
- m = 9.911… mol/21 kg
- = .472 m
- (Van't Hoff) $CaCl_2 \rightarrow Ca^{2+} + 2\ Cl^-$ i = 3
- $\Delta T = K_f\,(m)i$
- ΔT = 1.858 (.4719)3= 2.6
- FP_{water} = 0.00 – 2.6 = -2.6° C