Solutions/Mixtures

Chemistry

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By end of this unit I can…

SM1: define and describe the key terms of a mixture.

SM2: describe the differences between heterogeneous and homogeneous mixtures.

SM3: describe the differences between solid, liquid and gaseous mixtures.

SM4: describe and identify factors that impact the rate of dissolving.

SM5: calculate the molarity of a solution to determine its concentration.

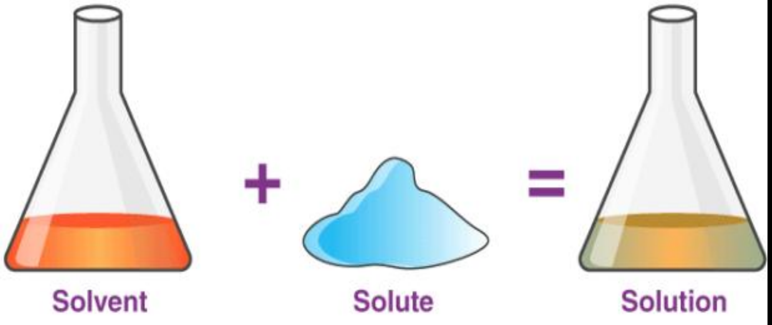
SM6: calculate the molality of a solution to determine its concentration.

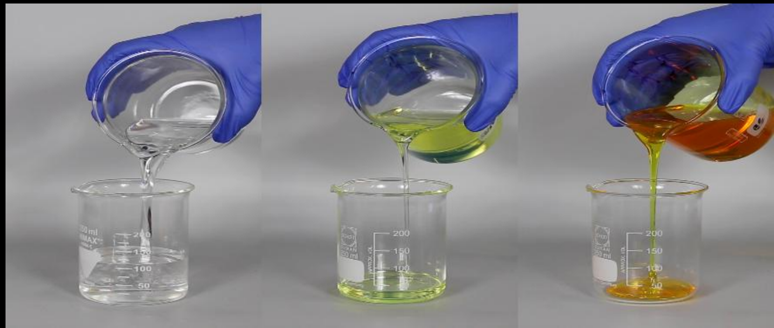
SM7: identify and describe the colligative properties of a solution.

SM8: calculate changes in temperature using the colligative properties of a solution.

Mixtures

- Mixtures have a few special terms associated with them.
  - **Solution**- A homogeneous mixture of two or more substances.
  - **Solvent**- The part of a mixture that is dissolving.
  - **Solute**- The part of a mixture that is being dissolved.
  - **Unsaturated**- No solute in solvent.
  - **Saturated**- A solution that can not hold any more solute at normal temperature.
  - **Supersaturated**- A solution that holds more solute than normal conditions allow.
  - **Precipitate**- A liquid or solid that is not uniformly mixed throughout the solution.
  - **Viscosity**- Flow of a material. (Water has a very low viscosity)





Other Terms: Colloids

- Suspension: A dispersion of a solid inside a liquid. (murky water)
- Aerosol: Liquid or solid suspended in a gas. (fog, smoke)
- Gel: Mixture of a solid and liquid where the liquid is trapped inside giving a flexible property to the solid. (custard, gelatin, pudding)
- Emulsion: Two liquids that do not mix together. Short lived. (Milk, Vinaigrette, Ice Cream)
- Foam: Gas held within a liquid that has a high surface tension. (colas, soap suds)





Why Won’t it Dissolve?

- Previously discussed the idea of the three liquid solvents: Water, Oil, Alcohol.
- Whether something will dissolve is based off the type of bonds:

Solvent	Polar Solute (water/alcohol)	Non-Polar Solute (oil)	Ionic Solute
Polar	Soluble	Insoluble	Soluble
Non-Polar	Insoluble	Soluble	Insoluble

Solution Types Examples

- Solvent-Solute
  - Gas-Gas: Air
  - Liquid-Gas: Soda
  - Solid-Gas: Pop Rocks, Charcoal Filter
  - Liquid-Liquid: Antifreeze
  - Liquid-Solid: Kool-Aid
  - Solid-Solid: Alloys (White Gold)
  - Solid-Liquid: Dental Fillings (Silver Amalgam)

Molarity

- Molarity ($\mathcal{M}$): A unit of concentration for solutions.
  - Equal to # moles solute (n)/1-L of solvent.
- The higher the $\mathcal{M}$, the stronger the solute in the solvent (normally water).
  - 12- $\mathcal{M}$ H_2SO_4 is the strongest concentration you can find, very dangerous. Experiments normally use 1- $\mathcal{M}$ or less.

Molarity Example I

- What is the molarity of a solution formed by mixing 100.0-g of H_2SO_4 with enough water to make 100.0-mL?

$$M = \frac{\mathrm{n}}{\mathrm{V}}$$

$$100 - \mathrm{g}\ x \frac{1 - \mathrm{mol}}{98.1 - \mathrm{g}} = 1.019 - \mathrm{mol}$$

M =

n = 1.019-mol

V = .1-L

$$M = \frac{1.019 - \mathrm{mol}}{.1 - \mathrm{L}}$$

$$M = 10.2 - \mathrm{Molar}$$

Molarity Example II

- How many milliliters of water are needed to make a 4.5-$\mathcal{M}$ solution with 52.0-g of table salt?

$$M = \frac{\text{n}}{\text{V}}$$

$$52 - g\ x\ \frac{1 - mol}{58.5 - g} = .889 - \text{mol}$$

M = 4.5-*M*olar

n = .889-mol

V =

$$4.5 - \frac{mol}{L} = \frac{.89 - \text{mol}}{\text{V}}$$

$$V = .1975 - \text{L}\ x\ \frac{m}{\frac{1}{1000}}$$

$$V = 197.5 - \text{mL}$$

Molality

- Molality (*m*): A unit of concentration for solutions.
  - Equal to # moles solute (n)/1-kg of solvent.
- This takes a mole to mass ratio instead of mole to volume.
  - Molality is independent of temperature, Molarity is not.

Molality Example

- What is the molality of a solution formed by mixing 750.0-g of Glucose with enough water to make 500-g?

$$m = \frac{\mathrm{n}}{\mathrm{m}}$$

$$750 - \mathrm{g}\ x \frac{1 - \mathrm{mol}}{180 - \mathrm{g}} = 4.17 - \mathrm{mol}$$

m =

n = 4.2-mol

m = .5-kg

$$m = \frac{4.2 - \mathrm{mol}}{.5 - \mathrm{kg}}$$

$$m = 8.3 - \mathrm{molal}$$

The 13th letter: Curse in Chem

- This unit, like science, uses m often. Keep track of them!

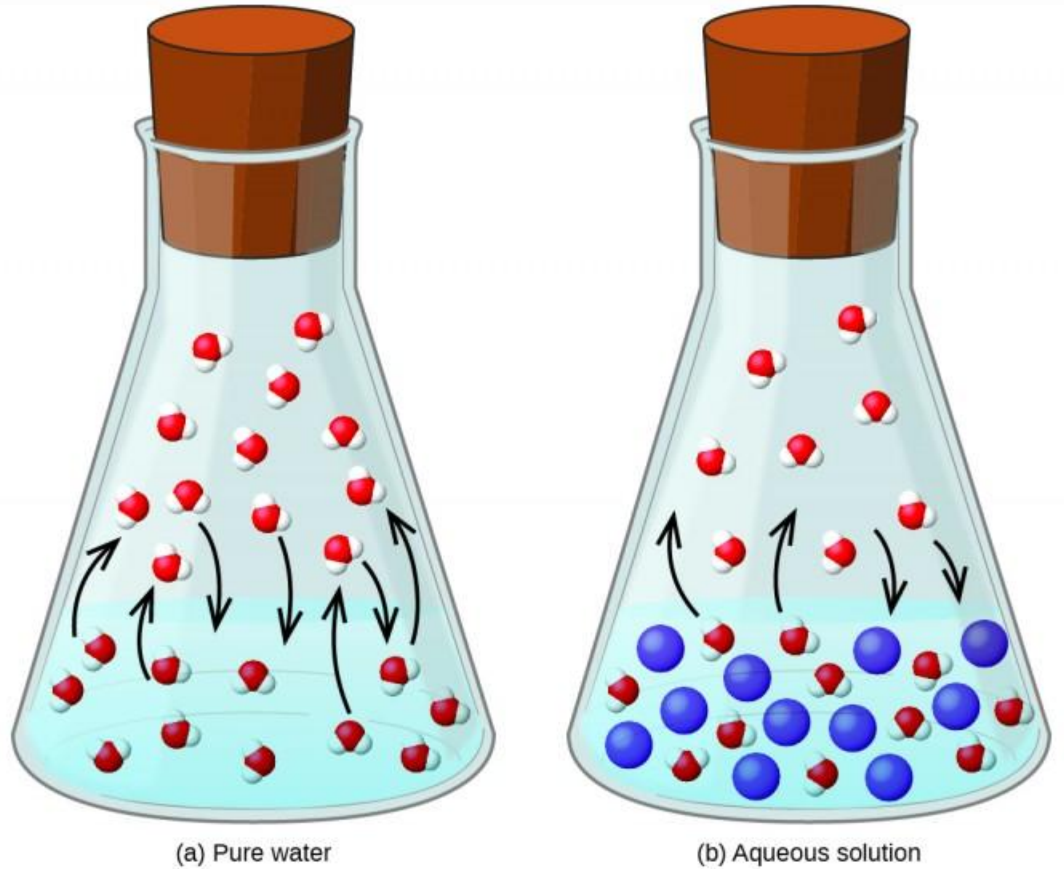
Letter	Type	Use	Example
m	#	mili (10^{-3})	1.0-mg (milligram)
M	#	Mega (10^{6})	2.0-Mb (Megabyte)
mol	Unit	moles	3.0-moles
Mol	Unit	Molecules	4.0-Molecules
m	Variable	mass	5.0-kg
m	Variable	molality	6.0-molal
M	Variable	Molarity	7.0-Molar

Colligative Properties

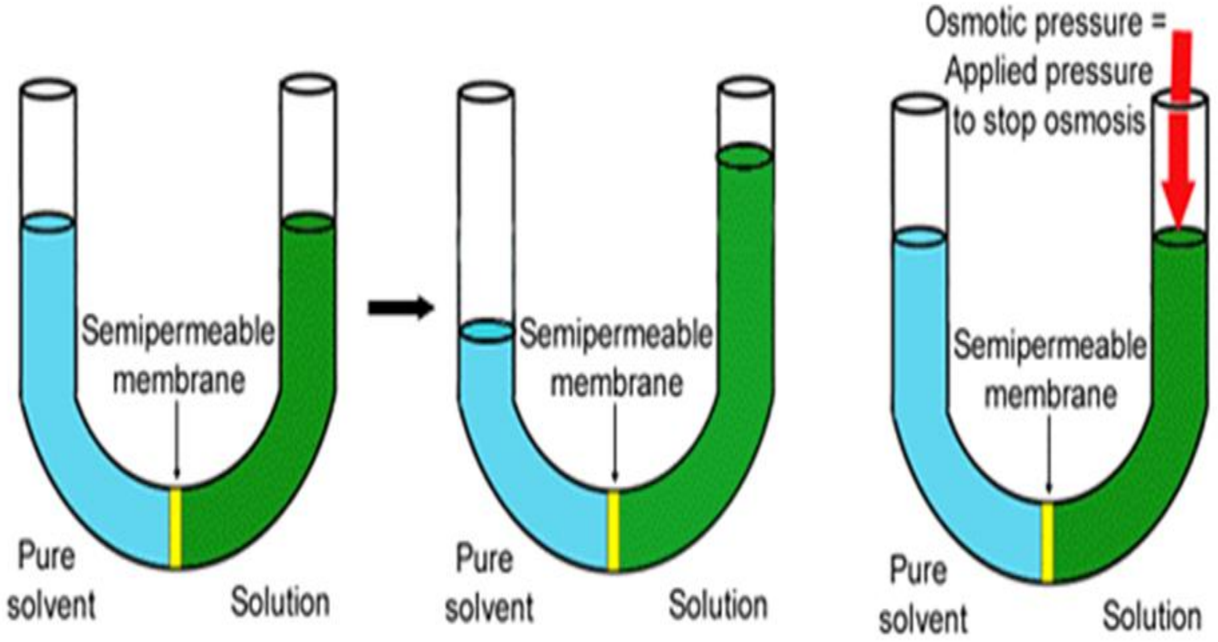
- Some physical properties of solutions will differ from the properties of the pure solvent.
  - Colligative Property: A property of a solvent that is dependant on the concentration.
- Four Properties: Boiling Point Elevation, Freezing Point Depression, Vapor Pressure Reduction, Osmotic Pressure.

Colligative Properties

Vapor Pressure Reduction



Osmotic Pressure



CP: Boiling Point Elevation

- **Solutes that are not volatile will raise the boiling point of a liquid.**
  - **Antifreeze mixes with water to make it harder for the coolant to boil out of the tank.**
  - **BPE (ΔT_b): The difference between the boiling point of the solution and the boiling point of the pure solvent.**
    - **This is directly related to molality *m*.**

$\Delta T_b = K_b m$ (K_b is a constant for each solvent)

Boiling Point Elevation Table

Solvent	K_b (°C/molal)
Acetic Acid ($C_2H_4O_2$)	2.93
Benzene (C_6H_6)	2.67
Carbon Tetrachloride (CCl_4)	5.02
Chloroform ($CHCl_3$)	3.85
Ethanol (C_2H_6O)	1.20
Water	0.52

- This is not on the Ion Chart.
- This change adds to the boiling point.
  - Water: 100.0-°C (373.15-K)

BPE Example

- What is the increase in boiling point when 100.0-g of sucrose ($C_{12}H_{22}O_{11}$) is added to 500-g of water?

$$100-\text{g}\; x\; \frac{1-\text{mol}}{342-\text{g}} = .29-\text{mol}$$

$$m = \frac{\text{n}}{\text{m}}$$

$$m = \frac{.29-\text{mol}}{.5-\text{kg}}$$

$$m = .58-\text{molal}$$

$$\Delta T_b = K_b m$$

$$\Delta T_b = .52-\frac{°C}{\text{molal}}\; x\; .58-\text{molal}$$

$$\Delta T_b = .304-°C$$

ΔT_b=

K_b= .52-°C/m

m = .5-kg

m = .58-molal

n = .29-mol

$$\Delta T_b = 3.0 \text{ x } 10^{-1} - °C$$

CP: Freezing Point Depression

- Much like the BPE, when a solute is added to a solvent, it can lower the temperature at which a pure solvent freezes.
  - This is why salt is used on Ice.
- The freezing point is also based on molals.

$\Delta T_f = K_f m$ (K_f is also a constant)

Freezing Point Depression Table

Solvent	K_f (°C/molal)
Acetic Acid ($C_2H_4O_2$)	3.90
Benzene (C_6H_6)	5.12
Naphthalene ($C_{10}H_8$)	7.00
Chloroform ($CHCl_3$)	4.68
Camphor ($C_{10}H_{16}O$)	40.0
Water	1.86

- This is not on the Ion Chart.
- This subtracts from the freezing point.
  - Water: 0.0-°C (273.15-K)

FPD Example

- At what temperature will water freeze at (in K) if 3.6-molal of antifreeze is added to water?

$$\Delta T_f = K_f m$$

$$\Delta T_f = 1.86 - \frac{°C}{\text{molal}} x\, 3.6 - \text{molal}$$

$$\Delta T_f = 6.7 - °C \text{ (also } 6.7 - K)$$

$$T = 273.15 - K - 6.7 - K$$

$$\boxed{T = 266.5 - K}$$

ΔT_f=

K_f= 1.86-°C/m

m = 3.6-m