Chapter 14

Mixtures

Warm Up

- What is the difference between a heterogeneous and homogeneous mixture?

- What does it mean for something to be soluble? What about miscible?

Today's Agenda

- QOTD: How can we describe various mixtures and how do we determine the concentration of solutions?

- Types of mixtures
- Percent by mass and volume review
- Molarity

Types of Mixtures

- Heterogeneous mixtures-

Suspension – liquid with solid precipitate

Tyndall Effect!

Flour mixed with water

Colloids – liquid with very small solid particles

- Homogeneous mixtures- solutions

Solutions – solute is soluble in the solvent

Liquids are said to be miscible

Milk

Expressing Concentration

- Concentration - how much solute is dissolved in solvent
- Solutions are either concentrated or dilute

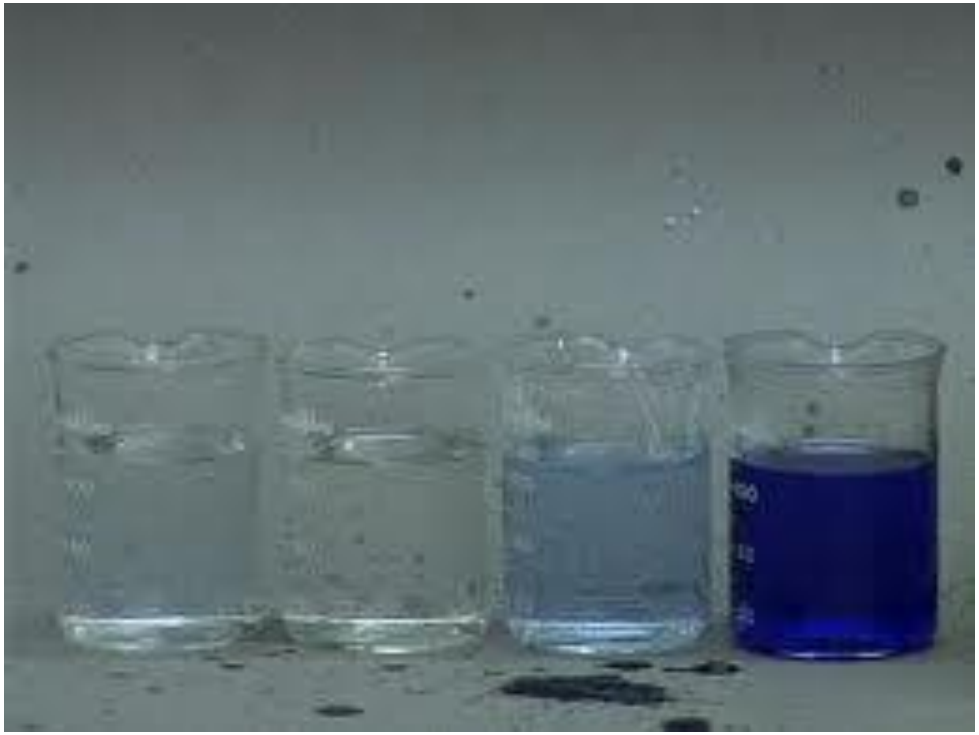


Table 14.3 Concentration Ratios

Concentration Description	Ratio
Percent by mass	$\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$
Percent by volume	$\frac{\text{volume of solute}}{\text{volume of solution}} \times 100$
Molarity	$\frac{\text{moles of solute}}{\text{liter of solution}}$
Molality	$\frac{\text{moles of solute}}{\text{kilogram of solvent}}$
Mole fraction	$\frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}}$

Solution Concentration

- REVIEW! Percent by mass = $\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$

Percent by volume = $\frac{\text{volume of solute}}{\text{volume of solution}} \times 100$

An aquarium contains 3.6 g of NaCl for every 100 g of water. What is the percent by mass of NaCl?

Your Turn

- What is the percent by mass of $NaHCO_3$ in a solution containing 20.0 g of $NaHCO_3$ dissolved in 600 mL of H_2O? (remember that D_{H2O} = 1 g/ml)

- What is the percent by volume of ethanol in a solution that contains 35 mL of ethanol dissolved in 155 mL of water?

Molarity

- **Molarity** is the most common way to express concentration (for chemists).
- Symbol – M 1 M = “one molar”

- Molarity (M) = $\frac{\text{moles of solute}}{\text{liters of solution}}$

A 100.5 mL IV solution contains 5.10 g of glucose ($C_6H_{12}O_6$). What is the molarity of this solution?

Your turn

- What is the molarity of an aqueous solution containing 40 g of glucose ($C_6H_{12}O_6$) in 1.5 L of a solution?

- Calculate the molarity of a 1.6 L of a solution containing 1.55 g of dissolved potassium bromide.

Preparing Solutions

I ask you to make 1 L of a 1.5 M solution of copper (II) sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$).

How do you make it?

We know that 1.5 M = 1.5 mol/L

Find mass in grams to dissolve in 1 L of solution!

$$1\text{L} \times \frac{1.5 \text{ mol } CuSO_4 \cdot 5H_2O}{1 \text{ L solution}} \times \frac{249.7 \text{ g } CuSO_4 \cdot 5H_2O}{1 \text{ mol } CuSO_4 \cdot 5H_2O} = 375 \text{ g } CuSO_4 \cdot 5H_2O$$

Your Turn

- How many grams of $CaCl_2$ would be dissolved in 1 L of a 0.10 M solution of $CaCl_2$?

- How many grams of $CaCl_2$ should be dissolved in water to make a 0.2 M solution of $CaCl_2$ if you only need 500 mL?

Warm Up

- I need about 350 mL 0.25 M solution of NaOH. How would you make it?

- I also need 450 mL of a 0.15 M solution of sulfuric acid. How do you make that?

Today's Agenda

- QOTD: How do you do dilutions and what is molality?

- Dilutions
- Molality
- Review mole fractions

Dilution Calculations

- Chemists often use a solution that is already prepared and dilute it to get to their desired concentration.

Dilution Equation: $M_1V_1 = M_2V_2$

What volume, in mL, of 2.0 M $CaCl_2$ stock solution would you use to make 0.5 L of a 0.3 M $CaCl_2$ solution?

Your Turn

- What volume of a 3.0 M potassium iodide stock solution would you use to make 0.3 L of a 1.25 M solution?

- How much water is needed to dilute a 5.0 M sulfuric acid stock to 0.25 M acid if you needed 500 mL?

Molality

- Volume changes with temperature, so to make measurements using a solution over a temperature range, we use molality instead of molarity!

$$\text{Molality } (m) = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

A student adds 4.5 g of NaCl to 100 g of water. What is the the molality of the solution?

Your Turn

- What is the molality of a solution containing 10 g of sodium sulfate dissolved in 1530.0 g of water?

- How many grams of sodium carbonate must be dissolved into 155 g of water to create a solution with a molality of 8.20 mol/kg?

Mole Fractions χ!

- *Review our past work with mole fractions, χ!!!*
- χ = $\frac{\text{mole of component}}{\text{total moles}}$

- What is the mole fraction of NaOH in an aqueous solution that contains 22.8% NaOH by mass?

Warm Up

- Remember: χ = $\frac{\text{mole of component}}{\text{total moles}}$
- What is the molality and mole fraction of solute in a 35.5 % by mass aqueous solution of H_2CO_2?
- Calculate the mole fraction and percent by mass of magnesium chloride in a solution created by dissolving 132.1 g of the salt in 175 mL of water.

Warm Up!

I have a stock solution of 5 M NaOH. For my experiment I need 300 mL of 1.5 M NaOH. How much stock solution do I need for my dilution?

How many grams of calcium nitrate ($Ca(NO_3)_2$) would you need to prepare 3.00 L of a 0.500*M* solution?

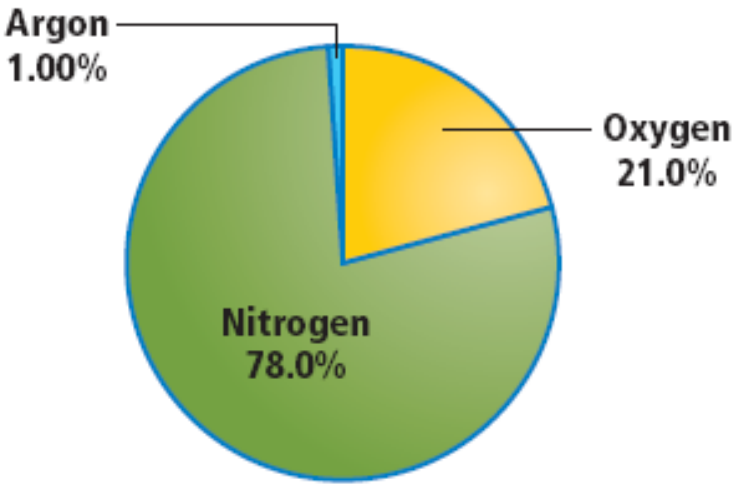


Figure 14.27

An air sample yields the percent composition shown in **Figure 14.27.** Calculate the mole fraction for each gas present in the sample.

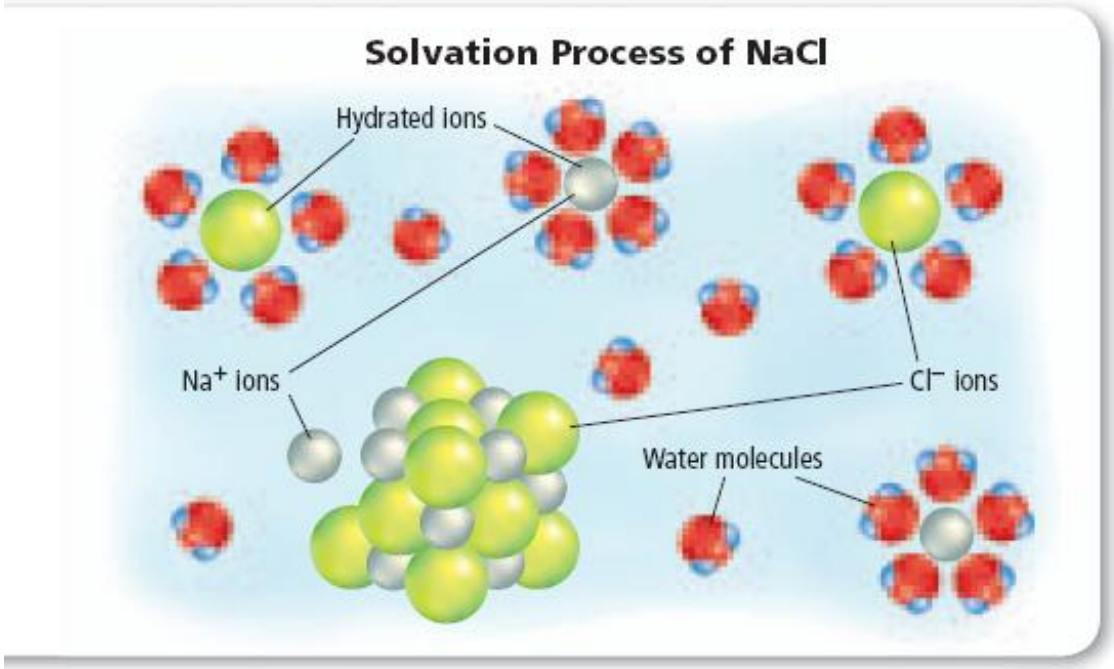
Factors Affecting Solubility

- When molecules dissolve in water they are ___solvated___.

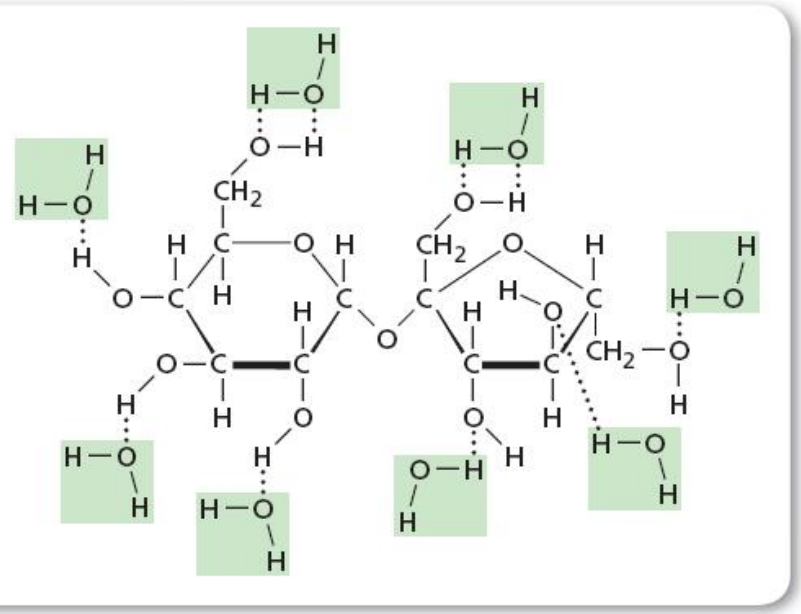
- If a solute is polar it is more likely to dissolve in a ___polar___ solvent. If the solute is non-polar it is more likely to dissolve in a ___non-polar___ solvent.

Knowing this…

Determine a rule for solubility…



Like Dissolves Like!



Solubility

- Saturated solutions – one that contains the maximum amount of dissolved solute for a solvent at a certain T and P
- Unsaturated solutions - one that contains less dissolved solute for a solvent at a certain T and P than a saturated solution.
- Supersaturated solution - one that contains more than the maximum amount of dissolved solute for a solvent at a certain T and P

Solubility of Gases

- As temperature increases the solubility of gases decreases.
  - More kinetic energy – more chances of escape!

- As external pressure increases gas solubility increases.
  - Soda is bottled under pressure so all that CO_2 is soluble until you open it!

Henry's Law

- At a given temperature, the solubility of a gas is directly proportional to external pressure.

- What's the equation?? $\frac{S_1}{P_1} = \frac{S_2}{P_2}$ (S = Solubility (g/L))

If 0.85 g of a gas at 4.0 atm of pressure dissolves in 1.0 L of water at 25 °C, how much will dissolve in 1.0 L at 1 atm?

Your Turn

- If 0.55 g of a gas dissolves in 1.0 L of water at 20 kPa, how much will dissolve at 110 kPa?

- A gas has a solubility of 0.66 g/L at 10 atm of pressure. What is the pressure on a 0.85 L sample that contains 1.5 g of gas?

Colligative Properties

- How physical properties of solutions are affected by the number of solute particles.

- Depend on the NUMBER of solute particles.

- Electrolytes vs. Nonelectrolytes
  - Remember that ionic compounds (salts) dissociate into ions in solution. Molecular compounds do not dissociate!

Electrolyte or Nonelectrolyte?!

Electrolyte!	$NaCl$	
	C_6H_6	Nonelectrolyte!
Electrolyte!	$KClO_3$	
	C_2H_6O	Nonelectrolyte!
	SO_3	Nonelectrolyte!
Electrolyte!	$KMnO_4$	
Electrolyte!	HCl	
Electrolyte!	$MgCO_3$	

4 Ways Solute Particles Change Properties

- Lower Vapor Pressure
  - Pressure of gas particles above a solution in a closed container
- Elevate (raise) Boiling Point
  - Vapor pressure equals atmospheric pressure
- Depress (lower) Freezing Point
  - Particles do not possess enough energy to overcome IMF's
- Determine osmotic pressure

Vapor Pressure Lowering

- Vapor pressure is lower in a solution than a pure solvent.

- Solute particles “get in the way” of solvent particles, so there are less of them in the gas phase!

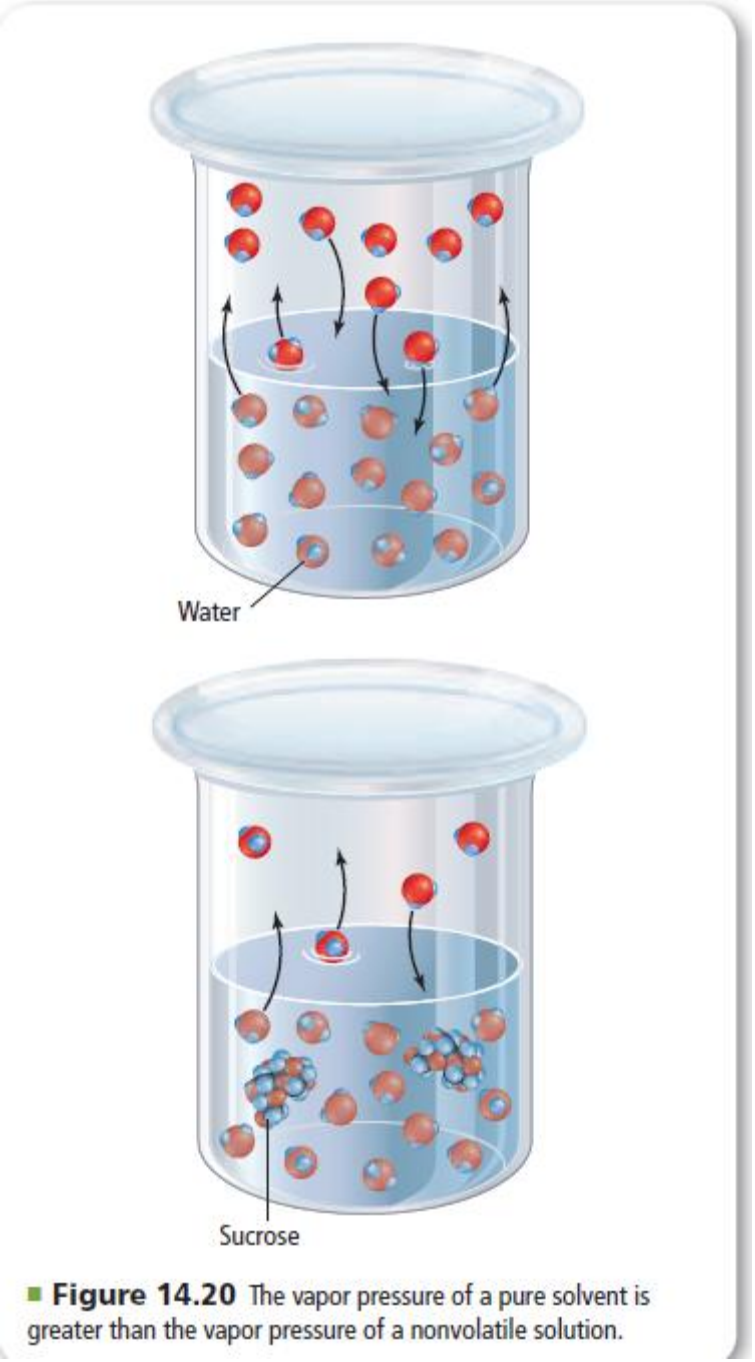


Figure 14.20 The vapor pressure of a pure solvent is greater than the vapor pressure of a nonvolatile solution.

Boiling Point Elevation

- Since vapor pressure and boiling point are related, if the vapor pressure is affected, so is the bp!
- VP of a solution is lowered so MORE energy is required to overcome P_{atm} and the BP is higher.

- $\Delta T_b = K_b mi$ ΔT_b = change in temperature

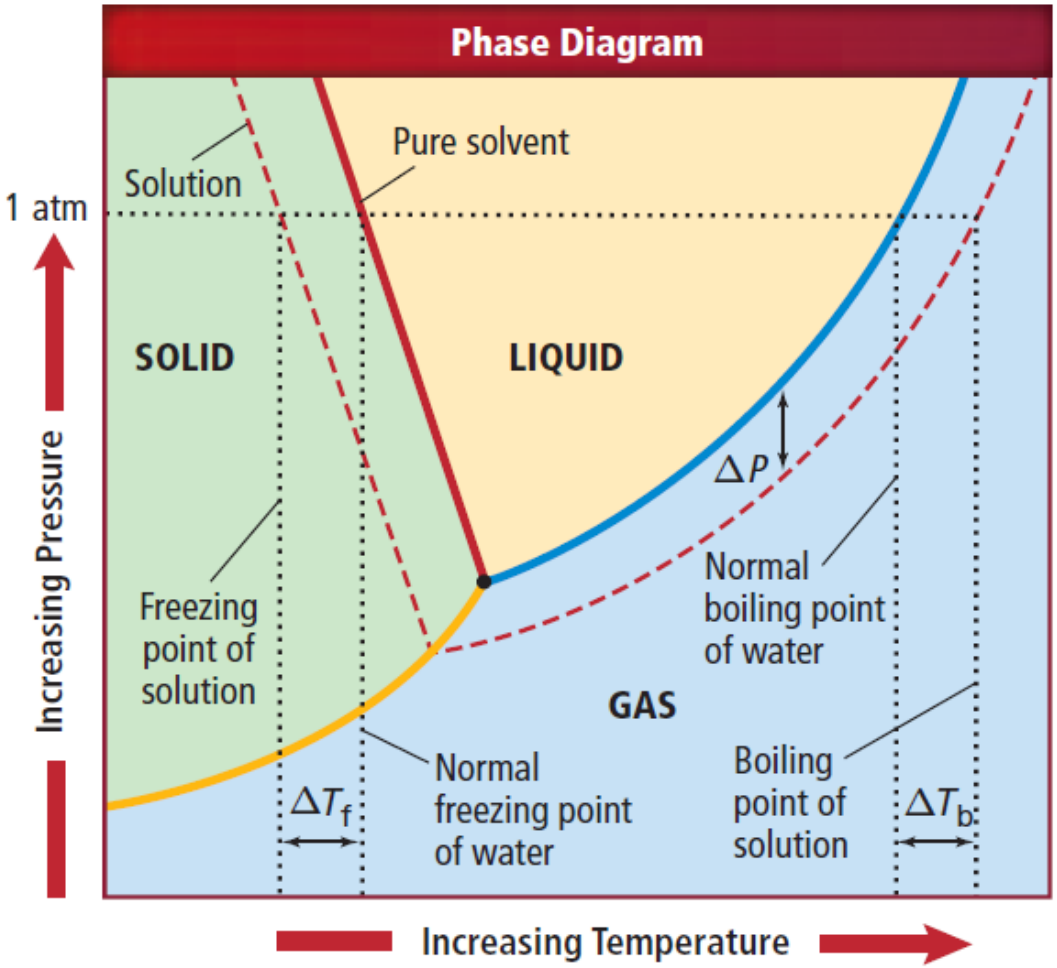
  K_b = molal bp elevation constant

  m = molality of solution

  i = # ions in solution

Freezing Point Depression

- Solute particles "get in the way" AGAIN and make it difficult for IMF's to take over, so more energy needs to be removed to freeze!



Freezing Point Depression

- $\Delta T_f = K_f m i$ ΔT_f = change in temperature

  K_f = molal fp depression constant

  m = molality of solution

  i = # of ions in solution

K_f and K_b are specific to solvents.

To find NEW bp and fp:

- Remember to ADD ΔT_b to normal boiling point

- Remember to SUBTRACT ΔT_f from normal freezing point

Practice Problem!

- NaCl is often used to prevent icy roads and to freeze ice cream!

Calculate the boiling and freezing points of a 0.029*m* aqueous solution of NaCl.

(Water : K_b = 0.512 °C/*m*, K_f = 1.86 °C/*m*)

Equation: $\Delta T = Kmi$

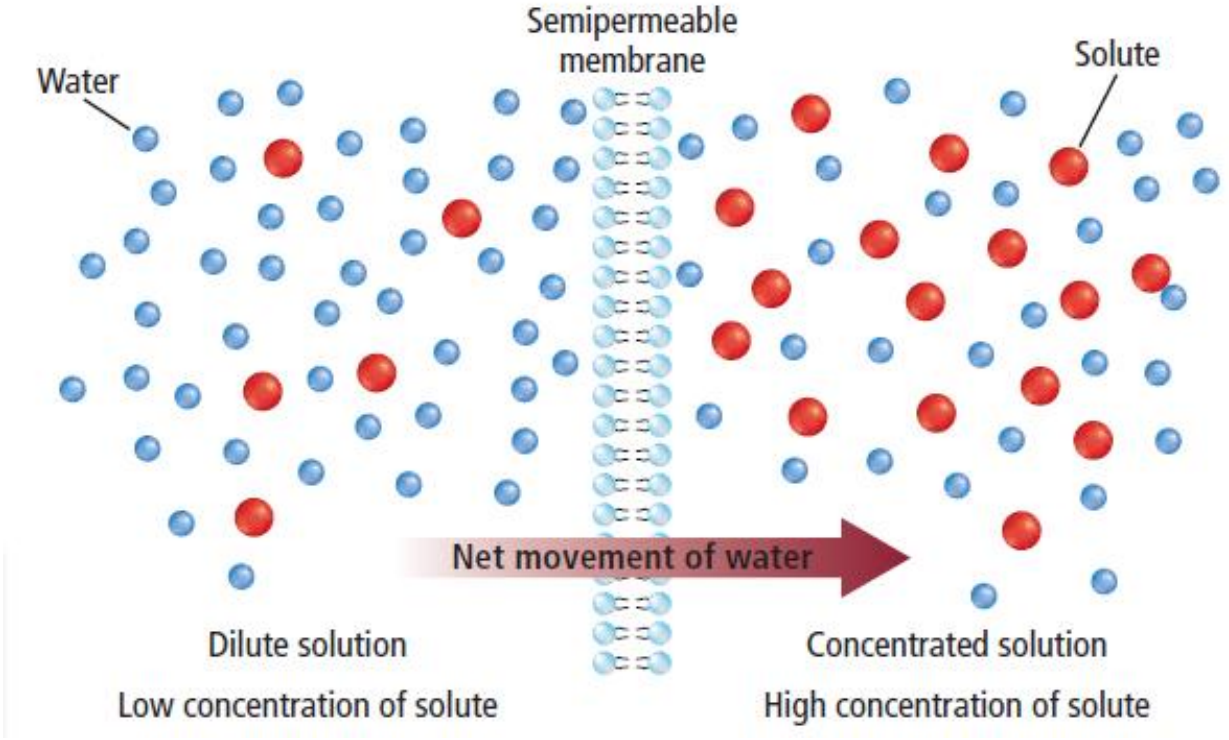
Practice problem

- What are the bp and fp of a 0.625 *m* aqueous solution of any nonvolatile, nonelectolyte solute?

  (Water : K_b = 0.512 °C/m, K_f = 1.86 °C/m)

Osmotic Pressure

- Osmosis: diffusion through a semi-permeable membrane



- Important for biological function

Osmotic Pressure

- Additional pressure caused by water molecules that moved into the concentrated solution.

- The more particles are present, the higher the osmotic pressure!