

Chapter 14

Mixtures

Warm Up

- What is the difference between a heterogeneous and homogeneous mixture?
- Give 1 example of a heterogeneous mixture and 1 example of a homogeneous mixture.

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
- Remember Labs are due tomorrow!
- Bookwork due Friday: Chapter 14 - 55, 56, 63, 68, 70, 72, 74, 78, 80, 81

Types of Mixtures

- Heterogeneous mixtures-

Suspension – liquid with solid precipitate

Colloids – liquid with very small
solid particles

- Homogeneous mixtures- solutions
- Solutions – solute is **soluble** in the solvent
- Liquids are said to be **miscible**

Tyndall Effect!



Flour mixed with water



Expressing Concentration

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



- Ways to express concentration – Table 14.3 in book!

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 $D_{\text{H}_2\text{O}} = 1 \text{ g/ml}$)
- 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 1M = “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 ($\text{C}_6\text{H}_{12}\text{O}_6$). What is the molarity of this solution?

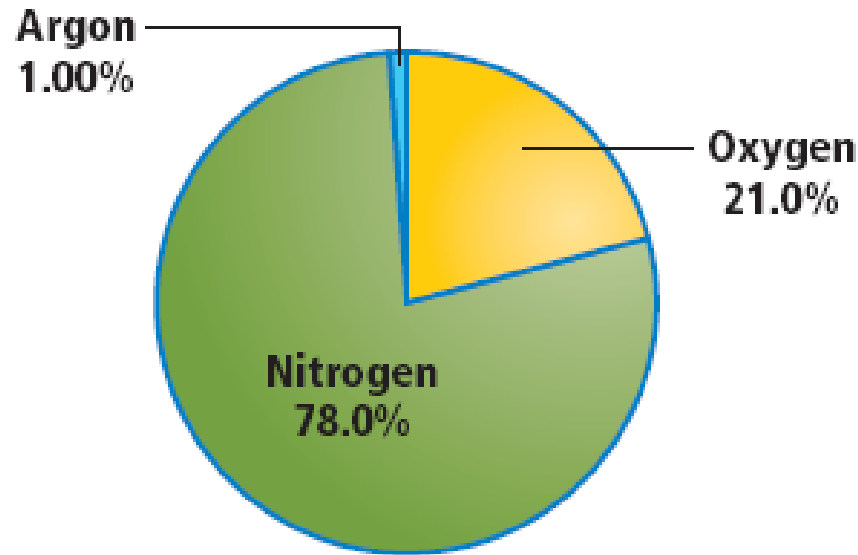
Your turn

- What is the molarity of an aqueous solution containing 40 g of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) in 1.5 L of a solution?
- Calculate the molarity of a 1.6 L of a solution containing 1.55 g of dissolved KBr.

Warm Up

- A solution is made by dissolving 3.2 g of CuCl_2 in 350 mL of water.
 - What is the percent of CuCl_2 by mass?
 - What is the molarity of the solution?

Warm Up



■ **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.

How many grams of calcium nitrate ($\text{Ca}(\text{NO}_3)_2$) would you need to prepare 3.00 L of a 0.500M solution?

Today's Agenda

- QOTD: How are solutions made with an accurate concentration?
- Preparing Solutions
- Dilution Calculations
- Molality
- Practice Problems

Preparing Solutions

I ask you to make 1 L of a 1.5 M solution of copper (II) sulfate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$).

How do you make it?

We know that $1.5 \text{ M} = 1.5 \text{ mol/L}$

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

$$1\text{L} \times \frac{1.5 \text{ mol CuSO}_4 \cdot 5\text{H}_2\text{O}}{1 \text{ L solution}} \times \frac{249.7 \text{ g CuSO}_4 \cdot 5\text{H}_2\text{O}}{1 \text{ mol CuSO}_4 \cdot 5\text{H}_2\text{O}} = 375 \text{ g CuSO}_4 \cdot 5\text{H}_2\text{O}$$

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?

Dilution Calculations

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

$$\text{Dilution Equation: } M_1V_1 = M_2V_2$$

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 KI stock solution would you use to make 0.3 L of a 1.25 M KI solution?
- How many milliliters of a 5.0 M H₂SO₄ stock solution would you need to prepare 100.0 mL of 0.25 M H₂SO₄?

Molality

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

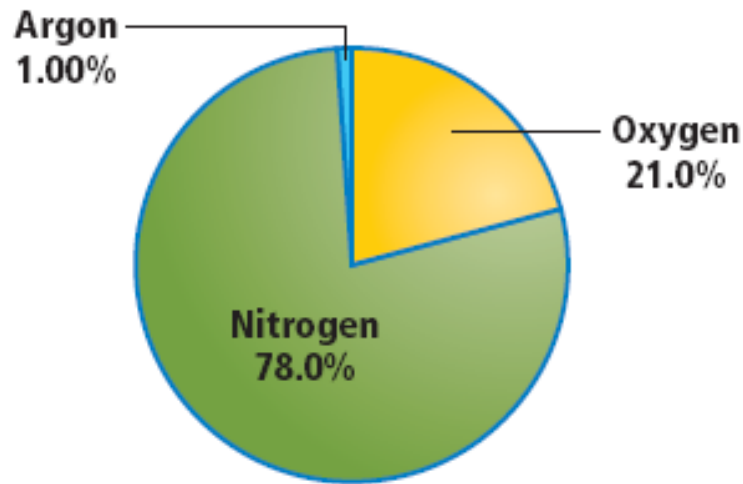
$$\text{Molality (} m \text{)} = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

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

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 ($\text{Ca}(\text{NO}_3)_2$) would you need to prepare 3.00 L of a 0.500M 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.

Today's Agenda

- QOTD: What factors affect solubility?
- Mole fraction review
- Solubility of solids and gases
- Henry's Law
- Concentration Practice Problems

Your Turn

- What is the molality of a solution containing 10 g of Na_2SO_4 dissolved in 1000.0 g of water?
- How many grams of Na_2CO_3 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 !!!*
- $\chi = \frac{\text{mole of component}}{\text{total moles}}$
- What is the mole fraction of NaOH in an aqueous solution that contains 22.8% NaOH by mass?

Your Turn

- What is the molality and mole fraction of a solute in a 35.5 % by mass aqueous solution of formic acid?
- Calculate the mole fraction of MgCl_2 in a solution created by dissolving 132.1 g of MgCl_2 in 175 mL of water.

Warm Up!

- Calculate the molarity of 1270 g of K_3PO_4 in 4.0 L of aqueous solution.
- What is the molality of the solution?

Today's Agenda

- QOTD: What factors affect solubility?
- Solubility
- Pressure and Henry's Law
- Homework due Wed: Ch 14 - 86-102 evens
- Concentration worksheet due Thurs
- **Quiz Thursday – Ch 14!**

Warm Up!

(I really had to figure these out this morning)
I need 1.5 L of 0.1 M solution of NaOH. How many grams of NaOH do I need?

We needed 900mL of 0.01M KMnO_4 solution.
How many grams should I have weighed out?

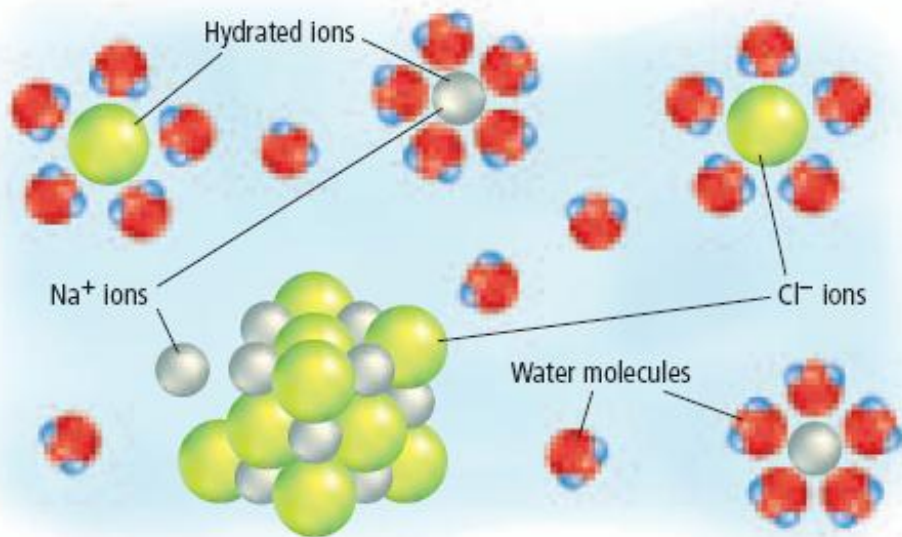
Factors Affecting Solubility

- 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.

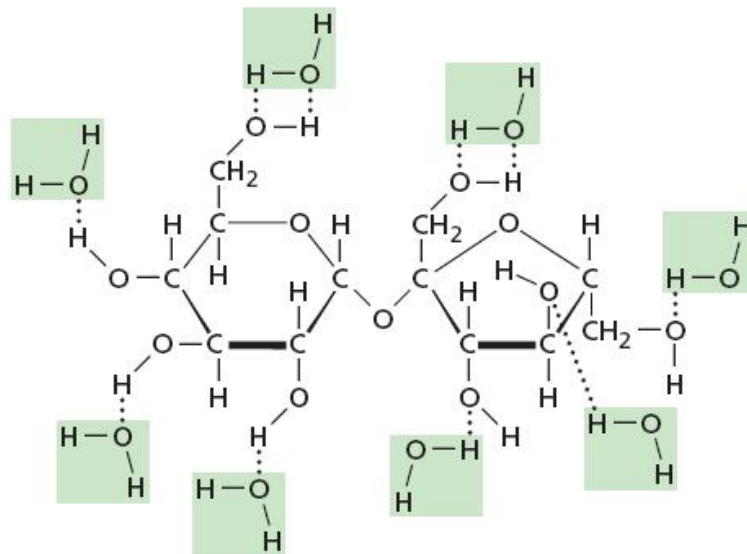
Knowing this...

Determine a rule for solubility!

Solvation Process of NaCl



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?

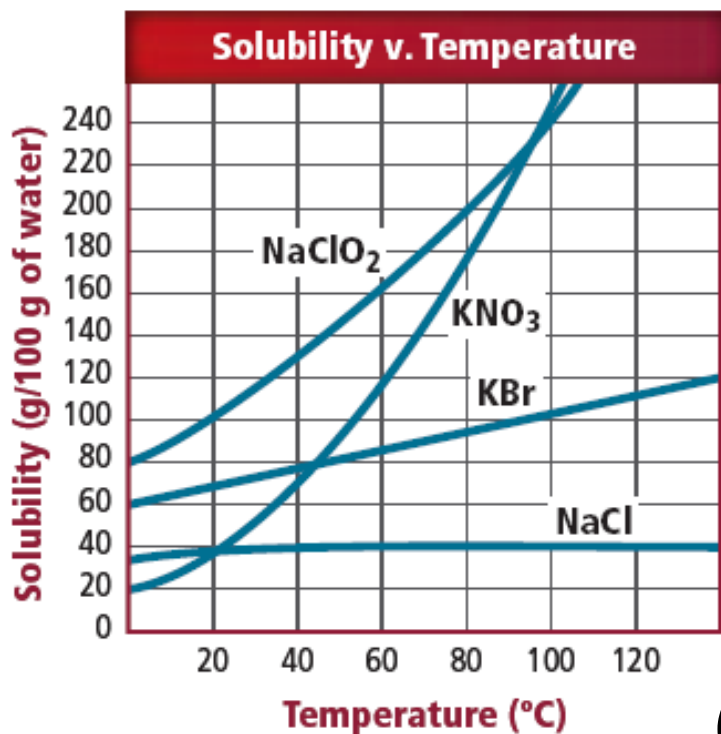
Your Turn

- 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 1.0 L sample that contains 1.5 g of gas?

Warm Up!

Use Henry's law to complete Table 14.8.

Solubility (g/L)	Pressure (kPa)
2.9	?
3.7	32
?	39



■ Figure 14.26

Using Figure 14.26, compare the solubility of potassium bromide (KBr) and potassium nitrate (KNO₃) at 80°C.

(I really had to figure this out this morning)
I need 1.5 L of 0.1 M solution of NaOH. How many grams of NaOH do I need?

Today's Agenda

- QOTD: What are the 4 colligative properties of solutions?
- Colligative Properties
- Electrolytes vs. Nonelectrolytes
- 4 Types
- Please check the “Missing” list to see if you're on it!!!

BOOK CHECK - Wednesday!

- Bring in the Glencoe chemistry book that was assigned to **you** to class on WEDNESDAY.
- If you lose your book you are required to replace it!!
- If you never took an assigned book, bring any that you find in lockers etc.

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

C₆H₆ **Nonelectrolyte!**

Electrolyte! KClO₃

C₂H₆O **Nonelectrolyte!**

SO₃ **Nonelectrolyte!**

Electrolyte! KMnO₄

Electrolyte! HCl

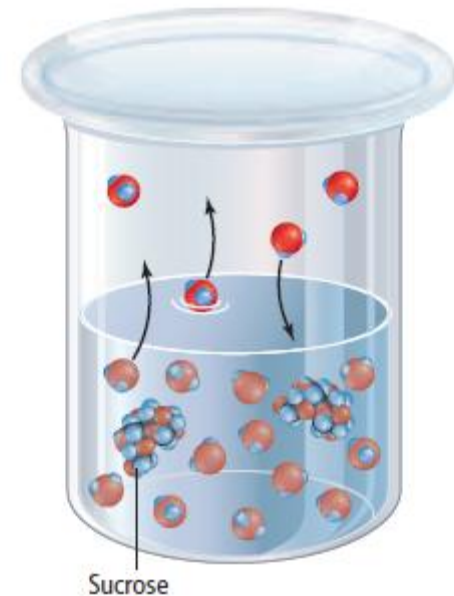
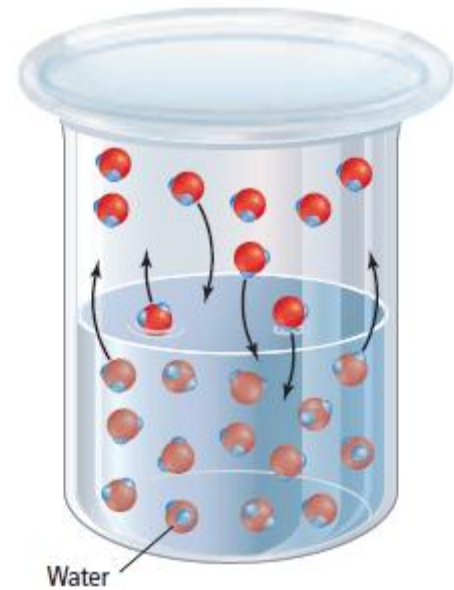
Electrolyte! MgCO₃

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.

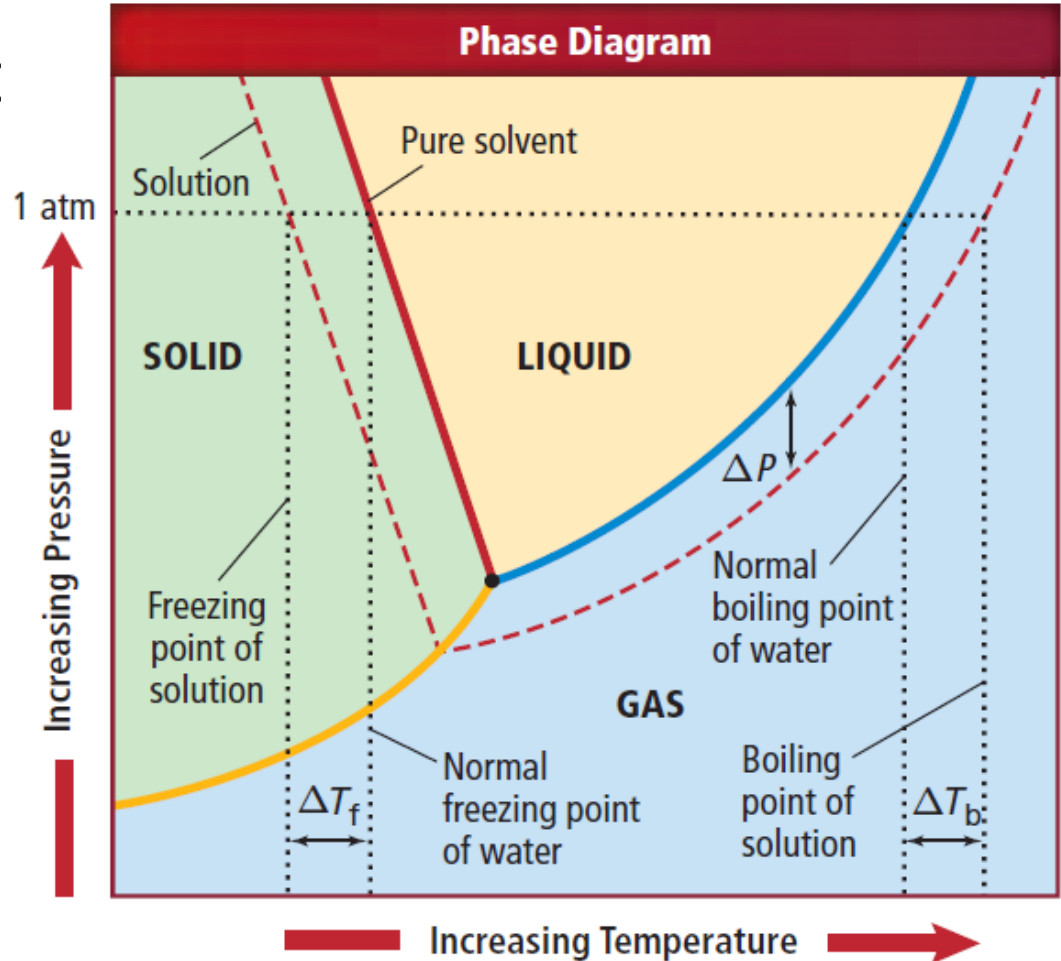
Boiling Point Elevation

- 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

- $\Delta T_f = K_f m i$ $\Delta T_b =$ 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.

Practice Problem!

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

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

(Water : $K_b = 0.512 \text{ }^\circ\text{C}/m$, $K_f = 1.86 \text{ }^\circ\text{C}/m$)

Equation: $\Delta T = Kmi$

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

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

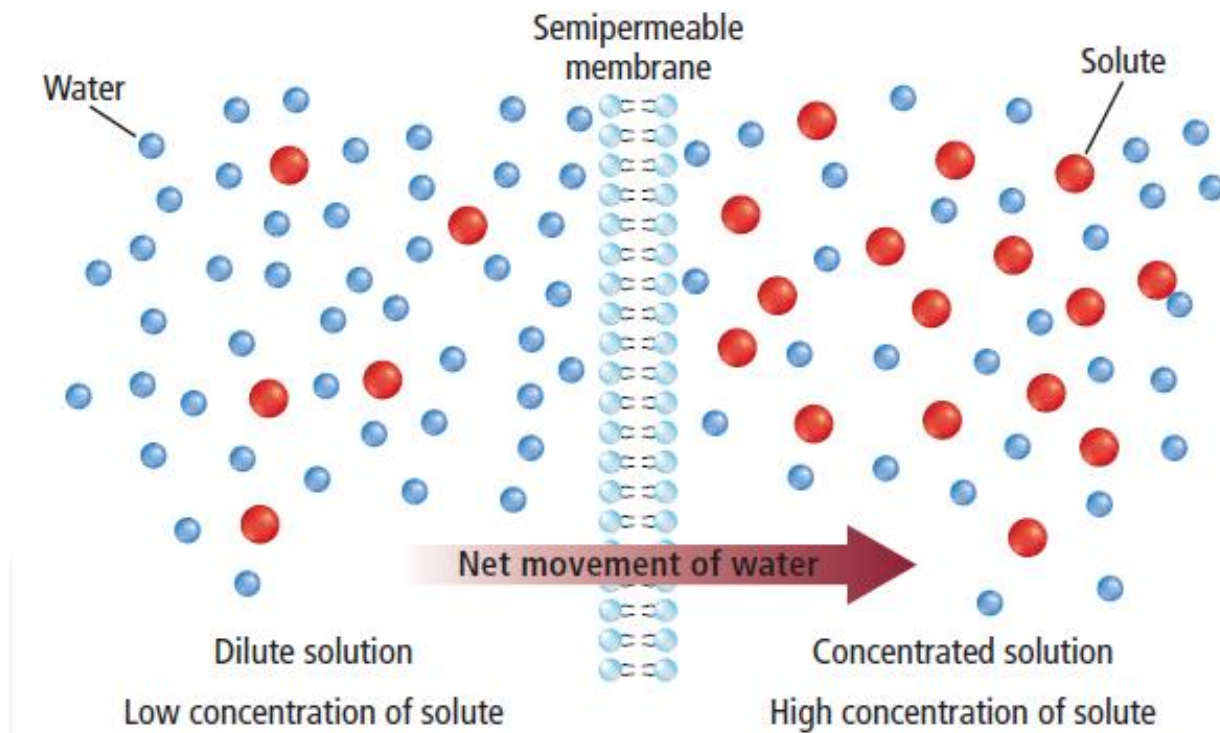
(Water : $K_b = 0.512 \text{ }^\circ\text{C}/m$, $K_f = 1.86 \text{ }^\circ\text{C}/m$)

Your Turn:

- A cook prepares a solution for boiling by adding 12.5 g of NaCl to a pot holding a 0.750 L of water. At what temperature will the pot boil?
Hint: Use water K constants.
- A rock salt NaCl, ice, water mixture is used to make ice cream. How many grams of rock salt must be added to lower the freezing point by 10 °C?

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!

Answer these!

- What are the 4 colligative properties of solutions?
- How do you distinguish between an electrolyte and non-electrolyte?
- Why do we put salt on icy roads?