Objective 4. Predict solution properties based on colligative properties

1. You add enough sugar to water to make a 1 m solution.
a. Why is i = 1 for sugar?
b. The b.p. of the solution is 100.5°C. Use the b.p. elevation equation to show how this b.p. is calculated.
c. The f.p. of this solution is -1.9°C. Use the f.p. elevation equation to show how this f.p. is calculated.
d. Explain why a 1 m NaCl solution has a lower f.p. than the 1 m sugar solution.

2. You add 50 g salt to water to 2 cups (480 ml) of water.
a. Calculate the molality of this solution. (Answer: approximately 2 m)
b. Why is i = 2 for this solution?
c. Calculate the freezing point of this salt/water solution. (Answer: between -3 to -8°C)
d. Would adding the same mass of road salt ($CaCl_2$) depress the freezing point of water the same amount as rock salt? Calculate the f.p. of each solution to support your answer.

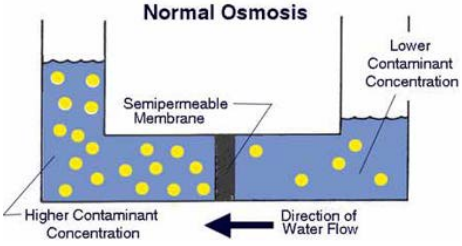
3. Sugar is used to preserve home-made jam and jelly by killing bacteria that may cause botulism. The appropriate sugar concentration will allow water to pass out of the cell and collapse (crenation) the cell. Should the sugar concentration that is used to preserve the jam be ***higher*** or ***lower*** than the sugar concentration inside bacteria cells? Give reasons.

4. Red blood cells (0.9% NaCl (m/V)) are placed in sea water (0.6 M NaCl).
a. Will water pass into the cells or out of the cells? Give reasons.
b. What happens to the concentration of NaCl in sea water as osmosis occurs?
c. Will you gain weight or lose weight if you drink sea water? Give reasons.

5. Red blood cells contain 0.9% NaCl (m/V).
a. Calculate the Molar concentration of red blood cells. (Answer: between 0.1 and 0.2 M)
b. Calculate the osmotic pressure of this solution at 37°C. (Answer: between 6 and 9 atm.)

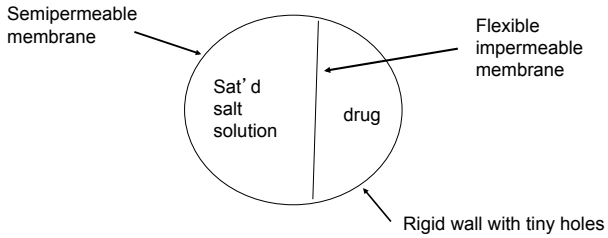
6. Hemoglobin is the oxygen carrying protein in our blood. 0.50 g of hemoglobin is dissolved in 100 ml of 25°C water. The osmotic pressure of this solution is 0.00178 atm. Calculate the molar mass of hemoglobin.
Hint: Molarity is moles/liter of solution. Molar mass is mass/moles. What information about hemoglobin are you given? What information can you find?
(Answer: molar mass is between 60,000 and 70,000 g/mole.)

7. Desalination is a process by which salts are removed from seawater. Three major ways to accomplish desalination are distillation, freezing, and reverse osmosis. The freezing method is based on the fact that when an aqueous solution freezes, the solid that separates from the solution is almost pure water. Reverse osmosis uses water movement from a more concentrated solution to a less concentrated one through a semipermeable membrane.
a. With reference to the picture below, draw a diagram showing how reverse osmosis can be carried out.



b. What are the advantages and disadvantages of reverse osmosis compared to the freezing and boiling methods?
c. What minimum pressure (in atm) must be applied to seawater at 25°C for reverse osmosis to occur? Treat seawater as a 0.60 M NaCl solution. (Answer: between 25-35 atm)

8. “Time-release” drugs have the advantage of releasing the drug to the body at a constant rate so that the drug concentration at any time is not so high to have harmful side effects or so low as to be ineffective. A schematic diagram of a pill that works on this basis is shown below. Explain how it works.



(See Chang, 6th ed., p. 463, Problem 13.85 for picture.)

9. Which substance has the *highest* vapor pressure at 25^{o}C?
a. Water (vapor pressure of pure water = 23.8 mm Hg at 25^{o}C)
b. sea water (use p = x p^{o}). Sea water is 0.6 M NaCl. The mole fraction of NaCl in sea water is 0.01. Confirm the mole fraction of NaCl. The vapor pressure of sea water is 0.24 mm Hg. Confirm the vapor pressure of sea water.
c. 0.9% NaCl (m/V). Calculate the vapor pressure of 0.9% NaCl.
Which substance evaporates the fastest?
Which substance has the highest boiling point?

10. On a "molecular basis", DRAW A PICTURE that explains why:
- the boiling point of a solution is higher than the pure solvent. Hint: solvent molecules have to escape into the gas phase to boil.
- The freezing point of a solution is lower than the pure solvent. Hint: solvent molecules have to move close together and form IM forces to turn from a liqud to a solid.
- Osmosis occurs.
- The vapor pressure of a solution is lower than the vapor pressure of a pure liquid.