17.7: Osmotic Pressure

Introduction

Semipermiable membranes do not let the solute pass through (Think of the sugar example). A solvent will move to the side that is more concentrated to try to make each side more similar! Since there is a flow of solvents, the height of each side changes, which is *osmotic pressure*. When we work with aqueous solutions, we use mm of H_2O to describe the difference.

Osmosis is the diffusion of a fluid through a semipermeable membrane. When a semipermeable membrane (animal bladders, skins of fruits and vegetables) separates a solution from a solvent, then only solvent molecules are able to pass through the membrane. The osmotic pressure of a solution is the pressure difference needed to stop the flow of solvent across a semipermeable membrane. The osmotic pressure of a solution is proportional to the *molar concentration* of the solute particles in solution.

$$\Pi = i\frac{n}{V}RT = iMRT \tag{17.7.1}$$

where

- Π is the osmotic pressure,
- R is the ideal gas constant (0.0821 L atm / mol K),
- T is the temperature in Kelvin,
- i is the van 't Hoff factor
- n is the number of moles of solute present,
- V is the volume of the solution, and
- M is the molar concentration of added solute (the i factor accounts for how many species in solution are generated)

? Exercise 17.7.1

Calculate molarity of a sugar solution in water (300 K) has osmotic pressure of 3.00 atm.

Answer

Since it is sugar, we know it doesn't dissociate in water, so i is 1. Then we use Equation 17.7.1directly

$$M = \frac{\Pi}{RT} = \frac{3.00\,atm}{(0.0821\,atm.\,L/mol.\,K)(300\,K)} = 0.122\,M$$

? Exercise 17.7.2

Calculate osmotic pressure for 0.10 M Na_3PO_4 aqueous solution at 20°C.

Answer

Since Na_3PO_4 ionizes into four particles (3 Na+1 + PO_4^{-3}), then $i = 4$. We can then calculate the osmotic pressure via Equation 17.7.1

$$\Pi = iMRT = (0.40)(0.0821)(293) = 9.6\,atm$$

? Exercise 17.7.3

Hemoglobin is a large molecule that carries oxygen in human blood. A water solution that contains 0.263 g of hemoglobin (Hb) in 10.0 mL of solution has an osmotic pressure of 7.51 torr at 25^oC. What is the molar mass of the hemoglobin?

Answer

$6.51 \times 10^4\ g/mol$