Overview of Chapter 14

- Solutions
- Concentrations:
  - Molarity
  - Molality
  - Mole fraction
- Colligative Properties
  - Freezing point depression
  - Boiling point elevation
- Osmosis

Questions to consider:

- How much salt do we need to add to ice to melt it?
- Why is it bad to drink sea water?
- How can you purify sea water?

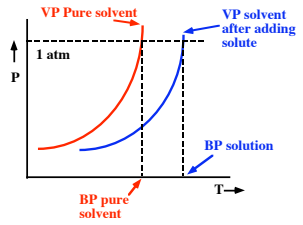
Today's Topics

- Boiling point elevation
- Freezing point depression
- Osmosis

Boiling Point Elevation

Elevation in BP = $\Delta T_{bp} = K_{bp} \cdot m$

(where K_{bp} is characteristic of solvent)



Change in Boiling Point

If we dissolve 62.1 g of ethylene glycol (1.00 mol) in 250. g of water, what is the boiling point of the solution?

K_{bp} = +0.512 °C/molal for water

Solution

1. Calculate solution molality = 4.00 m
2. $\Delta T_{bp} = K_{bp} \cdot m$

   ΔT_{bp} = +0.512 °C/molal (4.00 molal)

   ΔT_{bp} = +2.05 °C

   Boiling Point = 102.05 °C

Freezing Point Depression

Pure water | **Solution of Ethylene glycol and water**

The freezing point of a solution is lower than that of the pure solvent.

FP depression = $\Delta T_{fp} = K_{fp} \cdot m$

Freezing Point Depression

Calculate the freezing point of a 4.00 molal glycol/water solution.

K_{fp} = -1.86 °C/molal

Solution

$\Delta T_{fp} = K_{FP} \cdot m$

$= (-1.86\ ^{o}C/molal)(4.00\ m)$

$\Delta T_{fp} = -7.44\ ^{o}C$

Recall that ΔT_{bp} = +2.05 ˚C for this solution.

Boiling Point Elevation and Freezing Point Depression

$$\Delta T = K \cdot m \cdot i$$

i = van't Hoff factor = number of particles produced per formula unit.

Compound	Theoretical Value of i
Ethylene glycol	1
NaCl	2
$CaCl_2$	3

Freezing Point Depression

Q: How much NaCl must be dissolved in 4.00 kg of water to lower the freezing point to -10.00 °C?

(K_{fp} = -1.86 °C/molal)

Solution

First, get the concentration from $\Delta T_{fp} = K_{fp} \cdot m \cdot i$

Here, i = 2 for NaCl. For every mole of NaCl salt, we get Na^+ and Cl^- ions, so we get 2 moles of particles.

-10.00 °C = (-1.86 °C/molal) • Concentration • 2

Concentration = 2.69 molal NaCl

Freezing Point Depression

Q: How much NaCl must be dissolved in 4.00 kg of water to lower the freezing point to -10.00 °C?

(K_{fp} = -1.86 °C/molal)

Solution

Concentration = 2.69 molal NaCl

2.69 moles NaCl / kg water x (58.44 g/mole NaCl) = 157 g NaCl / kg water

157 g NaCl / kg water x 4 kg water = 629 g NaCl

Boiling and freezing point constants

Solvent	Normal Boiling Point (°C) Pure Solvent	K_{bp} (°C/m)	Normal Freezing Point (°C) Pure Solvent	K_{fp} (°C/m)
Water	100.00	+0.5121	0.0	−1.86
Benzene	80.10	+2.53	5.50	−5.12
Camphor	207.4	+5.611	179.75	−39.7
Chloroform ($CHCl_3$)	61.70	+3.63	—	—

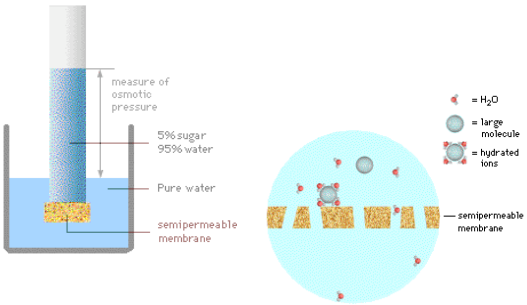
Osmosis

Dissolving the shell in vinegar

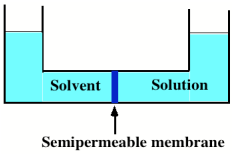
Egg in pure water

Egg in corn syrup

Osmosis



Osmosis

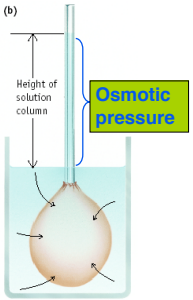


The semipermeable membrane allows only the movement of solvent molecules.

Solvent molecules move from pure solvent to solution in an attempt to make both have the same concentration of solute.

Driving force is entropy

Osmotic Pressure, Π



Equilibrium is reached when pressure produced by extra solution counterbalances pressure of solvent molecules moving through the membrane.

OSMOTIC PRESSURE, Π

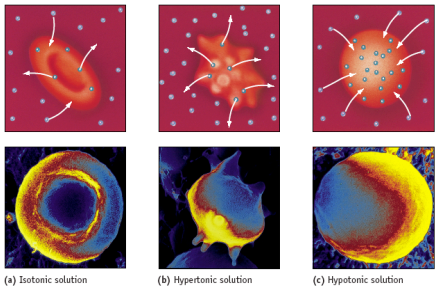
$$\Pi = cRT$$

(c is conc. in mol/L)

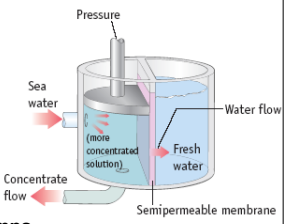
Osmosis

Osmosis of solvent from one solution to another can continue until the solutions are ISOTONIC — they have the same concentration.

Osmosis and Living Cells



No water in or out | Water goes out of cell | Water goes into cell

Reverse Osmosis: Water Desalination

Water desalination plant in Tampa