Chapter 13 part 4: Colligative Properties

**Read:** BLB 13.5-13.6

**HW:** BLB 13.9, 58, 61, 69, 75
Packet 13.13 - 18

**Know:** Colligative Properties, Colloids
- vapor pressure lowering
  Raoult’s Law: \( P_A = X_A P_A^0 \)
- boiling point elevation
  \( \Delta T_b = K_b m \)
- freezing point depression
  \( \Delta T_f = K_f m \)
- osmotic pressure
  \( \pi = \left( \frac{n}{V} \right) RT = MRT \)

When is the next SCT Deadline??

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**COLLIGATIVE PROPERTIES ARE:**
Properties that depend on the

**How many particles in Solution?**
0.2M solution of Pb(NO₃)₂
- Is it an electrolyte?
- What is the dissolution process?

Concentration Pb²⁺?
Concentration NO₃⁻?
Total concentration of particles =

0.5M solution of CH₃COOH (acetic acid)
- Is it an electrolyte?
- What is the dissolution process?

Solution has a concentration of particles greater than _____ but less than ______

**Examples of Colligative properties**
- vapor pressure lowering
- boiling point elevation
- freezing point depression
- osmotic pressure

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When/Where is Exam 3??

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When is the LATE DROP DEADLINE?
VAPOUR PRESSURE LOWERING:
Addition of a nonvolatile solute to a solvent lowers the vapor pressure

How does this affect the:
rate of evaporation?
vapor pressure of SOLVENT?

Raoult’s Law: \( P_A = X_A P^o_A \)

- \( P_A \) = vapor pressure of solution
- \( X_A \) = mole fraction of solvent
- \( P^o_A \) = vapor pressure of pure solvent

Vapor pressure lowering is a **colligative property**
It depends on the concentration but not on the nature of the solute.

Phase Diagrams for a pure solvent and for a solution of a nonvolatile solute

How is melting point affected by the solute particles?

How is boiling point affected by the solute particles?
BOILING POINT ELEVATION
FREEZING POINT DEPRESSION

Increase in boiling point: \[ \Delta T_b = K_b m \]
where \( K_b \) is molal boiling point elevation constant

Decrease in freezing point: \[ \Delta T_f = K_f m \]
where \( K_f \) is molal freezing point depression constant

\[ m = \text{molality of the solution} \]

\( K_b \) and \( K_f \) are tabulated for different solvents

Eg. water \( K_b = 0.512^\circ C/m \)
\( K_f = 1.86^\circ C/m \)

benzene \( K_b = 2.53^\circ C/m \)
\( K_f = 5.12^\circ C/m \)

Example:
Ocean salinity is about 35 g salt per 1 kg seawater.
What is the freezing point of seawater assuming all of the salinity\(^*\) is due to NaCl? (MW of NaCl = 58.5 g/mol)

\(^*\)seawater contains mainly: Cl\(^-\), Na\(^+\), SO\(_4\)\(^{2-}\), Mg\(^{2+}\), Ca\(^{2+}\), and K\(^+\)

Colligative Property Problems:
Which of the following solutions will have the lowest boiling point? (Choose all correct answers)

1. 0.2M NH\(_4\)NO\(_3\)
2. 0.2M Pb(NO\(_3\))\(_2\)
3. 0.2M Na\(_2\)SO\(_4\)
4. 0.2M AlPO\(_4\)
5. 0.2M AlBr\(_3\)
6. 0.5M CH\(_3\)COOH (acetic acid)

Which salt would you use to melt ice on the sidewalk, if you wanted to use the smallest quantity to do the job?

1. MgSO\(_4\) (Epsom salts)
2. NaCl
3. CaCl\(_2\)
4. KI
5. they would all work the same
Molecular Weight Determination

Stepwise problem solving
1. From $\Delta T_b$ or $\Delta T_f$ calculate $m$ for solution (molality).
2. From $m$ and knowledge of how solution was prepared, calculate MW.

Example:
A solution of 12 g of glucose in 100 g H$_2$O boils at 100.340°C. What is the MW of glucose?

$\Delta T_b = K_b m$

$m = \ldots$
Osmotic pressure \((\pi)\) is:

\[
\pi = \left( \frac{n}{V} \right)RT = MRT
\]

units of atm  

Reverse Osmosis: (Used to purify water)

1. Exert pressure on a concentrated solution, forcing solvent molecules through a membrane.

2. Solute molecules are trapped in the concentrated portion.

Osmosis through red blood cell walls

(a) Crenation  
(b) Hemolysis

Mixtures

Particle size

Small  Medium  Large

name

uniformity

particles

examples

Colloids

1.  
2.  
3.
**Tyndall effect:** light is scattered when λ of light ≠ particle size

For molecules (~5Å) λ in X-ray region
- visible light passes through solutions without scattering
- Atmosphere scatters small λ light
- Explains why the sky is blue.

For colloids (size~ 200nm) λ is in visible region:
- Light passes through colloidal suspensions with scattering (milk, fog).

**Why is the sky blue?**

**Light Scattering**

Colloids scatter blue light more than red light.
Hydrophilic vs. hydrophobic colloids

- **hydrophilic**: water-loving
- **hydrophobic**: water-fearing
- **(water-soluble) proteins**: hydrophobic core with hydrophilic surface

- **detergents**: hydrophobic tail with hydrophilic head