Universiti Malaysia PAHANG
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BSK1133 PHYSICAL CHEMISTRY

CHAPTER 3
IDEAL AND NON IDEAL SOLUTION
(PART B)

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Description

Aims

- To understand the colligative properties of solution
- To understand the colligative properties of electrolyte

Description

Expected Outcomes

- ❖ Able to understand the colligative properties of solution
- ❖ Able to understand the colligative properties of electrolyte

References

- ✓ Atkins, P & Julio, D. P. (2006).Physical Chemistry (8th ed.). New York: Oxford.
- ✓ Chang, R. (2005).Chemistry (8th ed.). New York: McGraw Hill.
- ✓ Atkins, P & Julio, D. P. (2012). Elements of Physical Chemistry (sixth ed.). Freeman, Oxford.
- ✓ Silbey, R. J., Alberty, A. A., & Bawendi, M. G. (2005). Physical Chemistry. New York: John Wiley & Sons.
- ✓ Mortimer R. G. (2008) Physical Chemistry, Third Edition , Elsevier Academic press, USA.

Contents

3.6 Colligative Properties of Solution

- Colligative properties of solution are properties that depend only on the *number* of solute particles present (concentration) and not on the *identity* of the solute particles.

- Colligative properties include:
  - Vapor pressure lowering
  - Boiling point elevation
  - Melting point depression
  - Osmotic pressure

Vapor Pressure:

- When a solute molecules being added into a solution, the solute-solvent interactions affected to decrease the vapor pressure of the solvent
- the solvent become less volatile
- Therefore, the vapor pressure of a solution (solute+solvent) is lower than that of the pure solvent (without solute

Roult's Law

Roult's law stated that the partial vapor pressure of each component of an ideal mixture of liquids is equivalent to the product of vapor pressure of the pure component and its mole fraction in the mixture

Vapor-Pressure Lowering

Raoult's law

$$P_1 = X_1 P_1^0$$

P_1^0 = vapor pressure of **pure** solvent

X_1 = mole fraction of the solvent

If the solution contains only one solute:

$X_1 = 1 - X_2$

$P_1^0 - P_1 = \Delta P = X_2 P_1^0$

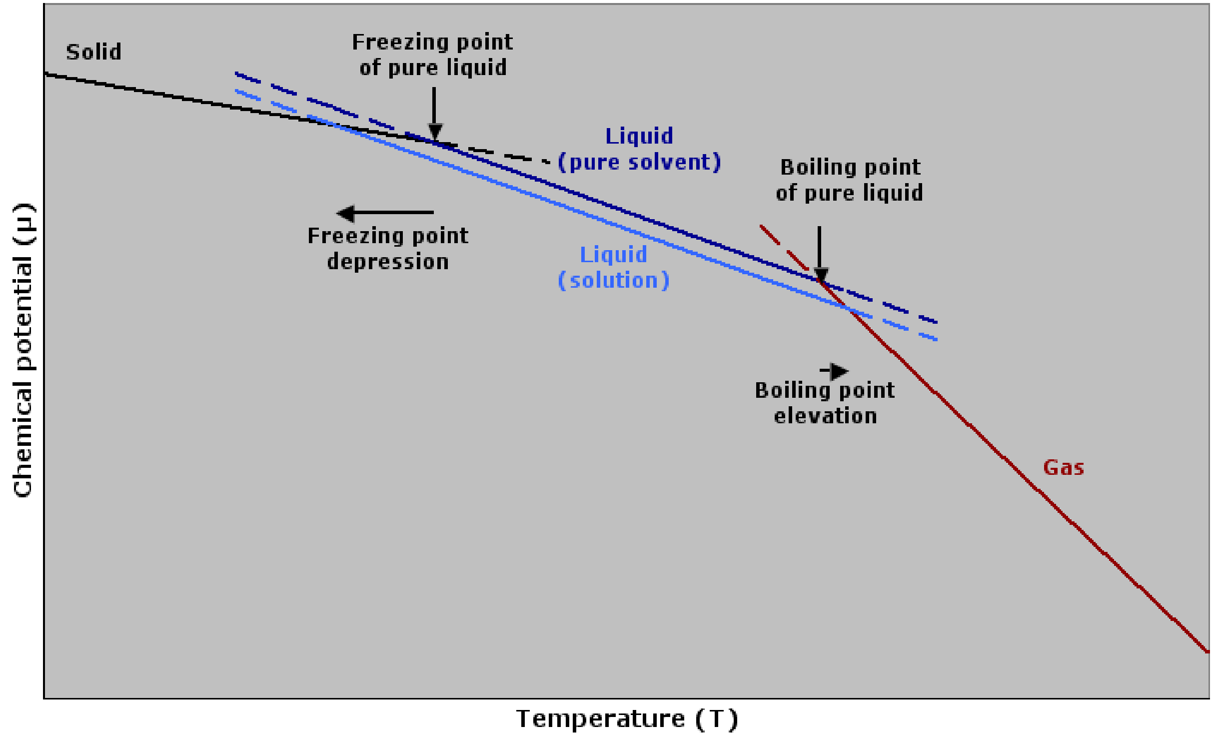
X_2 = mole fraction of the solute

Boiling Point and Freezing Point

The solute-solvent interactions has affected to:

- Increase in boiling points
- Decrease in freezing points

As compared to the pure solvent.



Boiling-Point Elevation

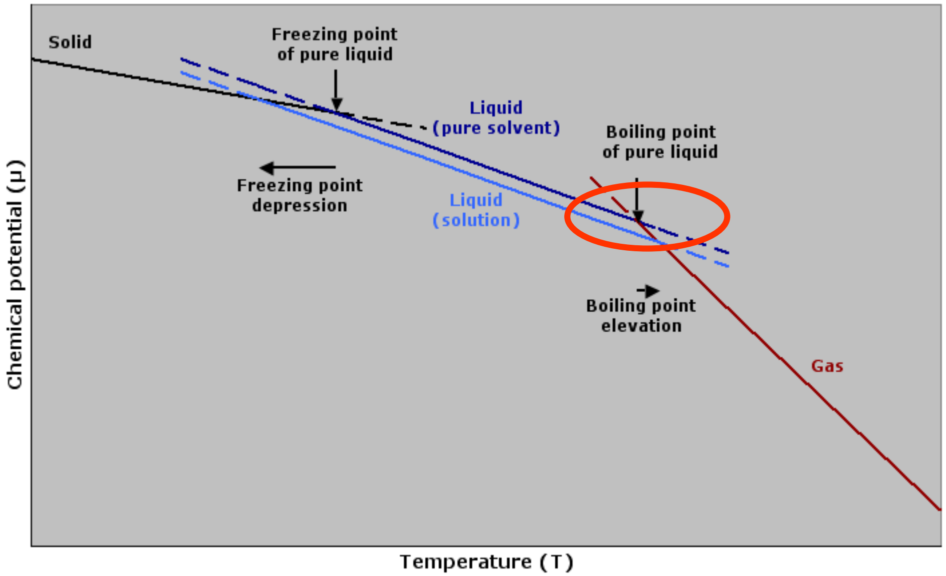
$$\Delta T_b = T_b - T_b^0$$

T_b^0 is the boiling point of the pure solvent

T_b is the boiling point of the solution

$T_b > T_b^0 \qquad \Delta T_b > 0$

$$\Delta T_b = K_b\, m$$



K_b is the molal boiling-point elevation constant (^{0}C/m)

Freezing-Point Depression

$$\Delta T_f = T_f^0 - T_f$$

T_f^0 is the freezing point of the pure solvent

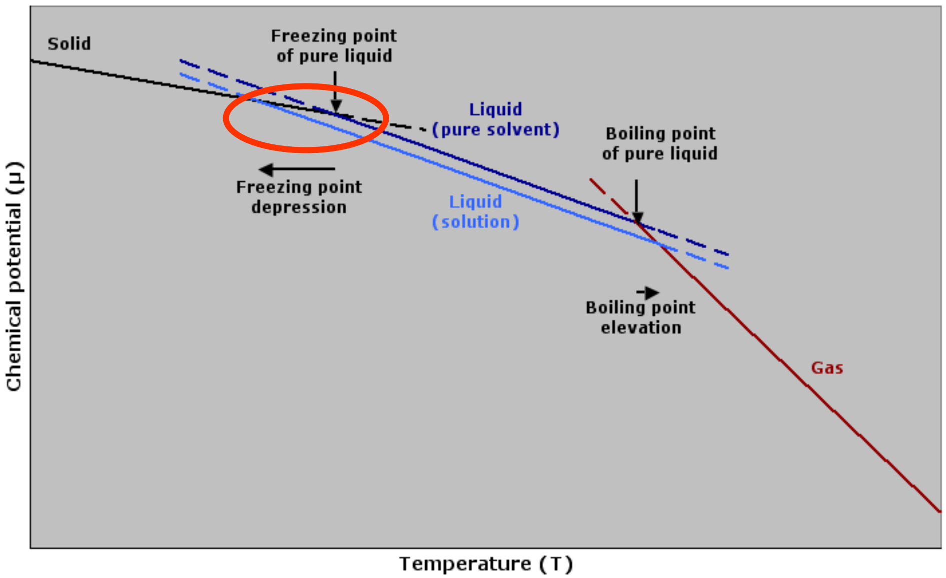
T_f is the freezing point of the solution

$T_f^0 > T_f$ $\Delta T_f > 0$

$$\Delta T_f = K_f m$$

m is the molality of the solution

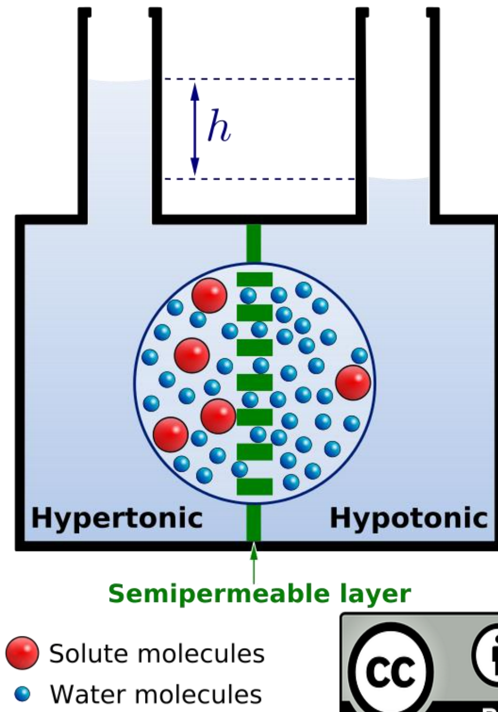
K_f is the molal freezing-point depression constant ($^0C/m$)



Source: Tomas er https://commons.wikimedia.org/wiki/File:Freezing_point_depression_and_boiling_point_elevation.png

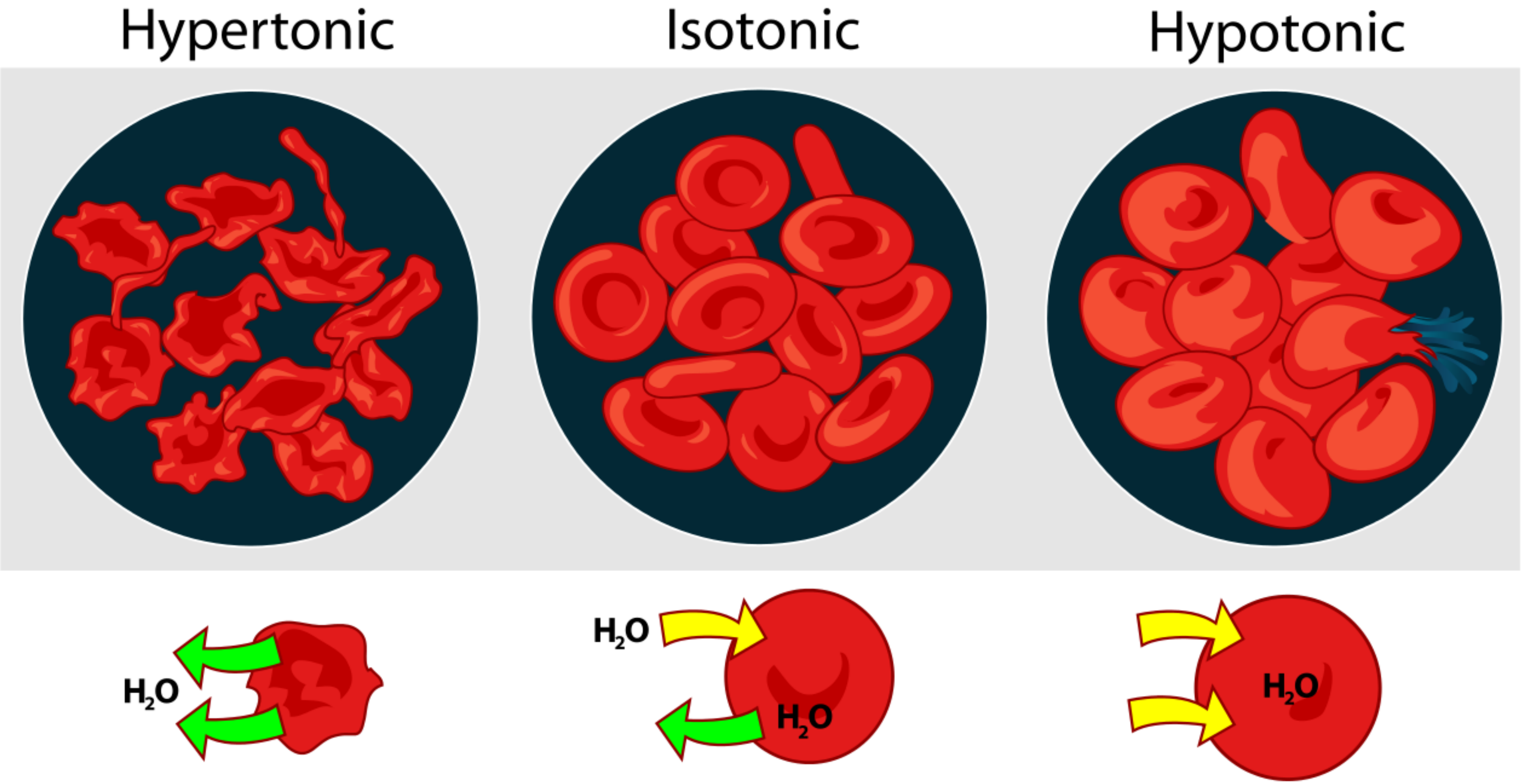
Osmosis

- **Semipermeable membranes** allow only some particles to pass through (such as water) and blocking others (solute particles).
- In osmosis process, solvent will move from **higher solvent concentration** (diluted) to **lower solvent concentration** (concentrated).
- The water tries to balance the concentration on both sides and this phenomenon affected to higher pressure.



Source: YassineMrabet
https://commons.wikimedia.org/wiki/File:Osmosis.svg

Effect of different type of solution on blood cells (please discuss):



Source: LadyofHats
https://en.wikipedia.org/wiki/File:Osmotic_pressure_on_blood_cells_diagram.svg

The pressure required to stop the osmosis process is called osmotic pressure, π :

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

where M = molarity of the solution

3.7 Colligative Properties of Electrolyte

- ✓ Electrolytes solutions will show greater changes in colligative properties than those of nonelectrolytes solution.

- ✓ This is due to the dissociation of ion in electrolyte solution which contributed to the increment of solution concentration.

Van't Hoff Factor

The van 't Hoff factor is:

$$: \frac{\text{actual concentration of particles produced (solution)}}{\text{concentration of a substance as calculated from its mass.}}$$

Example: NaCl in water,

NaCl dissociates into ion Na^+ and Cl^-
van't Hoff factor : 2.

However, 1 *M* NaCl solution not showing twice the change in freezing point. Because:

Some of Na^+ and Cl^- ion is reassociate as hydrated ion pairs, thus the real concentration of the particles is less than twice of the concentration of NaCl.

- ✓ Reassociation is more likely happen at higher concentration.
- ✓ Therefore, the number of particles present is concentration dependent.

	Concentration			
Compound	0.1 m	0.01 m	0.001 m	Limiting Value
Sucrose	1.00	1.00	1.00	1.00
NaCl	1.87	1.94	1.97	2.00
K2SO4	2.32	2.70	2.84	3.00
MgSO4	1.21	1.53	1.82	2.00

For electrolyte solution, the ΔT_f equations needs to multiply by the van't Hoff factor, *i*

$$\Delta T_f = K_f \cdot m \cdot i$$

Degree of dissociation and van’t Hoff factor calculation

Van’t Hoff can be calculated by using:

$$\frac{\Delta T_f \text{ of the ionic compound}}{\Delta T_f \text{ of the solution}}$$

3.8 Colloid

- ✓ Colloids is happen because suspensions of particles larger than individual ions or molecules.
- ✓ Moreover, it is too small to be settled out by gravity.

Phase of Colloid	Dispersing (solventlike) Substance	Dispersed (solutelike) Substance	Colloid Type	Example
Gas	Gas	Gas	—	None (all are solutions)
Gas	Gas	Liquid	Aerosol	Fog
Gas	Gas	Solid	Aerosol	Smoke
Liquid	Liquid	Gas	Foam	Whipped cream
Liquid	Liquid	Liquid	Emulsion	Milk
Liquid	Liquid	Solid	Sol	Paint
Solid	Solid	Gas	Solid foam	Marshmallow
Solid	Solid	Liquid	Solid emulsion	Butter
Solid	Solid	Solid	Solid sol	Ruby glass

✓ Colloidal suspensions can scatter rays of light **(Tyndall effect).**

Source: https://commons.wikimedia.org/wiki/Crepuscular_rays

Conclusion

- Solution in solvent affected to colligative properties of solution.

- Colloids is one of the types of solution due to solute suspension.

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