تفريغ فيزيكال

اسم الموضوع: Solutions of non electrolytes part 2

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لجان الدُّفعات

Seoul Academy

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Colligative Properties of Solutions

- Colligative properties are properties of solutions that depend upon the ratio of the number of solute particles to the number of solvent molecules in a solution, and not on the type of chemical species present.

تعتمد على
عدد الجزيئات
المذابة الى
عدد الجزيئات
المذيبة في
المحلول

وليس على
نوع الجزيئات

لو التركيز ثابت
وغيرت
من ملح لسكر
مثلاً
هذه الخصائص
مارح تتغير

- Colligative properties of solution include:
  1. Lowering of vapor pressure
  2. Elevation of boiling point
  3. Depression of freezing point
  4. Osmotic pressure

عندما تذوب مادة غير متطايرة
في solvent
الضغط البخاري للsolvent
يقل عن الضغط
البخاري للsolvent النقي.

كما يقل الضغط البخاري تزداد نقطة الغليان.

تقل نقطة التجمد.

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Colligative Properties of Solutions

Lowering of vapor pressure

- When a non-volatile solute is dissolved in a volatile solvent, the vapor above the solution is provided by the solvent only. The solute particles (atoms, molecules or ions) at the surface reduce the escaping tendency of the solvent

تقلل تبخر الجزيئات

- Therefore, the tendency of the solvent molecules to exert vapor pressure is lowered in the presence of the solute.

يتكون البخار فوق المحلول من solvent فقط

في وجود المذاب solute ،
يقل ضغط البخار

Colligative Properties of Solutions

Lowering of vapor pressure

- Vapor pressure lowering of a solution depends on the number of solute molecules (mole fraction) present in the solution.
- The higher the solute fraction, the lower the vapor pressure above the solution.
- Vapor pressure lowering is the key to all four of the colligative properties.

كلما زادت نسبة solute
يقل معدل التبخر
فيقل V.P

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Slide 23

$$P = P_1 = P_1^\circ X_1 = P_1^\circ(1 - X_2) \quad \text{---} \circledast$$

$$P_1 = P_1^\circ - P_1^\circ X_2$$

$$\frac{P_1^\circ - P_1}{P_1^\circ} = \cancel{P_1} X_2$$

$$\Delta P = \underset{\text{pure solvent}}{\underline{P_1^\circ}} - P_1$$

$$\frac{P_1^\circ - P_1}{P_1^\circ} = X_2$$

$$\frac{\Delta P}{P_1^\circ} = X_2 = \frac{n_2}{n_1 + n_2}$$

Slide 24

[الاشتقاق غير مطلوب بس للفهم كتبته]

Soln.
- → 171.2g sucrose (MW = 342.3)
- → 1000g water (MW = 18.02)

Vapor pressur lowering المطلوب

0.5 = عدد مولات السكر

55.5 = عدد مولات water

توضيح ؟؟ المقصود كم انخفض الضغط البخاري بعد اضافة solute ؟

$$\Delta P = \underset{\text{لما كان solvent نقي}}{\underline{\underline{P_1^\circ}}} - \underset{\text{بعد اضافة solute}}{\underline{\underline{P_1}}} \quad \text{المطلوب} \circledast$$

$$P_1 = P_1^\circ \times X_1$$

$$P_1 = P_1^\circ(1 - X_2)$$

$$P_1 = P_1^\circ - (P_1^\circ X_2)$$

$$\frac{P_1^\circ - P_1}{P_1^\circ} = \cancel{P_1} X_2 = \boxed{\frac{\Delta P}{P_1^\circ} = X_2}$$

$$\frac{\Delta P}{P_1^\circ} = \frac{0.5}{0.5 + 55.5} = 0.008$$

اذا عند اضافة السكر انخفض بنسبة 0.89%

slide

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Colligative Properties of Solutions

Boiling Point Elevation

- **Normal Boiling Point:** is the temperature at which the vapor pressure (P) of the liquid becomes equal to the atmospheric pressure. ضغط البخار Vp = Ap الضغط الجوي
- Presence of solute particles lower the vapor pressure of the solution (we need to increase temperature to increase p to make it boil).
- The boiling point of a solution (T) is higher than that of the pure solvent alone (T°)

يعني وجود solute ← مو بس قلل معدل التبخر و الضغط البخاري أيضًا اصبحنا نحتاج زيادة درجة الحرارة حتى يغلي

(*) يعني بعد اضافة solute رح نحتاج الى زيادة درجة الحرارة

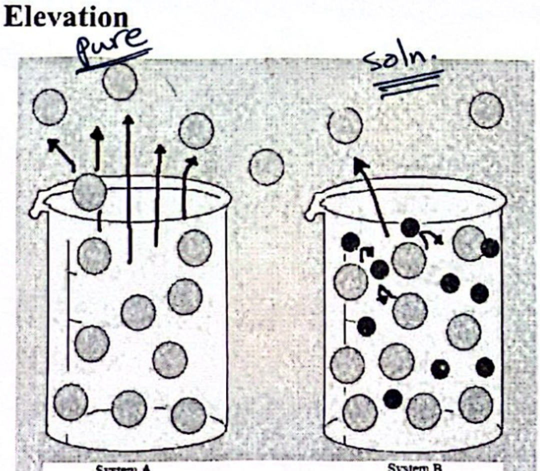
لذلك Boiling point تزداد

$B.P_{soln.} > B.P_{\text{solvent Pure}}$

Colligative Properties of Solutions

Boiling Point Elevation

عدد الجزيئات اللي بتتبخر من pure أكثر من عدد الجزيئات اللي بتتبخر من soln.



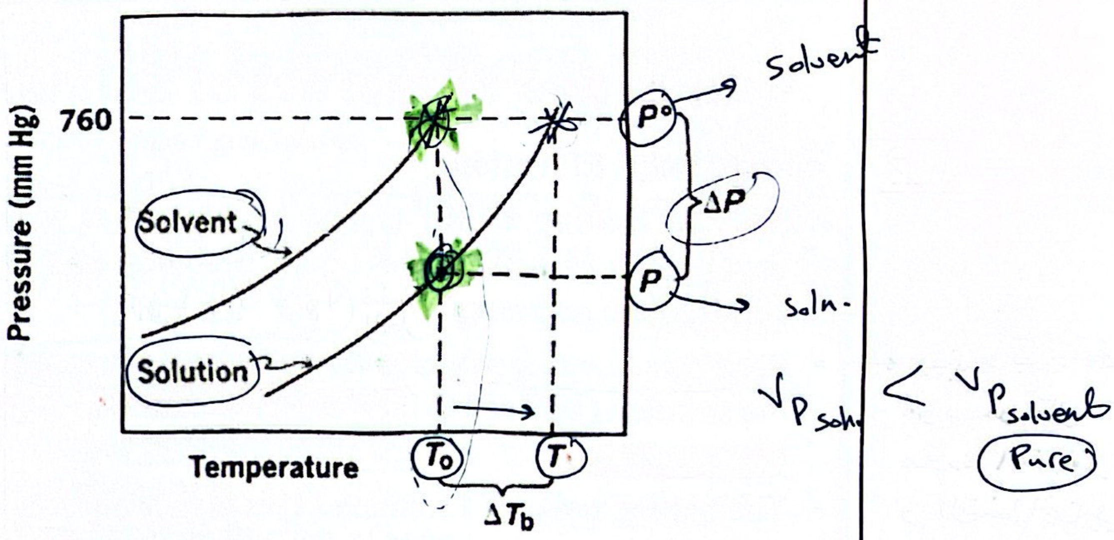
System A

In system A, the liquid particles easy shift into the gas phase at the normal boiling pressure. There are no obstacles for the liquid particles as there is in System B.

System B

In system B, the solute particles prevent the liquid particles from escaping the system to turn into gas. This requires the liquids to possess more energy to become a gas.

Hala



Boiling point elevation of solvent due to the addition of a solute

$B.P_{solvent} < B.P_{soln.}$

قبل اضافة solute

بعد اضافة solute

Colligative Properties of Solutions

Boiling Point Elevation

- The boiling point elevation, ΔT_b is estimated by this equation.

$$\Delta T_b = K_b m$$

$$T - T_0 = \Delta T_b$$

T: درجة غليان soln.

T_0: درجة غليان solvent

- $\mathbf{K_b}$: molal elevation constant (ebullioscopic constant)

ثابت خاص لكل solvent

- **m**: molality

$\dfrac{\text{n. of moles solute}}{1\ \text{Kg solvent}}$

$\Delta T_b = 0.103\,°C$

$K_{b\,water} = 0.515\ \frac{deg.kg}{mol}$

Colligative Properties of Solutions

Boiling Point Elevation: Example

An aqueous solution of a drug gave a boiling point elevation of 0.103 °C. Approximate Kb (ebullioscopic constant) for the solvent, water is 0.515 deg.kg/mol.

a. What is the molality of the drug?

b. If the M.wt of the drug is 185, what is the concentration in % w/w?

$\Delta T_b = K_b\, m$

$m = \Delta T_b / K_b$

$= 0.103 / 0.515 = 0.2\ \text{mol kg}^{-1} = 0.0002\ \text{mol g}^{-1}$

$\%\ w/w = m \times M.wt$

$= 0.0002 \times 185$

$= 0.037\ g / g = 3.7\ g / 100\ g = 3.7\ \%\ w/w$

$0.0002\ \frac{\cancel{mol}}{g} * 185\ \frac{g}{\cancel{mol}} = \frac{0.037}{1}\ \frac{g}{g}\ \frac{*100}{*100}$

$= \frac{3.7\ g}{100\ g} = 3.7\%\ w/w$

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Colligative Properties of Solutions

Depression of the Freezing Point

- Solute particles will lower the freezing point of the solution
- The freezing point of pure water is 0°C, but freezing point of aqueous solutions is lower $F.P_{Pure} > F.P_{soln.}$ (قبل اضافة solute) (بعد اضافة solute)
- Applications:
  1. Anti-freeze solution (ethylene glycol)
  2. Addition of salt to icy roads to melt the ice
- Solute interferes with ice crystal formation (ordered structure).
- Solute causing disorder (random state) preventing pure solvent to ice at 0°C and staying melted.

عند إضافة solute

تقل Freezing point

يستخدم في السيارات محلول يستخدم لمنع السوائل من التجمد (يتم اضافة solute ethylene glycol الى المحركات لتقليل F.P

عندما يضاف المذاب الى الماء يدخل solute مع تشكيل بلورات الجليد.

في حالة الماء النقي تتشكل بلورات الجليد من جزيئات الماء بطريقة منظمة ومنسقة.

اما اذا كان عندي solute واجيت بدي اشكل بلورات الجليد رح يتسبب عندي (disorder) فوضى وما رح تترتب بشكل منظم ويبقى سائل فيحتاج درجة حرارة اقل من 0°C حتى يتجمد.

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Colligative Properties of Solutions

Depression of the Freezing Point

- The lowering of the freezing point of a solution is directly proportional to the molar concentraton of the solute (i.e. number of particles in solution, (molecules or ions).

ثابت

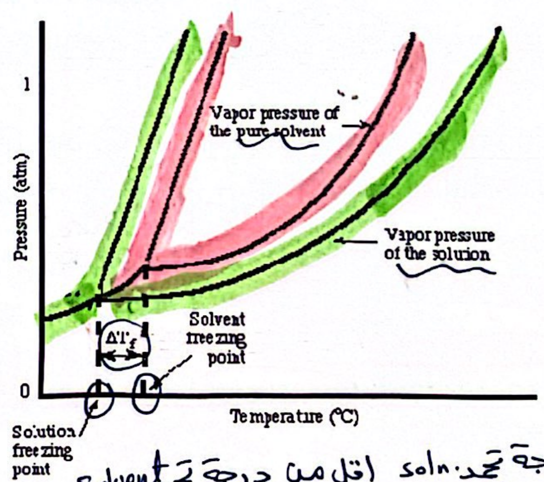
$$\Delta T_f = K_f m$$

- ΔT_f: Freezing point depression
- K_f: Cryoscopic constant
- m: molality of solution

n. of solute / 1 Kg of soln.

Colligative Properties of Solutions

Depression of the Freezing Point



درجة تجمد soln. اقل من درجة تجمد solvent

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Colligative Properties of Solutions

Depression of the Freezing Point: Example

$3.42\,g / 342\,\frac{g}{mol}$

$K_f = 1.86$

What is the freezing point of a solution comprising 3.42 g of sucrose (MW = 342) and 500 g of water? Take kf to be 1.86 (°C kg mol-1)

$\Delta T_f = K_f\, m$

m = molality of sucrose

solute

$$= \frac{\text{no. of mole}}{Wt_{solvent}} = \frac{Wt/MW}{Wt_{solvent}} = \frac{3.42/342}{0.5} = 0.02 \text{ mol kg}^{-1}$$

solvent

$\Delta T_f = K_f\, m = 1.86 \times 0.02 = 0.037$ °C (i.e. ΔT_f, freezing point depression)

Hence, the freezing point of this solution is –0.037 °C as (pure water $T_f = 0$ °C)

رح يضل

This solution will stay melted at temp of 0 °C

سائل

$0 - 0.037 = 0.037$°C

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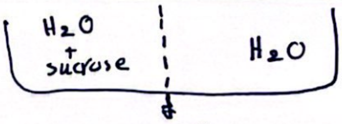
Colligative Properties of Solutions

Osmotic pressure

- Whenever a solution is separated from a solvent by a membrane that is permeable only to solvent molecules (referred to as a *semipermeable membrane*), there is a passage of solvent across the membrane into the solution.
- This is the phenomenon of *osmosis*
- If the solution is totally confined by a semipermeable membrane and immersed in the solvent, then a pressure differential develops across the membrane, which is referred to as the *osmotic pressure*.

soln. ← solvent

و الضغط الناتج



غشاء فقط يمرر solvent

solvent

Pure الماء) حركة

H_2O + sucrose الى

soln

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Colligative Properties of Solutions

Osmotic pressure

- Osmotic pressure is determined by the total number of particles in the solution, regardless of chemical nature
- قانون Van't Hoff recognized a proportionality between osmotic pressure concentration and temperature and suggested a relationship that corresponds to an ideal gas:

$\pi v = n\,R\,T \quad \Rightarrow \quad$ **Van't Hoff equation:** $\pi = c\,R\,T$

π: Osmotic pressure in atmospheres

c: molarity of solution

R: Gas constsant (0.082 L.atm/mol.deg)

T: Absolute temperature

العلاقة بين الضغط الأسموزي
و درجة الحرارة

Colligative Properties of Solutions

Osmotic pressure

- قانون Morse and others have shown that when the concetration is expressed in molality rather than in molarity, the results compare more nearly with the experimental findings:

Morse equation: $\pi = m\,R\,T$

π: Osmotic pressure in atmospheres

m: molality of solution

R: Gas constsant (0.082 L.atm/mol.deg)

T: Absolute temperature

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Colligative Properties of Solutions

Osmotic pressure: Example

الكتلة

One gram of sucrose, molecular weight 342, is dissolved in 1000 gm of solution at 25° C. What is the osmotic pressure in the solution?

Answer

Number of moles of sucrose = Wt/M.wt = 1/342 = 0.0029 mol

Molality = number of moles/kg = 0.0029/1kg = 2.9×10^{-3} m

$\pi = mRT$

T = 273+25 = 298 K

$\pi = 2.9\times10^{-3}\times0.082\times298 = 7.08\times10^{-2}$ atm

Molecular weight determination

رح نستخدم القوانين الي عرفناها حتى نحسب الـ M.W

- The colligative properties can be used to calculate molecular weights of non-electrolytes present as solutes.

Determination of molecular weight by boiling point elevation

$$\Delta T_b = K_b m \;\Rightarrow\; m = \frac{w_2/M_2}{w_1}\times 1000 = \frac{1000 w_2}{w_1 M_2}$$

$$m = \frac{\frac{\text{w.solute}}{\text{M.W (solute)}}}{\text{w.solvent}} \times 1000$$

ضربناه ب 1000 عشان وزن solvent دايركت نعوضه بالغرام.

$$\Delta T_b = K_b \frac{1000 w_2}{w_1 M_2} \;\Rightarrow\; M_2 = K_b \frac{1000 w_2}{w_1 \Delta T_b}$$

W_2 = weight of solute, W_1 = weight of solvent, M_2 = molecular weight of solute

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Molecular weight determination

EXAMPLE 5–15

Determination of the Molecular Weight of Sucrose by Boiling Point Elevation

w_2 w_1

A solution containing 10.0 g of sucrose dissolved in 100 g of water has a boiling point of 100.149°C. What is the molecular weight of sucrose? We write

$$M_2 = 0.51 \times \frac{1000 \times 10.0}{100 \times 0.149}$$
$$= 342 \text{ g/mole}$$

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

$$\Delta T_b = K_b * \frac{W_2/M.W}{W_1} * \underline{1000}$$

عكس

$$100.149 - 100 = 0.51 * \frac{10/MW}{100} * 1000$$

كرح

$$0.149 = 5.1 * \frac{10}{M.W}$$

$$M.W = \frac{5.1 * 10}{0.149}$$

$$M.W = 342 \text{ g/mol}$$

Molecular weight determination

- **Determination of molecular weight by freezing point depression**

$$M_2 = K_f \frac{1000 w_2}{\Delta T_f w_1}$$

عادي محكن تحفظوها

دايركت

EXAMPLE 5–16

Calculating Molecular Weight Using Freezing Point Depression

The freezing point depression of a solution of 2.000 g of 1,3-dinitrobenzene in 100.0 g of benzene was determined by the equilibrium method and was found to be 0.6095°C. Calculate the molecular weight of 1,3-dinitrobenzene. We write

$$M_2 = 5.12 \times \frac{1000 \times 2.000}{0.6095 \times 100.0} = 168.0 \text{ g/mole}$$

$$\Delta T_f = K_f * m$$

$$0.6095 = 5.12 * \frac{2.000/M.W}{100} * 1000$$

$$0.6095 = 51.2 * \frac{2}{M.W} \longrightarrow MW = 168 \text{ g/mol}$$

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