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ALQUSOUR ACADEMY

اكاديمية القصور

CHEMISTRY

103

Subject

Second Exam - Chapter Thirteen

تحذير: محاضراتنا (الملخصات) متوفرة فقط لدى:
1) أكاديمية القصور بفروعها. 2) جمعية التصوير الطبية (مدرج التمريض).

للإستفسار والتسجيل

إربد

0785 70 60 08

0795 33 99 34

للضرورة

مدير الأكاديمية

أ.إبراهيم الشواهين

0795 74 74 45

ساعات الدوام الرسمي

السبت - الخميس 12:30 ظهراً - 11:00 ليلاً

الجمعة 2:00 ظهراً - 11:00 ليلاً

للفصل الدراسي الأول

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2- Mole fraction (x) :

$$\text{mole fraction (X)} = \frac{\text{moles of solute}}{\text{moles of solution}}$$

mol/mol

$$X_A + X_B = 1$$

3- Part per million (ppm): for very dilute solutions

$$\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

mg/L

4- Part per billion (ppb)

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$

μ g/L

5- Molarity (M): only depends on Temperature

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}} \qquad M = \frac{\text{moles}}{L}$$

Vol. soln. = Vol. solt. + Vol.solv.

6- Molality (m)

$$\text{molality} = \frac{\text{moles of solute}}{\text{Kg of solvent}} \qquad m = \frac{\text{moles}}{\text{Kg}}$$

Ex.1: 12 g of urea (MM = 60 g/mol) is dissolved in 180 g of water. The mole fraction (x) of urea is?

Ans.:

$$x = (12_g/60_{g/mol})/[(12_g/60_{g/mol})+(180_g/18_{g/mol})]$$

$$= 0.02$$

If he asked about solvent (water) just do:

$$x = 1 - 0.02 = 0.98$$

Ex.2: Calculate the molality of 2.5 M NaCl solution? (density of solution = 1.08 g/ml) ?

Ans.:

Assume 1L soln.

$$m = \frac{n_{solt.}}{Kg_{solv.}}$$

2.5M which means:

$$\frac{2.5\ mol_{\ solt.}}{1\ L_{\ soln.}}, \therefore n_{solt.} = 2.5 mol$$

$$Vol._{\ soln.} = 1L = 10^3\ ml$$

Now,

$$m_{soln.} = m_{solt.} + m_{solv.}$$

$$\Rightarrow m_{solv.} = m_{soln.} - m_{solt.}$$

$$= (d \times V) - (n \times Mwt.)$$

$$= (1.08 \frac{g}{\cancel{ml}} \times 10^3 \cancel{ml}) - (2.5 \cancel{mol} \times 58.5 \frac{g}{\cancel{mol}}) = 934\ g$$

$$\Rightarrow m_{solv.} = 0.934\ Kg$$

$$\Rightarrow m = \frac{n_{solt.}}{Kg_{solv.}} = \frac{2.5\ mol}{0.934\ Kg} = 2.68m$$

Ex.3: Calculate the molality of 48.2 percent by mass (%mass) KBr solution (Mwt.=119g/mol) ?

48.2% which means: 48.2 g solt.

100 g soln.

$$\Rightarrow mass_{\ solv.} = m_{soln.} - m_{solt.}$$

$$= 100 - 48.2 = 51.8\ g = 0.0518\ Kg$$

$$\Rightarrow m = \frac{n_{\ solt.}}{Kg_{\ solv.}} = \frac{(m/Mwt.)_{solt.}}{Kg_{\ solv.}}$$

$$= \frac{(48.2 \cancel{g} / 119\ \cancel{g}/mol)}{0.0518 kg} = 7.82m$$

Q. For a 98 % by mass aqueous solution of sulfuric acid H_2SO_4 (98.09 g/mol) solution, (density = 1.83 g/ml). Calculate (a) molarity (b) molality?

(a) Molarity:

98 % ⇒ 98g solt.
100g soln

$$\Rightarrow M = \frac{n_{solt.}}{V_{L\,soln.}} = \frac{(m/Mwt.)_{solt.}}{(m/d_{soln.})} = \frac{(98g/98.09g/mol)}{(100g/1.83g/ml)\times 10^{-3}} = 1.83\ M$$

(b) 500 m

13.5: Colligative Properties of Non-electrolyte Solutions:

Colligative properties are solution properties that vary in proportion to the solute concentration and depend only on the number of solute particles, & not on the nature of solute particles.

These properties are:

1- Vapor pressure lower (P)
2- Boiling point elevation (increase) (T_b)
3- Freezing point depression (decrease) (T_f)
4- Osmotic pressure increase (π) [more accurate]

Non-electrolytes solution: no ions in the solution

1- Vapor pressure lower (P_{soln}):

The amount of pressure exerted by the vapor when a closed container is in equilibrium with its vapor

By Rault's Law:

$$P_{soln.} = P_{solv.}^{*}\ X_{solv.}$$

$X_{solv.}$: mole fraction = $mol_{solv.}/mol_{soln.}$

Ex. A solution of 1 mol of glucose in 15 mol of water at 25°C, The vapor pressure [illegible] mHg. Calculate vapor pressure for the solution?

2- Boiling-Point Elevation

$$\Delta T_b = K_b \times m$$

K_b, K_f : molal boiling & freezing point Constants (°C/m) or (°C.Kg/mol)
- depends only on types of solvent

- m = molality = mol/Kg

$$T_{b(soln)} = T_{b(solv)} + \Delta T_b$$

3- Freezing-Point Depression

$$\Delta T_f = K_f \times m$$

$$T_{f(soln)} = T_{f(solv)} - \Delta T_f$$

Ex.1: Ethylene glycol (EG) (M.wt. 60.052 g/mol) is commonly used automotive antifreeze. A 25% solution of EG is used. What is the molality of this solution?

Ans.: 5.5 m

Ex.2: Calculate the boiling point & the freezing point of the EG in Ex.1, if $k_b = 0.512$ °C/m, $K_f = 1.86$ °C/m for water, $T_f = 0$ °C?

a) boiling

$\Delta T_b = K_b \times m$

$= 0.512\ °C/\cancel{m} \times 5.5\ \cancel{m} = 2.8\ °C$

$\Rightarrow T_{bsoln.} = T_{bsolv.} + \Delta T_b$

$= 100 + 2.8 = 102.8\ °C$

b) Freezing

$\Delta T_f = K_f \times m$

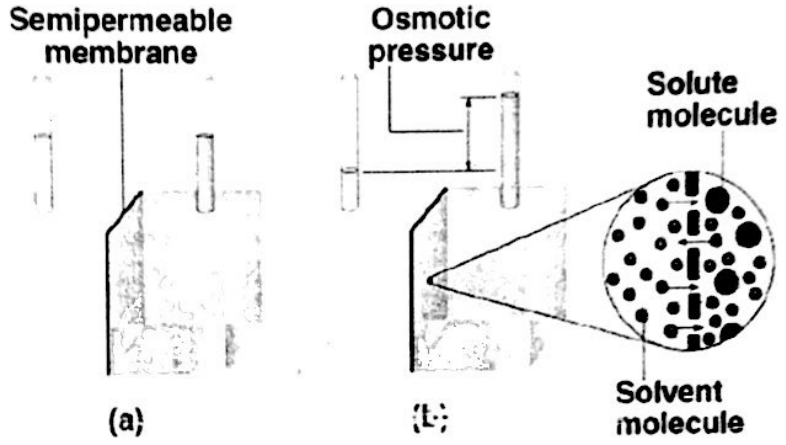
$= 1.86\ °C/\cancel{m} \times 5.5\ \cancel{m} = 10.22\ °C$

$\Rightarrow T_{fsoln.} = T_{fsolv.} - \Delta T_f$

$= 0 - 10.22 = -10.22\ °C$

Osmotic Pressure (Nonelectrolytes) :

The amount of pressure necessary to achieve the equilibrium



Osmosis: net movement of solvent from low concentration to high concentration solution via semipermeable membrane.

** This for one solution **

** For two solutions **
Isotonic: two soln have equal osmotic pressure ($\pi_1 = \pi_2$)

Hypertonic: more conc. soln given two soln's ($\pi_1 > \pi_2$)

Hypotonic: less conc. given two soln's ($\pi_1 < \pi_2$)

Osmotic Pressure:

$$\pi = M R T$$

Π : atm
M: molarity (mol/L)
R: 0.0821 L.atm/mol.K
T: temp. (K)

Note:

$$\pi = MRT$$

$$= \frac{(m/Mwt)\,RT}{V_L}$$

$$Mwt. = \frac{mRT}{V_L\,\pi}$$, where π = atm

also, Since, $d = (m/V)$

$$\boxed{Mwt. = \frac{dRT}{\pi}}$$

Ex. A solution is prepared by dissolving 35 g of hemoglobin in enough water to make up 1 L volume. If the osmotic pressure of the solution is found to be 10 mmHg at 25°C. Calculate the molar mass of hemoglobin?

Ans.: 65×10^3 g/mol

Colligative Properties of Electrolyte Solutions:

For colligative properties,
- Electrolyte solutions vary from those of nonelectrolyte solutions
  - electrolytes dissociate into ions in solutions
    - → increasing the total number of particles in solution
      - → freezing-point depression for 0.1*m* NaCl is nearly double that for 0.1*m* sucrose because NaCl breaks up in Na^+ and Cl^- ions whereas sucrose (a nonelectrolyte) does not break up at all

van't Hoff factor = i = number of moles of ions per mole of electrolyte
- a measure of the degree to which an electrolyte dissociates

$$i = \frac{\text{actual number of particles in solution after dissolving}}{\text{number of compounds involved before dissolving}}$$

Ex.: Find i in the following:

a) Na_3PO_4 b) $CaCl_2$ c) KOH
d) $Al(NO_3)_3$ e) H_2SO_4

Ans.:

a) $Na_3PO_4 \longrightarrow \underline{3}Na^+ + \underline{1}PO_4^{-3}$

3 ion 1 ion >>>>> i= 4

Note:

Some groups are be as one ion such as:

(PO_4^{-3}) , (OH^-), (SO_4^{-2}), (NO_3^-), (ClO_4^-)

b) 3 c) 2

d) 4 e) 3

>>>>

For electrolyte solutions, the van't Hoff factor must be included in the following:

$P_{soln} = i\, P_{solv.} \times X_{solv.}$ $\Delta T_b = i\, K_b\, m$ $\Delta T_f = i\, K_f\, m$ $\pi = i\, MRT$

Note:

a) as i increase T_b, π increase

b) as i increase T_f, P decrease

Ex. 1: Which one of the following would have the highest boiling point?

1.00*m* NaBr 1.00*m* $CaBr_2$ 1.00*m* $AlBr_3$ 1.00*m* $SrSO_4$

Ans.:

i x m

1- 2 x 1 = 2

2- 3 x 1 = 3

3- 4 x 1 = 4

4- 2 x 1 = 2

>>>>> $AlBr_3$ is the highest T_b

Q.: Estimate the boiling point of a 2.5 m solution of $MgCl_2$ if $k_b = 0.512\ ^oC/m$?

Ans.: 103.84 °C (Don't forget put i = 3)

Q.: Calculate the Van't Hoff factor (i) for KI at 0.01 M KI sclution, at 25 °C and osmotic pressure of 0.465 atm?

Ans.: i = 1.9 < 2 (KI) , why?

Because of ion pair effect???

>>> ion pair effect

In electrolyte solutions (have +ve & -ve ions) after they separate we said in this example to 3mole (+ve ions) & 1mole (-ve ion), so we say i=4, but they are an attraction between +ve & -ve >>>> held closely together >>>> to become not 4 ions

$$Na_3PO_4 \longrightarrow \underline{3}Na^+ + \underline{1}PO_4^{-3}$$

>>>> This the ion-pairing
>>>> Reduce Van't Hoff factor (i)

>>> Multicharged ions (Mg^{+2}, Al^{+3}, SO_4^{-2}, etc...) have greater tendency to form ion pair

Questions

1-Which of the following aqueous solutions has highest osmotic pressure at 25°C?
A. 0.2 M KBr B. 0.2 M ethanol C. 0.2 M Na_2SO_4 D. 0.2 M KCl

2- The osmotic pressure of a 0.010 M $MgSO_4$ solution at 25°C is 0.318 atm. Calculate *i*, the van't Hoff factor, for this $MgSO_4$ solution.
A. 0.013 B. 1.3 C. 1.5 D. 2.0

3- Which of the following aqueous solutions has the lowest freezing point?
A. 0.18 m KCl B. 0.15 m Na_2SO_4 C. 0.12 m $Ca(NO_3)_2$ D. pure water

4- At what temperature a 7% by mass aqueous solution of ethylene glycol (62g/mol), a nonelectrolyte, will freeze? (for H_2O, T_f = 0 °C , K_f = 1.86 °C/m)
a) 1.13 °C b) -1.13 °C c) 2.26 °C d) – 2.26 °C

4- The molality of lead nitrate in 0.726M $Pb(NO_3)_2$ (331g/mol, d = 1.202g/ml) solution:
a) 0.755m b) 1.928m c) 0.476 d) 0.819m

5- A solution was prepared by dissolving 3 g of unknown solute in enough water to make 0.5L solution. The osmotic pressure of this solution was 1 atm at 25°C. the molar mass (g/mol) of this unknown:
a) 392 b) 196 c) 147 d) 294

6- A solution was prepared by dissolving 15.6g of $CaBr_2$ (199.8g/mol), strong electrolyte, in 375g water. The density of the resulting solution was 1.04g/mL. the molarity of Br^- in this solution is:
a) 0.347M b) 0.748M c) 0.208M d) 0.416M

7- One of the following solutions has the lowest freezing point:
a) 0.30m $MgCl_2$ b) 0.60m glucose
c) 0.24m $FeCl_3$ d) 0.50m KF

8- How many grams of glycerol (92g/mol) should be added to 60 g of water to decrease freezing point of solution to -2.5 °C. (for H_2O, T_f= 0°C, K_f = 1.86 °C/m)

a) 9.9 b) 7.4 c) 4.9 d) 12.4

The solution

1	**C-** 0.2 M Na_2SO_4
2	**B -** 1.3
3	**B -** 0.15 m Na_2SO_4
4	**D -** - 2.26 °C
5	**A -** 0.755 m
6	**C-** 294
7	**D-** 0.416 M
8	**D -** 0.50m KF
9	**B -** 7.4