Yazan R Alkhateeb

civil engineering

lab Chemistry 108

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Exp. 8 | Colligative Properities: Molar mass of non volatile solute.

* When a non-vol. solute is dissolved in Certain amount of solvent, some of physical Properities of solvent is changed such as: (Quantitative كمية)

- Freezing Point: decreasing (f.p. depression انخفاض)
- Boiling Point: increasing (B.p. elevation ارتفاع)
- Vapor Pressure: decreasing (V.p. lowering انخفاض)

* **Objective:** To determine the Molar mass of a non-volatile, non-electrolyte by observing the difference between the f.p. of solvent & Soln.

* The decreasing in f.p. of solvent is called f.p. depression (f.p.d) & represents by:

$$\Delta T_f = f.p._{\text{solvent}} - f.p._{\text{soln.}}$$

* $\Delta T_b = b.p._{\text{solvent}} - b.p._{\text{soln.}}$

* f.p.: Temp. at which the solid & liquid states are present at eq. at the atmos. pressure.

③

* Amount of solute in solvent ↑ inc. :

* f.p.d. ↑ inc. * f.p. ↓ dec.

* $\Delta T_f \propto m$ (Molality) $\Rightarrow$ $\Delta T_f = k_f \cdot m$

* $m = \dfrac{\text{moles solute}}{\text{mass solvent (kg)}} = \dfrac{\text{Mass solute}}{M.m_{\text{solute}} \cdot \text{Mass (kg)}_{\text{solvent}}}$ mol/kg

$$\Rightarrow \Delta T_f = k_f \frac{\text{Mass}_{\text{solute}}}{(M.m_{\text{solute}})\ \text{Mass}_{\text{solvent}}} \Rightarrow M.m_{\text{solute}} = \frac{k_f \cdot \text{Mass}_{\text{solute}}}{\Delta T_f \cdot \text{Mass}_{\text{solvent}}}$$

$= \ldots\ldots$ g/mol

$\boxed{* \Delta T_b = k_b \cdot m}$

* K_f : f.p.d constant for solvent : $C^\circ/m \Rightarrow C^\circ kg/mol$
* k_b : b.p.e constant for solvent مذاب
* If we have an [electrolyte solute] ⇒ متفكك

we will have van 't hoff factor (i) ⇒ معامل التفكك

which leads to: non-electr.: $\underline{i=1}$ ⇐ *

$\Delta T_f = \underline{\underline{i}}\, k_f \cdot m \Rightarrow \uparrow$ f.p.d ← $\boxed{\Delta T_f \uparrow}$: * مادة متفككة

* f.p. : درجة التجمد
* f.p.d (ΔT_f) : الانخفاض في درجة التجمد

$$\Delta T_f = T_{solvent} - T_{soln.}$$

(+)

(5) Q] Students prepared Two cyclohexane solutions Having the same mass of solute. However student 1 used 13 g of cyclohexane student 2 used 15 g. Which student will observe the larger freezing p.t. change? Explain

ΔT_f

sol

$$\Delta T_f = \frac{\cancel{K_f} \cdot \cancel{\text{Mass}}\ \text{solute}}{\cancel{\text{M.m}}_{\text{solute}} \left(\text{Mass}_{\text{solvent}}\right)}$$

$$\Rightarrow \uparrow \Delta T_f \propto \frac{1}{\text{Mass solvent} \downarrow}$$

Student 1 ✓

6)

Q) A 0.597 g sample of a non-electrolyte $i=1$ dissolves in $\boxed{20\ g}$ of cyclohexane. The f.p.d is 3.62 °C. What's the M.m of the non electrolyte? K_f cyclohexane = 20 °C kg/mol

sol $M.m_{solute} = \dfrac{k_f \cdot M_{solute}}{\Delta T_f (M_{solvent\ kg})}$

$M.m = \dfrac{20 * 0.597}{3.62\,(0.02)}$ $20*10^{-3}$

$M.m = 164.92$ g/mol

$C_{10}H_8 \Leftarrow \boxed{i=1}$ مركبات عضوية

مهم

* NaCl → $i = 2$
* $MgCl_2$ → $i = 3$
* $AlCl_3$ → $i = 4$

(+)

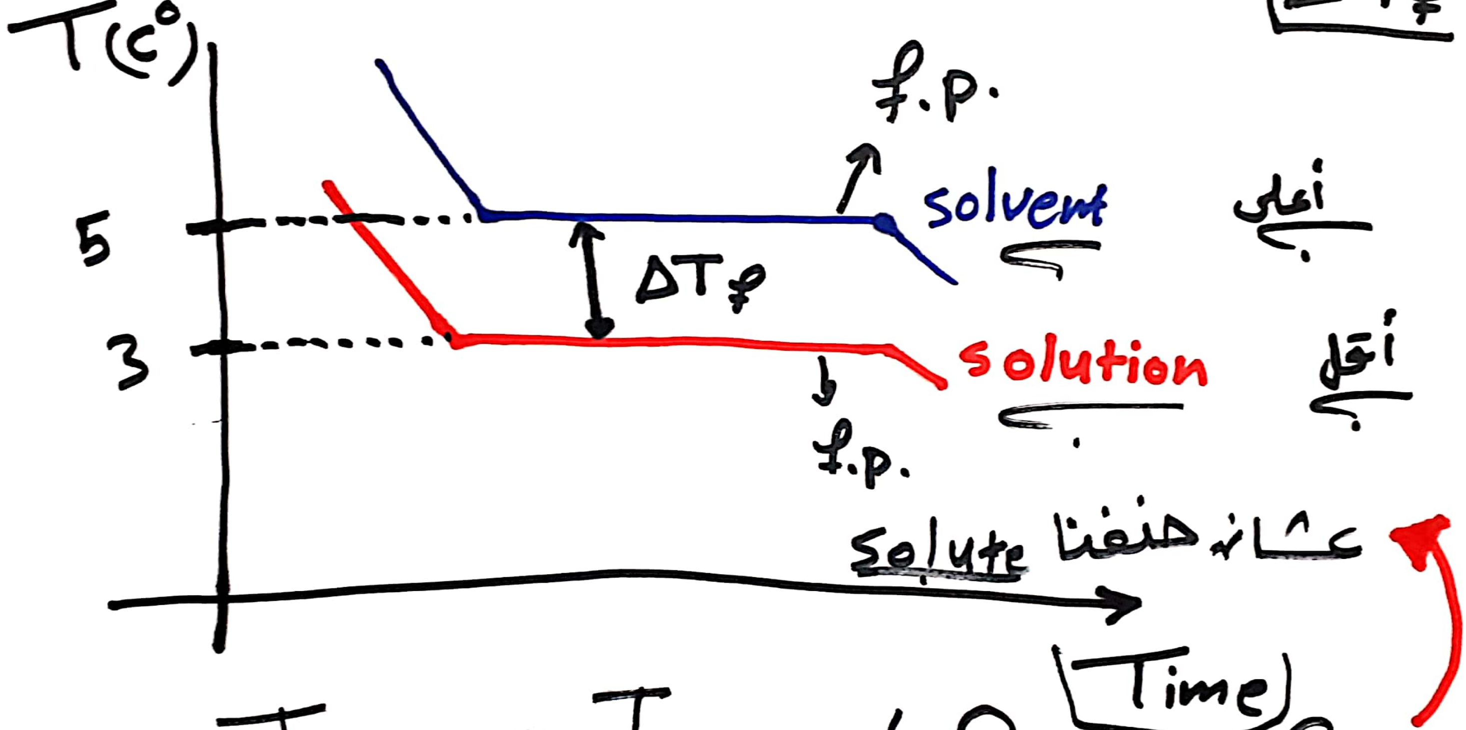
Q| Why should we keep Moving the solution when it freezes? To avoid super ~~cooling~~ cooling

* Cooling Curve : freezing point dep. as function of <u>Time</u>.

* Temp. remains constant at f.p. until the freezing is almost complete.

* ΔT_f is always <u>(+ve)</u>.

⑧ * Plot of Temp. Vs. Time You can determine $\boxed{\Delta T_f}$



$$\Delta T = T_{solvent} - T_{soln}$$
$$= 5 - 3 = \underline{2\ C^\circ}$$

$$f.p_{solvent} > f.p_{solvent + solute}$$

Scanned by CamScanner

(9)

Q) If the soln's f.p. is erroneously read 0.2°c lower than it should be, will the unknown's calculated Molar Mass be Too low OR Too High? Explain!!

sol) $$M.m_{\text{solute}} = \frac{K_f \cdot \text{Mass}_{\text{solute}}}{\Delta T_f \cdot \text{Mass (kg)}_{\text{Solvent}}}$$

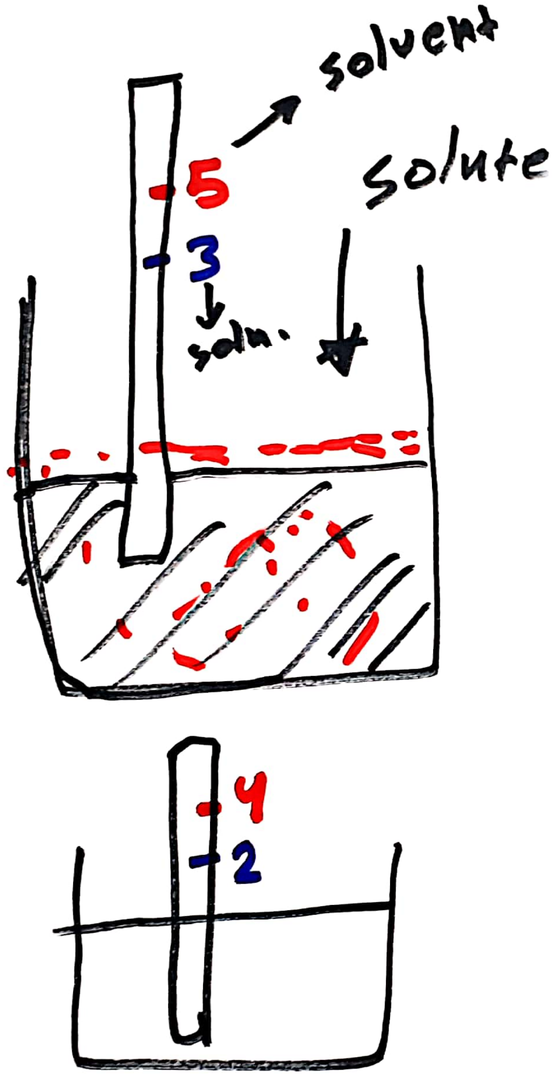
∴ M.m dec

$$\uparrow \Delta T_f = T_{\text{solvent}} - T_{\text{soln.}} \downarrow \Rightarrow \boxed{\Delta T_f \uparrow}$$

Q) If Thermo. reads 0.2 c° lower than the True Value : NO ef.

⇒ No effect

9*



$\Delta T_f = 2$

1 C° lower

$\Delta T_f = 2$

(15) Q] How will the f.p. change of cyclohexane be affected (Compared with the f.p. change by a non-volatile, non-associating & non-dissociating solute) by:

غير متطاير

غير مرتبط (سنجل) — غير متفكك

$i = 1$

A] A non-vol. solute that dissociates? Explain!!

تفكك

* $\Delta T_f = \boxed{i}\, k_f \cdot m$

$\uparrow i \Rightarrow \Delta T_f \uparrow$ inc.

(11)

$\boxed{B}$ Two solutes that react according to the equation $A + B \rightarrow C$? Explain!!

$$\begin{array}{ccccc} A & + & B & \rightarrow & C \\ 1 & & 1 & & 1 \\ i=1 & & i=1 & & i=1 \end{array}$$

$$\underline{\underline{i=2}} \longrightarrow i=1$$

$i \downarrow \Rightarrow \Delta T_f \downarrow$ <u>dec</u>

$\boxed{C}$ If equation $C \rightarrow A + B$? Explain!!

$$\begin{array}{ccccc} C & \rightarrow & A & + & B \\ 1 & & 1 & & 1 \\ i=1 & & & & \end{array}$$

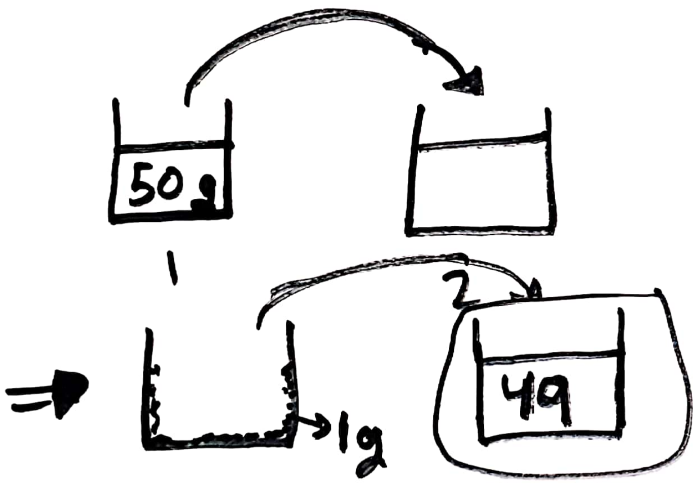
$$i=1 \longrightarrow i=2$$

$i \uparrow \Rightarrow \Delta T_f \uparrow$ inc.

?

(12) Q) If Some solute adheres to the test tube's wall in Part B.1, is the f.p. change ΔT_f greater OR less than it should be? Explain!!

sol) $\downarrow \Delta T_f = \dfrac{\text{Mass solute}\downarrow \cdot k_f}{\text{M.m solute} \cdot \text{Mass solvent (kg)}}$



ΔT_f dec

less

⑬ * True OR false :

[T] If the test tube contains an insoluble impurity, Then the calculated Molar Mass will be no effected.

[T] If the thermometer reading is always 1.5 °C higher than the correct Temp., The calculated Molar Mass will be not effected.

(14)

$\boxed{F}$ The f.p of soln. had been incorrectly read 0.6°c higher than the true f.p. , The calculated Molar Mass will be lower than ~~Act.~~ Actual.

$\therefore \Delta T_f \downarrow$ $\quad \therefore$ M.m $\uparrow$

$\boxed{F}$ The f.p.d of 0.2 Mole of NaCl ($i=2$) in 10 g of water is lower than the f.p.d of 0.2 mol $C_{10}H_8$ ($i=1$) in 10 g of water.

$\boxed{\Delta T_f = i\, k_f}$ $\dfrac{\cancel{\text{mole solute}}}{\cancel{\text{Mass solvent}}}$

k_f → solvent

$i \propto \Delta T_f$

$$\boxed{\Delta T_{f\,NaCl} > \Delta T_{C_{10}H_8}}$$

(15) Q) A soln. of 3.33 g [Mass solute] of unknown in 50 g [Mass solvent] of water freezes at -0.773 °c. What's the Molecular weight of the unknown? $K_f = 1.86$ C°/molal

verb

sol 1) 120 ~~2) 160~~ 3) 80 4) 100

M.m

* $T_{soln.} = -0.773$ C°

* $T_{solven\,(w)} = 0$ C°

$\Rightarrow \Delta T_f = 0 - (-0.773)$

$= 0.773$ C°

16

Sol

$$* \; M.m_{solute} = \frac{k_f \cdot M_{solute}}{\Delta T_f \cdot M_{solvent\,(kg)}}$$

$$= \frac{(1.86)(3.33)(1)^{\to i}}{(0.773)(0.05)}$$

$$M.m = 160.25 \text{ g/mol}$$

Yazan R Alkhateeb