Molal concentration (m)

Molal concentration (m): number of moles of solute per kilogram of solvent, (not per liter of solution). Molality does not change with temperature and is used for physicochemical measurements.

التركيز المولي (m): عدد مولات المذاب لكل كيلوجرام من المذيب،(وليس لكل لتر من المحلول).لا تتغير المولالية مع درجة الحرارة وتستخدم في القياسات الفيزيوكيميائية.

او تمثل عدد ملات المذاب في 1000 غم من المذيب.

Molality (m) $(\frac{mole}{Kg}) = \frac{no.of\ \ mol\ (solute)}{wt.of\ \ solvent\ (Kg)}$
Molality (m) $(\frac{mole}{Kg}) = \frac{wt\ (g)}{M.wt\ (\frac{g}{mol})} \times \frac{1000(\frac{g}{Kg})}{wt\ (g)}$
الوحدات Unit of Molality (m)= $\frac{mole}{Kg} = \frac{mmol}{g}$
Kg =1000 g
mol =1000 mmol

Example (1): Calculate the molal concentration for a solution preparing from mixing 4 g NaOH with 500 g water.(Na =23 g/mol, O=16 g/mol, H=1 g/mol)

Solution

Mwt NaOH = 23+16+1= 40 g/mol

$$\text{Molality (m)} = \frac{wt\ (g)}{M.wt\ \left(\frac{g}{mol}\right)} \times \frac{1000\left(\frac{g}{Kg}\right)}{wt\ (g)}$$

$$\text{Molality (m)} = \frac{4\ (g)}{40\ \left(\frac{g}{mol}\right)} \times \frac{1000\left(\frac{g}{Kg}\right)}{500\ (g)} = 0.2\ \text{m}$$

Example (2): Calculate the molality and Molarity concentration of a solution consisting of 0.5 mole solute in 200 g of solvent, the density of the solution is 1.02 g/mL, and the Mwt of the solute is 67 g/mole.

Solution:

لدينا المعطيات وهي عدد مولات المذاب 0.5 mole solute / وزن المذيب 200 g of solvent / كثافة المحلول الكليdensity 1.02 g/mL / الوزن الجزيئي للمذاب 67 g/mole

المطلب الاول استخراج المولالية

Kg=1000g $\Longrightarrow = \frac{200}{1000} = 0.2\ Kg$

$$\text{Molality (m)} \left(\frac{mole}{Kg}\right) = \frac{no.of\ \ mol\ (solute)}{wt.of\ solvent\ (Kg)} = \frac{0.5\ mol}{0.2\ Kg} = 2.5\ mol/Kg$$

المطلب الثاني استخراج المولارية :

$$\text{M}\left(\frac{\text{mole}}{\text{L}}\right) = \frac{\text{wt (g) solute}}{\text{M.wt (g/mole)}} \times \frac{1000\left(\frac{mL}{L}\right)}{V(mL)}$$

يجب استخراج وزن المذاب من قانون المول

$$\text{Mole} = \frac{weig\ ht\ (g)}{Formula\ \ weig\ ht\ \left(\frac{g}{mole}\right)}$$

$$0.5\ \text{mol} = \frac{weig\ ht}{67\ \left(\frac{g}{mole}\right)}$$

$$\text{Wt of solute} = 33.5\ \text{g}$$

المحلول يتكون من =مذاب + مذيب

wt of solution = wt of solvent + wt of solute = 200 +33.5 = 233.5 g

$$\text{Density of solution} = \frac{weig\ ht}{Volume}$$

$$1.02\ \text{g/mL} = \frac{233.5\ \text{g}}{Volume}$$

$$\text{Volume of solution} = 228.92\ \text{mL}$$

$$M= \frac{33.5\ g}{67(g/mole\ )} \times \frac{1000(\frac{mL}{L})}{228.92(mL)}$$

M= 2.18 mol/L

Example (3): Calculate the density of a solution consisting of 15 g solute in 400 g of solvent, the Molarity of this solution is 0.4 M, and the Mwt of the solute is 100 g/mole.

Solution:

$$M(\frac{mole}{L}) = \frac{wt\ (g)\ solute}{M.wt\ (g/mole\ )} \times \frac{1000(\frac{mL}{L})}{V(mL)}$$

$$0.4 = \frac{15\ (g)}{100\ (g/mole\ )} \times \frac{1000}{V}$$

$$V= \frac{15*1000}{0.4*100} = 375\ mL$$

المحلول يتكون من =مذاب + مذيب

wt of solution = wt of solvent + wt of solute = 15 +400 = 415 g

$$\text{Density of solution} = \frac{weight}{Volume}$$

$$\text{Density of solution} = \frac{415\ g}{375\ mL}$$

Density= 1.067 g/mL

Mole fraction concentration(X):

Mole fraction concentration(X):-The ratio between number of mole for solute or solvent to solution, the terms used in physical chemistry (phases equilibrium for example).

تركيز الكسر المولي (X) **:** النسبة بين عدد مولات المذاب أو المذيب إلى المحلول(مجموع مولات مذاب + مذيب)، هذا المصطلح يستخدم بكثرة في الكيمياء الفيزيائية (مثال توازن الأطوار).

Mole fraction for solute $(\mathbf{X_1})$ $= \frac{\textbf{no. mole solute } (\mathbf{n_1})}{\textbf{no. mole solute } (\mathbf{n_1}) + \textbf{no. mole solvent } (\mathbf{n_2})}$
Mole fraction for solvent $(\mathbf{X_2})$ $= \frac{\textbf{no. mole solvent } (\mathbf{n_2})}{\textbf{no. mole solute } (\mathbf{n_1}) + \textbf{no. mole solvent } (\mathbf{n_2})}$
Mole $= \frac{weight\ (g)}{Formula\ \ weight\ (\frac{g}{mole})}$ $X_1 + X_2 = 1$ unit
Density of solution $= \frac{weight}{Volume}$

***Example* (4):-**One litter of acetic acid solution contain 80.8 g of acetic acid, the solution density 1.00978 **g/cm^3**. Calculate the mole fraction(X1) for the solute and mole fraction (X2) for the solvent in the solution(M. wt of CH3COOH= 60g/mol)(Mwt water 18 g/mol).

***Solution*:**

(**cm^3 = mL**), density 1.00978 **g/ml**

من قانون الكثافة نستخرج وزن المحلول

L=1000 ml, volume =1000ml

$$\text{Density of solution} = \frac{weight}{Volume}$$

$$1.00978 = \frac{wt}{1000\ mL}$$

Wt = 1009.78 g solution

المحلول يتكون من =مذاب + مذيب

Wt of solution= wt of water(solvent) + wt of CH3COOH(solute)

1009.78= wt of water+ 80.8 g

Wt of water = 928.98 g

$$\text{Mole} = \frac{weig\ ht\ (g)}{Formula\ \ weig\ ht\ (\frac{g}{mole})}$$

$$\text{Mole}_{CH3COOH} = \frac{80.8(g)}{60(\frac{g}{mol})} = 1.34\ mol$$

$$\text{Mole}_{H2O} = \frac{928.98\ g}{18\ (\frac{g}{mol})} = 51.61\ mol$$

$$\textbf{Mole fraction for solute } (\mathbf{X_1}) (= \frac{\textbf{no. mole solute } (\mathbf{n_1})}{\textbf{no. mole solute } (\mathbf{n_1}) + \textbf{no. mole solvent } (\mathbf{n_2})}$$

$$\textbf{Mole fraction for CH3COOH } (\mathbf{X_1}) = \frac{1.34\ mol}{1.34\ mol + 51.61\ mol} = 0.025$$

$$\text{Mole fraction for solvent } (X_2) = \frac{\text{no. mole solvent}}{\text{no. mole solute } (n_1) + \text{no. mole solvent } (n_2)}$$

$$\text{Mole fraction for } H2O\ (X_2) = \frac{51.61\ mol}{1.34\ mol + 51.61\ mol} = 0.975$$

$$X_1 + X_2 = 1\ unit = 0.025 + 0.975 = 1.00\ unit$$

***Example*(5):-**Calculate the mole fraction(x) of water in a mixture consisting of 9.0 gm water, 120 gm Acetic Acid, and 115 gm ethyl alcohol CH_3CH_2OH? (M. wt of CH3COOH= 60g/mol)(Mwt water 18 g/mol) (Mwt ethyl alcohol 46 g/mol).

***Solution*:-**

$$\text{Mole} = \frac{weig\,ht\ (g)}{Formula\ \ weig\,ht\ (\frac{g}{mole})}$$

$$\text{Mol.}_{\text{ water}} = \frac{9}{18} = 0.5\ mol$$

$$\text{Mol.}_{\text{ acetic acid}} = \frac{120}{60} = 2\ mol$$

$$\text{Mol.}_{\text{ ethyl alcohol}} = \frac{115}{46} = 2.5\ mol$$

Sum of mole = 0.5 + 2.0 + 2.5 = 5.0 mole

$$\text{Mole fraction for water } \mathbf{X} = \frac{\text{no. mole water } (n_1)}{\text{sum of mole}}$$

$$\text{Mole fraction for water } \mathbf{X} = \frac{0.5 \text{ mole}}{5.0 \text{ mole}} = 0.1$$

Homework:1- Calculate the mole fraction(x) of CH3COOH(acetic acid)

2- Calculate the mole fraction(x) of ethyl alchol.

p-Functions

p-Functions

Scientists frequently express the concentration of a species in terms of its p-function, or p-value. The p-value is the negative logarithm (to the base 10) of the molar concentration of that species. Thus, for the species X,

$$\mathbf{pX = -\log [X]}$$

As shown by the following examples, p-values offer the advantage of allowing concentrations that vary over ten or more orders of magnitude to be expressed in terms of small positive numbers.

قيمة او دالة p : هي اللوغاريتم السالب (للاساس 10)

Example (**6**): Calculate the p-value for each ion in a solution that is 2.00×10^{-3} M in NaCl and 5.4×10^{-4} M in HCl.

Solution

$$\mathbf{HCl \longrightarrow Cl^{-1} + H^{+1}}$$

5.4×10^{-4} M $\quad$ 5.4×10^{-4} M $\quad$ 5.4×10^{-4} M

$$\mathbf{pH = -\log [H^+] = -\log (5.4 \times 10^{-4}) = 3.27}$$

$$\mathbf{NaCl \longrightarrow Cl^{-1} + Na^{+1}}$$

2.00×10^{-3} M $\quad$ 2.00×10^{-3} M $\quad$ 2.00×10^{-3} M

$$\mathbf{pNa = -\log (2.00 \times 10^{-3}) = -\log 2.00 \times 10^{-3} = 2.699}$$

تركيز ايون الكلور في المحلول هو مجموع تراكيز الكلور في HCl و NaCl

$$\mathbf{[Cl^-] = 2.00 \times 10^{-3}\ M + 5.4 \times 10^{-4}\ M}$$

$$\mathbf{= 2.00 \times 10^{-3}\ M + 0.54 \times 10^{-3}\ M = 2.54 \times 10^{-3}\ M}$$

$$\mathbf{pCl = -\log 2.54 \times 10^{-3}\ M = 2.595}$$

Example (7): Calculate the molar concentration of Ag^+ in a solution that has a pAg of 6.372.

Solution:

$pAg = -\log [Ag^+] = 6.372$

$\log [Ag^+] = -6.372$

$[Ag^+] = 4.246 \times 10^{-7} = 4.25 \times 10^{-7}$ M

Example (8): What is pNa for solution of 1.76×10^{-3} M Na_3PO_4?

Solution:

نستخدم علاقة مول مع التركيز

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

1mol — 3 mol

1.76×10^{-3} M — y

(Y) concentration of $[Na^{+1}] = 1.76\times10^{-3}\times3 = 5.28\times10^{-3}$ M

$pNa^+ = -\log[Na^+] = -\log(5.28\times10^{-3}) = 2.277$

Exercise

1. Convert the following p-functions to molar concentrations:

(a) pH = 9.67, (b) pLi = -0.221 , (c) pOH = 0.135

(d) pNO3 = 7.77

2. Calculate the p-functions for each ion in a solution that is: 4.8×10^{-8} M in $Zn(NO_3)_2$ and 5.6×10^{-7} M $Cd(NO_3)_2$
3. One liter of a 500 mg/L solution of $KClO_3$ contains how many grams K^+?

امثلة ضرورية للامتحان

Homework: A mixture contains 10 g of methane (CH4), 20 g of oxygen (O_2), and 30 g of carbon dioxide (CO_2). Calculate the mole fraction of oxygen and methane. **(M.WT** CH_4**= 16 g/mol,** O_2**=32 g/mol,** CO_2**=44 g/mol)**

Homework: What is the mole fraction of glucose ($C_6H_{12}O_6$) in a solution made by dissolving 18 g of glucose in 100 g of water?**(Mwt glucose (**$C_6H_{12}O_6$**)=** 180 g/mol**,** H_2O**=18 g/mol)**

Homework: Calculate the mole fraction of ethanol (C_2H_5OH) and water in a solution containing 46 g of ethanol and 54 g of water**? (Mwt** ethanol (C_2H_5OH)= 46 g/mol**,** H_2O**=18 g/mol)**

Homework:A 500 mL solution contains 25 g of sodium chloride (NaCl). The solution's density is 1.02 g/mL. Calculate the mole fraction of NaCl (solute) and water (solvent). (M.wt of NaCl = 58.44 g/mol, M.wt of H_2O = 18 g/mol)

Homework:A 2 L solution of sulfuric acid (H_2SO_4) and contains 196 g of H_2SO_4. The solution's density is 1. 2 g/mL . Calculate the mole fraction of H_2SO_4 and water. (M.wt of H_2SO_4 = 98 g/mol, M.wt of H_2O = 18 g/mol)

Homework: 250 cm^3 of a solution contains 10 g of potassium hydroxide (KOH). The solution density is 1.05 g/cm^3. Calculate the mole fraction of KOH and water. (M.wt of KOH = 56.11 g/mol, M.wt of H2O = 18 g/mol)

Homework Calculate the molality of a solution prepared by dissolving 10 g of glucose (C6H12O6) in 200 g of water. (Molar mass of glucose = 180 g/mol)

Homework: A solution is made by dissolving 25 g of potassium chloride (KCl) in 150 g of water. Calculate the molality of the KCl solution. (Molar mass of KCl = 74.5 g/mol)

Homework: What is the molality of a solution containing 5 g of urea (CH_4N_2O) in 100 g of ethanol? (Molar mass of urea = 60 g/mol)

Homework: Calculate the molality and molarity of a solution containing 1 mole of solute dissolved in 500 g of solvent. The density of the solution is 1.10 g/mL, and the molar mass of the solute is 50 g/mol.

Homework: A solution is prepared by dissolving 0.25 moles of NaOH(solute) in 100 g of ethanol. The density of the resulting solution is 0.95 g/mL, and the molar mass of the NaOH is 40 g/mol. Calculate the molality and molarity.

Homework: Calculate the molality and molarity of a solution made by dissolving 0.75 moles of a urea (CH_4N_2O) in 250 g of solvent. The solution has a density of 1.05 g/mL, and the molar mass of the urea (CH_4N_2O) is 60 g/mol.

Homework: What is pK for a solution of 2.5 x 10^{-4} M K_2SO_4?

Homework: Calculate pCl for a solution containing 1.2 x 10^{-2} M $MgCl_2$.

Homework: A solution has a concentration of Ca^{2+} ions of 8.7 x 10^{-5} M. What is the pCa?

Homework: A solution is 1.5 × 10^{-2} M in $CaCl_2$ and 3.0 × 10^{-3} M in KCl. Calculate pCa and pCl.

Homework: A solution contains 4.0 × 10^{-4} M in $Al(NO_3)_3$ and 1.0 × 10^{-3} M in HNO_3. Calculate pAl and pNO_3.

ملخص القوانين		
name	**unit**	**symbol**
molarity	$\frac{moles\ solute}{liters\ solution}$	M
formality	$\frac{number\ FW\ \ solute}{liters\ solution}$	F
normality	$\frac{number\ Eq\ \ solute}{liters\ solution}$	N
molality	$\frac{moles\ solute}{Kg\ solvent}$	m
Weight%	$\frac{g\ \ solute}{100\ g\ \ solution}$	w/w%
Volume%	$\frac{ml\ solute}{100\ ml\ \ solution}$	v/v%
Weight-to-volume%	$\frac{g\ \ solute}{100\ ml\ \ solution}$	w/v%
Parts per million	$\frac{g\ \ solute}{10^6 g\ \ solution}$	ppm
Parts per billion	$\frac{g\ \ solute}{10^9 g\ \ solution}$	ppb
$FW = formula\ weight$		
Eq= equivalent weight		

Exercises

1. How many moles and millimoles of benzoic acid (Mw = 122.1 g/mol) are contained in 20.0 g of the pure acid?
2. How many grams of Na^+ (22.99 g/mol) are contained in 25.0 g of Na_2SO_4 (142.0 g/mol)?
3. Describe the preparation of 500 mL of 0.0740 M Cl^- solution from solid $BaCl_2.2H_2O$ (244.3 g/mol).
4. Find the number of millimoles of the indicated species in: a) 57 mg of P_2O_5 b) 12.92 g of CO_2 c) 40.0 g of $NaHCO_3$ d) 850 mg of $MgNH_4PO_4$
5. What is the mass in grams of: a) 1.1 mol of KBr b) 20.1 mmol of PbO c) 3.76 mol of $MgSO_4$
6. Calculate the p-value for each of the indicated ions in the following: a) Ba^{2+}, Mn^{2+}, and Cl^- in a solution that is 7.65 x 10^{-3} M in BaCl2 and 1.54 M in MnCl2. b) Cu2+, Zn2+, and NO3- in a solution that is 4.78 x 10^{-2} M in $Cu(NO_3)_2$ and 0.104 M in $Zn(NO_3)_2$. c) H^+, Ba^{2+}, and ClO4$^-$ in a solution that is 3.35 x 10^{-4} M in $Ba(ClO_4)_2$ and 6.75 x 10^{-4} M in $HClO_4$.
7. Sea water contains an average of 1.08 x 10^3 ppm of Na^+ and 270 ppm of $SO4^{2-}$. Calculate: (a) the molar concentrations of Na^+ and $SO4^{2-}$ (b) the pNa and pSO4 for sea water, given that the average density of sea water is 1.02 g/mL.
8. A solution was prepared by dissolving 1210 mg of K3Fe(CN)$_6$ (329.2 g/mol) in sufficient water to give 775 mL. Calculate: (a) the molar analytical concentration of $K_3Fe(CN)_6$ (b) the molar concentration of K^+ (c) the molar concentration of $Fe(CN)6^{3-}$ (d) the weight/volume percentage of $K_3Fe(CN)_6$ (e) the number of millimoles of $Fe(CN)6^{3-}$ (f) the number of millimoles of K^+ (g) pK for the solution (h) pFe(CN)6 for the solution
9. A 12.5% (w/w) $NiCl_2$ (129.61 g/mol) solution has a density of 1.149 g/mL. Calculate: (a) the molar concentration of $NiCl_2$ in this solution (b) the mass in grams of $NiCl_2$ contained in each liter of this solution

10. A solution containing 10.0 mmol $CaCl_2$ is diluted to 1 L. Calculate the number of grams of $CaCl_2.2H_2O$ per milliliter of the final solution.

11. Calculate the grams of each substance required to prepare the following solutions: (a) 250 mL of 0.100 M KOH (b) 1.00 L of 0.0275 M $K_2Cr_2O_7$ (c) 500 mL of 0.0500 M $CuSO_4$

12. How many milliliters of concentrated hydrochloric acid, 38.0% (wt/wt), specific gravity 1.19, are required to prepare 1 L of a 0.100 M solution?

13. Calculate the molar concentrations of solutions of each of the following: (a) 1.00 mg/L $AgNO_3$ (b) $Al_2(SO_4)_3$ (c) CO_2 (d) $(NH_4)_4Ce(SO_4)_4.2H_2O$ (e) HCl (f) $HClO_4$

14. How many grams NaCl should be weighed out to prepare 1 L of a 100 mg/L solution of: (a) Na^+ (b) Cl^-

15. What volume of 0.50 M H_2SO_4 must be added to 65 mL of 0.20 M H_2SO_4 to give a final solution of 0.35 M?

16. What is the molar concentration of NO^{3-} in a solution prepared by mixing 50.0 mL of 0.050 M KNO_3 with 40.0 mL of 0.075 M $NaNO_3$? What is pNO3 for the mixture?

17. For each of the following, explain how you would prepare 1.0 L of a solution that is 0.10 M in K^+. Repeat for concentrations of 1.0 x 10^2 ppm K^+ and 1.0% w/v K^+. (a) KCl (b) K_2SO_4 (c) K3Fe(CN)$_6$

18. A solution was prepared by dissolving 5.76 g of $KCl.MgCl_2.6H_2O$ (277.85 g/mol) in sufficient water to give 2.000 L. Calculate: (a) the molar analytical concentration of KCl.MgCl2 in this solution (b) the molar concentration of Mg^{2+} (c) the molar concentration of Cl- (d) the weight/volume percentage of $KCl.MgCl_2.6H_2O$

19. Explain how to make one liter of a 1.25 molal sodium hydroxide solution.

20. What is the molarity of a solution made when 52 grams of potassium sulfate are diluted to a volume of 4100 mL?

21. The density of ethylene glycol (antifreeze, HOCH2CH2OH) is 1.09 g/mL. How many grams of ethylene glycol should be mixed with 375 mL of water to make a 7.50% (v/v) mixture?

22. Find the volume of a 0.75 M solution if it contains 39 grams of potassium hydroxide.

23. A 38.2 g of borax ($Na_2B_4O_7.10H_2O$) is dissolved in 1080 g of water. Calculate the molarity, normality, %(wt/wt), %(wt/v), molality, and mole fraction of this solution. The density of the solution = 1.01 g/mL.

24. Sea water contains an average of 1.08×10^3 ppm of Na^+ and 270 ppm of $SO4^{2-}$. Calculate: (a) the molar concentrations of Na+ and SO_4^{2-} given that the average density of sea water is 1.02 g/mL. (b) the pNa and pSO_4 for sea water.

25. How many milliliters of 0.10 M H_2SO_4 must be added to 50 mL of 0.10 M NaOH to give a solution that is 0.050 M in H_2SO_4?

26. A solution was prepared by dissolving 1210 mg of $K_3Fe(CN)_6$ (329.2 g/mol) in sufficient water to give 775 mL. Calculate: (a) the molar concentration of $K_3Fe(CN)_6$ (b) the molar concentration of K^+ (c) the molar concentration of $Fe(CN)_6^{3-}$ (d) the weight/volume percentage of $K_3Fe(CN)_6$ (e) the number of millimoles of K+ in 50.0 mL of this solution. (f) ppm $Fe(CN)_6^{3-}$ (g) pK for the solution. (h) $pFe(CN)_6$ for the solution.

27. Describe the preparation of 750 mL of 6.00 M H_3PO_4 from the commercial reagent that is 86% H_3PO_4 (w/w) and has a specific gravity of 1.71.