Methods of expression of concentrations

طرائق التعبير عن التراكيز

1-Molarity (M):

Number of grams molecular weight (moles) of solute per liter of solution.

المولارية :- وتعرف بأنها عدد الاوزان الجزيئية الغرامية (moles) من المادة المذابة في لتر من المحلول

$$M = \frac{number\ of\ moles}{v(liter)} \quad \text{------} \quad M = \frac{n}{V(liter)}$$

(where $n = \frac{Wt}{Mwt}$ ---------- عدد المولات = $\frac{\text{الوزن}}{\text{الوزن الجزيئي}}$)

(or) $M = \frac{no.of\ millimoles}{V\ mL}$

$$\boxed{M = \frac{Wt}{M.Wt} x \frac{1000}{VmL}}$$

$$M = \frac{wt(gm)}{M.Wt\left(\frac{gm}{mol}\right)} / L = mole/L)$$

Wt يمثل وزن المادة المذابة بالغرام ، eq.Wt يمثل الوزن المكافئ للمادة المذابة ، VmL حجم المحلول بالملليلتر .

Units: mole/L , ole/mL

Ex: How many grams of 0.125 M $AgNO_3$ used to prepare 500ml of its solution.

(M.Wt= 169.9 g/mole)

$$M = \frac{Wt}{M.Wt} x \frac{1000}{VmL} \quad \Rightarrow \quad 0.125 = \frac{Wt}{169.9} x \frac{1000}{500}$$

$$Wt = \frac{M\ x\ M.Wt x\ Vml}{1000}$$

$$Wt = \frac{0.125\ x\ 169.9 x\ 500}{1000} = 10.619\ g$$

Ex: Calculate the Molarity (M) of solution result from dissolving 20 g of Sodium hydroxide in 2 Litters of solution. **Na = 23 , O = 16 , H = 1**

$$M = \frac{n}{V(liter)} \qquad NaOH \quad M.Wt = 23 + 16 + 1 = 40g/mol$$

$$n = \frac{Wt}{M.Wt} = \frac{20}{40} = 0.5\ mole \qquad \frac{0.5}{2} = 0.25M$$

حل آخر

$$M = \frac{Wt}{M.Wt} x \frac{1000}{VmL} \Rightarrow M = \frac{20}{40} x \frac{1000}{2000} = 0.25M$$

$$M = \frac{Wt}{M.Wt} x \frac{1}{VL} \Rightarrow M = \frac{20}{40} x \frac{1}{2} = 0.25M$$

2-Normality(N):

Number of gram equivalent weight of solute per liter of solution .

العيارية (النورمالية) وتعرف بأنها عدد المكافئات الغرامية من المذاب في لتر من المحلول .

$$N = \frac{number\ of\ equialent}{V(liter)} \quad , \quad N = \frac{no.of\ eq}{V(\ liter)} \quad , \quad N = \frac{no.of\ meq}{V\ mL}$$

$$\frac{\text{الوزن بالغرام}}{\text{الوزن المكافئ}} = \text{عدد المكافئات الغرامية}, \qquad \frac{\text{عدد المكافئات الغرامية}}{\text{الحجم}} = N$$

$$N = \frac{Wt}{eq.wt} x \frac{1000}{VmL}$$

Units: **eq /L** , **meq/mL**

حيث ان :-

Wt يمثل وزن المادة المذابة بالغرام ، eq.Wt يمثل الوزن المكافئ للمادة المذابة ، VmL حجم المحلول بالمليلتر .

Ex: How many grams of 0.2 N Sodium carbonate in 250 ml solution . (M.Wt =106g / mole)

$$eq.wt(salt) = \frac{M.wt}{no.of\ cations\ x\ oxidation\ number\ of\ cations}$$

$$eq.wtNa_2co_3 \frac{106}{2\times1} = 53\ g/eq$$

$$N = \frac{Wt}{eq.wt} x \frac{1000}{VmL}$$

$$0.2 = \frac{Wt}{53} x \frac{1000}{250} \Rightarrow Wt = \frac{0.2x53x250}{1000} = 2.650g$$

Ex: Calculate the normality (N) of solution result from dissolving 0.5 g of $Cu(OH)_2$ in 100 mL of distilled water. (Cu =63.5 O=16 H=1)

SOL)

$[Cu(OH)_2]$ $M.wt = 63.5 + (2x16) + (2x1) = 97.5 g/mol_e$

$$eq.wt(base) = \frac{M.Wt}{no.of\ OH\ ions\ ready\ to\ substituted}$$

$$eq.wt = \frac{97.5}{2} = 48.75\ g/eq$$

$$N = \frac{Wt}{eq.wt}\ x\frac{1000}{VmL} \quad \Rightarrow \quad \frac{0.5}{48.75}\ x\frac{1000}{100} = 0.103N$$

3-Formality (F):

Number of gram formula weight of solute per liter of solution .

الفورمالية : هي عدد اوزان الصيغة الغرامية للمذاب في لتر من المحلول

$$F = \frac{number\ of\ formula\ weight}{V\ (liter)}$$

$$F = \frac{no.of\ milliformula\ weight}{VmL} \qquad F = \frac{\text{no. of m. fw}}{\text{VmL}}$$

$$\boxed{F = \frac{Wt}{g.fw}\ x\frac{1000}{VmL}}$$

حيث : Wt يمثل وزن المادة المذابة بالغرام ، fw يمثل الوزن الصيغة للمادة المذابة ، VmLحجم المحلول بالمليلتر .

Units: **fw/L , mfw/mL**

4-Molality(m):

Number of Moles of solute per Kilogram (1000g) of solvent.

المولالية : تمثل عدد مولات المذاب في كيلو غرام (**1000**غم) من المذيب.

$$m = \frac{number\ \text{of solute moles}}{Wt.solvent.(Kg)}$$

$$m = \frac{Wt}{M.Wt}\ x\ \frac{1000}{Wt.solvent.(g)}$$

Units: Mole/kg or mmole/g

Ex: Calculate the molality (m) of solution result from dissolving 5 g of Sodium hydroxide in 250 g of distilled water. (M.Wt=40g/mole)

$$n_{NaOH} = \frac{wt}{M.wt} = \frac{5g}{40\frac{g}{mole}} = 0.125\ mole$$

$$Kg = 1000mg \Rightarrow 250g = 0.250Kg$$

$$m = \frac{number\ of moles\ of\ solute}{Wt.solvent.(Kg)} = = \frac{0.125}{0.250} = 0.5m$$

or: $$m = \frac{Wt}{M.Wt} \times \frac{1000}{Wt.solvent(gm)} \qquad m = \frac{5}{40} \times \frac{1000}{250} = 0.5mmole/gm$$

5- Mole Fraction:

The ratio between the number of moles of solute or solvent to the total number of moles of solute or solvent .

الكسر المولي هو النسبة بين عدد مولات المذاب او المذيب الى العدد الكلي لمولات المذاب والمذيب .

$$X_1 = \frac{n_1}{n_1+n_2} \qquad X_2 = \frac{n_2}{n_1+n_2} \qquad \text{---------} \qquad (X_1+X_2 = 1)$$

X_1 يمثل الكسر المولي للمذاب X_2 يمثل الكسر المولي للمذيب n_1 عدد مولات المذاب n_2 عدد مولات المذيب

Ex: Calculate the mole fraction for A and B in its mixture if you know number of Moles of A = 18 moles and B= 40 moles .

$$X_1 = \frac{18}{18+40} = 0.310$$

$$X_2 = \frac{40}{18+40} = 0.690$$

or) $X_2 = 1.0 - 0.310 = 0.690$ (X_2 طريقة اخرى لحساب)

6- Percentage Ratio: النسبة المئوية

A- Weight Volume Percentage Concentration (weigh to volume percent ratio):

It is the number of grams of solute in 100ml of solution .

النسبة المئوية الوزنية الحجمية : عدد غرامات المذاب في 100ملليلتر من المحلول .

$$\%W/V = \frac{\text{Wt(g) of solute}}{\text{V(mL) of solution}} \times 100$$

$$\%W/V = \frac{\text{وزن المذاب بالغرام}}{\text{حجم المحلول بالملليلتر}} \times 100$$

ملاحظة : حجم المحلول = حجم المذاب + حجم المذيب

B- Volume Percentage Concentration(volume percent ratio) :

It is the number of milliliters of solute in 100 mL of solution

النسبة المئوية الحجمية : عدد ملليلترات المذاب في 100ملليلتر من المحلول .

$$\%\ V/V = \frac{\text{VmL of solute}}{\text{VmL of solution}} \times 100$$

$$\%\ V/V = \frac{\text{حجم المذاب بالملليلتر}}{\text{حجم المحلول بالملليلتر}} \times 100$$

ملاحظة : حجم المحلول = حجم المذاب + حجم المذيب

C- Weight Percentage Concentration (weight percent ratio):

It is the number of grams of solute 100 g of solution.

النسبة المئوية االوزنية : عدد غرامات المذاب في100غرام من المحلول .

$$\%W/W = \frac{\text{Wt (g) of solute}}{\text{Wt (g) of solution}} \times 100$$

$$\%W/W = \frac{\text{وزن المذاب بالغرام}}{\text{وزن المحلول بالغرام}} \times 100$$

ملاحظة : وزن المحلول = وزن المذاب + وزن المذيب

Ex1: Calculate the percentage ratio for solution result from dissolving 5 g of Sodium hydroxide in 0.25 L of solution

$$\%W/V = \frac{\text{Wtg of solute}}{\text{VmL of solution}} \times 100 = \frac{5}{250} \times 100 = 2\%$$

Ex2: Calculate the percentage ratio for solution result from addition of 200 mL of Methanol to 400 mL distilled water.

$$\%\ V/V = \frac{\text{VmL of solute}}{\text{VmL of solution}} \times 100$$

$$\%\ V/V = \frac{200}{200 + 400} \times 100 = 33.333\%$$

Ex3: Calculate the No. of g of glucose solution in 800 mL industrial solution, if its percentage ratio is 15%

$$\%W/V = \frac{\text{Wtg of solute}}{\text{VmL of solution}} \times 100$$

$$15 = \frac{Wt_g \text{ of glucose}}{800} \times 100 = 120g$$

7-Parts per thousand (ppt) جزء لكل الف جزء

$$ppt = \frac{Wt\ of\ solute(\text{وزن المذاب})}{Wt\ of\ solution(\text{وزن المحلول})} \times 10^3$$

$$(\text{or}) \quad ppt = \frac{Wt\ of\ solute\ (g)}{Volume\ of\ solution(L)} = \frac{mg}{mL}$$

8-Parts per million (ppm) جزء لكل مليون جزء

$$ppm = \frac{Wt.of\ solute(\text{وزن المذاب})}{Wt.of\ solution(\text{وزن المحلول})} \times 10^6$$

$$(\text{or}) \quad ppm = \frac{Wt\ of\ solute\ (mg)}{Volume\ of\ solution\ (L)} = \frac{\mu g}{mL}$$

9-Parts per billion)ppb جزء لكل بليون جزء

$$ppb = \frac{Wt\ of\ solute(\text{وزن المذاب})}{Wt\ of\ solution(\text{وزن المحلول})} \times 10^9$$

$$(\text{or}) \ ppb = \frac{Wt\ of\ solute(\mu g)}{Volume\ of\ solution(L)} = \frac{ng}{mL}$$

Gram (g) = 1000 Milligram (mg)

Milligram (mg) =1000 Microgram (µg)

Microgram (µg) = 1000 Nangram(ng)

Liter (L) = 1000 Milliliter (mL)

Milliliter (mL) = 1000 Microliter(µL)

Microliter(µL) = 1000 Nanoliter(nL)

part	iquid in liquid	Solid in liquid	Solid in solid
ppt	mL/L = µL/mL	g/L = mg/mL	g/kg = mg/g
ppm	µL/L = nL/mL	mg/L = µg/mL	mg/kg = µg/g
ppb	nL/L	µg/L = ng/mL	µg/kg = ng/g

10- يمكن استخدام القوانين الاتية لإيجاد تراكيز المحاليل السائلة من معرفة نسبتها المئوية ووزنها النوعي :

$$\mathbf{M} = \frac{\%\times sp.gr \times 1000}{Mwt} \qquad \frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times 1000}{\text{الوزن الجزيئي}} = M$$

$$N = \frac{\% \times sp.gr \times 1000}{eg.wt} \qquad \frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times 1000}{\text{الوزن المكافئ}} = N$$

$$F = \frac{\% \times sp.gr \times 1000}{g.fw} \qquad \frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times 1000}{\text{وزن الصيغة}} = F$$

Also these laws:

$$N_1 V_1 = N_2 V_2 \quad , \quad M_1 V_1 = M_2 V_2 \quad , \quad F_1 V_1 = F_2 V_2$$

$$\text{Density (d)} = \frac{Wt\ (g)}{V(mL)} \quad \text{(UNIT : g / mL or Kg /L)} \qquad \left(\text{الكثافة} = \frac{\text{الكتلة بالغرام}}{\text{الحجم بالملليلتر}} \right)$$

$$\text{Specific gravity (sp. gr)} = \frac{density\ of\ substance}{density\ of\ water}$$

ملاحظة : الوزن النوعي للمادة خالي من الوحدات

$$\text{الوزن النوعي} = \frac{\text{كثافة المادة}}{\text{كثافة الماء}}$$

Ex1: Calculate the normality (N) of solution result from dilution 100mL of 0.25 N Nitric Acid to 250mL

$N_1V_1 = N_2V_2$

$0.25 \times 100 = N_2 \times 250 \quad \Rightarrow \quad N_2 = 0.1N$

Ex2: How can you prepare 0.1 N of 250 mL Sulfuric Acid if you know Sp. Gr.

1.84, percentage ratio 96% and M.Wt. 98 g/mole

$$eq.wt(acid) = \frac{M.Wt}{no.\ of\ H\ ions\ ready\ to\ substituted}$$

$$\frac{98}{2} = 49$$

$$N = \frac{\%\ x\ sp.gr\ x\ 1000}{eq.wt} = \frac{0.96\ x\ 1.84\ x\ 1000}{49} = 36.049N$$

$N_1\ V_1 = N_2\ V_2$

$36.049 \times V_1 = 0.1 \times 250$

$V_1 = 0.694$ mL

By add 0.694 mL of acid and in 250 mL volumetric flask then complete the volume up to the mark with distilled water.

Q(خارجي) How can you prepare 0.5 N of 500 mL Hydrochloric Acid if you know Sp. Gr. 1.184, percentage ratio 37% and A.Wt. H=1 Cl=35.5

Solved questions on concentrations

Q1- What is the formal concentration of NaCl solution (M.Wt 58.5 g/mole) if 0.1753 g of the salt dissolved in sufficient amount of water to give 240mL of solution?

$$F = \frac{Wt}{g.\text{fw}} x \frac{1000}{VmL}$$

$$F = \frac{0.1735}{58.5} x \frac{1000}{240}$$

$$= 0.0125\, F\, (mfw/mL)$$

Q2- Calculate the molality (m) of a solution which is 10% by weight NaOH (M.Wt 40g/mole), supposing that we take 100gm of solution.

Sol.

In 100 g of solution: **10g NaOH + 90 g H_2O**

$$m = \frac{Wt}{M.Wt} \; x \; \frac{1000}{Wt.solvent.(g)}$$

$$\frac{10}{40} \times \frac{1000}{90} = 2.778\, m(mmole/g)$$

Q3- Calculate the molarity and normality of a solution containing 10.6g of sodium carbonateNa_2CO_3(M.Wt 106g/mole) in one liter of aqueous solution?

$$\mathbf{M} = \frac{n}{V(Liter)}$$

$$n = \frac{wt}{Mwt} = \frac{10.6}{106} = 0.1\, mole$$

$$M = \frac{0.1}{1} = 0.1\, M(\frac{mole}{l})$$

حل آخر

$$M = \frac{wt}{Mwt} \times \frac{1000}{V(ml)}$$

$$M = \frac{10.6}{106} \times \frac{1000}{1000} = 0.1\ M\ (mmole/mL)$$

$$eq.wt(salt) = \frac{M.wt}{no.of\ cations\ x\ oxidation\ number\ of\ cations}$$

$$\text{eq.wt}(Na_2co_3) = \frac{106}{2\times1} = 53g/eq$$

$$N = \frac{no.ofeq}{V(liter)}, \qquad no.ofeq = \frac{Wt}{eq.wt} = \frac{10.6}{53} = 0.2\ eq$$

$$N = \frac{0.2}{1} = 0.2\ N(eq/L)$$

(or)

$$N = \frac{Wt}{eq.wt}\ x\frac{1000}{VmL} = \frac{10.6}{53}\ x\frac{1000}{1000} = 0.2N(meq/mL)$$

Q4- 16 gram of KNO_3 is dissolved in 84 g of water to give 16%(w/w) KNO_3 solution express the concentration in ppm.

$$ppm = \frac{wt\ of\ soluute}{wt\ of\ solution} \times 10^6$$

$$ppm = \frac{16}{84} \times 10^6 = 0.1905\ ppm(\frac{\mu g}{g})$$

Q5- Calculate the number of grams of solute in:

a- 1 liter of 0.2 N $Ba(OH)_2$ solution.

b- 5 liter of 0.2 N (NaOH) solution.

a) eq. Wt $(Ba(OH)_2 = \frac{171}{2} = 85.5$ g / eg

$$N = \frac{Wt}{eq.wt} x \frac{1000}{VmL} \Rightarrow Wt = \frac{N\ x\ eq.wt\ x\ Vml}{1000}$$

$$Wt = \frac{0.2\ x\ 85.5x\ 1000}{1000} = 17.1\ g$$

b) $$\text{eq.wt (base)} = \frac{M.Wt}{no.of\ hydroxide\ atoms\ ionized(OH^-)}$$

$$\text{eq.wt NaOH} = \frac{40}{1} = 40\ g/eq$$

$$N = \frac{Wt}{eq.wt} x \frac{1000}{VmL} \Rightarrow Wt = \frac{N\ x\ eq.wt\ x\ Vml}{1000}$$

$$Wt = \frac{0.2\ x\ 40x\ 5000}{1000} = 40\ g$$

Q6- How can you prepare:

a- 250 mL of 0.25 F HCl, if sp. gravity of HCl a=1.184 and containing about 37% HCl by weight.

b- 250 ml of 0.1M H_2SO_4. if sp. Gravity = 1.84 and containing about 96% H_2SO_4 .

a-

$$F = \frac{\%\ x\ sp.gr\ x\ 1000}{g.fw} = \frac{0.37\ x\ 1.184\ x\ 1000}{36.5} = 12.002F$$

هذا يمثل تركيز الحامض الاصلي ولتحضير محلول مخفف منه تطبق قانون التخفيف وكما يلي :-

$F_1V_1 = F_2V_2$

$12.002 \times V_1 = 0.25 \times 250$

$$v_1 = \frac{0.25 \times 250}{12.002} = 5.207\ mL$$

By add 5.207 mL of acid and in 250 mL volumetric flask then complete the volume up to the mark with distilled water.

b-

$$M = \frac{\% \; x \; sp.gr \; x \; 1000}{M.Wt} = \frac{0.96 \; x \; 1.84 \; x \; 1000}{98} = 18.024M$$

$M_1V_1 = M_2V_2$

$18.024 \times V_1 = 0.1 \times 250$

$$v_1 = \frac{25 \times 250}{18.024} = 1.387 \; mL$$

By add 1.378mL of acid and in 250 mL volumetric flask then complete the volume up to the mark with distilled water.

Q7- Calculate the normality (N) of a 500 ml solution containing 20gms of NaOH (M.Wt 40 g/mole).

$$N = \frac{Wt}{eq.wt} \; x \frac{1000}{VmL} = \frac{20}{40} \; x \frac{1000}{500} = 1N(meq/mL)$$

Q8- Find the molarity (M) of NaCl solution if 1.17 %(W/V), M.Wt=58.5 .

Sol.

% W/V = No. of grams of solute(1.17g) in 100 ml 0f solution

$$M = \frac{Wt}{M.Wt} \; x \frac{1000}{VmL}$$

$$M = \frac{1.17}{58.5} \; x \frac{1000}{100}$$

M = 0.2M (mmole/mL)

Q9- Calculate the mole fraction of 15% by weight aqueous sugar solution (15% (w/w) $C_6H_{12}O_6$).

Sol.

M.Wt: $C_6H_{12}O_6$ = 180 g/mole, H_2O = 18 g/mole

In 100 g of solution: 15g $C_6H_{12}O_6$ + 85 g H_2O

$$\textit{mole fractoin of sugar}(X1) = \frac{\textit{No. of moles of sugar}}{\textit{No. of moles of sugar} + \textit{No. of moles of water}}$$

$$\textit{mole fraction of water}(X2) = \frac{\textit{No. of moles of water}}{\textit{No. of moles of sugar} + \textit{No. of molesof water}}$$

Numbers of mole of $C_6H_{12}O_6$ (n_1) =

$$n_1 = \frac{Wt}{M.Wt} = \frac{15}{180} = 0.083\ mole$$

Numbers of mole of water (n_2) =

$$n_2 = \frac{Wt}{M.Wt} = \frac{85}{180} = 4.722\ mole$$

$$X_1 = \frac{n_1}{n_1 + n_2} = \frac{0.083}{4.805} = 0.017\ (\text{mole fraction of sugar})$$

$$X_2 = \frac{n_2}{n_1 + n_2} = \frac{4.722}{4.805} = 0.983\ (\text{mole fraction of water})$$

$X_1 + X_2 = 1$

$0.017 + 0.983 = 1$