# Methods of expression of concentrations

## طرائق التعبير عن التراكيز

### 1-Molarity (M):

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

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

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

Wt يمثل وزن المادة المذابة بالغرام ، VmL حجم المحلول بالملليلتر .

**Units: mole/L , mmole /mL**

### 2-Normality (N):

**Number of grams equivalent weight of solute per liter of solution.**

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

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

### 3- Formality (F):

**Number of grams formula weight of solute per liter of solution.**

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

Units: **fw/L , m.fw/mL**

حيث : Wt يمثل وزن المادة المذابة بالغرام , fw يمثل وزن الصيغة للمادة المذابة , VmL حجم المحلول بالملليلتر .

### 4-Molality (m):

**Number of moles of solute per kilogram (1000 g) of solvent.**

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

**Units: Mole/kg or mmole/g**

## 5- Mole Fraction:

**The ratio of moles of solute or solvent to the total moles of solute and solvent.**

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

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

## 6- Percentage Ratio: النسبة المئوية

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

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

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

ملاحظة : حجم المحلول = حجم المذاب + حجم المذيب

### B- Volume Percentage (volume percent ratio):

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

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

ملاحظة : حجم المحلول = حجم المذاب + حجم المذيب

### C- Weight Percentage (weight percent ratio):

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

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

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

$$\frac{W}{V}\ \% = \frac{\text{Wt (g) of solute}}{\text{VmL of solution}} \times 100 = \frac{W}{W}\ \% = \frac{5}{250} \times 100 = 2\ \%$$

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

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

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

**= 33.3333 %**

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

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

$$15 = \frac{\text{Wtg of glucose}}{800} \times 100$$

**= 120 g**

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

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

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

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

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

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

## 9- (Parts per billion) ppb جزء لكل بليون جزء

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

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

| | |
|---|---|
| **Gram (g) =** | **1000 Milligram (mg)** |
| **Milligram (mg) =** | **1000 Microgram (µg)** |
| **Microgram (µg) =** | **1000 Nanogram (ng)** |
| **Liter (L) =** | **1000 Milliliter (mL)** |
| **Milliliter (mL) =** | **1000 Microliter (µL)** |
| **Microliter (µL) =** | **1000 Nanoliter (nL)** |

| Part | liquid 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 :

$$\mathbf{M} = \frac{\% \times \boldsymbol{sp.gr} \times \mathbf{1000}}{\boldsymbol{M.wt.}}$$

$$\frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times \mathbf{1000}}{\text{الوزن الجزيئي}} = \boldsymbol{M}$$

$$\boldsymbol{N} = \frac{\% \times \boldsymbol{sp.gr} \times \mathbf{1000}}{\boldsymbol{eg.wt}}$$

$$\frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times \mathbf{1000}}{\text{الوزن المكافئ}} = \boldsymbol{N}$$

$$\boldsymbol{F} = \frac{\% \times \boldsymbol{sp.gr} \times \mathbf{1000}}{\boldsymbol{g.fw}}$$

$$\frac{\text{النسبة المئوية} \times \text{الوزن النوعي} \times \mathbf{1000}}{\text{وزن الصيغة}} = \boldsymbol{F}$$

**Also, these laws:**

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

$$\boldsymbol{Density\ (d) = \frac{Wt\ (g)}{V(mL)} = (unit: \frac{g}{ml} \ \ or \ \ \frac{Kg}{L})}$$

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

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

ملاحظة : الوزن النوعي للمادة خالي من الوحدات

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

$$N_1V_1 = N_2V_2$$

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

**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**

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

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

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

$$N_1\ V_1 = N_2\ V_2$$

$$36.049 \times V_1 = 0.1 \times 250$$

$$V_1 = 0.694\ mL$$

By adding 0.694 mL of acid in a 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 is dissolved in a sufficient amount of water to give 240 mL 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 40 g/mole), supposing that we take 100 gm of solution.**

Sol.

**In 100 g of solution: 10 g 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 10.6 g of sodium carbonate $Na_2CO_3$ (M.Wt 106 g/mole) in one liter of the aqueous solution.**

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

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

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

حل آخر

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

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

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

eq.wt $(Na_2CO_3) = \frac{106}{2\times1} = 53\ g/eq$

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

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

**(or)**

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

**Q4- 16 grams of $KNO_3$ dissolved in 84 g of water, 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 liters of 0.2 N (NaOH) solution.**

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

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

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

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

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

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

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

**Q6- How can you prepare:**

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

b- 250 ml of 0.1 M $H_2SO_4$. if the 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 :-

$F_1V_1 = F_2V_2$

$12.002 \times V_1 = 0.25 \times 250$

$$v_1 = \frac{0.25\times250}{12.002} = 5.207\ mL$$

**By adding 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 adding 1.378 mL of acid in a 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 20 g 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 g/mole**

Sol.

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

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

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

**M = 0.2 M (mmole/mL)**

**Q9- Calculate the mole fraction of 15 % by weight of 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 $H_2O$**

$$\textit{mole fraction of sugar}(X_1) = \frac{\textit{No. of moles of sugar}}{\textit{No. of moles of sugar} + \textit{No. of moles of water}}$$

$$\textit{mole fraction of water}(X_2) = \frac{\textit{No. of moles of water}}{\textit{No. of moles of sugar} + \textit{No. of moles of water}}$$

**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 the mole of water ($n_2$) =**

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

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

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

$X_1 + X_2 = 1$

$0.017 + 0.983 = 1$