Almustaqbal University College

Medical Laboratories Techniques Department

First year students

Subject : General chemistry 1 - Lecture 2A

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Expressing concentrations By chemical units :

The mole:

Is a unit for the amount of a chemical species , always associated with a chemical formula and represents Avogadro's number (6.022×10^{23}) of particles and represented by that formula .

Molar Mass : Is the mass in grams of 1 mole of the substance ,it is calculated by summing the atomic masses of all the atoms appearing in a chemical formula .

$$\text{Molar mass} = \sum \textit{atomic mass}$$

Example :- Molar mass of glucose $C_6H_{12}O_6$:

$$M_{C_6H_{12}O_6} = \sum (6 mole\ carbon + 12 mole\ hydrogen + 6 mole\ oxygen) atom$$

$$M_{C_6H_{12}O_6} = 6\ x 12.0 + 12\ x\ 1.0 + 6\ x\ 16.0 = 180 \text{ g /mole}$$

Important Relations:-

M.wt = g /mole or mg /mmole

$$\text{No. of moles} = \frac{\text{wt}(_\text{g})}{\text{M. wt}(_\text{g})}$$

Wt (g) = No. of moles x M.wt

Mole $=10^{3}$mmole , mmole = 10^{-3}mole

Example1: How many grams of Na^+ (M.wt = 22.99 g /mol) are contained in (25 gm) of Na_2SO_4 (M.wt = 142.0 g /mol)?

Solution:

$$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}$$

1mole **2mole** **1mole**

$$\text{moles of } Na_2SO_4 \ (n_{Na_2SO_4}) = \frac{\text{Wt}_{(g)} Na_2SO_4}{\text{M.Wt}_{(g)} Na_2SO_4} = \frac{25.0}{142.0} = 0.176$$

No. of moles of $Na^+ (n_{Na^+})$= Number of moles Na_2SO_4 x 2

No. of moles of $Na^+ (n_{Na^+})$= 0.176 x 2 = 0.352 moles Na^+

Wt (g) = No. of moles x M.wt

Weight of Na^+(g) = moles Na^+ x 22.99(g) Na^+

Weight of Na^+(g) = 0.352 x 22.99 = 8.10 (g) Na^+

Hints

-No. of moles of Na^+ (n_{Na^+}) in NaCl is = 1 x No. of moles of NaCl as

$$NaCl \longrightarrow Na^+ + Cl^-$$

1 mole **1 mole**

No. of moles of Na^+ (n_{Na^+}) in **Na_3PO_4** is = 3 x No. of moles of **Na_3PO_4** as

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

1 mole **3 mole**

Exercise:

How many grams of Na^+ (22.99 g /mol) are contained in 25 g of Na_3PO_4 (164 g /mol)?

Exercise :

1. No. of moles of K^{+} (n_{k^+}) in **K_2SO_4 = ?**
2. No. of moles of K^{+} (n_{k^+}) in **KNO_3 = ?**
3. No. of moles of Mg^{2+} ($n_{Mg^{2+}}$) in **$MgSO_4$ = ?**
4. No. of moles of Fe^{3+} (n_{Fe3+}) in **$FeCl_3$ = ?**
5. No. of moles of Cl^{-} (n_{Cl-}) in **$FeCl_3$ = ?**

Molar concentration (M):

Molarity: Number of moles of solute per liter of solution Or number of mmoles of solute per milliter of solution.

$$\mathbf{M} = \frac{\text{number of moles of solute}}{\text{volume of solution(liter)}}$$

Or

$$\mathbf{M} = \frac{\textbf{number of mmole of solute}}{\textbf{volume of solution mL}}$$

Molarity calculations:

$$\textbf{Molarity(M)} = \frac{\textbf{No.of moles}}{\textbf{volume(L)}} = \frac{\frac{\textbf{wt}_{(g)}}{\textbf{M.wt}}}{\textbf{V}_L}$$

$$\textbf{Molarity(M)} = \frac{\textbf{wt}_{(g)}}{\textbf{M.wt x V}_L} \qquad \textbf{V}_L = \frac{\textbf{V}_{mL}}{\textbf{1000}}$$

$$\textbf{Molarity}(\boldsymbol{M}) = \frac{\textbf{wt}_{(g)}}{\textbf{M.wt x}\frac{\textbf{VmL}}{\textbf{1000}}}$$

$$\textbf{Molarity(M)} = \frac{\textbf{wt}_{(g)}\textbf{ x 1000}}{\textbf{M. wt x V}_{mL}}$$

Example: calculate the molar concentration of KNO_3 aqueous solution that contains (2.02 g) of KNO_3 (101 g /mole) in (2.0 L) of solution?

Solution:

$$\textbf{Molarity(M)} = \frac{wt_{(g)}}{M.wt \times V_L} = \frac{2.02_{(g)}}{101 \times 2.0\ L} = \mathbf{0.1\ M}$$

or

$$\textbf{Molarity(M)} = \frac{wt_{(g)} \times 1000}{M.wt \times V_{mL}} = \frac{2.02_{(g)} \times 1000}{101 \times 2000\ mL} = \mathbf{0.1\ M}$$

Preaparation of molar solutions

Molarity represents the number of moles of solute in one liter of solution or number of mmole in one mililiter .

e.g: a sulfuric acid(98 g/mol) solution that has an analytical concentration of (1.0M) can be prepared by dissolving (1.0 mole) or (98 g) of H_2SO_4 in water and dilution to exactly (1.0 L).

$$\{\ \text{Molarity(M)} = \frac{No.of\ moles}{Vol.(\ L)} = \frac{1\ mole}{1\ L} = 1M\ \}$$

* **Example:** Describe the preparation of (2.00 liter) of (0.18 M) $BaCl_2$ from $BaCl_2.2H_2O$ (244.3 g/mole) .

Solution:

$BaCl_2.2H_2O \rightarrow BaCl_2 + 2H_2O$
1mole 1mole 2mole

Each (1mole $BaCl_2.2H_2O$) gives (1 mole $BaCl_2$).
for 2 liter solution we have

$$\textbf{Molarity(M)} = \frac{\textbf{No.of moles}}{\textbf{volume(L)}}$$

No. of moles = molarity M x volume (L)

No. of moles $BaCl_2$ in Solution = $0.18\ \frac{moles\ BaCl_2}{L} \times 2.00\ L = 0.36 mole\ (BaCl_2)$

Then No. of moles $BaCl_2.2H_2O$ needed = 0.36 moles

The mass of ($BaCl_2.2H_2O$) = 0.36mole x 244.3 g /mol = 87.95 g $BaCl_2.2H_2O$

The solution is prepared by dissolving 87.95gm $BaCl_2.2H_2O$ in water and complete the volume to 2.00 L

Example:

Describe the preparation of 500 mL of 0.0740 M Cl^- solution from solid $BaCl_2$ (208 g/mol).

Solution:

$BaCl_2 \rightarrow Ba^{2+} + 2\ Cl^-$

1 mole   2 moles

No of moles = Molarity (mol / liter) x Volume (Liters)

moles Cl^- = 0.0740 x 0.5 = 0.037 moles Cl^-

No.of moles $BaCl_2$ needed = $\frac{1}{2}$ (No. of moles of Cl^-)

No .moles $BaCl_2$ needed = $\frac{0.037}{2}$ = 0.0185 mole

weight of $BaCl_2$ = No. of moles $BaCl_2$ x M wt (208)

weight of $BaCl_2$ = 0.0185 x 208 = 3.85 grams

Then the required solution is prepared by dissolving 3.85 g of $BaCl_2$ in water and dilute to 0.500 L (500 mL).

Example:

Calculate the number of molecules (particles) of NaCl (58.5 g/mol) present in 1liter of 0.1 M solution.

Answer:

Each 1 mole contains Avogadro's number (6.022 x 10^{23}) of molecules then

No. of moles = Molarity(M) x V(liter) = 0.1 x 1= 0.1 mole

No. of moles = $\frac{No.of\ molecules}{6.02 \times 10^{23}}$

No. of molecules = No. of moles x 6.02 x 10^{23} = 0.1 x 6.02 x 10^{23}
No. of molecules = 6.02 x 10^{22} molecules

Excercise:
Describe the preparation of 700 mL of 0.0740 M Cl^- solution from solid $BaCl_2.2H_2O$ (244.3 g/mol).

Conversion to molarity:

1. Conversion of $\left(\frac{w}{v}\right)\%$ to Molarity(M)

$$\textbf{Molarity (M)} = \frac{\left(\frac{w}{v}\right)\% \; x10}{M.wt}$$

2.Conversion of Molarity(M) to mmol/L

mmol/L = Molarity(M) x 1000

3.Conversion of mmol/L to mg/dl

$$C_{mg/dl} = \frac{mmol/dl \; x \; Mwt}{10}$$

Example:

Calculate the concentration of the solution that is 20(w/v)% of KCl (74.5 g /mol) in: a. Molarity(M) b. mmol/L c. mg/dl

solution:

a.

$$\text{Molarity(M)} = \frac{\left(\frac{w}{v}\right)\% \; x10}{M.wt}$$

$$\textbf{Molarity(M)} = \frac{20 \times 10}{74.5} = 2.68 \text{ M}$$

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$$\text{Molarity(M)} = \frac{wt_{(g)} \times 1000}{M.wt \times V_{mL}} = \frac{20_{(g)} \times 1000}{74.5 \times 100_{mL}} = 2.68 \text{ M}$$

b. $C_{mmol/L}$ = Molarity(M) x 1000

$C_{mmol/L}$ = 2.68 x 1000 = 2680 mmol/L

$$\text{c. } C_{mg/dl} = \frac{mmol/dl \times Mwt}{10} = \frac{2680 \times 74.5}{10} = 19966 \text{ mg/dl}$$

$C_{mg/dl}$ = 19966 mg/dl

Exercises:

1.Which of the following contains the largest number of molecules :

a) 66g of CO_2 (44 g/mol)

b) 80 g of NaOH (40 g/mol)

c) 32 g of CH_3OH (32 g/mol)

2. Describe the preparation of 500 mL of 0.0740 M Cl^- aqueous solution from solid $CaCl_2.2H_2O$ (147 g/mol).

3. Calculate the weight in grams of solid K_2SO_4 (174.26 g/mol) required to prepare 500 mL of 0.04 M aqueous solution of K^+ .

4. Calculate the weight in grams of solid NaCl (58.5 g/mol) required to prepare 250 mL of 0.04 M aqueous solution of Na^+ .

5. Calculate the concentration of the solution that is 5(w/v)% of NaCl (58.5 g /mol) in: a. Molarity(M) b. mmol/L c. mg/dl