ALMUSTAQBAL UNIVERSITY COLLEGE

Medical Laboratories Techniques Department

Stage : First year students

Subject : General chemistry -A - Lecture 4

Lecturer: Assistant professor Dr. SADIQ . J. BAQIR

Molarity of liquids:

The molarity of liquids Can be determined by applying the following formula:

$$\textbf{Molarity of liquid (M) } = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x1000}{Mwt}$$

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

$$\textbf{Specific gravity (Sp.gr) } = \frac{d_{substance}}{d_{H_2O}}$$

$$(\ sp.gr\ \approx\ d_{substance}) \quad \text{as} \quad d_{H_2O} = 1$$

Example:

Calculate the molarity of of HNO_3 (63 g/mol) solution of 70.5 $\left(\frac{w}{w}\right)\%$ and its specific gravity(sp.gr) is 1.420 .

Solution:

$$\textbf{Molarity (M)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{Mwt}$$

$$\mathbf{M} = \frac{1.420\ x\ \left(\frac{70.5}{100}\right) x\ 1000}{63.0} = \frac{1.420\ x\ 70.5 x\ 10}{63.0} = \mathbf{15.9\ M}$$

Example :

Calculate the molarity of NaOH (40 g/mol) solution of 50 $\left(\frac{w}{w}\right)\%$ knowing that its specific gravity(sp.gr) is 1.525 .

Solution:

$$\textbf{Molarity (M)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{Mwt}$$

$$\textbf{Molarity (M)} = \frac{1.525\ x\ \left(\frac{50}{100}\right) x\ 1000}{40} = \frac{1.525\ x\ 50.5 x\ 10}{40} = \mathbf{19.06\ M}$$

Exercises:

1. **Calculate the molarity of perchloric acid $HClO_4$ (100.05 g/mol) solution of 71 $\left(\frac{w}{w}\right)\%$ knowing that its specific gravity(sp.gr) is 1.67 .**
2. **Calculate the molarity of H_3PO_4 (98 g/mol) solution of 86 $\left(\frac{w}{w}\right)\%$ knowing that its specific gravity(sp.gr) is 1.71 .**

Example:

Describe the preparation of (100 mL) of (6.0 M) HCl (36.5 g /mole) from its concentrated solution that is 37.1 % (w/w)% and has specific gravity (sp.gr) of (1.18) .

Solution:

١. نحسب تركيز الحامض الاصلي (المركز) من القانون التالي:

$$M_{HCl} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{Mwt}$$

$$M_{HCl} = \frac{1.18\ x\ \frac{37.1}{100}\ x\ 1000}{36.5}$$

$$M_{HCl} = \frac{1.18\ x\ 37.1\ x\ 10}{36.5} = 12.0\ M$$

The Molarity of the concentrated acid is 12.0M

الان نذهب الى قانون التخفيف لحساب الحجم المطلوب اخذه من الحامض المركز وتخفيفه الى الحجم المطلوب (١٠٠ مللتر في هذا المثال) وكمايلي:

No. of moles of Conc. solution = No. of moles of dil. Solution

No. of mmoles of Conc. solution = No. of mmoles of dil. Solution

$M_{conc.}\ V_{conc.} = M_{dil.}\ V_{dil.}$

$12.0\ x\ V_{conc} = 6.0\ x\ 100$

$$V_{conc} = \frac{6.0\ x\ 100}{12} = 50\ mL.$$

Then 50 mL of concentrated acid is to be diluted to 100 mL to give 6 M solution

Example:

Describe the preparation of 500 mL of 3.00 M H_2SO_4 (98 g /mol) from the commercial reagent that is 93% H_2SO_4 (w/w) and has a specific gravity of 1.830.

Solution:

1. **We have to calculate the concentration of the original conc. Solution**

$$\mathbf{M_{H2SO4}} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ \%\ x\ 1000}{M.wt}$$

$$\mathbf{M_{H2SO4}} = \frac{1.830\ x\ \frac{93}{100}\ x\ 1000}{98}$$

$$\mathbf{M_{H2SO4}} = \frac{1.830\ x\ 93\ x\ 10}{98} = \mathbf{17.37\ M}$$

لحساب الحجم المطلوب اخذه من الحامض المركز وتخفيفه الى الحجم المطلوب (٥٠٠ مللتر في هذا المثال) نطبق قانون التخفيف التالي:

$$\mathbf{M_{conc.}\ V_{conc.}} = \mathbf{M_{dil.}\ V_{dil.}}$$

$$\mathbf{17.37\ x\ V_{conc} = 3.0\ x\ 500}$$

$$\mathbf{V_{conc} = \frac{3.0\ x\ 500}{17.37} = 86.36\ mL.}$$

Then 86.36 mL of concentrated acid is to be diluted to 500 mL to give 3 M solution.

Exercise:

Describe the preparation of 250 mL of 2 M acetic acid CH_3COOH (60 g/mol) solution from its concentrated solution that is 99.5 $\left(\frac{w}{w}\right)$ % and its specific gravity(sp.g) is 1.05 .

Calculation of Normality of liquids

$$\textbf{Normality of liquid(N)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ x\ 1000}{eq.wt}$$

Example:

Describe the preparation of 500 mL of 3.00 N H_2SO_4(98 g /mol) from the commercial reagent that is 96% H_2SO_4 (w/w) and has a specific gravity of 1.840.

Solution:

$$\textbf{Normality (N}_{H2SO4}\textbf{)} = \frac{sp.gr\ x\ \left(\frac{w}{w}\right)\%\ \ x\ 1000}{eq.wt}$$

$$\text{eq.wt} = \frac{Mwt}{\eta}$$

For H_2SO_4 **η=2 then**

eq.wt = $\frac{98}{2}$ = 49

Normality (N_{H2SO4}) = $\frac{1.840 \; x \; \frac{96}{100} \; x \; 1000}{49}$

Normality (N_{H2SO4}) = $\frac{1.840 \; x \; 96 \; x \; 10}{49}$ **= 36.04 N**

The Normality of the concentrated acid is 36.04 N

لحساب الحجم المطلوب اخذه من الحامض المركز وتخفيفه الى الحجم المطلوب (٥٠٠ مللتر في هذا المثال) نطبق قانون التخفيف التالي:

$N_{conc.} V_{conc.} = N_{dil.} V_{dil.}$

36.04 x V_{conc} = 3.0 x 500

$V_{conc} = \frac{3.0 \; x \; 500}{36.04}$ **= 41.62 mL.**

Then 41.62 mL of concentrated acid is to be diluted to 500 mL to give 3 N solution.

Example:
A solution of 6.42 (w/w)% of $Fe(NO_3)_3$ (241.86 g/mol) has a specific gravity of 1.059. Calculate:

(a) the molar concentration of this solution.
(b) the mass in grams of $Fe(NO_3)_3$ contained in each liter of this solution

Answer:

a) To calculate the molar concentration of the solution

$$M_{Fe(NO3)3} = \frac{\text{sp.gr x } \left(\frac{w}{w}\right)\% \text{ x 1000}}{\text{Mwt}}$$

$$M_{Fe(NO3)3} = \frac{1.059 x \frac{6.42}{100} x 1000}{241.86} = 0.281$$

(c) the mass in grams of $Fe(NO_3)_3$ contained in each liter of this solution(i.e: the concentration of solution in g / L).

Weight (g) = Molarity x volume(liter) x M.wt

Weight = 0.281 x 1 liter x 241.86 = 67.96 g

The concentration of solution in g / L = 67.96 g / L

Example:

A 12.5% (w/w) aqueous solution of $NiCl_2$ (129.61 g/mol) has specific gravity of 1.149. Calculate:

(a) the Molarity of $NiCl_2$ in this solution.

(b) the molar concentration of Cl^- in the solution.

(c) the mass in grams of $NiCl_2$ contained in 500 mL of this solution.

Answer:

(a) the Molarity of $NiCl_2$ in this solution

$$M_{NiCl2} = \frac{sp.gr\ x \left(\frac{w}{w}\right)\% \ x\ 1000}{Mwt}$$

$$M_{NiCl2} = \frac{1.149\ x \frac{6.42}{100} x\ 1000}{129.61} = 0.569\ M$$

(b) the molarity of Cl^- concentration in the solution.

$NiCl_2 \rightarrow Ni^{2+} + 2Cl^-$

Each 1 mole gives 1 mole 2 mole

Molarity of Cl^- = 2 x Molarity of $NiCl_2$

Molarity of Cl^- = 2 x 0.569 = 1.138 M

(d) the mass in grams of $NiCl_2$ contained in 500 mL of this solution.

Weight (g) = Molarity x volume(liter) x M.wt

Weight = 0.569 x ($\frac{500}{1000}$) L x 129.61 = 36.87 g

Example:

A solution was prepared by dissolving 327. 8 mg of Na_3PO_4 (163.9 g/mol) in sufficient water to give 750 mL . Calculate:

A) The Molarity and Normality of the solution

B) the Molar concentration of Na^+ in the solution.

Answer:

A) The Molarity and Normality of the solution

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

Weight of Na_3PO_4 (g) = $\frac{327.8\ mg}{1000}$ = 0.3278 g

$$\textbf{Molarity(M)} = \frac{0.3278 \textbf{ x } 1000}{163.9 \textbf{ x } 750} = 0.00267 \text{ M} = 2.67 \text{ x } 10^{-3} \text{ M}$$

Normality (N) = Molarity(M) x η

(η) = Σ [no. of cations x its valency (cation charge)]

For Na_3PO_4 (η) = Σ [3 Na^+ x (+1)] = 3

Normality (N) = 2.67 x 10^{-3} x 3 = 8.01 x 10^{-3} N

B) the Molar concentration of Na^+ in the solution.

Na_3PO_4 → 3 Na^+ + PO_4^{3-}

1 mole 3 mole

Molarity of Na^+ = 3 x Molarity of Na_3PO_4

Molarity of Na^+ = 3 x 2.67x10^{-3} = 8.01x 10^{-3} M

Exercise:

A solution was prepared by dissolving 32.92 g of $K_3Fe(CN)_6$ (329.24 g/mol) in sufficient water to give 700 mL . Calculate:

A) The Molarity and Normality of the solution

B) the Molar concentration of K^+ in the solution.