ALMUSTAQBAL UNIVERSITY COLLEGE

Biomedical Engineering Department

Stage : Second year students

Subject : General chemistry - Lecture 6

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Molarity of liquids:

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

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

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

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

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

Example:

Calculate the molarity of the solution of 70.5 % HNO_3 (w/w) (63.0 g /mol) that has specific gravity of (1.42) .

Solution:

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

$$M = \frac{1.42\ x\ \left(\frac{70.5}{100}\right) x\ 1000}{63.0} = \frac{1.42\ x\ 70.5 x\ 10}{63.0} = 15.9\ M$$

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:

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

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

Example:

Describe the preparation of (100 mL) of (6.0 M) HCl from its concentrated solution that is 37.1 % (w/w) HCl (36.5 g /mole) and has specific gravity (sp.gr) of (1.181) .

<u>Solution:</u>

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

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

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

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

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

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

also

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

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

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

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

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 calculte the concentration of the original conc. Solution**

$$M_{H2SO4} = \frac{sp.gr \, x \, \% \, x \, 1000}{M.wt}$$

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

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

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

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

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

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

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

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

Calculation of Normality of liquids

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

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:

$$M_{H2SO4} = \frac{sp.gr\ x\ \%\ x\ 1000}{eq.wt}$$

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

For H_2SO_4 **η=2 then**

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

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

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

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

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:

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

$$36.04\ x\ V_{conc} = 3.0\ x\ 500$$

$$V_{conc} = \frac{3.0 \times 500}{36.04} = 41.62 \text{ mL.}$$

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

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

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

(b) 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

Second method:

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

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

$$wt(g) = \frac{0.281 \text{ x } 241.86 \text{ x } 1000_{mL}}{1000} = 67.96 \text{ g}$$

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

$$M_{NiCl2} = \frac{sp.gr \ x \ \% \ x \ 1000}{Mwt}$$

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

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

$$NiCl_2 \quad \text{---------} \quad Ni^{2+} \quad + \quad 2Cl^-$$

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

(c) 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

$$\text{Molarity}(M) = \frac{wt_{(g)} \times 1000}{M.wt \times V_{mL}}$$

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

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

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) = $2.67 \times 10^{-3} \times 3 = 8.01 \times 10^{-3}$ N

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

$$Na_3PO_4 \rightarrow 3\,Na^+ + PO_4^{3-}$$

1 mole 3 mole

Molarity of Na^+ = 3 x Molarity of Na_3PO_4

Molarity of Na^+ = $3 \times 2.67\times10^{-3} = 8.01\times 10^{-3}$ M