Methods of Preparation Solutions & Volumetric Titration Calculations

Standard solution : is the solution of accurately known concentration, such as 0.1M Na_2CO_3, and to 0.1 N or 0.1 M NaCl solutions.

- These standard solutions are prepared from the primary standard materials by direct weighing.

Characteristics of standard solution

- Its concentration remains constant for months or years, or at least within the period of calibration.
- It rapidly reacts with the analyte and the reaction is complete within the period of the experiment.
- Its reaction with the analyte can be expressed as balanced equation in order to get the exact weight of the analyte.
- A sudden change of the reaction should occur in order to identify the equivalence point of the reaction by suitable chemical indicator.

Different Between primary and secondary standards solution

Primary standards solution

- Primary stander solution are solution made out of primary stander substances .
- Extremely pure (about 99.9 %).
- Less or not reactive .
- Not hygroscopic .
- Used standardize secondary standards and other reagent

Secondary standards solution

- Secondary stander solution are solution made specifically for a certain analysis .
- Not very pure .
- Comparatively more reactive .
- Somewhat hygroscopic.
- Used for specific analytical experiments

Methods of preparation of solutions

1- From Solid materials.

The solid material may be primary standard material, therefore, the prepared solution is standard of the solid material is not primary standard, the prepared solution is not standard (has an approximate concentration).

$$Wt = \frac{M \times M.wt \times V_{ml}}{1000}$$

$$Wt = \frac{N \times eq.wt \times V_{ml}}{1000}$$

$$eq.wt = \frac{M.wt}{n}$$

1-Equivalent weight in neutralization reaction:

- *Equivalent weight of Acid* = molecular weight/ number of H^+
- *Equivalent weight of base* = molecular weight/ number of OH^-

2-Equivalent weight in Oxidation –Reduction:

The equivalent weight of an oxidant or a reducing is the number of electrons which 1mol of the substance gains or losses in the reaction.

3- *Equivalent weight of salt* **=** molecular weight/ valency of the metal ion

Example – 1

Show by calculation how could you prepare 250 ml of 0.1N Na_2CO_3 from the solid primary standard of Na_2CO_3.

The solution:

$$\text{Eq.wt of } Na_2CO_3 = \frac{\mathbf{2\times23+12\times1+16\times3}}{\mathbf{2}}$$

$$=53 \text{ g/mol}$$

$$\text{wt of } Na_2CO_3 = \text{Eq. wt} \times N \times V.L$$

$$\text{wt of } Na_2CO_3 = 53 \times 0.1 \times 250/1000$$

$$\text{wt of } Na_2CO_3 = 1.325 \text{ g}$$

Example - 2

Show by calculation how could you prepare 2 liters of 0.2 M NaOH solution from Solid NaOH.

The solution:

$$\text{Mw of NaOH} = 23+16+1 = 40 \text{ g/mol}$$

$$\text{wt. of NaOH} = \text{Mw} \times M \times V_L$$

$$\text{wt. of NaOH} = 40 \times 0.2 \times 2$$

$$\text{wt. of NaOH} = 16 \text{ g}$$

2- Preparation of dilute solution from concentrated solution.

The concentrated solutions are always acids or bases kept in bottles carrying some information's such as: **percent (w/w), density of the solution, purity, or its specific gravity and the formula of the solute and its formula weight.**

From these information's, can calculate the concentration of solution which is an approximate because the information's on the bottle are approximate in formal, normal and molar concentrations we are dealing with weight of solute in liter of solution.

$$N = \frac{\% \times Sp.gr. \times 1000}{Eq.wt}$$

$$M = \frac{\% \times Sp.gr. \times 1000}{M.wt}$$

From this concentration, we can Calculate the value of concentrated solution that when is diluted to the wanted volume, it gives the required concentration. This concentration is also approximate since we use approximate figures.

No. of mill eq of solution before dilution = No. of mill eq of solution after dilution

$(N \times V)$ before = $(N \times V)$ after

Example - 3

show by calculation how could you prepare 500 ml of 0.1N H_2SO_4 from its concentrated solution has density of 1.84 g/ml and percentage of acid equals 98% (w/w).

The solution:

$$\text{Eq.wt of } H_2SO_4 = \frac{2\times1+32\times1+16\times4}{2}$$

=49 g/mol

$$\text{N1 of } H_2SO_4 = \frac{\% \times Sp.gr. \times 1000}{Eq.wt}$$

$$= \frac{0.98\times1.84\times1000}{49}$$

= 36.8

$N_1 \times V_1 = N_2 \times V_2$

$36.8 \times V_1 = 500 \times 0.1$

$V_1 = 1.4$ ml

- Thus, 1.4 ml of conc. sulphuric acid is measured by graduated cylinder and transferred into a beaker containing 300 ml distilled water with stirring and cooling and then transferred to volumetric flask of 500 ml.
- The solution is diluted to the mark with distilled water and stirred vigorously to get homogeneous solution.
- The same steps are followed when formal and molar concentration are required with employing formula weigh and **molecular weight**.

Example – 4

Show by calculation how could you prepare 500 ml of 2M ammonia solution from concentrated solution has specific gravity all of 0.9 and percentage of ammonia = 27%

The solution:

$$\text{Mw of } NH_3 = 14+3\times1 = 17 \text{ g/mol}$$

$$\text{Molarity of cone } NH_3 \text{ solution} = \frac{0.9\times0.27\times1000}{17}$$

$$=14.5$$

$$M_1 \times V_1 = M_2 \times V_2$$

$$14.5 \times V_1 = 2 \times 500$$

$$V_1 = 70 \text{ ml}$$

- Therefore, 70 ml of cone NH_3 solution is measured by graduated cylinder and transferred to 500 ml volumetric flask and diluted to the mark with distilled water.

Part per million (ppm) and Part per billion (ppb) :

The concentration units parts per million (ppm) and parts per billion (ppb) fine use when dealing with extremely dilute solutions.

Environmental chemists frequently use such units in specifying the concentration of trace pollutants or toxic chemicals in air and water samples.

Because amounts of solute and solution present may be stated in terms of either mass or volume, there are three different forms for each unit:

- mass-mass (m/m)
- volume-volume (v/v)
- mass-volume (m/v).

A part per million (ppm) is one part of solute per million parts of solution. In terms of defining equations, we can write:

$$\text{ppm (m/m)} = \text{mass solute(g)} \backslash \text{ mass solution(g)} \times 10^6$$

$$\text{ppm (v/v)} = \text{volume solute(ml)} \backslash \text{ volume solution(ml)} \times 10^6$$

$$\text{ppm (m/v)} = \text{mass solute(g)} \backslash \text{ volume solution (mL)} \times 10^6$$

A part per billion (ppb) is one part of solute per billion parts of solution. Here the factor is 10^9 instead of the factor of 106 for parts per million.

Example:A sample of water upon analysis was found to contain 6.3 x 10-3 grams of lead per 375 mL of solution. What is the lead concentration in
a) ppm (m/v) and
b) ppb (m/v)?

- Set up:

$$\text{ppm (m/v)} = \frac{\text{mass solute(g)}}{\text{volume solution (mL)}} \times 10^6$$

- Solution:

$$\text{ppm (m/v)} = \frac{6.3 \times 10^{-3}\ \text{g}}{375\ \text{mL}} \times 10^6 = 17\ \text{ppm}$$

- Set up:

$$ppb\ (m/v) = \frac{\text{mass solute(g)}}{\text{volume solution (mL)}} \times 10^9$$

- Solution:

$$ppb\ (m/v) = \frac{6.3 \times 10^{-3}\ g}{375\ mL} \times 10^9 = 17,000\ ppb$$

Home Work

1- Determine the volume (ml) required to dilute a solution of HCl from conc. 37% and Sp.g. 1.2 to 1000ml if the Normality is 0.25 eq/l.
2- What the difference between primary and secondary standard substances?
3- Calculate the volume of conc. HCl required for preparing 250 ml 0.1 M?
4- Calculate the weight of Na2CO3 required for preparing 100 ml 0.1 M?
5- Why is sodium carbonate primary solution?
6- Why standard solution should be colorless?
7- Why is HCl not primary solution?