Standard solutions.

Standard solution is the solution of accurately known concentration, such as 0.1 N Na_2CO_3, 0.1 N Borax (0.1 N $Na_2B_4O_7.10H_2O$), 0.1M $H_2C_2O_4$ and 0.1 N or 0.1 M NaCl solutions.

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

Standardised solution is a solution of approximate concentration which can be known exactly by standardising it with standard solution. Such as preparation of approximately 0.1 M or 0.1 N HCl and standardising it with standard solution of Na_2CO_3 or Borax. Standard solutions of Na_2CO_3 and Borax can be prepared from the pure solid materials by weighing.

When the standardised solution is prepared and standardised, its properties become identical to the properties of standard solution.

Characteristics of standard solution:

1- Its concentration remains constant for months or years, or at least within the period of titration.

2- It rapidly reacts with the analyte and the reaction is complete within the period of the experiment.

3- Its reaction with the analyte can be expressed as balanced equation in order to get the exact weight of the analyte.

4- A sudden change of the reaction should occur in order to identify the equivalence point of the reaction by suitable chemical indicator.

Examples: solutions of oxalic acid (0.1 N), sodium carbonate (0.1 N), sodium chloride (0.1 N) and borax (0.1 N).

Primary standard materials.

It is a material or chemical of high purity and characterised by the following requirements:

1- Its purity should not be less than 99.5%, otherwise purification methods should be available to confirm its purity.
2- It should be stable and not be hydrated or efflorescent.
3- It can be easily obtained and not expensive.
4- It is preferred to have high equivalent weight. For example, if we compare the equivalent weights of Na_2CO_3 (53) and borax (191), we find that the equivalent wt. of borax is four times larger than sodium carbonate. If we want to prepare 0.1 N of both solutions we should use: 1.325 g Na_2CO_3 and 4.775 g borax.

If an error of 0.02 g is occurs in weighing, therefore the percentages of error equal:

$$\frac{0.02}{1.325} \times 100 = 1.6\% \text{ and } \frac{0.02}{4.775} \times 100 = 0.4\%$$ respectively.

Therefore, the percentage of error with Na_2CO_3 is four times higher than borax. As the weight is increased the percentage of error is decreased.

5- The primary standard material is easily soluble in water or the applicable solvent. Examples: oxalic acid, sodium carbonate, borax, sodium chloride and zinc sulphate hepta hydrate.

Methods of preparation of solutions.

From solid materials.

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

Ex(1): Show by calculation how could you prepare 250 ml of 0.1 N Na_2CO_3 from the solid primary standard of Na_2CO_3.

The solution:

$$\textbf{Eq. wt. on } Na_2CO_3 = \frac{2\times23 + 12 + 3\times16}{2} = \frac{106}{2} = 53$$

Number of equivalents of solid Na_2CO_3 = Number of equivalents of Na_2CO_3 in solution.

Also:

Number of milliequivalents of solid Na_2CO_3 = Number of milliequivalents of Na_2CO_3 in solution.

$$\textbf{Number of equivalents of solid } Na_2CO_3 = \frac{\text{wt.}}{\text{its eq. wt.}}$$

$$\textbf{Number of milliequivalents of solid } Na_2CO_3 = \frac{\text{wt.}}{\text{its eq. wt.}} \times 1000$$

Number of milliequivalents of Na_2CO_3 in solution=

$$\textbf{volume of solution (ml)} \times \textbf{Normality} \left(\frac{\text{meq}}{\text{ml}}\right)$$

Number of meqts of solid Na_2CO_3 = Number of meqts of Na_2CO_3 in solution.

$$\frac{\text{wt of } Na_2CO_3}{\text{its eq. wt.}} \times 1000 = \text{volume of } Na_2CO_3 \text{ solution} \times N$$

$$\frac{\text{wt of } Na_2CO_3}{53(\text{g/ meq})} = 250(\text{ml}) \times 0.1(\text{meq /ml})$$

$$\text{wt of } Na_2CO_3 = \frac{53 \times 0.1 \times 250}{1000} = 1.325 \text{ g/ 250ml.}$$

Therefore, 1.325 g of Na_2CO_3 is exactly weighed by sensitive balance and dissolved in 250ml of solution in 250ml size volumetric flask to get 0.1 N of Na_2CO_3 solution. This solution is a standard solution which is prepared from high purity of solid Na_2CO_3.

Ex(2): Show by calculation how could you prepare 2 litres of 0.2 M NaOH solution from solid NaOH.

The solution:

Mol. wt. of NaOH =23+16+1 =40

Number of moles of solid NaOH = Number of moles of NaOH in solution.

$$\text{Number of millimoles of solid NaOH} = \frac{\text{wt. of NaOH}}{40} \times 1000$$

Number of millimoles of NaOH in solution = volume of solution(ml)×M (mmol/ml)

$$\therefore \quad \frac{\text{wt. of NaOH}}{40} \times 1000 = 2000 \times 0.2$$

$$\text{wt. of NaOH} = \frac{40 \times 0.2 \times 2000}{1000} = 16\text{g}$$

Therefore, 16 g of NaOH is weighed by usual balance and dissolved in 2 litres of solution to get 0.2 M. This solution is not standard since NaOH is not primary standard material because:

a) It absorbs water from atmosphere and dissolves in it.
b) It reacts with CO_2 from atmosphere and forms thin layer of Na_2CO_3 surrounding NaOH. Thus NaOH is not pure.

$$2\ NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

Therefore, this solution is standardised with standard solution of an acid such as standard oxalic acid solution using suitable indicator.

Preparation of dilute solutions from concentrated solutions which are commercially available.

The concentrated solutions are always acids or bases kept in bottles carrying some information such as :percent (w/w), purity, density of the solution or its specific gravity and the formula of the solute and its formula weight. From this information, one can calculate the concentration of solution which is an approximate because the information on the bottle approximate.

In formal, normal and molar concentrations we are dealing with weight of solute in litre of solution.

Wt. of litre of concentrated solution = volume of solution × its density.

Wt. of solute in litre of solution = volume of solution × density × percentage of solute.

$\therefore$ **Normality of concentrated solution** $= \dfrac{\text{wt. of solute in litre}}{\text{eq. wt. of solute}}$

Therefore, the normality of concd. solution $= \dfrac{1000 \times \text{density} \times \text{percentage}}{\text{eq. wt. of solute}}$

From this concentration, we can calculate the volume 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.

Number of milliequivalents of solution before dilution =

Number of milliequivalents of solution after dilution.

$$(N_1V_1)_{\text{before dilution}} = (N_2V_2)_{\text{after dilution}}.$$

V_1 is the wanted volume of concentrated solution when is diluted to V_2 it gives N_2.

Ex(1): Show by calculation how could you prepare 500 ml of 0.1 N H_2SO_4 from its concentrated solution has density of 1.84 g/ml and percentage of acid equals 98% (w/w).

The solution:

$$\textbf{Eq. wt. of } H_2SO_4 = \frac{2\times1 + 32 + 4\times16}{2} = \frac{98}{2} = 49$$

Wt. of H_2SO_4 in litre of solution = 1000× 1.84× 0.98

$$\textbf{Normality of concentrated } H_2SO_4 \textbf{ solution} = \frac{1000\times 1.84\times 0.98}{49} = 36.8 \text{ eq/lit}$$

Or meq/ml

$N_1V_1 = N_2V_2 \longrightarrow 36.8 \times V_1 = 500 \times 0.1 \longrightarrow V_1 = \dfrac{500\times0.1}{36.8} = 1.4 \text{ ml}$

Thus, 1.4 ml of concd. sulphuric acid is measured by a 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 size. 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 concentrations are required with employing formula weight and molecular weight.

Ex(2): Show by calculation how could you prepare 500 ml of 2 M ammonia solution from concentrated solution which has specific gravity of 0.9 and percentage of ammonia =27%.

The solution:

$$\textbf{Molarity of concentrated ammonia solution} = \frac{1000 \times 0.9 \times 0.27}{17}$$

=14.5 m mol/ml.

$M_1V_1 = M_2V_2$

$$14.5 \times V_1 = 2 \times 500 \quad \therefore \quad V_1 = \frac{2 \times 500}{14.5} = 70 \text{ ml.}$$

Therefore, 70 ml of concentrated ammonia solution is measured by suitable cylinder and transferred to 500 ml size volumetric flask and diluted to the mark with distilled water.