Al-Mustaqbal-College University

Chemical Engineering and Petroleum Industry Department

Analytical chemistry

First class / first term

Lecture Two part 2

By

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Lecture Two

⇒Dilutions−Preparing The Right Concentration

We often must prepare dilute solutions from more concentrated stock solutions. For example, we may prepare a dilute HCI solution from concentrated HCI to be used for titrations . Or, we may have a stock standard solution from which we wish to prepare a series of more dilute standards. The millimoles of stock solution taken for dilution will be identical to the millimoles in the final diluted solution, remember, $C_1 V_1 = C_2V_2$.

Example : You wish to prepare a calibration curve for the spectrophotometric determination of permanganate. You have a stock 0.100 M solution of KMnO4 and a series of 100-mL volumetric flasks. What volumes of the stock solution will you have to pipet into the flasks to prepare standards of a) $1* 10^{-3}$ M ,b) $2 *10^{-3}$ M, c) $5* 10^{-3}$ M, d) 10.0×10^{-3} M KMnO$_4$ solutions?
Solve :

a) C_1 = 0.1 M , V_1 = ml? , C_2 = $1* 10^{-3}$ M , V_2= 100 ml

$C_1 V_1 = C_2V_2$

0.1 M $* V_1$ = $1* 10^{-3}$ M $*$ 100 ml

V_1 = $1* 10^{-3}$ M $*$ 100 ml / 0.1 M

V_1 = 1 ml

b) C1 = 0.1 M , V1 = ml? , C2 = $2* 10^{-3}$ M , V2= 100 ml

$C_1 V_1 = C_2V_2$

0.1 M $* V_1$ = $2* 10^{-3}$ M $*$ 100 ml

V_1 = $2* 10^{-3}$ M $*$ 100 ml / 0.1 M

V_1 = 2 ml

c)Home work
d) Home work

Example : You are analyzing for the manganese content in an ore sample by dissolving it and oxidizing the manganese to permanganate for spectrophotometric measurement. The ore contains about 5% Mn. A 5-g sample is dissolved and diluted to 100 mL, following the oxidation step. By how much must the solution be diluted to be in the range of the calibration curve is prepared about 3×10^{-3} M permanganate? M.wt $_{Mn}$ = 55 g/gmol

Solve:

The solution contains manganese (Mn) $= 0.05 * 5$ g $= 0.25$ g

$C_1 = n\,(mol)\ /\ V\,(ml)$

$n\,(mol) =$ weight (g) / M.wt. (g/gmol) $= (\,0.25$ g / 55 g/gmol)$= 4.5 * 10^{-3}$ mol

$C_1 = 4.5 * 10^{-3}$ mol / 100 ml $= 4.5 * 10^{-5}$ M

$(C_1\,V_1\,)_{before\ dilute} = (C_2\,V_2)_{after\ dilute}$

$4.5 * 10^{-5}$ M $* V_1 = 3 \times 10^{-3}$ M $* 100$ ml

$V_1 = 66.7$ ml

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Example : What volume of 0.40 M Ba(OH)$_2$ must be added to 50mL of 0.30 M NaOH to give a solution 0.50 M in OH$^-$?

Solve :

Volumes of dilute aqueous solutions can be assumed to be additive, i.e., if x mL of Ba(OH)$_2$ is added to 50mL NaOH, the total volume is going to be **50 + x mL.**

We x can use a modified form of $C_1V_1 = C_2V_2$ where all the initial solution components are added in this manner and these sum up to the final solution components: $\sum C_{in} V_{in} = \sum C_{fin} V_{fin}$

In the present case,

M $_{NaOH}$ * V $_{NaOH}$ + 2 × M $_{Ba(OH)2}$ * V $_{Ba(OH)2}$ = M $_{OH-}$ × V$_{fin}$

that 1 M Ba(OH)$_2$ is 2 M in OH$^-$. (Ba(OH)$_2$ → Ba$^+$ + 2OH$^-$)

Thus 0.30 M × 50 mL + 2 × 0.40 M × x mL = 0.50 M × (50 + x) mL.

15 + 0.8 x = 25 + 0.50 x

0.8 x – 0.50 x = 25 – 15 → 0.3 x = 10

X = 10 / 0.3 = 33.3 ml volume of Ba(OH)$_2$ must be added NaOH

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⇒Titration

In a titration, the test substance (analyte) reacts with an added reagent of known concentration, generally instantaneously. The reagent of known concentration is referred to as a standard solution. It is typically delivered from a buret; the solution delivered by the buret is called the titrant. (In some instances, the reverse may also be carried out where a known volume of the standard solution is taken and it is titrated with the analyte of unknown concentration as the titrant.) The volume of titrant required to just completely react with the analyte is measured. Since we know the reagent concentration as well as the reaction stoichiometry between the analyte and the reagent, we can calculate the amount of analyte,
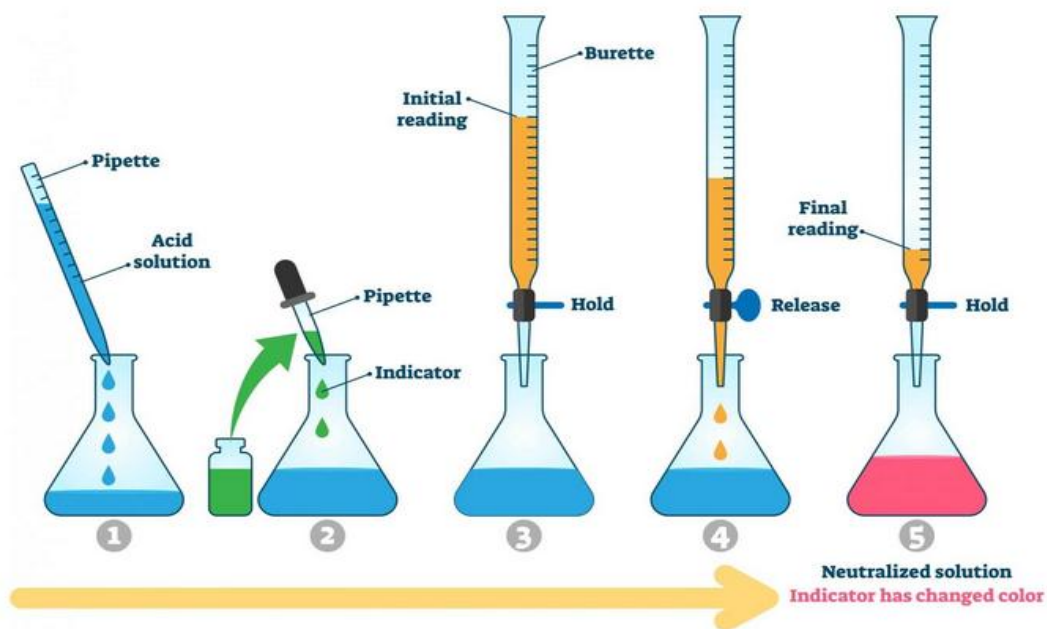

The equivalence point : is the theoretical end of the titration where the number equivalents of the analyte exactly equals the number of equivalents of the titrant added

The end point : is the observed end of the titration.

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Name of indicator	Colour in acid solution	Colour in basic solution	pH range
Methyl Orange	Red	Orange – yellow	3.1 – 4.6
Bromophenol Blue	Yellow	Blue – violet	3.0 – 4.6
Methyl Red	Red	Yellow	4.2 – 6.3
Bromothymol Blue	Yellow	Blue	6.0 – 7.6
Thymol Blue	Yellow	Blue	8.0 – 9.6

Phenolphthalein	Colourless	Red	8.0 – 9.8
Thymolphthalein	Colourless	Blue	9.4 – 10.6
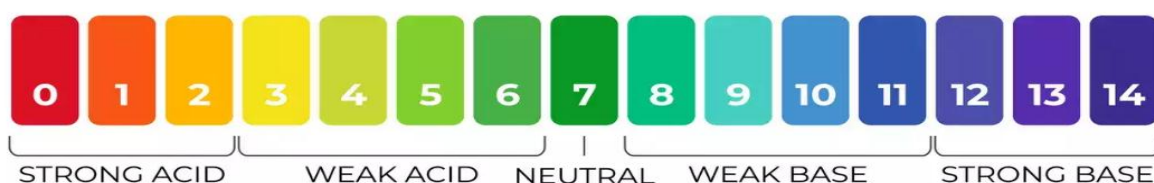
The requirements of a titration are as follows:

1. The reaction must be stoichiometric. That is, there must be a well-defined and known reaction between the analyte and the titrant. In the titration of acetic acid in vinegar with sodium hydroxide, for example, a well-defined reaction takes place:
   $$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$
2. The reaction should be rapid. Most ionic reactions, as above, are very rapid
3. There should be no side reactions; the reaction should be specific.
4. There should be a marked change in some property of the solution when the reaction is complete. This may be a change in color of the solution or in some electrical or other physical property of the solution.
5. The point at which an equivalent or stoichiometric amount of titrant is added is called the equivalence point. The point at which the reaction is observed to be complete is called the end point, that is, when a change in some property of the solution is detected. The end point should coincide with the equivalence point or be at a reproducible interval from it.

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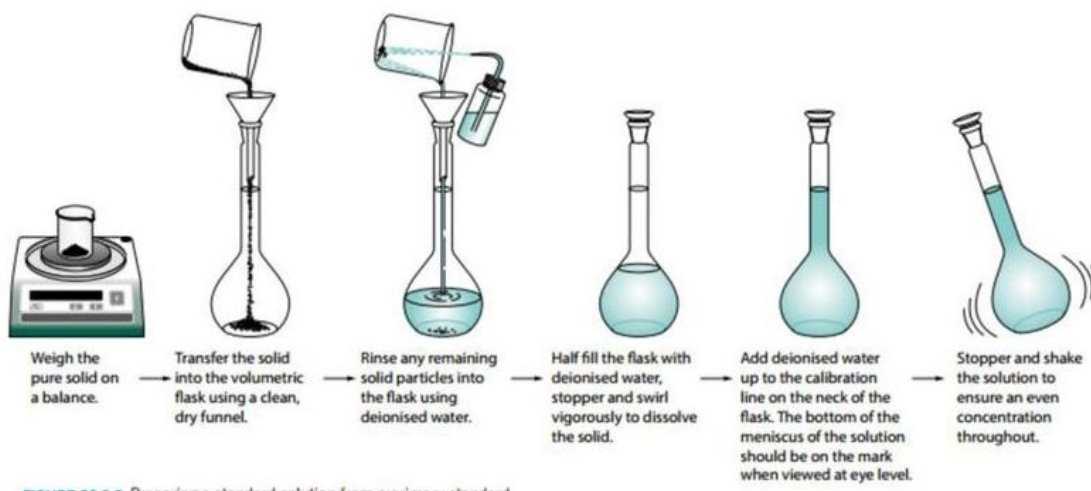## ⟹Analytical Solutions – standard solution

A solution of accurately known concentration, prepared by dissolving a known amount of solute in a known volume of solvent.

1- Primary standard solution

A solution of accurately known concentration prepared from primary standard material which has the following properties:

1- High purity (99.99%)
2- Stable toward air (not absorb H_2O or CO_2 from atmosphere).
3- Available in reasonable price (inexpensive)
4- Soluble in titration medium.
5- Has a large molecular weight (M.wt.) so that the relative error associated with weighing would be low.

Steps for preparing a standard solution

| Weigh the pure solid on a balance. | Transfer the solid into the volumetric flask using a clean, dry funnel. | Rinse any remaining solid particles into the flask using deionised water. | Half fill the flask with deionised water, stopper and swirl vigorously to dissolve the solid. | Add deionised water up to the calibration line on the neck of the flask. The bottom of the meniscus of the solution should be on the mark when viewed at eye level. | Stopper and shake the solution to ensure an even concentration throughout. |

2- Secondary standard solution

This is usually prepared from non-primary standard substance and prepared in approximate concentration ≈ 0.1M,and its concentration Is then determined accurately by titration with a solution of primary standard material.