Acid-Base Titrations:

Acid-base reactions are of great practical importance in analysis, not only because of their use in titrating a large number of inorganic and organic substances, but also because the hydrogen ion concentration of a solution often is of great importance in controlling reactions.

Titration:

The process of determining the volume of a given solution of a reagent equivalent to the amount of another reactant present in a standard solution is known as titration.

Equivalent Weight of Acids and Bases:

The equivalent weight of an acid is that weight which yields one mole of hydrogen ions in the reaction employed whereas the equivalent weight of a base is that weight which reacts with one mole of hydrogen ions in the reaction.

Normal solution:

A solution containing one equivalent weight of solute per litre of solution.

Equivalence Point:

When the number of equivalents of acid (respectively base) added is equal to the number of equivalents of base (respectively acid) taken initially, we have reached the equivalence point.

Acid-Base Indicators:

Weak organic acids or bases having different colours for their dissociated or undissociated forms e.g., phenol red which is yellow in colour in its undissociated form in acidic solution and red in its dissociated form in basic solution constitute these indicators.

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

Objective: Determination the strength of given alkali mixture ($NaHCO_3$ & Na_2CO_3) by titrating it against standard N/50 HCl solution using phenolphthalein and methyl orange as an indicators

Materials Required

1. Burette
2. Pipette
3. Conical flask
4. Burette stand
5. Funnel
6. Stirrer
7. White glazed tile
8. Measuring flask
9. Hydrochloric acid
10. Sodium carbonate
11. Methyl orange

Theory:

Carbonate ion reacts with hydrogen ions in steps:

$$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$$

$$HCO_3^- + H^+ \longrightarrow H_2CO_3 \longrightarrow H_2O + CO_2\uparrow$$

The pKa1 and pKa2 values of $H2CO_3$ are quite distinct and so when a carbonate solution is titrated against hydrochloric acid, there occur two distinct regions of sharp pH change. The first corresponding to the formation of HCO (pH 8 to 10) and the second due to complete neutralization at pH 4-6. The first is roughly in the pH range in which colour of phenolphthalein changes from red to colourless and the second is that at which methyl orange changes from yellow to orange red. This end point, however, is not very sharp in the titration of the strong base NaOH. The sharp change of pH occurs over a range of pH that includes the regions of colour change of both the indicators, so both of them give the end point correctly.

When we have both sodium carbonate and sodium hydroxide present together in a solution, a titration using phenolphthalein gives the titre (volume at the equivalence point) corresponding to sodium hydroxide plus half the carbonate and the titre obtained with methyl orange corresponds to the total alkali. The individual sodium carbonate and hydroxide concentrations may be calculated from the data.

$$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl \text{] P}$$
$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O \text{] M}$$
$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O \text{] M}$$

Procedure:

Pipette out 10 ml of alkali mixture in a conical flask + 1-2 drops of phenolphthalein indicator → Pink color appears → Titrate this against N/50 HCl until pink color just disappears → This is the first end point P (Note down the value) → to the same mixture add 1-2 drops of methyl orange → light yellow color appears → continue the titration with N/50 HCl until the light yellow color changed to orange - red color → This gives the second end point M.

Observation:

S.No.	Volume of N/50 HCl used with phenolphthalein (V_1 ml)	Volume of N/50 HCl used with methyl orange (V_2 ml)
1.		
2.		
3.		

Calculation:

V_1 ml ≡ Half neutralization of Na_2CO_3

V_2 ml ≡ Half neutralization of Na_2CO_3 + neutralization of $NaHCO_3$

Hence, (1) for complete neutralization of Na_2CO_3 required HCl (N/50) = $2V_1$ ml

(2) for complete neutralization of $NaHCO_3$ required HCl (N/50) = $(V_2 - V_1)$ ml

Using Formula: $N_1V_1 = N_2 V_2$

For $NaHCO_3$, $N_1 \times 10 = 1/50 \times (V_2 - V_2)$

Strength of $NaHCO_3$ = $N_1 \times$ Eq. wt. (84) gm/lit. (Eq.wt. of $NaHCO_3$ = 84)

For Na_2CO_3, $N_1 \times 10 = 1/50 \times 2\,V_1$

Strength of Na_2CO_3 = $N_1 \times$ Eq. wt. (53) gm/lit. (Eq.wt. of Na_2CO_3 = 53)

Result:

(1) The strength of $NaHCO_3$ is ....gm/lit.

(2) The strength of Na_2CO_3 is .... gm/lit.

Precautions:

(1) Burette should be vertical throughout the experiment.

(2) The reaction mixture should continuously be shaken during titration.

(3) Glass ware should be washed and dried before doing the experiments.

(4) The amount of indicators should be same.

Frequently Asked Questions on Titration of Hydrochloric Acid against Standard Sodium Carbonate

What is the burette used for?

Burette is a glass apparatus used for titration. It is used for delivering out any volume of a liquid under controlled conditions between a certain ranges.

What is the end point?

The stage during titration at which the reaction is just complete is known as end point. At the end point the chemical reaction is said to be completed. Indicators are used to find out the end point accurately.

Why is it necessary to rinse the burette or pipette with the liquid it is filled?

It is to be washed with water and then with distilled water only and it is not to be rinsed.

Name few common indicators.

Phenolphthalein, methyl orange, starch etc. are some common indicators used to find out the endpoint in volumetric analysis.