EXPERIMENT

AIM

Estimate the strength of given sodium carbonate solution by titrating it against HCl solution using methyl orange as indicator.

Approximately M/40 HCl solution is provided. Prepare your own standard solution of sodium carbonate.

APPARATUS REQUIRED

A burette , burette stand, two 100mL beakers, weighing bottle, volumetric flask, glass funnel, plastic funnel, white tile, watch glass, wash bottle, 20mL pipette, spatula and titrating flask.

CHEMICALS REQUIRED

Standardised, Na_2CO_3 solution, HCl solution, methyl orange as acid base indicators, given Na_2CO_3 solution, distilled water.

THEORY

Titrimetric analysis: It refers to quantitative chemical analysis carried out by determining the volume of a solution of accurately known concentration which is required to react quantitatively with a measured volume of a solution of the substance to be determined.

Standard solution: The solution of accurately known strength is called the standard solution (Expressed in molarity).

Titrant: In titrimetric analysis the reagent of known concentration is called the titrant.

Titrand: The substance being titrated is called titrand.

In volumetric or titrimetric, a reaction must fulfill the following the conditions:

i. The substance to be determined should react completely with the reagent in 'equivalent proportions' or 'stoitiometric ratio'.
ii. The reaction should be 'spontaneous and fast'.
iii. There should be a proper 'indicator' to detect the end point.
iv. There should not be any side product.

Types of titrimetric (volumetric) analysis: These are of four types:

1. Neutralisation titration (or acid- base titration)
   These include the titration of free bases with a standard acid and the titration of free acids with a standard base.
2. Redox titration (oxidation –reduction titration)
   The standard solutions are either oxidising or reducing agents.
3. Complexometric titration
   These depend upon the combination of ions, slightly dissociated ions or compounds.
4. Precipitation titration

These depend upon the combination of ions to form a simple precipitate.

- Neutralisation titration: It includes titration of free bases by standard acid and titration of free acid with a standard base. The reaction involves formation of water.

Example: $HCl + NaOH \longrightarrow NaCl + H_2O$

Types of standard solution: These are of two types:

1. **Primary standard solution:** A primary standard solution is a compound of sufficient purity from which a standard solution can be prepared by directly weighing of a quantity of it, followed by dilution to give a defined volume of solution.
   A primary standard solution must follow these conditions:
   - Compound should be free from impurity.
   - Compound should be completely soluble in dissolving solvent.
   - Compound should not be hygroscopic.
   - Solution formed should be stable and should not decompose with light / time.
   - There should not be any reaction between solute and solvent.
2. **Secondary standard solution:** These are the solution which are standardised first by primary standard solution and then used as a secondary standard solution.

Indicators: Indicators are the compounds which show the colour change at end point.

- Equivalence point: It is the theoretical point for a chemical reaction at which the added titrant is stoichiometrically equal to the moles of titrand.
- End point: It refers to the point at which the indicators changes colour in titration.
- **Acid - base indicators are organic substances(weak acids or weak bases).They change their colour within a certain pH range**. Considering two important indicators ,

  Phenolphthalein: It is weak organic acid, pH range is from 8.3 to 10.5, in acid it is colourless and in base it is pink in colour.

  Methyl orange: It is a weak organic base, pH range is from 3.2 to 4.4, in acid it is orange/ red in colour and in base it is yellow in colour.

Theory of Indicators: There are two theories,

1. **Ostwald theory:** It is based upon ionization of indicators with respect to the pH of solution and the fact that the unionised form has different colour than the ionised form.

   For phenolphthalein:

   $$\underset{\text{(Colourless)}}{HPh} \rightleftharpoons H^+ + \underset{\text{(Pink)}}{Ph^-}$$

   On adding acid, concentration of H^+ ions increases so equilibrium will shift in backward direction and solution will be colourless

On adding base, concentration of OH^- increases so equilibrium will shift in forward direction and colour of the solution will be pink.

For methyl orange:

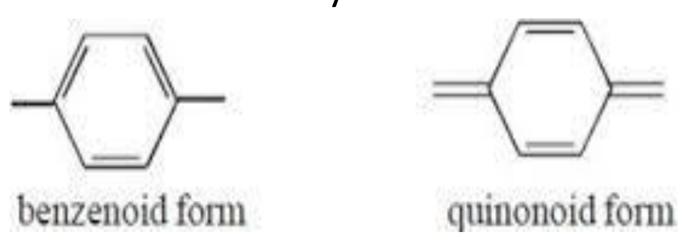
$MeOH^- \rightleftharpoons Me^+ + OH^-$

(Yellow) (Orange)

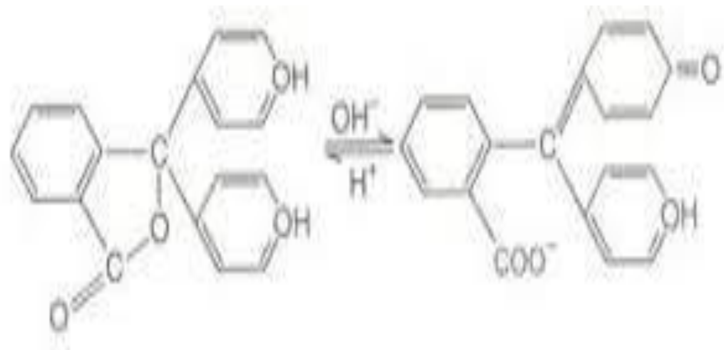
On adding acid, concentration of H^+ ions increases so equilibrium will shift in forward direction and solution will be orange in colour

On adding base, concentration of OH^- ions increases so equilibrium will shift in backward direction and solution will be yellow in colour.

2. **Quinoid theory:** It is based on tautomerism so that two forms coexist but mainly one is in excess in an alkaline/acidic medium responsible for colouring. More will be the conjugation more will be the intensity of colour.

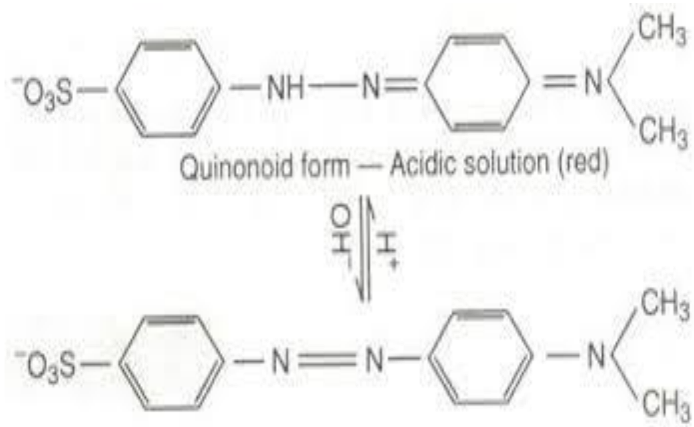


For phenolphthalein,



Coloulerless (Benzenoid form) pink (Quinonoid form)

For methyl orange,



- Neutralisation reaction taking place are:

a) $Na_2CO_3 + HCl \longrightarrow NaCl + NaHCO_3$

b) $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$ $\{H_2CO_3$ - carbonic acid$\}$

We know, phenolphthalein is an acidic indicator and it works in the basic medium that is why it causes only 50% neutralisation of Na_2CO_3 because in the step b) the medium turns acidic due to the formation of carbonic acid and phenolphthalein does not work.

On the other hand methyl orange is a basic indicator and works in the acidic indicator and hence causes 100% neutralisation of Na_2CO_3.

PROCEDURE

1. Prepare the standard solution of Na_2CO_3.Weigh the given amount of Na_2CO_3 in weighing bottle using mass balance and then transfer it to the standard flask and fill it up to the mark to make 250 ml standard solution of Na_2CO_3.
2. Rinse and fill the burette with HCl solution and note down the initial reading.
3. Pipette out 20mL of Na_2CO_3 solution in the titrating flask and add two drops of methyl orange indicator to get a yellow colour.
4. Now, titrate the solution in the conical flask against the solution of HCl in the burette drop wise with constant shaking until the colour changes to orange (end point). Note down the final reading of the burette.
5. Titrate the given solution of Na_2CO_3 against HCl solution i.e. same procedure is repeated with (as described in 4.) using methyl orange as indicator.
   Record upto two concordant readings.

OBSERVATIONS

1. **Preparation of 250 mL M/80 standard Na_2CO_3 solution**:

   Mass, w of Na_2CO_3 to be weighed for the preparation of solution

$$w = \frac{1 \times 106 \times 250}{80 \times 1000} = 0.3312 \text{ g}$$

Mass of empty weighing bottle = x =

Mass of weighing bottle and Na_2CO_3 = y =

Mass of weighing bottle after transfer = z =

Actual mass of Na_2CO_3 transfer = w_1 = (y-z) =

2. **Titration of standard Na_2CO_3 solution against HCl**:
   Solution in burette = HCl
   Solution in titrating flask = V_1= 20 mL standard Na_2CO_3
   Indicator used = methyl orange
   End point = yellow to orange

S.no.	Burette reading		Volume of HCl used
	Initial	Final	
1.			
2.			
3.			

Concordant volume (V_2) =

3. **Titration of given Na_2CO_3 solution against HCl solution.**
   Solution in burette = HCl
   Solution in titrating flask = V_3=20 mL of given Na_2CO_3 solution
   Indicator used = methyl orange
   End point = yellow to orange

S.no.	Burette reading		Volume of HCl used
	Initial	Final	

1.			
2.			
3.			

Concordant volume (V_4) =

CALCULATIONS

1. **Molarity of standard Na_2CO_3 solution**:

   $M_1 = w_1 \times 1000/(\text{molar mass} \times V)$

   $M_1 = w_1 \times 1000/106 \times 250$

   $M_1 =$

2. **Molarity of given HCl solution**:

   $$M_1 V_1 / n_1 = M_2 V_2 / n_2$$

   (Standard Na_2CO_3) (HCl)

   $n_1 = 1$; $n_2 = 2$

   $$M_2 = \frac{M_1 \times V_1 \times n_2}{V_2 \times n_1}$$

   =

3. **Molarity of given Na_2CO_3 solution**:

   $$M_3 V_3 \times 2 = M_2 V_4 \times 1$$

   (Given Na_2CO_3) (HCl)

$$M_3 = \frac{M_2 \times V_4}{2V_3}$$

$$=$$

Strength of the given Na_2CO_3 will therefore be = M_3 x 106 =

RESULT

The Strength of given Na_2CO_3 solution is = ………….. g L^{-1}

PRECAUTIONS

1. Always add the solution from the burette drop wise with constant shaking until colour change is observed.

2. The weighing bottle should be free of moisture.

3. For coloured solutions note the upper meniscus and for colourless solutions note the lower meniscus.