EXPERIMENT NO 1

(1) Aim: Determination of alkalinity of water sample containing carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions.

(2) Objective: To determine the alkalinity of the given water sample containing carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions by titrating it against standard[N/10] HCl solution using phenolphthalein and methyl orange as indicators by acid –base titration.

(3)Theory: Each student should collect additional information related to theory of the experiment from library and other literature sources and add it.

i) Alkalinity means basicity. Alkalinity of water is mainly due to presence of carbonate (CO_3^{2-}) ions, bicarbonate (HCO_3^-) ions or hydroxyl (OH^-) ions. It may also be either due to the presence of CO_3^{2-} ions and OH^- ions or due to combination of carbonate and bicarbonates ions. Bicarbonate and hydroxyl ion do not exist together because they combine to form CO_3^{2-} and H_2O.

$$HCO_3^- + OH^- \rightarrow H_2O + CO_3^{2-}$$

ii) The alkalinity of a given water sample may be estimated by titrating it against standard solution of
N/10 HCl using phenolphthalein and methyl orange as an indicator.

iii) When alkaline solution containing carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions is titrated against N/10 HCl in presence of phenolphthalein, the disappearance of pink colour shows phenolphthalein end point. Conversion of carbonate to bicarbonate ions occurs at this point.

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

On further titrating it against standard N/10 HCl in presence of methyl orange indicator, all the bicarbonate ions are neutralized and the colour of indicator changes from light yellow to wine red.

$$HCO_3^- + H^+ \rightarrow H_2O + CO_2$$

The overall reaction is as follows:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

Sodium Carbonate (Washing Soda)

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

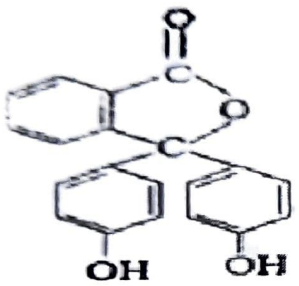
Sodium Bicarbonate (Baking Soda)

(4)Experimental Setup:

(a) Apparatus: Burette, pipette, conical flask, beaker, funnel, burette stand.
(b) Chemicals: Water sample containing carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions, standard [N/10] HCl solution.
(c) Indicator: Phenolphthalein and Methyl orange.

(5) Schematic Diagram: Left hand side. Each student should draw the overall diagram of experiment.

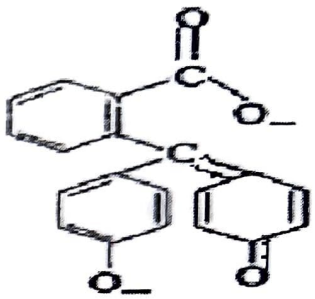
Phenolphthalein has benzenoid form in acidic medium and thus, it is colourless while it has quinonoid form in alkaline medium which has pink colour.



Colourless
Benzenoid form in acid solution

$\overset{OH^-}{\underset{H^+}{\rightleftharpoons}}$

Phenolphthalein
pH range 8.1 to 10.0



Pink Colour
Quinoid form in base

Methyl orange has quinonoid form in acidic solution and benzenoid form in alkaline solution. The color of benzenoid form is yellow while that of quinoniod form is red.

Yellow
(Benzenoid form in alkaline medium)

$\overset{H^+}{\underset{OH^-}{\rightleftharpoons}}$

Methyl orange
pH range 3.1 to 4.4

(Quinoid form in acidic medium)

(6) Experimental Procedure:

i) Fill up the burette with standard solution of N/10 HCl solution and make it up to the zero mark.

ii) Pipette out 10ml of water sample containing carbonate and bicarbonate ions in a conical flask and add 1 drop of phenolphthalein indicator to it. A pink colour will appear.

iii) Titrate the conical flask sample solution with standard N/10 HCl with continuous shaking till the pink colour disappears, note down this reading and this will be the phenolphthalein end point.

iv) Now add 2 drops of methyl orange indicator to the same solution a light yellow colour will appear. Start titrating the solution against N/10 HCl with continuous shaking till the wine red colour appears. This is the methyl orange end point. All the bicarbonate ions are neutralized at this point.

v) Note down the reading of the burette. This will be the methyl orange end point.

vi) Repeat the process till two concordant readings are obtained.

(7) Observation (Left hand side with pencil)

S. No.	Vol. of sample solution Taken (10 ml)	Burette Reading				Volume of HCl used by CO_3^{2-} (2x) ml	Volume of HCl used by HCO_3^- (y-2x) ml
		Phenolphthalein		Methyl orange			
		Initial	Final (x ml)	Initial (x ml)	Final (y ml)		

(8) Calculation: According to Normality equation;

For CO_3^{2-} Ions

N_1V_1 (Water sample) = N_2V_2 (HCl solution)

N_1 = N_2V_2/V_1

Strength of given solution = N X Eq. weight of carbonate (30)

---------- gm/liter

.....x 1000 mg/L

For HCO_3^- Ions

N_1V_1 (Water sample) = N_2V_2 (HCl solution)

N_1 = N_2V_2/V_1

Strength of given solution = N X Eq. weight of bicarbonate (61)

---------- gm / liter

.....x 1000 mg/L

(9) Result: The alkalinity of the given water sample due to carbonate ions =..... mg/L and due the bicarbonate ions =..... mg/L.

Total alkalinity = alkalinity due to CO_3^{2-} ions + alkalinity due to HCO_3^- ions=.....mg/L.

(10) Result analysis and Discussion: This part should be written by students.
Experimental result reveals that the water sample contains .....CO_3^{-2} and HCO_3^- ions.....mg/L. The quality of water is judged by the absence of alkalinity of water.

(11) Inference and Conclusion: This part should be written by students.
Alkalinity is a measure of the capacity of water to neutralize acids. The predominant chemical system present in natural waters is one where carbonates, bicarbonates and hydroxides are present. The bicarbonate ion is usually prevalent. However, the ratio of these ions is a function of pH, mineral composition, temperature and ionic strength. Water may have a low alkalinity rating but a relatively high pH or vice versa, so alkalinity alone is not of major importance as a measure of water quality. High alkalinity waters may have unpleasant taste. Based on the testing, it is found that the total alkalinity of the sample is .....mg/L.
As per the provisional code, alkalinity should not exceed 200 mg/ L for potable water. For the fresh water alkalinity ranges between 20 –100 mg/L. Alkalinity of tested sample is not within the limits specified in the standards. Hence the water sample is not fit for drinking purpose.

(12) Learning Outcome: This method is applied to find out alkalinity in drinking water and the water which is used in industry for different purpose.

(13) Applications:

(i) To check the alkalinity of water which is used for drinking purpose because large amount of alkalinity imparts bitter taste in water.

(ii) To check the alkalinity of water which is used in industry because highly alkaline water may lead to caustic embrittlement and may causes deposition of scales/sludges in boiler tubes and pipes.

(14) Precautions:

i) Wash the glass apparatus with distilled water before the experiment.

ii) Since the solution is more alkaline initially, so Phenolphthalein indicator is used first due to its higher pH range.

iii) Use only 1 or 2 drops of indicators in each titration.