Analysis of soda ash and carbonate-bicarbonate mixture essay sample

Science, Chemistry

Abstract

A standard acid solution like HCl can be used as titrant for the analysis of both soda ash and a carbonate-bicarbonate mixture. In the analysis of soda ash, the volume needed to neutralize the soda ash is used to compute for its alkalinity, in this experiment we obtained a 17. 6 % alkalinity with an error of 15. 14% In the analysis of a carbonate-bicarbonate mixture two indicators (phenolphthalein and methyl orange) were used. The first endpoint determines the half-neutralization of the carbonate and the second determines that of the bicarbonate. The experiment results to an analysis of 4. 92% carbonate and 5. 07% bicarbonate content in the unknown sample.

Introduction

Soda ash or sodium carbonate is a sodium salt of carbonic acid. It is commonly known for its everyday use as water softener.[1] It can be naturally extracted from plants of synthetically produced from large amounts of sodium. It may contain small to moderate amounts of chlorides and hydroxides as impurities. The hydroxide present in sodium carbonate reacts with an acid titrant like HCl and its total alkaline strength is increased. Titration of soda ash with a standard acid solution with methyl orange as indicator, neutralizes its carbonate ions. The usual endpoint of this titration is at pH 4.

A standard HCl can also be used to neutralize a carbonate-bicarbonate mixture through the use of the double indicator method. A bicarbonate is an immediate form of deprotonation of carbonic acid while carbonates as mentioned above is a salt from carbonic acid.[2] In the analysis of a

carbonate- mixture, there are two endpoints, first is the phenolphthalein endpoint which is the volume needed to half-neutralize the carbonate content. The second endpoint uses another indicator, the methyl orange, when the solution turns orange in color, this endpoint determines the volume at which the bicarbonate was neutralized. The usual endpoint of the phenolphthalein is around a pH of 8. 3 while the methyl orange endpoint is usually at a pH of 4.

Experimental Section

Chemicals and Reagents

All chemical reagents used in this experiment (Na2CO3, standardized NaOH solution, standardized HCl solution, unknown carbonate-bicarbonate solid, Phenolphthaelin and methyl orange indicators) were provided inside the laboratory. The buret and other apparatuses used in the titration process were also provided inside the lab. A pH meter was also made available inside the balance room for the analysis of the carbonate-bicarbonate mixture.

Preparation and Standardization of HCl Solution

Approximately 500 mL of distilled water was placed in a beaker and 4. 2 mL of concentrated HCl was allowed to flow slowly along the wall of the beaker. The solution was then kept in a labelled storage bottle. Two burets were prepared, the first buret was used to transfer 20 ml of the standard NaOH solution from experiment 3 into a dry beaker, the other buret was filled with the prepared acid solution and was set-up for titration. 3 drops of methyl orange was added to the beaker containing the NaOH solution. The base was titrated with the HCl solution until the formation of an orange-colored

solution. The molarity of the acid was computed and resulted to an average molarity of 0. 0727 M HCl. The standardized HCl solution was used as titrant for both the analysis of the soda ash and the analysis of the carbonate-bicarbonate mixture.

Determination of Alkalinity of the Soda Ash

The unknown soda ash sample was weighed from 0. 3000-0. 6000 g. The sample was then dissolved in 150 mL distilled water and was transferred into a 250-mL volumetric flask. Distilled water was added quantitatively until the solution reached the blue mark of the flask. The contents were mixed thoroughly by inverting the flask several times. A 50 mL aliquot was accurately measured and 3 drops of methyl orange indicator was added to the solution. The solution was then titrated with the standardized acid solution to the methyl orange endpoint. Three trials were made and the average percentage alkalinity was reported.

Analysis of Carbonate-Bicarbonate Mixture

For this experiment, a pH meter was used so this part of the experiment began with the calibration of the pH meter with specified buffers. The buret was then filled with the standard HCl solution and a set-up for titration was prepared. 200g of the carbonate-bicarbonate solid sample was weighed and dissolved in 100 mL of distilled water. The sample solution was then transferred into a 250-ml volumetric flask and was diluted to the 250-mL mark. The flask was inverted several times for uniform mixing. A 50-mL aliquot of the sample solution was measured and placed unto a beaker. 3 drops of the phenolphthalein indicator was added to the solution in the

beaker. The electrode of the pH meter was then immersed in the beaker and the solution containing the carbonate-bicarbonate mixture was titrated with the standard HCl solution to the phenolphthalein endpoint. Readings of the pH were taken at an interval of 0. 5 mL addition of the titrant. After the first endpoint is obtained, 3 drops of the methyl orange was added to the same solution and was titrated with the standard acid until the formation of an orange-colored solution. Readings of the pH were also taken at 0. 5 mL addition of the titrant.

Results and Discussion

In the standardization of the HCl solution, the acid is neutralized as it reacts with the base titrant NaOH in the given reaction:

HCl + NaOH NaCl + HOH

The mixture of 500 ml distilled water and 4. 2 ml concentrated HCl was standardized with 20 mL of 0. 0954 M NaOH. Two trials were made resulting to an average Molarity of 0. 0727 M HCl.

Standardization of NaOH

Trial 1Trial 2

Vol of NaOH0. 020 L0. 020 L

Vf HCl26. 5 mL26. 0 mL

Vi HCl0 mL0 mL

Vol of HCl used26. 5 mL26 mL

M NaOH0. 0954 M0. 0954 M

M HCl0. 0720 M0. 0734 M

Ave M HCl0. 0727 M

In the analysis of the soda ash or sodium carbonate, the sample is neutralized with a standard acid titrant HCl, with methyl orange as indicator in the following reaction:

$Na_2CO_3 + 2\ HCl\ 2\ NaCl + CO_2 + HOH$

The soda ash sample was weighed at a range of 0. 3000g -0. 6000 g and was dissolved into a 250-mL volumetric flask. It was then titrated with the standardized acid solution of 0. 0727 M until the methyl-orange endpoint was reached. The volume readings were recorded and were used to compute for the percentage alkalinity of the soda as sample. Three trials were made resulting to an average percentage alkalinity of 17. 60% which had an error of 15. 14% from the real value of the unknown soda ash sample. Alkalinity of Soda Ash

Trial 1Trial 2Trial 3

Mass of sample0. 2276 g0. 2276 g0. 2276 g

Vf HCl2. 1 mL4. 0 mL6. 3 mL

Vi HCl0 mL2. 1 mL4. 0 mL

Vol of HCl used2. 1 mL1. 9 mL2. 3 mL

Mass of $Na_2CO_3$0. 04 g0. 0363 g0. 0886 g

% Alkalinity17. 57%15. 95%19. 47%

Ave % Alkalinity17. 60 %

% Error 15. 14%

In the analysis of carbonate-bicarbonate mixture the neutralization of the carbonate and bicarbonate content as it reacts with the acid titrant may be represented by the following reactions:

$CO_3^{-2} + H^+ \rightarrow HCO_3^{-1}$

$HCO_3^{-1} + H^+ \rightarrow CO_2 + H_2O$

A weight of 1. 9937 g of the solid carbonate-bicarbonate sample was dissolved with distilled water and was diluted in a 250-mL volumetric flask. 50 mL aliquots of the solution were prepared and were titrated with the standard HCl solution of 0. 0727 M. Two indicators were used first the phenolphthalein for the half- neutralization of the carbonate and the methyl orange for the neutralization of the bicarbonate. Three trials were made and the recorded volume readings are as follows:

	Trial 1	Trial 2	Trial 3
Initial Volume	0. 0 mL	0. 0 mL	0. 0 mL
Vol H_2Ph endpt	14. 2 mL	12. 0 mL	12. 0 mL
Vol MO endpt	41. 8 mL	42. 0 mL	42. 2 mL

	Trial 1	Trial 2	Trial 3
Vol HCl to neutralize CO_3^{2-}	28. 4 mL	24. 0 mL	24. 0 mL
Vol HCl to neutralize HCO_3	13. 4 mL	18. 0mL	18. 2 mL

These volumes were used to compute for the percentage carbonate and bicarbonate content of the mixture. The average weight of the carbonate in the mixture resulted as 0. 0980 g while the average weight of the bicarbonate content resulted as 0. 101 g. The resulting average percentage

of carbonate in the mixture was 4. 92 % while the carbonate had an average percentage of 5. 07 %

Average weight of carbonate and bicarbonate content:

ave wt of Na_2CO_3 = (0. 109+0. 0925+0. 0925)/3 = 0. 0980 g Na_2CO_3 ave wt of $NaHCO_3$ = (0. 0818+0. 110+0. 111)/3 = 0. 101 g $NaHCO_3$

Average percentage of carbonate and bicarbonate content:

%Na_2CO_3 =(0. 0980 g Na2Co3)/(1. 9937 g Sx) ×100= 4. 92%

%$NaHCO_3$ =(0. 101g NaHCo3)/(1. 9937 g Sx) ×100= 5. 07%

During the titration process of the carbonate-bicarbonate mixture, the pH meter electrode was immersed in the solution being titrated. pH readings were taken at an interval of 0. 5 mL addition of the titrant. Using the recorded readings the following graph is obtained by plotting the pH against the volume of HCl:

This shows that at the phenolphthalein endpoint (12. 0 mL) the pH reading is at 8. 04, at the neutralization point of the carbonate (24. 0 mL) the pH reading is 6. 5, and at the methyl orange endpoint and bicarbonate neutralization point (42 mL) the pH reading is 3. 99

References:

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“ Clinical correlates of pH levels: bicarbonate as a buffer”. Biology. arizona. edu. October 2006.