Experiment 8 (10-12-08)

Determining of Calcium Carbonate in Eggshell

Objective

To determine the percentage of calcium carbonate in eggshell by acid/base titration.

Theory

Titration cannot be used directly to titrate calcium carbonate in eggshell because it is very slow when the reaction is close to the endpoint. Therefore, instead, excess hydrochloric is used to dissolve the calcium carbonate and the remaining acid is used to titrate with sodium hydroxide solution to determine the unreacted hydrochloric acid. This way, hydrochloric acid used to react with calcium carbonate and then percentage of calcium carbonate in eggshell can be determined.

Reaction between hydrochloric acid and calcium carbonate:

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O$$

Reaction between hydrochloric acid and sodium hydroxide solution:

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Procedures

Part A Sample preparation

a. Boil 2 eggs for about 20 minutes.
b. Cool the eggs down.
c. Obtain the eggshell sample with the protein membrane removed.
d. Dry the shell in an oven at about 110°C for 20 minutes to obtain a more precise result.
e. Grind the shell into fine powder for easy dissolution.
f. Weigh and record accurately 0.20 g of powder.
g. Add about 5 cm^3 of ethanol to help the eggshell to dissolve in conical flask. (Sample 1)
h. Repeat step(f)-(g) for preparing Sample 2 and Sample 3.

Part B Determination of calcium carbonate in eggshell

a. Wash a 25.0 cm^3 pipette with distilled water and then with 0.200M hydrochloric acid.
b. Pipette 25.0 cm^3 of 0.200M hydrochloric acid into conical flasks containing the eggshell.
c. Boil the solution for about 10 minutes and allow it to cool down.
d. Wash a burette with distilled water and then with 0.100M sodium hydroxide solution.
e. Pour 0.100M sodium hydroxide solution into the burette and ensure the tip of the burette is filled.
f. Record the initial burette reading.
g. Add a few drops of methyl orange in the conical flasks.
h. Run the solution from the burette into the conical flask, swirling the flask all the time.
i. Stop the titration when the colour of solution in the conical flask just changes from red to yellow.
j. Record the final burette reading.
k. Repeat steps(e)-(i) two more times.

Results

Volume of hydrochloric acid used to dissolve calcium carbonate: 25.0 cm^3

Sample	1	2	3
Weight of eggshell powder (g)	0.20	0.20	0.20

Volume of sodium hydroxide solution used for titration with sample:

Sample	1	2	3
Final burette reading (cm^3)	24.00	47.30	42.60
Initial burette reading (cm^3)	1.70	24.80	20.30
Volume of NaOH solution used (cm^3)	22.30	22.50	22.30

Calculations

Sample 1

No. of moles of NaOH = $0.100 \times \frac{22.3}{1000} = 2.23 \times 10^{-3}$ mol

By equation, no of moles of NaOH : HCl = 1 : 1

$\therefore$ no. of moles of remaining HCl = 2.23×10^{-3} mol

No. of moles of HCl added into the conical flask = $0.200 \times \frac{25.0}{1000} = 5 \times 10^{-3}$ mol

No. of moles of HCl reacted with $CaCO_3$ = $5 \times 10^{-3} - 2.23 \times 10^{-3} = 2.77 \times 10^{-3}$ mol

By equation, no of moles of HCl : $CaCO_3$ = 2 : 1

∴ no. of moles of remaining HCl = $2.77 \times 10^{-3} / 2 = 1.385 \times 10^{-3}$ mol

Mass of $CaCO_3$ in 0.20 g sample = 1.385×10^{-3} x (40.1 + 12.0 + 16.0 x 3) = 0.1386 g

Percentage of calcium carbonate in eggshell = $\frac{0.1386}{0.20}$ x 100% = 69.31%

Sample2

No. of moles of NaOH = $0.100 \times \frac{22.5}{1000} = 2.25 \times 10^{-3}$ mol

By equation, no of moles of NaOH : HCl = 1 : 1

∴ no. of moles of remaining HCl = 2.25×10^{-3} mol

No. of moles of HCl added into the conical flask = $0.200 \times \frac{25.0}{1000} = 5 \times 10^{-3}$ mol

No. of moles of HCl reacted with $CaCO_3$ = $5 \times 10^{-3} - 2.25 \times 10^{-3} = 2.75 \times 10^{-3}$ mol

By equation, no of moles of HCl : $CaCO_3$ = 2 : 1

∴ no. of moles of remaining HCl = $2.75 \times 10^{-3} / 2 = 1.375 \times 10^{-3}$ mol

Mass of $CaCO_3$ in 0.20 g sample = 1.375×10^{-3} x (40.1 + 12.0 + 16.0 x 3) = 0.1376 g

Percentage of calcium carbonate in eggshell = $\frac{0.1376}{0.20}$ x 100% = 68.82%

Sample 3

No. of moles of NaOH = $0.100 \times \frac{22.3}{1000} = 2.23 \times 10^{-3}$ mol

By equation, no of moles of NaOH : HCl = 1 : 1

∴ no. of moles of remaining HCl = 2.23×10^{-3} mol

No. of moles of HCl added into the conical flask = $0.200 \times \frac{25.0}{1000} = 5 \times 10^{-3}$ mol

No. of moles of HCl reacted with $CaCO_3$ = $5 \times 10^{-3} - 2.23 \times 10^{-3} = 2.77 \times 10^{-3}$ mol

By equation, no of moles of HCl : $CaCO_3$ = 2 : 1

∴ no. of moles of remaining HCl = $2.77 \times 10^{-3} / 2 = 1.385 \times 10^{-3}$ mol

Mass of $CaCO_3$ in 0.20 g sample = 1.385×10^{-3} x (40.1 + 12.0 + 16.0 x 3) = 0.1386 g

Percentage of calcium carbonate in eggshell = $\frac{0.1386}{0.20}$ x 100% = 69.31%

Conclusion

The weight percentages of calcium carbonate in three samples are 69.3%, 68.8% and 69.3 %. The mean percentage is 69.13%

Discussion

Sources of errors

- Some egg membrane may still remain on the shell as it is impossible to clear all of them. Some sodium hydroxide solution may have reacted with the membrane. Therefore, the volume of sodium hydroxide solution recorded may be larger than the actually value.
- Not all calcium carbonate dissolves in hydrochloric acid. The calculated mass percentage would be smaller than the expected value.
- The eggshell may contain other substances which can react with hydrochloric acid or sodium hydroxide solution.

Suggestion for the improvement

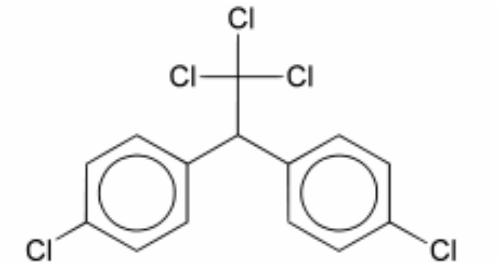
- Remove the egg membrane as much as possible.
- Heat the solution for 5-10 more minutes to ensure all calcium carbonate is dissolved.

Question

1. When the hydrochloric acid is added into the conical flasks containing eggshell, gas bubbles were given out and some solid were dissolved.
   When the solution was being boiled, gas bubbles were given out at a higher rate and most of the solid left were dissolved.

   $$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O$$

2. Chemical formula : $C_{14}H_9Cl_5$
   Structure:



3. Because of the weakening of eggshell, the eggs break before the young could hatch. This causes a low birth rate among the species and eventually leads to extinction.