

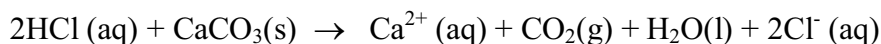
DETERMINATION OF CALCIUM CARBONATE IN EGGSHELLS BY ACID/BASE TITRATION

OBJECTIVE

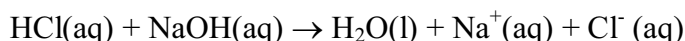
To determine the mass percent of calcium carbonate (CaCO_3) in an eggshell.

INTRODUCTION

During this lab, the percentage of CaCO_3 in an eggshell is determined by reacting the eggshell with hydrochloric acid. The equation for this reaction is:



This reaction cannot be used directly to titrate the CaCO_3 . Instead, an excess of hydrochloric acid is added to dissolve the eggshell, and the remaining acid is titrated with NaOH solution to determine the amount of acid that did not react with the eggshell. The equation used to determine the amount of leftover acid is:



In order to help the hydrochloric acid dissolve the CaCO_3 , ethyl alcohol is added to the eggshell as a wetting agent. Wetting agents are chemicals that increase the spreading and penetrating properties of a liquid by lowering its surface tension—that is, the tendency of its molecules to adhere to each other.

Although it is now banned in the United States, the pesticide DDT has caused significant damage to the environment and its wildlife. Birds are especially affected because the DDT weakens the shells of their eggs, which would break before hatching. This caused certain bird species to become endangered (i.e. the American bald eagle). One method of monitoring the strength of the egg is by determining the percent calcium carbonate in the eggshell.¹

The percentages calculated from the experiment will be compared against a **reported value of 95% CaCO_3** in a dry eggshell.²

MATERIALS and PROCEDURE

Please refer to handout sheet.

¹ Brewer, Warren B. <http://chem.lapeer.org/Chem1Docs/EggshellTitration.html>

² Butcher, Dr. Gary D. and Miles, Dr. Richard D. Concepts of Eggshell Quality.
<http://www.afn.org/~poultry/flkman4.htm>

SAFETY

CHEMICAL NAME	RISK AND SAFETY DATA
Reactants	
Calcium carbonate	Dust may cause irritation to eyes, respiratory system, and skin. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
Hydrochloric acid	Extremely corrosive. Inhalation of vapor can cause serious injury. Ingestion may be fatal. Liquid can cause severe damage to skin and eyes.
Sodium hydroxide	Very corrosive. Causes severe burns. May cause serious permanent eye damage. Very harmful by ingestion. Harmful by skin contact or by inhalation of dust. Wear suitable gloves (Neoprene or PVC).
Products	
Calcium chloride (anhydrous)	Irritating to eyes. Do not breathe dust and avoid contact with skin.
Carbon dioxide	In high concentration acts as an asphyxiant. Respiratory stimulant. If working with carbon dioxide in confined spaces where the concentration of gas may build up, ensure adequate ventilation.
Sodium chloride	May cause skin, eye or respiratory irritation. Not believed to present a significant hazard to health.
Others	
Ethyl alcohol	Causes skin, eye and respiratory system irritation. Ingestion can cause nausea, vomiting and inebriation; chronic use can cause serious liver damage. Highly flammable. Keep container tightly closed.
Phenolphthalein	Irritating to eyes, respiratory system and skin.

DATA

	FLASK ONE	FLASK TWO	FLASK THREE
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Mass of Eggshell in Flask (g)	0.50 g	0.54 g	0.47 g
Volume of 1.0 M HCl added to Eggshell (mL)	9.89 mL	9.79 g	9.89 mL
Initial Volume Reading of 0.1 M NaOH titrant in buret (mL)	0.15 mL	12.79 mL	14.69 mL
Final Volume Reading of 0.1 M NaOH titrant in buret (mL)	22.38 mL	39.01 mL	45.29 mL
Volume of 0.1 M NaOH titrant used (mL) (Volume of Titrant Used = Final Volume – Initial Volume)	22.23 mL	26.22 mL	30.60 mL

CALCULATIONS

- 1) Calculate the number of moles of hydrochloric acid added to the eggshell in each flask.

Flask One

$$9.89 \text{ mL HCl} \times \frac{1.0 \text{ mol HCl}}{1000 \text{ mL HCl}} = 0.00989 \text{ moles HCl}$$

Flask Two

$$9.79 \text{ mL HCl} \times \frac{1.0 \text{ mol HCl}}{1000 \text{ mL HCl}} = 0.00979 \text{ moles HCl}$$

Flask Three

$$9.89 \text{ mL HCl} \times \frac{1.0 \text{ mol HCl}}{1000 \text{ mL HCl}} = 0.00989 \text{ moles HCl}$$

- 2) Calculate the number of moles of hydrochloric acid remaining after the reaction with CaCO_3 in each flask.

Flask One

$$22.23 \text{ mL NaOH} \times \frac{0.1 \text{ mol NaOH}}{1000 \text{ mL NaOH}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = 0.002223 \text{ mol HCl}$$

Flask Two

$$26.22 \text{ mL NaOH} \times \frac{0.1 \text{ mol NaOH}}{1000 \text{ mL NaOH}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = 0.002622 \text{ mol HCl}$$

Flask Three

$$30.60 \text{ mL NaOH} \times \frac{0.1 \text{ mol NaOH}}{1000 \text{ mL NaOH}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = 0.003060 \text{ mol HCl}$$

CALCULATIONS (Cont'd)

- 3) Calculate the number of moles of hydrochloric acid that reacted with CaCO_3 .
(Moles of HCl Added – Moles of HCl Remaining)

Flask One

$$0.00989 \text{ moles HCl} - 0.002223 \text{ mol HCl} = 0.007667 \text{ mol HCl}$$

Flask Two

$$0.00979 \text{ moles HCl} - 0.002622 \text{ mol HCl} = 0.007168 \text{ mol HCl}$$

Flask Three

$$0.00989 \text{ moles HCl} - 0.003060 \text{ mol HCl} = 0.00683 \text{ mol HCl}$$

- 4) Calculate the mass in grams of CaCO_3 in each flask.

Flask One

$$0.007667 \text{ mol HCl} \times \frac{1 \text{ mol CaCO}_3}{2 \text{ mol HCl}} \times \frac{100.09 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = 0.3837 \text{ g CaCO}_3$$

Flask Two

$$0.007168 \text{ mol HCl} \times \frac{1 \text{ mol CaCO}_3}{2 \text{ mol HCl}} \times \frac{100.09 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = 0.3587 \text{ g CaCO}_3$$

Flask Three

$$0.00683 \text{ mol HCl} \times \frac{1 \text{ mol CaCO}_3}{2 \text{ mol HCl}} \times \frac{100.09 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = 0.3418 \text{ g CaCO}_3$$

- 5) Calculate the mass percent of CaCO_3 in each flask.

Flask One

$$\frac{0.3837 \text{ g CaCO}_3}{0.50 \text{ g eggshell}} \times 100 = 76.74\% = \mathbf{77\% \text{ CaCO}_3}$$

Flask Two

$$\frac{0.3587 \text{ g CaCO}_3}{0.54 \text{ g eggshell}} \times 100 = 66.43\% = \mathbf{66\% \text{ CaCO}_3}$$

Flask Three

$$\frac{0.3418 \text{ g CaCO}_3}{0.47 \text{ g eggshell}} \times 100 = 72.72\% = \mathbf{73\% \text{ CaCO}_3}$$

- 6) Calculate the average mass percent of CaCO_3 and percent error.

$$\frac{(0.77 + 0.66 + 0.73)}{3} \times 100 = \mathbf{72\% \text{ CaCO}_3}$$

$$\text{Percent Error} = \frac{(\text{Experimental Value} - \text{Actual Value})}{\text{Actual Value}} \times 100$$

$$= \frac{(0.72 - 0.95)}{0.95} \times 100$$

$$= \mathbf{24\% \text{ error}}$$

CONCLUSION

The calculations reveal that there was an average mass percent of 72% CaCO_3 in the eggshell. Compared against the reported value of 95% CaCO_3 , there was a 24% error in the results of this experiment.

ERROR ANALYSIS

Certain factors that may have led to error in the results include:

- Egg membrane remaining on the shell

Some of the membrane could have probably been found with the ground eggshells in the flasks, especially since it can be very difficult to see and remove.

Any membrane remnants would have reacted with the NaOH titrant; therefore, not all of the titrant would have reacted directly with the hydrochloric acid. One would have to consider that the volumes of the titrant measured would also include the amount of titrant reacted with the membranes.

- Incomplete Dissolution of the Eggshell

It is important that all of the ground eggshell dissolves because it contains the CaCO_3 that is being analyzed in the experiment. The reaction between the CaCO_3 and the hydrochloric acid might not have been completed if the flasks were removed from hotplates too early, since the higher temperature is beneficial in increasing the rate of said reaction.

If that is the case, there would have been a greater volume of hydrochloric acid remaining in the flasks before the titrations. Therefore, the calculated mass percent CaCO_3 in the eggshell would be lower than it would have been had all of the CaCO_3 dissolved.