Determination of the amount of calcium carbonate in the eggshell

Science, Chemistry

Determining the amount of CaCO3 in the eggshell of hen's egg

-	Design	DCP	CE
Aspect 1			
Aspect 2			
Aspect 3			

Introduction

Back titration is a method used in determining the amount of excess of the reagent. The calcium carbonate is a substance that gives the eggshell stiffness.

Research question: What is the amount of calcium carbonate in the eggshell measured by back titration?

Table 1. Variables.

Type of variable	Variable	Unit
Dependent	Amount of	% by

	calcium carbonate in eggshell	mass
Independent	Volume of titrated excess of hydrochloric acid	cm3
Controlled	Volume of hydrochloric acid Weight of eggshell Temperature Amount of phenolphthalein	cm3 g oC drop
Uncontrolled	Purity of solutions Biological diversity of	- - hPa

	eggs Pressure	

Equipment: buret 5 beakers 50 cm3 baguette 1 plastic pipette balance clamp 2, 5 g of eggshell mortar 100 cm3 of 1moldm-3 hydrochloric acid ap. 70 cm3 of 1moldm-3 sodium hydroxide 20 cm3 pipette

Risk assessment: you have to remember to wear gloves, goggles, and apron. Solutions may be irritating.

Method: Crush to dust eggshell in the mortar. Fill each of the 5 beakers with 20 cm3 of hydrochloric acid measured by glass pipette. Add 0. 5 g of eggshell dust to each beaker, measured by balance. While the reaction of the eggshell with acid occurs, prepare the buret and clamp for titration. Make sure they are clean. Pour NaOH solution into the buret to the '0' level. Make sure all of the eggshells reacted with the HCl. If not, you can help the reaction by using the baguette.

Put two drops of phenolphthalein into each beaker using the plastic pipette. Take the first beaker and titrate the excess of hydrochloric acid. When the solution starts to be pinkish, record the volume of titrated NaOH. Refill the buret to the '0' level and repeat the procedure for each beaker. Remember to record the results. Remember to be careful and to leave your workplace clean!

Data Collection

Table 2. Raw data. The weight of eggshell reacting with HCl and titrated NaOH.

Number of trial	Weight of eggshell [g±0, 01g]	Volume of HCl [cm3±0, 05cm3]	Volume of titrated NaOH [cm3±0, 05cm3]
1	0. 9	20. 00	9. 60
2	0. 50	20. 00	11. 50
3	0. 51	20. 00	11. 60
4	0. 50	20. 00	9. 90
5	0. 50	20. 00	10. 30
Mean	0. 50±0, 01	20. 00±0, 05	9. 93±0, 05
Standard deviatio	0. 00047	0. 00	0. 29

n			

Uncertainties were taken as in measurements, not calculated by formula, to avoid too large and unreliable uncertainties in further calculations in which they're calculated according to formulas: in case of division and multiplication: = dA/A+dB/B, where d is overall uncertainty, dA is the uncertainty of A and dB is the uncertainty of B in case of addition and subtraction: d= dA+dB, where d is overall uncertainty, dA is the uncertainty of A and dB is the uncertainty of B Trials 2 and 3 were rejected because of too large differentiation of results.

Data Processing

Two reactions occurred in the experiment.

Firstly, the HCl reacted with CaCO3 and secondly, the excess of HCl was neutralized by NaOH.

2HCl + CaCO3 > CaCl2 + CO2 + H2O HCl + NaOH > NaCl + H2O

1. Calculating the amount of HCl at the beginning of reaction CmHCl = 1. 0 mol dm-3 V HCl = 20. 00 cm3 = 0. 20 dm3 ± 0. 00005 n = Cm * V n = 1. 0* 0. 020 = 0. 020 mol ± 0. 00025
2. Calculating mean amount of NaOH which neutralized the excess of HCl CmNaOH = 1. 0 mol dm-3 VNaOH = 9. 93 cm3 = 0. 0099 dm3 ± 0. 00005 n = Cm * V n = 1. 0 * 0. 0099 = 0. 0099 mol ± 0. 0005
3. Calculating the amount of HCl which reacted with CaCO3 0. 020 mol - 0. 0099dm3 = 0. 010 mol ± 0. 00075

4. Calculating the amount of $CaCO_3$ which was in the eggshell We know that the molar ratio in the reaction between HCl and $CaCO_3$ is 2/1, which means that 2 moles of HCl react with 1 mole of $CaCO_3$. If 0. 010 moles of HCl reacted with $CaCO_3$ then there was 0. 05 mole of $CaCO_3$ in the eggshell. $nCaCO_3$ = 0. 010/2 = 0. 005±0. 0075
5. Calculating the percentage of $CaCO_3$ in the eggshell. $MCaCO_3$ = 40. 09 + 12. 01 + 3 * 16, 00 = 100. 1 gmol-1 $nCaCO_3$ = 0. 005 mol ± 0. 0075 m = M * n m = 0. 005*100. 1 = 0. 50 g ± 0. 0075 meggshell= 0. 50 ± 0. 01 $CCaCO_3$ in eggshell = 0. 50 / 0. 50 = 100 % ± 3. 5%

Table 3. The results and uncertainties

Calculated value	Value	Uncertainty
Number of moles of HCl at the beginning of the reaction	0. 020 mol	0. 00025 mol
Mean amount of NaOH which neutralized	0. 0099 mol	0. 005 mol

HCl		
Mean amount of HCl which reacted with CaCO3 in the eggshell	0. 010 mol	0. 00075 mol
Number of moles of CaCO3 in the eggshell	0. 005 mol	0. 0075 mol
Molar mass of CaCO3	100, 1 gmol-1	-
Percentage of CaCO3	100%	3. 5%

The eggshell consists of 94-97% of calcium carbonate, meanly 95. 5 %. From the collected data, it is 100%, which suggests that the percentage error was not big and remains in the accepted value of 20%.

percentage error = (theoretical value - experimental value)/ theoretical value x 100% = (95. 5 - 100) / 95. 5 = 4 %

Conclusion and Evaluation

The eggshell consists of 94 - 97% of calcium carbonate. The experiment suggests that the eggshell has 100% of calcium carbonate and the percentage error is 4 % which means calculations and results where accurate. The fact that the result has shown 100% of calcium carbonate in the eggshell may lay in the construction of the eggshell which is a biological " machine" to give hen's embryo the best possibleenvironmentfor development. Apart from calcium carbonate, there are other components of eggshell, for example, magnesium carbonate and calcium phosphate which also reacts with hydrochloric acid.

The reaction of calcium phosphate with hydrochloric acid: $Ca3(PO4)2 + 6HCl > 3CaCl2 + 2H3PO4$ this reaction shouldn't have an influence on titration that much, because as a result there's the same number of hydrogen ions which can be neutralized, but the second reaction, of magnesium carbonate and hydrochloric acid: $MgCO3 + 2HCl > MgCl2 + CO2 + H2O$ also takes HCl to its reaction, decreases the number of H+ ions and so suggests that more HCl reacted with calcium carbonate. This is the uncontrolled variable, the impurity of the eggshell, which affected the result.

Another factor, which may have had an influence on the results is the human's imprecision. The used equipment was as accurate as possible in the school laboratory, but still, the titration is made by hand and by eye, which may make mistakes although back titration is the best possible way in the school laboratory to check the number of particular components in mixtures. Another method, which would distinguish between magnesium carbonate and calcium carbonate is gas spectrometry - mass spectrometry. This method uses combined gas chromatography and mass spectrometry. First, the substance is put into a gas chromatograph.

The mobile phase, in which the particles of substances move towards the stationary phase is made of unreactive gas, such as nitrogen or helium. In this, the substance is separated into particular components, and then, the mass spectrometer analyses the components to identify them. This method is commonly used to determine the ingredients of substances, food, beverages, perfumes. Also, it is useful in medicine and in exploring Universe, for example, one GC-MS was taken by Curiosity to examine the surface of Mars.

Summing up: in the school laboratory, the accuracy of experiments is limited by equipment.

Better accuracy can be obtained by using a more accurate balance, as no other equipment can be changed in the used method. Back titration can't be replaced by other methods of determining the percentage of $CaCO_3$ in the eggshell, as it is the best way to do it in the school laboratory, although generally more accurate methods are created, using machines which exclude the human factor from experiments, for example, gas chromatography-mass spectrometry.

Bibliography

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