Titration Report: Using The Concentration Of A Known Solution To Find The Concentration Of An Unknown Solution

Titration report

Introduction

Titration is using the concentration of a known solution to find the concentration of an unknown solution (Chemed.chem.purdue.edu, 2018). In our case we tried to find out the concentration of hydrochloric acid using sodium carbonate solution. To help complete this experiment we used a fair few new pieces of equipment, for example we used a top pan balance to get the correct weight of sodium carbonate, to make the solution we used a glass pipette by taking 25cm3 of sodium carbonate solution and finally used a burette to calculate how much hydrochloric acid was used to neutralise the solution. To make sure there was the correct amount in the burette we used a pipette to get the exact amount making sure the meniscus was on the desired line.

Making sodium carbonate standard solution

When doing this experiment there are a few things you have to be careful with for example, some of the chemicals used are irritant and can cause burns. To avoid getting in your eyes and on your skin always wear safety goggles and never sit down so if it spills you can quickly and easily move out of the way. If you do get it on your skin, it is a good idea to wash it off immediately before it gets deep into your skin.

- Mass(g) / Test 1 / Test 2 / Test 3 / Average
- 10 10.48 10.47 10.47 10.47
- 20 20.88 20.87 20.85 20.86
- 30 31.11 31.36 31.67 31.38
- 40 42.09 42.18 42.16 42.14
- 50 52.55 52.56 52.57 52.56

Before we started we had to calibrate a balance so to do this we placed 5 different masses on a scale, making sure that we didn’t change the scale half way through. We did this to see how accurate the scale was and here are the results…

By looking at these results we can see that the results are fairly close but as the weight increased the balance becomes slightly unreliable. This could be due to a few factors, such as dirt on the scale adding weight or the weight could be damaged meaning it will not be accurate. To improve the accuracy of future results we could use a scale with more decimal points so instead of using 2 decimal point we could use 4 decimal points.

It is very important that you use the equipment that you used before you begin the experiment and after each test, so if you test something 3 times you should use the equipment a total of four times. It is important that you also rinse the equipment used after you complete the

experiment for the next person that will use them. The reason you should always rinse the equipment is to avoid contamination because if two chemicals mix that should not be together can lead to the experiment being ruined meaning you would need to re do it from the very start and in this case we would need to re-start from calibrating the scale. Another reason why they need to be rinsed is because it can be dangerous if two very reactive chemicals are mixed and it can be unexpected and can cause harm.

We used the balance to get as close to 1.40g of crystals and we managed to get exactly 1.40g. We then transferred those into a round bottom flask making sure we don't drop any and then we added some water to begin to dissolve and the added enough water to reach the line, we then placed the stopper on top and shook the flask until it was all dissolved. To improve this process we could have used a magnetic stirrer and a hot place instead of just hot water as it would improve the accuracy of the final result. Another method we could have used to improve accuracy is with the pipette filler which eliminates human error which is a big factor in any experiment.

To calculate the moles of sodium carbonate made we did: (2x25) +12+ (3x16) = 106 to work out the Mr. We then used the equation: Moles = Mass/Mr to find out the moles which was 1.4/106= 0.0013 moles in 250cm3

Moles of Na2CO3 = 0.0013 (in 250cm3) ÷ 10 = 0.0013 in 25cm3

Titration to standardise hydrochloric acid

Before beginning the experiment we made sure we all wore protective eye gear to ensure nothing harmful got into our eyes. We also tucked any stool under the tables so that we wouldn't sit down in case we had to move out of the way of something or to reduce the risk of tripping hazard. We also made sure we didn't spill any chemicals on our hands and if we did wed wash it out immediately.

- Equipment / Equipment capacity / Balance result 1 / Balance result 2 / Balance result 3 / Average / Degree of error
- Burette 50cm3 53.2g 53.2g 53.2.g 53.2g (+)3.2g
- Pipette 25cm3 24.83g 24.81g 25.84g 24.83g (-)0.17g

To calibrate the pipette and the burette we used the same method for both. We filled up both of them up until the line with water and then we poured in a beaker on a scale that was already at zero to see if the pipette and burette matched the weight shown on the scale (Titrations, 2018). These were the results…

From doing this test I can see that the results of the burette were very consistent but only at 53.2g instead of 50g. I will need to take this into consideration when looking at my final results. The same thing goes for the pipette, even though it was fairly consistent it was just 0.17g short which I will also need to bear in mind. So to make experiment more reliable we could possible use a different balance that is more accurate.

- Trial run / Test 1 / Test 2 / Test 3 / Test 4 / Test 5 / Average
- Initial titre (cm3) 0 0 13.9 28.5 0 14.2 11.32

- Final titre (cm3) 14.2 13.9 28.5 43 14.6 30.4 20
- Titre (cm3) 14.2 13.9 14.6 14.5 14.6 16.2 14.76

We started off by placing exactly 50ml of hydrochloric acid in burette making sure the meniscus was on the line and making sure it was at eye level for a more accurate result and also making sure there are no air bubbles that may affect the final result. We then added 25ml of sodium carbonate in glass pipette and poured it into a flask and mixed it with phenolthalein which acted as our indicator. The solution would start of pink and go completely colourless when the solution has neutralised. We would add in the hydrochloric acid one drop at a time to ensure we could find the exact point where the solution is neutralised. While adding the hydrochloric acid in we would also be swirling the two solutions to make sure the reaction is successful. We took note as when the solution when colourless and these are the results:

We could have improved the accuracy of this part of the experiment by using a magnetic stirrer instead of doing it by hand as it would ensure that the solution is mixed correctly and would mean that the results would not be affected by poor stirring such as swirling it too slow. We used trial runs to determine what the results will roughly be that we know if were going wrong so in a way this massively helps improve the accuracy of the titration. Another way we could have improved this assessment is by using an electronic pipette filler to measure the amount of sodium carbonate and make sure it was exact. Using this method would have lowered the risk of error as there would not be a possibility for human error as we would not need to ensure the meniscus was at eye level.

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

1 : 2

Ratio = 1:2

Moles of HCl = 0.0013 x 2 = 0.0026 moles

Concentration of HCl = moles ÷ (volume ÷ 1000) = 0.0026 ÷ (14.56 ÷ 1000) = 0.18 moles per dm3

For this test we were 0.02 moles per dm3 which is 10% under what it should be. This error was caused the equipment not being correctly calibrated which

Titration to identify the concentration of sodium hydroxide sample

To identify the concentration of sodium hydroxide sample we used two different methods to see what as the most accurate at given results between a pH probe and an indicator.

For this part of the practical we used the exact same method we used when standardising hydrochloric acid expect this time we used sodium hydroxide instead of sodium carbonate because this was the unknown solution.

- Trial / Test 1 / Test 2 / Test 3 / Test 4 / Average
- Initial (cm3) 0 0 0 0 0 0
- Final (cm3) 26.5 25.9 26.2 25.5 26 25.9

- Titre (cm3) 26.5 25.9 26.2 25.5 26 25.9

Average titre (cm3) = 25.9

NaOH + HCl NaCl + H2O

Moles of HCl = volume x concentration = (25.9 ÷ 1000) x 0.18 = 0.004662

Ratio = 1:1

Moles of NaOH = 0.004662 moles

(Actual value of concentration of NaOH = 0.2 moles per dm3)

(Actual value of concentration of HCl = 0.2 moles per dm3)

Concentration of NaOH = moles ÷ volume = 0.004662 ÷ (25 ÷ 1000) = 0.18648 moles per dm3

We were 0.01352 moles per dm3 under the actual value which is an error percentage of 6.76%. This error was cause by the pipette and burette not being 100% accurate as we proved when we tested the accuracy at the beginning. Another factor that added to the error is the fact that people see colour different so using the indicator was risky as people may have a different interpretation of colour compared to others.

Before using the pH meter we used it for calibration to see how accurate it was. We saw how close the pH value was to the substances that we tested to which we already knew the pH value of Chemed.chem.purdue.edu, 2018). These were the results…

Substance pH value 1 pH value 2 Average

HCl 0.1 moles

0.34 0.15 0.245

Sodium hydroxide 1 mole 12.74 12.85 12.79

Ethanoic acid

1.93 1.95 1.94

Water

6.33 6.44 6.39

Nitric acid

0.19 0.19 0.19

Sodium hydroxide 0.1 moles 7.43 7.53 7.48

Ammonium hydroxide 1 mole 8.25 8.24 8.245

These are the results for the second titration method we did with the pH meter…

- Volume of HCl (cm3) / pH1 / pH2 / Average
- 0 12.38 12.39 12.385
- 1 12.32 12.26 12.29
- 2 12.21 12.13 12.17
- 3 12.14 12.15 12.145
- 4 12.13 12.02 12.075
- 5 12.11 12.07 12.09
- 6 12.01 11.97 11.99
- 7 12.04 11.87 11.955
- 8 11.79 11.80 11.795
- 9 11.77 11.78 11.75
- 10 11.73 11.72 11.725
- 11 8.99 9.97 8.98
- 12 8.46 8.49 8.475
- 13 7.95 7.91 7.93
- 14 7.50 7.42 7.46
- 15 7.31 7.27 7.29
- 16 7.12 6.98 7.05
- 17 6.73 6.61 6.67
- 18 6.55 6.50 6.525
- 19 6.37 6.27 6.32
- 20 6.36 6.15 6.225
- 21 5.90 7.76 5.83
- 22 5.67 5.56 5.615
- 23 5.42 5.11 5.265
- 24 3.26 3.18 3.22
- 25 2.14 2.17 2.155
- 26 1.71 1.64 1.675
- 27 1.65 1.57 1.61
- 28 1.51 1.48 1.495
- 29 1.46 1.42 1.44
- 30 1.38 1.37 1.375

Moles of HCl = volume x concentration

= (16 ÷ 1000) x 0.18 = 0.00288 moles

Ratio = 1:1

Moles of NaOH = 0.00288 moles

Concentration of NaOH = moles ÷ volume =

0.00288 ÷ (25÷ 1000) = 0.1152 moles per dm3

I used hand drawn graphs instead of using a computer software as I find it easier to plot the graph on paper and it makes it easier for me to rad out the results. I also didn't want to do it on a computer in case my work would get lost so that I would always have a hard copy.

To determine the point of neutralisation more easily we used a neutralised solution so we could compare the expected colour change

After looking at the results from both methods we can see that the method where we used the indicator was more accurate as the final result was closer to 0.2 moles per dm3. In fact that method gave use 0.18648 moles per dm3 whereas the method where we used the pH meter gave us 0.18648 moles per dm3 which is quite far off. This could be due to a few different reasons. For example as we were adding 1 cm3of HCl at a time we noticed that our tap on the burette was slightly loose which effected how much HCl we actually used as it was very difficult to determine how much 1 cm3of HCl actually was. Another reason why results may have varied is because everyone has different perception of colour meaning people saw the solution go colourless at different times.

I assessed other groups and noticed that one group got 0.1909128 moles per dm3 which is slightly more accurate to my result for the first titration this is because when using the indicator they stopped adding hydrochloric acid before the solution went colourless meaning it was more accurate as they could always add more if needed instead of going over. I in fact got 0.18648 moles per dm3 which is a difference of 0.0044328 moles per dm3. The same group also got 0.11394 moles per dm3 which is very close to our result of 0.11152 moles per dm3 as they also had some issues with their equipment. This time there was only a difference of 0.00242 moles per dm3

Colorimetry introduction

This method is used to determine the concentration of coloured compounds in solution (Encyclopedia Britannica, 2018). This is achieved using a colorimeter which is an analytical tool used specifically to determine the concentration of a substance based on the absorbance of light. In this case we were trying to find the unknown concentration of copper sulfate.

- Concentration (moles) / Volume of copper sulfate solution (cm3) / Volume of water (cm3)
- 0.00 0 10
- 0.02 2 8
- 0.04 4 6
- 0.06 6 4
- 0.08 8 2
- 0.10 10 0

We used the balance to get as close to 2.495g of copper sulfate crystals and we managed to get exactly that value. We then transferred those into a round bottom flask making sure we don't drop any and then we added some water to begin to dissolve and the added enough water to reach the line which was 100cm3, we then placed the stopper on top and shook the flask until it was all dissolved

In total each concentration will be made to 10cm3 using copper sulfate solution and water. For

example to make 0.02 moles we used 2cm3 of copper sulfate and 8cm3 of water which adds up to 10cm3. On the other hand to get 0.08 moles we mixed 8cm3of copper sulfate and 2cm3 of water which also adds up to 10cm3. To measure these solutions we used a cylinder but we could have used a pipette to ensure the standard solutions were as reliable as possible.

Before beginning our experiment we needed to calibrate the colorimeter to determine its accuracy. We did this by testing water which we know is 100% transparent. We used this as our standard reference throughout the test. I have never used a colorimeter meaning the results may not be as accurate as I may have done something wrong so I will need more training to make sure the results are as accurate as possible. Another reason why the colorimeter may have not been accurate is because the machine we used is pretty old and may have not been very accurate and may malfunction

During this experiment we had to take precautionary measures to make sure nothing goes wrong and to make sure no one gets hurt. We particularly were careful when using the copper sulfate solution because of all the harmful effects it can cause. For example if it comes in contact with skin it will cause pain and redness so to prevent this we would wear protective gloves. If ingested it would also cause a lot of issues such as abdominal pains and nausea and can sometimes lead to someone collapsing, so to make sure this didn't happen we would label everything so that we knew what we were touching and would also make sure we washed our hands before eating. Finally we had to make sure they solution would not get i9nto our eyes otherwise it would cause blurred vision as well as a burning pain, so we wore protective goggles to stay safe (Cdc.gov, 2018).

- Concentration (moles) / Absorbance 1 / Absorbance 2 / Average
- 0.00 0 0 0
- 0.02 0.32 0.36 0.34
- 0.04 0.59 0.60 0.595
- 0.06 0.98 0.95 0.965
- 0.08 1.18 1.21 1.195
- 0.10 1.66 1.74 1.70

- Concentration (moles/dm3) / Absorbance 1 / Absorbance 2 / Average / Transmission 1 (%) / Transmission 2 (%) / Average
- 0.00 0.00 0.00 0.00 100 100 100
- 0.02 0.52 0.53 0.525 31 32 31.5
- 0.04 0.70 0.71 0.705 22 21 21.5
- 0.06 0.58 0.58 0.58 28 27 27.5
- 0.08 0.92 0.93 0.925 13 14 13.5
- 0.10 0.90 0.91 0.905 14 15 14.5

For the concentration of 0.00 moles/dm3 we used water as we knew it would be 100% transparent and by testing it we can see there is no absorbance and 100% transmission so we used that as a standard reference. By looking at these results we can see that as the concentration increase, the absorbance increases as it becomes less transparent which also explains why the transmission decreases. There are 2 anomalies for 2 of the concentration. The results for 0.06 and 0.10 moles/dm3 do not fit the pattern of the table. This could due to faulty equipment or the people running the test may have made a mistake or two.

It was fairly difficult determining the exact value of the absorbance and transmission as there were drifting values. The valued kept flicking up and down so to make sure we were as accurate as possible we worked out an average. To also make sure the values were as accurate as possible we wore gloves when handling the cuvettes to make sure we left no finger prints as they would drastically effect the finals results of the absorbance and transmission.

To make sure that the results were extremely accurate we could have used a date logger which is a small piece of equipment that attaches to the colorimeter and will keep track of the readings at regular interviews to completely eliminate human error. This piece of equipment will load the data straight onto a computer to view the accurate results (Ukrs, 2018).

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