National Certificate of Educational Achievement
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Exemplar for Internal Achievement Standard

Chemistry Level 2

This exemplar supports assessment against:

Achievement Standard 91910

Carry out a practical investigation into a substance present in a consumer product using quantitative analysis

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Grade Boundary: Low Excellence
1.	For Excellence, the student needs to carry out a comprehensive practical investigation into a substance present in a consumer product using quantitative analysis. This involves accurately determining the concentration of the substance in the consumer product (including correct use of significant figures and units), justifying how modifying the consumer product sample and/or titration procedure improved the validity and accuracy of the investigation, and evaluating the outcome of the investigation in relation to the consumer product. This student has modified the consumer sample and collected, recorded and processed quality data. The concentration of the substance was accurately determined (1). The learner has justified why the consumer product was modified based on the trials (2), and there is some justification of showing how the procedure used improved the accuracy and validity (3). The learner has evaluated the outcome of the investigation (4). For a more secure Excellence, the student should clearly show how the modifications resulted in an increase in validity and accuracy. For example, the justification of the rinsing of the glassware should explain how the flask only needs to be rinsed with distilled water, but the burette and pipette get rinsed with distilled water and then the solution that is used in them. This can then be used to justify an increase in the validity/accuracy of the investigation (5).

Student 1: Low Excellence

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Results from your trial:

I added 1mL of undiluted vinegar and 1 drop of phenolphthalein indicator to my small beaker. I then pipetted NaOH into the beaker until I observed the solution changing from clear to pink. My results were: 6.2mL, 6.25mL, 6.2mL. This shows that I need about 6.2mL of NaOH for every 1mL of undiluted vinegar. I will use 20mL of my vinegar solution in the experiment, so I would need about 124mL (20x6.2) of NaOH in order to observe a colour change in the actual titration.

Proposed procedure:

The original solution of vinegar needs to be diluted 10 x times to make a 1 in 10 dilution. A 20 mL sample of the diluted solution will be used in the titration.

The required dilution can be made by pipetting 25 mL of the original vinegar solution and adding distilled water to make it up to the mark on a 250 mL volumetric flask.

In the actual titration with the sodium hydroxide I will use a 20 mL pipette to add the diluted vinegar solution to the conical flask, add a few drops of phenolphthalein indicator and titrate with the standardised NaOH until a colour change from colourless to pink occurs.

Using this procedure, I would predict an average titre volume of approximately 12.4mL.

If I did not dilute the vinegar, I would need to use about 124mL of NaOH in order to observe a colour change from colourless to pink. This is not only a waste of resources and time, but would also reduce the accuracy of my experiment. This is because I would have to refill the burette two times after beginning my titration to get the full amount, which means there is a higher chance of making errors. These could include contaminating the solution, measuring incorrectly, forgetting how many times I had refilled the burette, leaving the funnel in etc. Alternatively, a lower dilution (eg. 1 in 20) would also not be ideal, as this would make the titre value small (about 6.2mL for 1 in 20 dilution). This would increase the likelihood of making significant errors. This is because proportionally, a 0.2mL difference in titres is a lot more significant to a 6.2mL titre than to a 15mL titre. My predicted titre of 12.4mL is good, as it is large enough that minor errors/differences are not too significant, but small enough that I will not have to refill to burette many times. This means that I am better able to control other variables, and my results are more likely to be accurate which enables me to draw a valid conclusion. I will try to obtain this predicted titre of 12.4mL using a 1 in 10 dilution of vinegar (CH_3COOH). 2

Discussion:

In order for my experiment to be valid and provide accurate results, I had to control (keep the same) any variables that could alter my results. These Included:

Taking all measurements from the bottom of the meniscus, which meant that my measurements were consistent and accurate. If I had measures from a different/varying part of the meniscus (or somewhere else), my measurements would be incorrect and inconsistent, and I probably wouldn't have been able to get concordant titres. This would have made my experiment invalid/unreliable, and my calculations incorrect. This would have meant that I would not be able to draw a valid conclusion.

Measurements were taken from eye level, so that they were all accurate and consistent. If I did not do this, my measurements (and therefore calculations) would be wrong. This is because the values indicated on the measuring cylinders, burettes, pipettes etc. appear different from below/above. Controlling this made my investigation more valid as my calculations and measurements were more likely to be accurate.

I improved the quality of my experiment by trialling the titre of the undiluted vinegar three times. This was to ensure that my results were not anomalies/outliers. This helped me to know that the amount was accurate and true, so that I was able to make the most sensible decision of what my dilution should be.

Before using the equipment, I rinsed it with the solution that was going in it to get rid of any other particles that would contaminate my solutions and make my results unreliable. For example, if there was water in the burette and I did not rinse it with NaOH, they would mix and the concentration of the NaOH would decrease, by an unknown amount, which would make my calculations wrong. This would make my investigation unreliable and my conclusion would not be valid. 5

When pouring solutions into flasks, measuring cylinders etc., I put the pipette near the bottom of the container, and did not touch the sides so that all of the solution got in, and none was lost on the sides or splashed out. This meant that I knew exactly how much of each solution was in the flask and none was lost, which would also make it unreliable. This would have made my calculations incorrect, thus making my conclusion inaccurate and invalid.

During my titrations, I accidentally put two drops of indicator into one flask instead of one like I did in the rest of my titrations. I tipped this into the waste beaker and started again (remeasured CH_3COOH and redid indicator) so that all of my trials had the same amount of phenolphthalein indicator (one drop). I did this because having more indicator may have made the colour change brighter at an earlier stage, so my measurement for when I observed this would have likely been wrong. This would have made my experiment inaccurate and my conclusion unreliable. 3

I always stopped titrating and took the measurement at the same colour (as soon as I saw pink colouring that remained in the flask). This meant that I was always measuring the same thing. If I had not done this, I would have been unable to get concordant titres, and my results would therefore be unreliable.

Evaluation: 1

I found that the concentration of CH_3COOH in the vinegar to be $39.7gL^{-1}$, which is $10.3gL^{-1}$ lower than the manufacturers claim of $50gL^{-1}$. There are several potential reasons for this, including:

The vinegar bottle has been open for a long time, and is past its use by date. If this were the case, air would have gotten into the product being opened. The vinegar would react with the air, which would alter the concentration of the vinegar.

The vinegar may have been made incorrectly. It is possible that the wrong amounts of ingredients were added, which would mean that the concentration of CH_3COOH would be incorrect. In addition to this, it is possible that the quality control of the vinegar production was poor, so mistakes in the concentration may have gone unnoticed. 4

The vinegar may contain $50gL^{-1}$ like the manufacturer claims, but it is not evenly distributed throughout the bottle. This may open if the vinegar had not been used in a while, and the CH_3COOH particles had begun to settle on the bottom of the bottle, reducing the concentration of the top part of the vinegar, even though the overall concentration would still be $50g^{-1}$.

There are many possible reasons for why the concentration I found ($39.7gL^{-1}$) is different to the $50gL^{-1}$ claimed by the manufacturer; either in human error, reaction to the air, improper equipment, etc.

	Grade Boundary: High Merit
2.	For Merit, the student needs to carry out an in-depth practical investigation into a substance present in a consumer product using quantitative analysis. This involves using results from the trials to develop a valid plan to modify the consumer product sample and/or titration procedure, and collecting, recording and processing quality data that enables a valid conclusion to be reached. This also involves accurately determining the concentration of the standard solution and the substance present, as well as explaining how the control of variables improved the quality of the investigation. This student has developed a valid plan based on the results of the trials (1) and collected, recorded and processed (2) quality data to make a valid conclusion (3). The student has explained how diluting the consumer product (4) and the rinsing of the glassware (5) improves the quality of the investigation. To reach Excellence, the student could explain how aspects of the investigation improved the validity and accuracy of the investigation. For example, linking the control of the amount of indicator to the possible effect on the colour change at the endpoint, or explaining how leftover ammonia/sulfuric acid in the flask could change the concentration of the sample and its effect on the titres, would be required to show justification of the titration procedure (6).

Student 2: High Merit

Intended for teacher use only

RESULTS (of trials):

trial 1 - 1ml of NH_3 and 5ml of H_2SO_4 it took 7ml of

trial 2 - 1ml of NH_3 and 7.2ml of H_2SO_4 around 7ml

trial 3 - 1 ml of NH_3 and 7.4 ml of H_2SO_4 of H_2SO_4

trial 4 - 1 ml of NH_3 and 7.0 ml of H_2SO_4 needed to react with 1ml of NH_3. This means I will dilute it 10x so it only take 0.7 ml of H_2SO_4 to react with 1ml of NH_3

1

PROPOSED PROCEDURE:

To do this experiment, the **original cloudy ammonia** needs to be diluted 10 x times.

This dilution can be achieved by pipetting 26 mL of the original cloudy ammonia into a 200 mL volumetric flask and adding distilled water to make it up to the mark.

In the actual titration I will use a 20 mL pipette to deliver an aliquot of the diluted cloudy ammonia into a titration flask, add a few drops of methyl orange indicator and titrate with the standardised sulfuric acid in the burette until a colour change from orange to red occurs.

Using this procedure, I would predict an average titre volume of approximately 14 mL.

Justification:

By diluting the NH_3 by 10 this will improve the quality of my data. This is because the ammonia is about 7 time stronger than the H_2SO_4. If I was to use this and not dilute it to do a titration if I was to use 20mL of the fully concentrated NH_3 it would take around 140mL. This would mean that I would have to fill up the burette 3 times to do 1 titration. So by diluting the NH_3 x10 it will improve my titration as I will only have to fill it up once. By diluting the acid I will get a range of 10-30mL which I want as below 10mL it is unaccurate and can have large percentage error and over 30mL it will be too large and too time consuming.

4

1. The molar mass of sodium carbonate $M(Na_2CO_3)$ = **106 g mol^{-1}** and M =m/n.
   Calculate the amount, in moles, of sodium carbonate dissolved in the volumetric flask.

   $n(Na_2CO_3) = \frac{m}{M}$ $m = 0.639$ $M = 106\ g\ mol^{-1}$

   $n = \frac{0.639}{106}$ $n = 0.006028301$ mol

2. Use the known amount of anhydrous sodium carbonate calculated above, the volume of the volumetric flask used and the relationship c = n/V, to calculate the concentration of the sodium carbonate standard solution.

   $c(Na_2CO_3) = \frac{n}{V}$ $n = 0.006028301$ $V = 0.25$ L

   $c = \frac{n}{V}$ $c = \frac{0.006028301}{0.25}$ $c = 0.024113207$ M

6. Use the known volume of sulfuric acid solution used in this titration and your answer to Q5 to calculate the concentration of the sulfuric solution (to 3 sig figs and including units).

   $c(H_2SO_4)$ = $V = 0.01$ L $n = 0.000512164$ mol

   $c = \frac{n}{V}$ $c = \frac{0.000512164}{0.01}$ $c = 0.0512164$

   $c = 0.0512$ mol/L

CALCULATIONS ($c = n/V$)

7. Calculate the average volume of your concordant titres (to 3 sig figs and including units)

$V(H_2SO_4)$ = $\frac{15.09 + 15.05 + 14.98 + 15.16}{4}$ $V = \frac{15.05}{1000}$ $V = 0.01505\ L$

8. Use your average titre from Q7 and the known concentration of sulfuric acid (**0.0512 mol L^{-1}**) to calculate the amount, in moles, of sulfuric acid present in the titration flask.

$n(H_2SO_4)$ = $n = c \times V$ $n = 0.0512 \times 0.01505$ $n = 0.0007710048$ mol $n = 0.000771584$ mol

$V = 0.01504$ $c = 0.0512$

9. The balanced equation for the reaction occurring in this titration is: (2)

$$2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

Use the mole ratio in this equation and your answer to Q8 to determine the amount, in moles, of ammonia present in each titration at the endpoint.

$n(NH_3)$ = $2NH_3 : 1\ H_2SO_4$ 2:1 ratio 0.000771584×2 $n = 0.0007710048 \times 2$ $n = 0.00154$ mol $n(NH_3) = 0.00154$ mol

10. Use the volume of ammonia solution used in each titration and your answer to Q9 to calculate the concentration of ammonia in the **diluted** household cleaner (**to 3 sig figs and including units**).

$c(NH_3) = \frac{n}{V}$ $c = \frac{0.00154}{0.02}$ $c = 0.07715$ mol/L (diluted) $c = 0.0771$ mol/L

$V = 0.02$ $n = 0.00154$ $c = 0.077$ mol/L

Summary Report:

The aim of this investigation was to determine the concentration of Ammonia present. Before starting my investigation I rinsed out my pipette out with the NH_3. I washed out my burette with H_2SO_4 and I washed my flask out with water. I did this too so I could know that there wasn't any left over particles in the equipment that could affect the concordancy of my results. Then I filled my burette with H_2SO_4 and made sure there were no bubbles in the burette. This made my results accurate as there were no air bubbles so the reading I took off the burette was more accurate. A variable I controlled was that I did a titration and added the indicator until it changed colour I then poured this into a beaker so I could compare the colour of each titration to make sure they were all the same. By controlling this variable it made my results accurate. I also prevented parallax error by making sure when I was reading the measurements I was always eye level. Another variable I controlled was that after every titration I rinsed out my flask with water so no left over NH_3 or H_2SO_4 could effect my results. (5) (6)

Also, I repeated my titration 7 times, then I took an average of the 4 results that were in a range of 0.3mL. This made the gL^{-1} to be 13.124gL^{-1} and the gL^{-1} concentration on the bottle says 18.0gL^{-1}. This means the the gL^{-1} concentration on the bottle is higher then the actual gL^{-1} concentration. This could be because the bottle is old and the concentration has diluted a little bit or because the company that made the cleaning agent didn't have as much concentration of ammonia in the cleaning agent as they said. (3)

	Grade Boundary: Low Merit
3.	For Merit, the student needs to carry out an in-depth practical investigation into a substance present in a consumer product using quantitative analysis. This involves using results from the trials to develop a valid plan to modify the consumer product sample and/or titration procedure, and collecting, recording and processing quality data that enables a valid conclusion to be reached. This also involves accurately determining the concentration of the standard solution and the substance present, as well as explaining how the control of variables improved the quality of the investigation. This student has developed a valid plan and collected, recorded and processed quality data (1) to make a valid conclusion (2). The student has explained how the removal of the air bubble improves the quality of the investigation (3). For a more secure Merit, the student should show correct working for either the concentration of the secondary standard solution or the concentration of the ethanoic acid (4). The learner could also further explain how using specific lab equipment improves the quality of the investigation (5).

Student 3: Low Merit

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Preparation of oxalic acid:

$n(C_2H_2O_4.2H_2O) = n = \frac{m}{M}$

$n = \frac{1.61g}{126.1 g mol^{-1}}$

$n = 0.012767644 73$

$n = 0.0128 mol$ (3 sig fig)

$c(C_2H_2O_4) = c = \frac{n}{v}$

$c = \frac{0.0128 mol}{0.25L}$

$c = 0.051070578 92$

$c = 0.0511 mol L^{-1}$ (3 sig fig)

Standardisation of sodium hydroxide solution:

Titration	1	2	3	4	5
Final Reading / mL	24.35	47.95	23.75	46.95	24.85
Initial Reading / mL	0.40	24.35	0.00	23.75	1.25
Titre / mL	23.95	23.60	23.75	23.20	23.60

$V(NaOH) = \frac{23.60 + 23.75 + 23.60}{3} = 23.65$

$= 0.02365L$

$n(C_2H_2O_4) = n = c \times v$

$n = 0.0510705 7892 mol L^{-1} \times 0.025L$

$n = 0.012767642 5$

$n = 0.0128 mol$ (3 sig fig)

4

$n(NaOH) = 1 : 2$

$2 \times 0.012767642 5 mol$

$n = 0.025535285$

$n = 0.0255 mol$ (3 sig fig)

$c(NaOH) = c = \frac{n}{v}$

$c = \frac{0.025535285 mol}{0.02365L}$

$c = 0.107971606 8$

$c = 0.108 mol L^{-1}$ (3 sig fig)

1

Analysis of white vinegar:

$V(NaOH) = \frac{20.70 + 21.00 + 21.00}{3} = 20.9$

$= 0.0209L$

$n(NaOH) = n = c \times v$

$n = 0.108 mol L^{-1} \times 0.0209L$

$= 0.022572$

$= 0.0226 mol$ (3 sig fig)

4

$n(CH_3COOH) = 1 : 1$

$= 1 \times 0.022572 mol$

$= 0.022572 mol$

$= 0.0226 mol$ (3 sig fig)

$c(CH_3COOH) = c = \frac{n}{v}$

$c = \frac{0.022572 mol}{0.025L}$

~~$c = 0.090288$~~

~~$= 0.0903 mol L^{-1}$ (3 sig fig)~~

$c = 0.090288$

$c = 0.0903 mol L^{-1}$ (3 sig fig)

From **Q10** in Part C	c(diluted CH_3COOH) = 0.0903 mol L^{-1} (3 sig fig)
From dilution information above	dilution factor = 10
Combining the above two	original concentration = 0.90288 mol L^{-1} 0.903 mol L^{-1} (3 sig fig)

12. The molar mass of ethanoic acid is $M(CH_3COOH) = 60.0$ gmol^{-1} and $M = m/n$
Use this information and your final value in **Q11** above to calculate the concentration of ethanoic acid present in the original Homebrand vinegar in units of gL^{-1}.

concentration × molar mass
0.903 mol L^{-1} × 60.0 g mol^{-1}
= 54.1728
= 54.173 g L^{-1} (3 sig fig)

Summary Report:

Some control variables used in this investigation was the volume. By using the equipment of the burette, conical flasks and pipette this ensured that the volume of ethanoic acid and the original homebrand vinegar were all kept at the exact and same volumes needed. Another controled variable was the concentration. This was ~~#~~ controled due to the repeating of the expirment 4 times. By repeating the expirmend multiple times, this ensured that the results would be fairly accurate and kept at a titre value of between 0.30ml. From there, ~~#~~ by taking the most concordant titre measurments, an average can be found to show a high accuracy. Other control of variables were through ensuring that the burette was free of any air bubbles. By freeing the air bubbles this ensured the final result of the reading would be more accurate. This is due to the fact that the air bubbles stuck in the burrette give an inaccurate showing of the amount and also make it harder to release the acid into the conical flask. Overall the concentration found was 54.173 g L^{-1}, which was 5.827 g L^{-1} less than the 60.0 g L^{-1} found by the manufacturer. Although they are close, the concentration found was lesser, this could be because of a slight inaccuracy when using the burette to pour into the conical flask and accidentally going slight over the infact needed amount. Overall though, the concentration was found very close and somewhat accurate when compared to the concentration claimed by the manufacturer.

5

3

2

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to carry out a practical investigation into a substance present in a consumer product using quantitative analysis. This involves developing a workable plan to determine if the consumer product and/or titration procedure require modification, and collecting, recording and processing sufficient data to enable a conclusion to be reached. This also involves determining the concentration of a substance relevant to the investigation (using stoichiometric principles and both relationships n=m/M and c=n/V) and describing how significant variables were controlled. This student has developed a workable plan (1) and collected, recorded and processed sufficient data for a conclusion to be reached (2). The learner has calculated the concentration of a substance (3) and described the significant variables that were controlled (4). To reach Merit, the student could explain how the control of the significant variables improved the quality of the investigation. For example, explaining that all glassware is rinsed with distilled water first, and then the burette and pipette are rinsed with the solution to be added to ensure there are no contaminants that could react, and the concentrations of the solutions in the pipette and burette are kept constant. This ensures the titre values are accurate and concordant (5).

Student 4: High Achieved

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Preparation of anhydrous sodium carbonate solution

0.639 g of anhydrous Na_2CO_3 was weighed on a laboratory balance and added to a 250 mL volumetric flask. The flask was then made up to volume using distilled water and shaken until all had fully dissolved.

$M(Na_2CO_3) = 106\ g\ mol^{-1}$

$n = m / M$ $\qquad$ $C = n / V$

1. Calculate the concentration of the sodium carbonate standard solution using the information above.

$n_{Na_2CO_3} = 0,639 / 106 = 0,0060283\ mol$

$c(Na_2CO_3) = \frac{n}{V} = \frac{0,0060283}{0,250} = 0,0241132075 \approx 0,0241\ mol\ L^{-1}$

Standardisation of sulfuric acid solution

10.0 mL samples of the sulfuric acid were then titrated with the sodium carbonate standard solution, using phenolphthalein as the indicator.

The sodium carbonate burette readings gathered is provided in the table below:

Titration	1	2	3	4	5
Final Reading/mL	22.92	44.10	24.64	45.92	27.08
Initial Reading/mL	1.30	22.92	3.10	24.64	5.82
Titre / mL	21,62	21.18	21.54	21.28	21.26

2. Indicate the concordant titres and calculate the average volume.

$V(Na_2CO_3) = (21.18 + 21.28 + 21.26) : 3 = 21,24\ ml$

The balanced equation for this standardisation titration is

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

3. Use your answers to Q1 and Q2 to calculate the concentration of the sulfuric acid solution (to 3 sig figs and with appropriate units).

	R	n	V	C
Na_2CO_3	1	0,0011346516	21.24	0,0241
H_2SO_4	1	0,0011346516	10	0,05411884

	R	n	V	C
Na_2CO_3	1	0,0005411884	21,24	0,0241
H_2SO_4	1	0,0005411884	10	0,05411884

$c(H_2SO_4) = 0,05411884 \approx 0,0512\ mol\ L^{-1}$ (3)

CALCULATIONS $C = n / V$

4. Indicate the concordant titres and calculate the average volume of sulfuric acid.

$V(H_2SO_4)$ = 19,5 mL

The balanced equation for the reaction occurring in the titration is

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

5. Use your answer to Q4 and the information at the top of the sheet to calculate the concentration of ammonia in the **diluted** household cleaner (to 3 sig figs and including units).

	R	n	V mL	C mol L^{-1}
NH_3	2	~~0,0004992~~ 0,0019968	10	~~0,04992~~ 0,19968
H_2SO_4	1	0,0009984	19,5	0,0512

$c(NH_3)$ = ~~0,04992~~ 0,19968 ≈ ~~0,0499~~ 0,200 mol/L

Summary Report:

Aim of the investigation is to find out the concentration of ammonia in the real product and contrast it with claim of the producer.

To ensure the procedure has less error and improves the quality of the investigation I checked if there were any air bubbles in the tip of the burette and remove the funnel before titration. This will stop the incorrect readings from variables like air bubbles and dripping. I also dip the pipette just below the solution to give a correct reading of the aliquot. Another controlled variable was to rinse the burette and pipette with the appropriate solution to remove residual water. (4) (5)

The product I tested has a concentration of ammonia of 13.6gL^{-1} unlike what the producer claimed of 24gL^{-1}. This is due to factors like the manufacturer adding too much aliquot or adding a few chemicals or it could also be that the chemical was old and the chemical has degraded which reduced the concentration or too much exposure to the environment like sunlight or humidity. (2)

In the real world there is a huge variety of concentration. Therefore we need to dilute the chemical so that when we do the titration, the titration value is around 10mL to 25mL. This is because when it is lower than 10mL there is a large percentage error as one incorrect drop could make a big difference. When it is larger than 25mL, it would be time consuming, wasteful and might add other errors when we refill the burette. (1)

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to carry out a practical investigation into a substance present in a consumer product using quantitative analysis. This involves developing a workable plan to determine if the consumer product and/or titration procedure require modification, and collecting, recording and processing sufficient data to enable a conclusion to be reached. This also involves determining the concentration of a substance relevant to the investigation (using stoichiometric principles and both relationships n=m/M and c=n/V) and describing how significant variables were controlled. This student has developed a workable plan and collected, recorded (1) and processed sufficient data for a conclusion to be reached (2). The learner has calculated the concentration of a substance (3) and has described the significant variables that were controlled (4). For a more secure Achieved, the student could show the correct calculation using n=m/M. The student has got the correct working for n=m/M but the wrong answer for question 1 (5). The conclusion could also refer to the concentration that was calculated for the consumer product.

Student 5: Low Achieved

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1. Calculate the concentration of the sodium carbonate standard solution using the information above.

0.639 g ÷ 106 = 0.6028301887 (5) 250 ÷ 1000 = 0.25

Ans ÷ 0.25 = 2.411320755

$c(Na_2CO_3)$ = 2.41 mol L^{-1}

Standardisation of sulfuric acid solution

10.0 mL samples of the sulfuric acid were then titrated with the sodium carbonate standard solution, using phenolphthalein as the indicator.

The sodium carbonate burette readings gathered is provided in the table below:

Titration	1	2	3	4	5
Final Reading/mL	22.92	44.10	24.64	45.92	27.08
Initial Reading/mL	1.30	22.92	3.10	24.64	5.82
Titre / mL	21.62	21.18	21.54	21.28	21.26

2. Indicate the concordant titres and calculate the average volume.

$V(Na_2CO_3)$ = $\left(\frac{21.28 + 21.26 + 21.18}{3}\right)$ = 21.24 ml

The balanced equation for this standardisation titration is

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

1 : 1

3. Use your answers to Q1 and Q2 to calculate the concentration of the sulfuric acid solution (to 3 sig figs and with appropriate units).

1 Na_2CO_3 = C x V = 2.41 x 0.02124 = 0.05118484

MOLE RATIO = 1:1

$n(H_2SO_4)$ = 0.05118484

K: C 2.41, V 0.02124, N 0.05118484

UK: C 5.11884, V 0.01, N 0.05118484

$c(H_2SO_4)$ = 5.12 mol L^{-1}

C = N/V

0.05118484 ÷ 0.01 = 5.11884 (3)

RESULTS

Titration	1	2	3	4	5
Final Reading / mL	27.5	40.6	20.10	46.40	~~3~~
Initial reading / mL	14.2	27.5	~~7.93~~	33.50	~~3.464~~
Titre / mL	13.3	13.1	12.8	12.9	13

5 ← 19.3 ← 6.3 ← ~~13~~

CALCULATIONS $C = n / V$

4. Indicate the concordant titres and calculate the average volume of sulfuric acid.

$V(H_2SO_4) = \left(\frac{12.8 + 12.9 + 13}{3}\right)$ = 12.9 ml = 0.0129 L

The balanced equation for the reaction occurring in the titration is

$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

5. Use your answer to Q4 and the information at the top of the sheet to calculate the concentration of ammonia in the **diluted** household cleaner (to 3 sig figs and including units).

(a) H_2SO_4 = 0.0512 mol L^{-1}

Molar ratio = 2 : 1

0.0512 x 2 = 0.1024

0.0512 X

$c(NH_3)$ = ~~0.00132~~ 0.00132 mol L^{-1}

c 0.0512 c
V 0.0129 V ~~0.01~~
N ~~0.0512~~ N ~~0.1024~~

H_2SO_4
C ~~6.6048 x 10^{-4}~~ 0.0512
V 0.0129
N ~~6.6048 x 10^{-6}~~ ~~0.0512~~

NH_3
C 1.32096 x 10^{-3}
V 0.01
N 1.32096 x 10^{-5}

The purpose of the investigation is to work out the concentration of NH_3 in a cleaning product. In order to ensure accurate results were obtained from the titration I rinsed the burette in the solution I was titrating sulfuric acid. I did this because if anything else was remaining in the burette it could have diluted the solution. When titrating I only filled the burette as high as I could read the measurements at eye level. I did this to avoid parallax error, not reading the measurements at eye level could have a significant impact on the result. When filling the pipette I made sure the bottom of the meniscus was on the line. The endpoint of each titration was met by one drop of H_2SO_4. If these variables aren't controlled it could significantly change the results. A titre volume lower than 10mL reflects a large % error when having to refill the burette, it is also very time consuming.

I found that the concentration was higher than the manufacturers claim. This is likely because they put more of the chemical in so that when it degrades overtime it doesn't fall below the concentration they stated.

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to carry out a practical investigation into a substance present in a consumer product using quantitative analysis. This involves developing a workable plan to determine if the consumer product and/or titration procedure require modification, and collecting, recording and processing sufficient data to enable a conclusion to be reached. This also involves determining the concentration of a substance relevant to the investigation (using stoichiometric principles and both relationships n=m/M and c=n/V) and describing how significant variables were controlled. This student has developed a workable plan and collected, recorded (1) and processed sufficient data for a conclusion to be reached (2). The learner has calculated the concentration of a substance (3) using stoichiometric principles (4) and both relationships n=m/M (5) and c=n/V. To reach Achieved, the student should describe how significant variables were controlled. For example, describing what the different glassware was rinsed with, and how the use of white paper behind the glassware (burette) along with taking the reading while being at eye level and from the bottom of the meniscus. The statements used to describe the control of the significant variables need to be specific to the investigation rather than generic statements (6).

Student 6: High Not Achieved

Intended for teacher use only

Results (of trials):

In my trial of finding out how many mL of NaOH I needed to dilute the commercial vinegar. I needed 10 mLs of NaOH to turn the vinegar pink. I also added an indicator named phenolphthalein and put a few drops of that in before I started to add the NaOH. This was my rough trial.

PROPOSED PROCEDURE:

The original solution of commercial vinegar needs to be diluted 10 x times and a 10 mL sample of this diluted solution will be titrated .

The required dilution can be achieved by pipetting 10 mL of the original solution and adding distilled water to make it up to the mark on a 100 mL volumetric flask.

In the actual titration with the sodium hydroxide I will use a 10 mL pipette to deliver an aliquot of the diluted vinegar into a titration flask, add a few drops of phenolphthalein indicator and titrate with the standardised sodium hydroxide until a colour change from colour to pink occurs.
less

Using this procedure, I would predict an average titre volume of approximately ____ mL.

Preparation of the oxalic acid solution

This oxalic acid solution was made by adding 1.36 g of hydrated oxalic acid crystals ($C_2H_2O_4.2H_2O$) into a 250 mL volumetric flask and making up to the mark with distilled water.

$M(C_2H_2O_4.2H_2O)$ = 126.1 g mol^{-1} n = m/M and c = n/V

Use this information to calculate the number of moles of oxalic acid added and the concentration of the final solution.

m = 1.36 g
V = 250 mL
M = 126.1 g mol^{-1}
n = 0.010785
C = 0.04314

1. $n_{(oxalic\ acid)}$ = 0.010785
n = m ÷ M
1.36 ÷ 126.1 = 0.010785 (5)

2. $c_{(oxalic\ acid)}$ = 0.04314
c = n ÷ V
0.010785 ÷ 0.25 = 0.04314
250 ÷ 1000 = 0.25 (3)

3. Calculate the average volume of the concordant titres (to 3 sig figs and including units)

V(NaOH) = 20.4

20.4
+20.4
+20.5
61.3 ÷ 3
20.4
I am using 2, 3 and 4 to get my average.

Average = 20.4

4. Use the known volume and concentration of the oxalic acid solution calculated in Q2 above to calculate the amount, in moles, of oxalic acid used in the standardisation. (c = n/V) c x V = n

n(oxalic acid) = 0.0010785
25.0 ÷ 1000 = 0.025
0.04314 x 0.025 = 0.0010785
c x v = n

5. The balanced equation for the titration can be summarised as:

$$C_2H_2O_4 + 2NaOH \longrightarrow Na_2C_2O_4 + 2H_2O$$

Use the mole ratio in this equation and your answer to Q4 to determine the amount, in moles, of sodium hydroxide present in each titration at the endpoint.

n(NaOH) = 0.002157

0.0010785 x 2 = 0.002157 ÷ 1 = 0.002157 (4)

• I crossed my titres to get the n for NaOH

6. Use the volume of sodium hydroxide solution reacted in this titration and your answer to Q5 to calculate the concentration of the sodium hydroxide (to 3 sig figs and including units).

c(NaOH) = 0.105 7352

(3)

• n ÷ V = C

• 0.002157 ÷ 0.0204 = 0.105 7352.

RESULTS

Titration	1	2	3	4	5	6
Final Reading / mL	16.78mL	34.45	16.54	34.76	17.20	16.78
Initial reading / mL	0.00mL	16.98mL	0.00	16.54	0.00	0.00
Titre / mL	16.78mL	17.45	16.54	18.22	17.20	16.78

(1)

Report Summary:

Controlled variables – In my investigation I tried to make everything controlled and I did this by rinsing all the equipment with the solution I was going to put in it. (6)

When I was doing my readings I made sure I put a paper behind it and read from the bottom of the meniscus.

Conclusion – from my results the concentration of the of the vinegar sample was 0.078. (2)