Violet J. Lule Yr13
Chemistry C/W

How Much Acid is there in a Solution?

Aim: The aim of this experiment is to find out the accurate concentration of sulphuric acid, H_2SO_4, using sodium carbonate, Na_2CO_3.

Introduction:

What is Titration?

Titration is a laboratory technique used to find out the unknown concentration of the reactant. In this technique the titrant reacts with a solution of the analyte. You will know when you have doing your titre when the colour of the solution changes to a permanent colour. This can be explained through this equation:

$HIn\ (aq) \quad H^+\ (aq) + In^-\ (aq)$

Acid is orange **Base is pale pink**

Here is the equation of what happens when the methly orange indicator is involved in the acid- base reaction. The HIn represents the methyl orange indicator. When the colour of the solution changes to a permanent colour, it is called the end point; the colour of the solution changes due to the presence of an indicator (such as methyl orange or phenolphthalein).

Different Types of Titrations:

There are different types of titrations used by scientists such as:

- Acid number titration – this is used to determine the free fatty acid present in the solution.
- Karl Fischer titration – this is used to analyse the trace of water in a substance
- Acid-Base titration – this is used to determine how much acid there is in a solution by using an alkaline solution.

Plan:

How much anhydrous sodium carbonate will I need?

The amount of anhydrous sodium carbonate I need is 2.65g. This amount of mass can be worked out by using this formula:

$$= \text{Molar Mass} \times \frac{\text{volume}}{1000} \times \text{concentration}$$

$$= 106 \times \frac{250}{1000} \times 0.1$$

The molar mass of sodium carbonate is 106. To calculate the mola r mass of sodium carbonate I added the mass numbers of sodium, carbon and oxygen. Since there are two lots of sodium I multiplied its mass of 23 by 2, which gave me the answer 46. Also since there were 3 lots of oxygen, I multiplied its mass number of 16 by 3 which gave me the answer 48. The mass number of carbon is 12, and once I added all these values together, this gave me the relative molecular of 106.

I then multiplied this by the volume, which is 0.25dm^3. To work out the accurate volume I divided 250 by 1000. This amount of volume was used because it is enough to get me through 3 consecutive titrations. Afterwards I multiplied this by 0.1 because that is the concentration of Na_2CO_3 that I am going to use. The reason why I used a concentration of 0.1 mol dm^{-3} was because we know that the concentration of the unknown acid lies between 2 certain concentrations and 0.1 is halfway between these ranges. Once doing this I got the answer 2.65, which is the amount of grams of anhydrous sodium carbonate I am goi ng to use.

Equation for the reaction:

The formula equation for this reaction I will be carrying out is:

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

Indicator:

Once I have finished making my sodium carbonate solution, it will be ready to use in the titration, then afterwards, I will add methyl orange indicator to it. I chose this indicator because it is a coloured substance and a weak acid too, which is a suitable property to use in the titration .This will enable to see when I have reached end point whilst doing my titres because the colour will change.

Health and Safety:

Hazards of Sulphuric Acid (H_2SO_4):

Sulphuric acid is highly corrosive to all parts of the body. Its vapours are corrosive to the respiratory tract and can cause fluid build up on the lungs which could be fatal. Because of this there were safety procedures I took to protect myself:

- On skin contact if sulphuric acid is splashed you it may cause severe burns. To protect myself from this happening, I wore a lab coat which prevented any spillages getting in contact with my skin. Also if any is spilt onto a table I will wipe it straight away with a cloth.

- On eye contact it may cause severe burns or prolonged and permanent damage. To protect my eyes I wore safety goggles, this prevented acid from getting into my eyes.

- To prevent the vapour from the acid becoming an irritant to the respiratory tract, the teacher opened the window; this ensured that the room was well ventilated.

- There also could be hazards with the range of concentration of sulphuric acid that will come during the titration. The higher the concentration, the more dangerous the risks are and the more I have to prevent this from happening. The safety procedures I took to prevent this from happening included wearing safety goggles, a lab coat and making sure that a cloth is near just in case there are any spillages.

Hazards of Anhydrous Sodium Carbonate (Na_2CO_3):

Inhalation of the anhydrous sodium carbonate may cause irritation to the respiratory tract and also can cause irritation to the eyes too if eyes are kept constantly closed. Symptoms from excessive inhalation may include coughing and difficulty in breathing. Also if digested this may cause vomiting, diarrhoea, collapse or even death. Furthermore excessive skin contact may cause irritation to the skin with blistering and redness

The precautions I took were to:

- Make sure all the windows and doors were open to avoid inhalation of the anhydrous sodium carbonate. Also I made sure to clean my area so that no cross contamination takes place.

- To prevent irritation of my skin I wore a lab coat so that it prevents my skin from getting in contact with the anhydrous sodium carbonate.

- To prevent injury to my eyes I wore safety goggles which prevented the anhydrous sodium carbonate solution from getting in contact with my eyes.

Hazards of Methyl Orange Indicator:

Methyl orange indicator acts as an irritant to the skin and eyes. Also severe exposure in inhalation and ingestion can result in death:

To prevent incidents such as these happening I:

- Wore a lab coat and eye goggles to protect my skin and eyes from irritation and to help avoid contact with the methyl orange indicator.
- Also my teacher made sure that the room was well ventilated by opening all the windows and doors.

Apparatus:

Apparatus Used:	**Why I'm Using It:**
Solid Anhydrous Sodium Carbonate	Used to titrate against the H_2SO_4 to find out the concentration that is present
H_2SO_4 of unknown concentration	To find out the unknown concentration of the acid.
Clamp Stand	To help keep the burette in a vertical straight position.
Burette ($50cm^3$)	Will be used to pour in the sulphuric acid, and used to read off my titre when I have reached end point.
Pipette ($25cm^3$)	To transfer accurately $25cm^3$ of the solution of sodium carbonate.
Indicator (methyl orange) solution	So that I know when I have reached my end point (by a permanent colour change).
Funnel	So that it removes any impurities when transferring solutions.
Distilled Water	To help clean my equipment, e.g. pipette, before starting my experiment. Furthermore if there are drops of acid left at the side of the beaker, I can use it to help me put the acid drops in the beaker.
Volumetric Flask/Graduated Flask ($250cm^3$)	To put in the solution of sodium carbonate solution, where it can be

	transferred easily. Also it has a graduated mark so I can accurately fill in the flask.
Conical Flask (250cm^3)	To put in the solution of sodium carbonate after transferring it from the volumetric flask. This is also going to be used during my titration.
Electronic Balance	To weigh out accurately 2.65g of anhydrous sodium carbonate.
Beaker (250cm^3)	It is where the anhydrous sodium carbonate will be dissolved in distilled water.
Glass Stirring Rod	To stir the mixture of anhydrous sodium carbonate with distilled water. It must be stirred until the anhydrous sodium carbonate has been completely dissolved.
Pipette Filler	It will be positioned onto the pipette (25cm^3) when transferring solutions. It also helps with the transfer of solutions.
Spatula	Used at the start of the investigation when transferring the anhydrous sodium carbonate to the weighing boat till it reaches 2.65g
White Tile	It will be used to indicate when the colour of the solution of sodium carbonate has permanently
Safety Goggles	To protect my eyes from harm when using the acids. Also as precaution if one of the acids were to spill. (must be worn at all times)
Lab Coat	To protect myself from any spillages that may take place.

Method:

Preparing the anhydrous sodium carbonate:

1. Wear safety goggles and a lab coat for the protection of harm from acids.
2. Make sure the electronic balance is set to 0.00g.
3. Get the weighing boat and weigh 2.65g of anhydrous sodium carbonate.
4. Record the mass of the anhydrous sodium carbonate.

Making a solution of sodium carbonate of unknown concentration:

1. Pour the contents of the anhydrous sodium carbonate into a 250cm^3 beaker, with the assistance of a spatula. Then with distilled water clean out any bits of anhydrous sodium carbonate left on the spatula or/and the weighing boat i nto the 250cm^3.
2. Afterwards dissolve the anhydrous sodium carbonate with distilled water until it has completely dissolved. After that stir using a glass stirring rod till all of the anhydrous sodium carbonate.
3. With the distilled water use it on the stirring rod so that the solution of the sodium carbonate solution transfers to the beaker.
4. Put a funnel on top of the graduated flask whilst pouring the solution of sodium carbonate from the 250cm^3 beaker to the 250cm^3 graduated flask.
5. Rinse out the funnel with distilled water which still may contain the solution of sodium carbonate and pour in the graduated flask.
6. Also rinse out the 250cm^3 beaker with distilled water and pour it into the 250cm^3 graduated flask so that all the sodium carbonate solution goes in.
7. Afterwards fill the 250cm^3 graduated flask with distilled water till it reaches the graduated mark.
8. When filling up to the graduated mark, make sure that the dip is accurately on the line.
9. Put a stopper on top of the 250cm^3 graduated flask, then shake it un til the solution has mixed.

Titration method:

1. Put a funnel on top of the burette
2. Get a clamp to hold the burette in a vertical, straight position.
3. Rinse the burette with sulphuric acid because this prevents inaccuracy in results and also that is the acid that will be used in the experiment.

4. Fill up the burette with sulphuric acid again once you have finished rinsing the burette, making sure that there are no air bubbles.
5. Make sure that the burette is filled to $50cm^3$ and the dip is accurately on the meniscus line.
6. When finished pouring the sulphuric acid into the burette, remove the funnel.
7. Rinse the $25cm^3$ pipette with distilled water before pipetting the solution of sodium carbonate.
8. Pipette $25cm^3$ of the solution of sodium carbonate using a pipette, until it reaches the meniscus line. Use a pipette filler to help pipette it out.
9. Use a white tile to see that the solution is up to the meniscus line and that the dip is accurately on the line.
10. Take off the pipette filler and release the solution of sodium carbonate to a $250cm^3$ conical flask. It's likely there will be some solution left on the tip of the pipette so knock it gently against the conical flask so that exactly $25cm^3$ of the solution has been transferred.
11. Before releasing the solution of sodium carbonate to the conical flask, make sure the conical flask was rinsed with distilled water beforehand so that it is clean.
12. Add 3 drops of methyl orange solution to the sodium carbonate solution in the conical flask.
13. Place conical flask with the solution of sodium carbonate on top of the white tile, so that it is easier to see when the colour has permanently changed.
14. Once the conical flask has been placed on top of the white tile you may start to begin the titre by adding sulphuric acid to the conical flask.
15. Swirl the conical flask whilst adding in the sulphuric acid.
16. If the colour changes slightly then goes back to the original colour of the sodium carbonate solution, add in the sulphuric acid drop by drop.
17. Once a first permanent colour has been reached, this is when you have reached endpoint.
18. Record the approximate value of the volume of sulphuric acid needed to reach end point in the investigation.
19. Use a white tile behind the burette as a measurement tool to help record the volume required. Also whilst recording the volume makes sure to have good eye-level, this is needed to ensure accurate results.

20. Clean out the conical flask with distilled water so that you can use it again when repeating titres.

21. Keep repeating the titration method until you get 3 consecutive titres which are within 0.1 of each other.

Justification for Getting Accurate Results:

Before and whilst doing the titration there are a number of things to do to get accurate results.

Titration Checklist:

- Check that the balance is clean
- Use white tile whilst doing the titre to record volume
- The weighing boat is placed in the middle of the balance
- Repeat 3 times till results are 0.1 of each other
- The weighing boat is dry and clean
- Use the same amount of drops of methyl orange solution each time
- The balance is set to 0.00g before weighing the anhydrous sodium carbonate
- Take the funnel off the burette whilst doing the titre
- Make sure that 2.65g of anhydrous sodium carbonate has been accurately weighed.

Use of Pipettes:

- Pipettes has been cleaned with distilled water
- Not to pipette straight from the reagent bottle
- That the tip of the pipette is not blocked
- After transferring the sodium carbonate solution to the conical flask, make sure that the tip of the pipette is lightly tapped against the conical flask, so that all the solution goes in

Using Burettes:

- The burettes are cleaned with sulphuric acid (since that is what I am going to use in the titration)
- No bubbles are present

- The burette tip is not damaged
- The tap is not leaking
- The burette is in a vertical position whilst being held in place by the clamp
- That the outside of the burette is clean so that you can read the volume required to decolourise the sodium carbonate solution

Implementing:

Table of Initial and Final Mass of Anhydrous Sodium Carbonate Weighed:

Here is a table showing the initial and final mass of the anhydrous sodium carbonate used:

Mass (g)	**Anhydrous Sodium Carbonate:**
Initial Mass:	0.00
Final Mass:	2.65

Results Table:

Here are my results for the titration:

Titration (cm^3)	Rough	1	2	3	4	5	6
Final Burette Reading	29.80	27.90	27.60	28.00	27.90	28.00	28.00
Initial Burette Reading	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Titre (cm^3)	29.80	27.90	27.60	28.00	27.90	28.00	28.00

Average Results:

This is my average table of results showing my average tires. It also shows my best three titres which were in 0.1 of each other.

Titration (cm^3)	1	2	3
Final Burette Reading	28.00	27.90	28.00
Initial Burette Reading	0.00	0.00	0.00
Titre (cm^3)	28.00	27.90	28.00

Analysing:

Working out the average titre:

I will be working out the average titre from my titration investigation. To work out the average titre I will be using the three consecutive results that were in 0.1 of each other.

First of all I add my three consecutive titres together, and then I will divi de this by 3. Doing this will enable me to get my average titre.

$$\frac{28.00 + 27.90 + 28.00}{3} = \frac{83.9}{3} = 27.96cm^3$$

Therefore my average titre is $27.96cm^3$.

Working out the number of moles:

The equation for this reaction is:

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

From this equation I can see that all the molecules have the same amount of moles which is 1 mole. To work out the number of moles for Na_2CO_3 I will use this equation:

$$\text{Number of Moles} = \text{Concentration} \times \frac{\text{Volume}}{1000}$$

I will need to put in the concentration and volume I used during the titration to work out the number of moles. The concentration of the Na_2CO_3 is 0.1 mol dm^{-3}, and the volume will be 25cm^3 since that is that is the amount of Na_2CO_3 I used during the titre. So the equation will therefore be:

$$\text{Number of Moles} = 0.1 \times \frac{25}{1000} =$$

$$\text{Number of Moles} = 0.1 \times 0.025 = 0.0025$$

Here I have worked out that the number of moles of Na_2CO_3. Once I have worked this out I will need to work out the unknown concentration of H_2SO_4, to do this I will use the equation:

$$\text{Concentration} = \frac{\text{Number of Moles}}{\text{Volume}/1000}$$

I will need to put in the number of moles and volume to work out the concentration. The number of moles would be 0.0025 and the volume will be 27.96 (since that was my average titre).

$$\text{Concentration} = \frac{0.0025}{27.96/1000} = \frac{0.0025}{0.02796} = 0.09 \text{ mol dm}^{-3}$$

In this equation I had to divide 27.96 by 1000 to get the accurate volume. The concentration worked out to be 0.09 mol dm^{-3}. Thus the unknown concentration of the H_2SO_4 I used is 0.09 mol dm^{-3}.

Evaluation:

Anomalies in Results:

At the start of the titration I had 2 anomalies which were in 0.3 of each other. This may have been because I may have failed to accurately pipette 25cm^3 of the sodium carbonate solution in to the conical flask. This may have affected my results since I added in more than enough of the Na_2CO_3 solution, so this may have made it longer for me to reach end point. Another possible reason is that I forgot to remove the funnel from the burette whilst doing the titre. This may have hindered my results for extra drops of sulphuric acid may have gone into the burette.

Accurate Results:

To get accurate results I did a number of procedures. Firstly when I was weighing out the anhydrous sodium carbonate I made sure that I accurately weighed 2.65g. However before weighing out the anhydrous sodium carbonate I made sure that the balance was set to 0.0g and that the surface of the balance was clean. I also made to sure to use distilled water to clean out the spatula when I was using it to help transfer the anhydrous Na_2CO_3 into the beaker. By using distilled water, this made sure that all of the 2.65g of anhydrous sodium carbonate was transferred into the beaker. Distilled water was also used to clean out the stirring rod and the weighing boat. When filling up the sodium carbonate solution in the 250cm^3 graduated flask, I made sure that I was up to the graduation mark. I also placed a white tile behind the graduated flask and made sure that I had good eye-level to make sure I accurately filled up 250cm^3. Furthermore I rinsed my burette with sulphuric acid because that was the acid I was using in the titration and also made sure there were no air bubbles. Rinsing the burette with sulphuric acid also prevents inaccuracy of results and also when placing the burette on the clamp I made sure that it was held in a vertical position, this enabled me to record accurate results when I have reached end point. In addition I added the same amount of drops of methyl orange solution to the sodium carbonate solution in the conical flask. Before starting the titration I placed the conical flask on top of a white tile, so that it was easier to tell when I have reached end point. Also when I was coming near to my end point I added in sulphuric acid drip by drip, this makes sure that I get more accurate results because if I didn't do this I would end up getting lots of anomalies. Lastly I repeated this titration method until I got 3 consecutive titres which were in 0.1 of each other.

Percentage Error:

The percentage error of a 50cm^3 burette, a 25cm^3 pipette and a 250cm^3 volumetric flask can be worked out by using this formula:

$$\frac{\text{Error x 100}}{\text{Reading}}$$

Percentage Error of the 50cm^3 burette:

One drop from a 50cm^3 class B burette has the error of 0.05. To work out the percentage error I will have to multiply 0.05 by 100 and then divide by 27.96 (which was the average titre).

$$\text{Percentage error} = \frac{0.05 \times 100}{27.96} = 0.17\%$$

So my percentage error for the 50cm^3 burette is 0.17%

Percentage Error of the 25cm^3 pipette:

The error for a 25cm^3 class B pipette is 0.06cm^3; also the reading will work out to be 25. Therefore the formula will work out to be:

$$\text{Percentage Error} = \frac{0.06 \times 100}{25} = 0.24\%$$

Thus the percentage error for the 25cm^3 class B pipette in this experiment is 0.24%

Percentage Error of the 250cm^3 volumetric flask:

The error for the 250cm^3 class B volumetric flask is 0.2cm^3 and the reading will be 250. Therefore my formula will work out to be:

$$\text{Percentage Error} = \frac{0.2 \times 100}{250} = 0.08\%$$

So the percentage error for the 250cm^3 class B volumetric flask I used is 0.08%.

Overall Percentage Error:

I will now need to work out the overall percentage error, to do this I will need to add the percentage errors from the 25cm^3 pipette, 250cm^3 volumetric flask and the 50cm^3 burette.

Overall percentage error = 0.24 + 0.08 + 0.17 = 0.49%

So the overall percentage error of this investigation is 0.49%.

The biggest percentage error I got was the 25cm^3 pipette, this may have hindered my results previously because I may have pipette too much or too little, which may have caused the different readings when I reached end point.

Levels of Uncertainties:

To work out the level of uncertainties I will need to use this formula:

$$\text{Levels f uncertainties} = \frac{\text{overall percentage error}}{100} \times \text{unknown concentration of } H_2SO_4$$

$$= \frac{0.49}{100} \times 0.09 = 0.00041$$

In this formula I had to use my overall percentage error which was 0.49 I also had to use the concentration of H_2SO_4 which is 0.09. After doing this formula, the levels of uncertainty worked out to being 0.00041. I think that this is a small significant error; this shows that the concentration of H_2SO_4 is quite accurate.

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