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Chemistry
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FINDING THE UNKNOWN MOLARITY OF ETHANOIC ACID IN VINEGAR.

Objective

The aim of this experiment is to determine the molarity of ethanoic acid in vinegar (CH_3COOH) by adding a volume of sodium hydroxide (NaOH).

Hypothesis

The more volume of vinegar (CH_3COOH) we put in, the more volume of sodium hydroxide (NaOH) we need.

Variables

- Independent Variables: Volume of acid (0.5 mL, 1 mL, 1.5 mL, 2 mL, 2.5 mL.)
- Dependent Variable: The molarity of acid.
- Controlled Variables: The molarity of sodium hydroxide (1M), the type of vinegar (CH_3COOH), room temperature, pressure, the addition of phenolphthalein indicator (3 drops), the volume of distilled water into the acid (50 mL).

Theoretical Background

Vinegar is a versatile liquid that is created from the fermentation of ethanol. According to the *Merriam-Webster* dictionary, Vinegar is, "A sour liquid obtained by fermentation of dilute alcoholic liquids and used as a condiment or preservative." The main ingredient of vinegar is a type of acid called the ethanoic acid (CH_3COOH). Other acids such as the tartaric and citric acid is also a part of the ingredient. The pH range of a vinegar is usually from 3 to 3.5. Vinegar can be used for many different things, one of them is in food. It can be used as an ingredient and condiments while cooking. Other than using it as an ingredient in a meal, vinegar can be used for household cleaning and other uses too.

One of the methods that can be used to analyze the content of a vinegar is titration. Titration is a method used in chemistry to determine the molarity of an acid or a base. A chemical reaction is made between a known volume of solution of an unknown concentration and a known volume of a solution with a known concentration. To conduct this method, you will need a burette to hold the reactant. Then a stopcock will be attached to the burette that can enable us to control the amount of liquid that is coming through.

Some acids and bases are polyprotic, which means that each mole can release more than one acid or base equivalent. When the solution of known concentration and the solution of unknown concentration equals, a chemical reaction happens. The equivalence point of a strong acid or a strong base will occur at pH 7. For weak acids and bases, the equivalence point will not be at pH 7.

To estimate the equivalence point we can use the pH meter or use an indicator. While using the pH meter a graph will be made and will plot the pH of the solution. Using an indicator, we will observe the change of color in the solution. However, this method is used in low concentration, which is why indicators can't really change the equivalence point of a titration. The point which the indicator changes color is called the end point. A common method to get the pH of solution is to use

an acid base indicator. An indicator is a large organic molecule that is similar like a color dye. These acid base indicators reacts when there is a change in the concentration of hydrogen ion.

In any titration, end point is the point where the indicator changes its color. After this point, the reaction is complete. The equivalence point in a titration is the point when the chemical reaction is complete. Although the end point is when the color change, but it sometimes is not the end of the reaction. At this equivalence point, medium is neutral. Equivalence point happens right before the end point. The equivalence point is that point at which the moles of the titrant and analyte are equal.

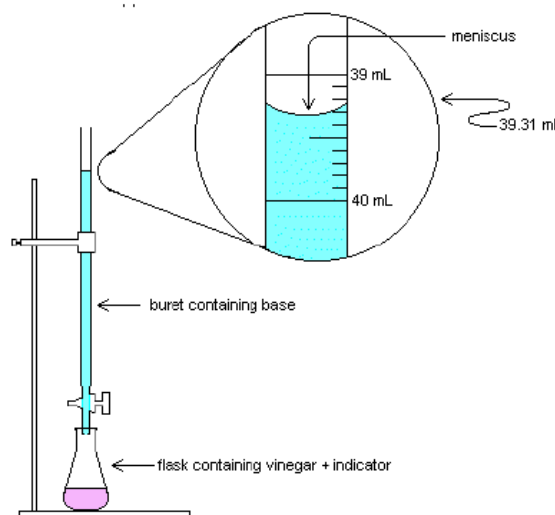
Materials/Tools

- Burette (1)
- 250 mL Erlenmeyer Flask (5)
- 50 mL Measuring Cylinder (1)
- 10 mL Measuring Cylinder (1)
- 250 mL Beaker (3)
- 150 mL beaker (2)
- 10 mL beaker (1)
- Retort Stand and Clamp (1)
- 25 mL of Vinegar (CH_3COOH)
- 600 mL of Sodium Hydroxide Indicator
- 20 mL of Phenolphthalein Indicator
- 1 L of Distilled Water
- Wash Bottle (1)
- 5 mL Pipette (3)
- Dropper (1)
- Funnel (1)
- Goggles
- Gloves
- Lab Coat
- Sheet of White and Dark Paper

Method

1. Rinse the tools (burette, flasks, and beakers).
2. Make sure the burette stopcock is closed.
3. Fill the burette with 25 mL of sodium hydroxide.
4. Place a beaker under the burette.
5. Open the stopcock to allow the liquid to drain out into the beaker and then close the stopcock. Make sure that there is no air bubbles remain in the stopcock.
6. Remove the beaker.
7. Using the 5 mL pipette, pour 0.5 mL of vinegar solution into the Erlenmeyer flask.
8. Measure 50 mL of distilled water using the 50 mL measuring cylinder and add it to the vinegar solution.
9. Add 3 drops of phenolphthalein into the vinegar solution in the Erlenmeyer flask. The solution should remain colorless at this point.
10. Place the flask under the burette. Put a sheet of white paper under the flask to make the endpoint easier to see.
11. Read the volume of the sodium hydroxide in the burette. This is your initial volume. Reading is made easier by holding a piece of dark paper behind the burette.

12. Slowly open the burette stopcock and add some sodium hydroxide into the flask, while doing so, swirl the flask. Observe the colour of the solution, you may notice a temporary colour change in the solution.
13. Continue adding the sodium hydroxide. The colour change will take longer to disappear. This is a signal that the endpoint is getting closer and the sodium hydroxide should be added drop wise.
14. Stop adding the sodium hydroxide when a permanent colour change is observed (a pale pink; longer than 30 seconds). This indicates that the solution has reached its endpoint.
15. Record the volume of sodium hydroxide in the burette. This is your final volume. Subtract the initial volume from the final volume to determine the volume of sodium hydroxide added.
16. Repeat step 1 to 15 using different volume of vinegar. 1 mL, 1.5 mL, 2 mL, and 2.5 mL.
17. Refill the burette with sodium hydroxide solution if it was not enough but remember to record the volume of sodium hydroxide used.
18. Repeat step 1 to 17 three times to obtain accurate results.



Data Collection (Raw)

		Volume Of NaOH (mL)		
Volume of Vinegar (mL)	Distilled Water (mL)	1 st Trial	2 nd Trial	3 rd Trial
0.5	50	4	5	11.7
1	50	16.5	18.3	17.2
1.5	50	29.6	31.5	26
2	50	34	48.1	58
2.5	50	53	44	42

Data Processing

After conducting this experiment, as a group, we found out that the chemical equation is $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$. Through this equation, we can say that the molarity of NaOH and the molarity of CH_3COONa is equal since their ratio is **1:1**. Since the NaOH is a standard solution, it reacts with the Acetic Acid (CH_3COOH).

The formula to find the moles and the molarity:

$$\text{Moles} = \text{Molarity} \times \frac{\text{Volume (cm}^3\text{)}}{1000} \text{ or } \text{Molarity} \times \text{Volume (l)}$$

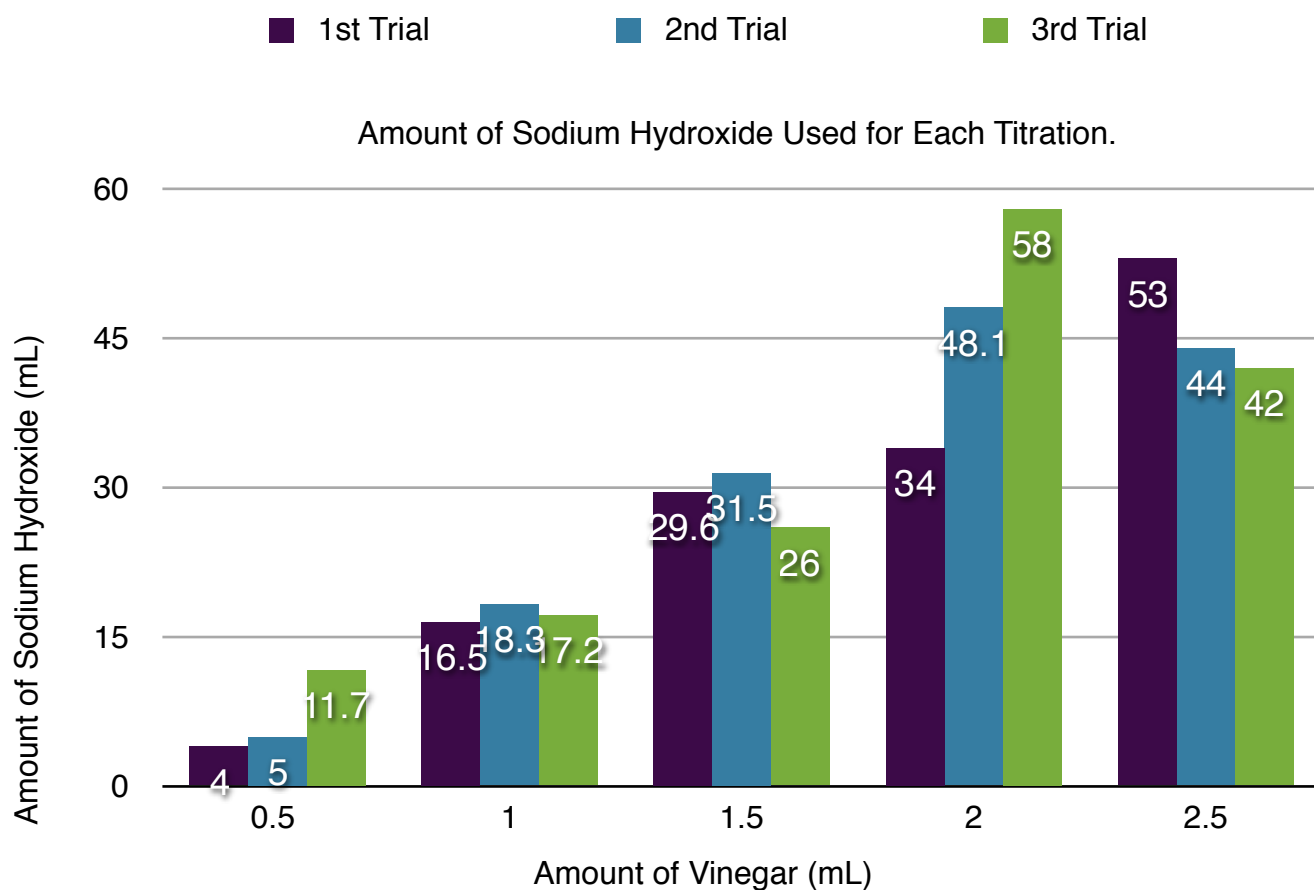
$$\text{Molarity (Mol/L)} = \frac{\text{Moles}}{\text{Volume (in L)}}$$

This means that 1M of NaOH means that there is 1 mole in the NaOH/L.

Data Presentation

Volume of Vinegar Used (mL)	Volume of NaOH Used (mL)	Moles of NaOH (moles)	Molarity of CH ₃ COOH (M)	Moles of CH ₃ COOH
0.5	4	$1 \times 0.04 = 4$	$0.04 / 0.0505 = 0.7292$	0.04
	5	$1 \times 0.05 = 0.05$	$0.05 / 0.0505 = 0.99$	0.05
	11.7	$1 \times 0.0117 = 0.0117$	$0.0117 / 0.0505 = 0.361$	0.0117
1	16.5	$1 \times 0.0165 = 0.0165$	$0.065 / 0.051 = 0.0232$	0.0165
	18.3	$1 \times 0.0183 = 0.0183$	$0.0183 / 0.051 = 0.359$	0.0183
	17.3	$1 \times 0.0173 = 0.0173$	$0.0173 / 0.051 = 0.339$	0.0173
1.5	29.6	$1 \times 0.0296 = 0.0364$	$0.0296 / 0.0515 = 0.575$	0.0296
	31.5	$1 \times 0.0315 = 0.0315$	$0.0315 / 0.0515 = 0.612$	0.0315
	26	$1 \times 0.026 = 0.026$	$0.026 / 0.0515 = 0.504$	0.026
2	34	$1 \times 0.034 = 0.034$	$0.034 / 0.052 = 0.653$	0.034
	48.1	$1 \times 0.0481 = 0.0481$	$0.0481 / 0.052 = 0.925$	0.0481
	58	1×0.0443	$0.058 / 0.052 = 1.12$	0.058
2.5	53	$1 \times 0.058 = 0.058$	$0.053 / 0.0525 = 1.01$	0.053
	44	$1 \times 0.044 = 0.044$	$0.044 / 0.0525 = 0.838$	0.044
	42	$1 \times 0.042 = 0.042$	$0.042 / 0.0525 = 0.8$	0.042

From the table above, we can see that our experiment has succeed. The volumes for NaOH were similar with each other. We can also see that the more vinegar we used, the more NaOH we need to pour.



The graph above can help you visualize more about how our method was conducted. Before we started to conduct this experiment, our science teacher showed us how to do it, but because I was absent at that time, I did not see it. Our teacher said that it is better if we can get a really pale pink rather than really dark pink. From the pictures (you can see at the **Appendix** category), you can see that most of our experiments' color are very pale pink. However we do have some that has become full pink. Through the graph we can see that our last experiment was more accurate because out of all the experiments, the one that has 2.5 mL of vinegar is the ones that has the most similar amount of Sodium Hydroxide.

The table below will prove that we has conducted the experiment well. This table can also answer the objective and also my hypothesis because as you can see, the more vinegar we put in, the more NaOH we need to pour in to enable it to have a color reaction.

Amount of Vinegar (mL)	0.5			1			1.5			2			2.5		
Amount of NaOH (mL)	4	5	11.7	16.5	18.3	17.2	29.6	31.5	26	34	48.1	58	53	44	42
Average amount of NaOH (mL)	6.8			17.3			29.1			46.7			46.3		

Discussion

In this experiment that my group and I have conducted, I can say that the results we got are accurate. The results that we got also supports my hypothesis and the objective. Through the results, we can see that the more vinegar we add, the more sodium hydroxide we need to add. Also to answer the objective, which is to determine the molarity of ethanoic acid in vinegar (CH_3COOH) by adding a volume of sodium hydroxide (NaOH), we have made a few tables and graphs that can help to determine the molarity of ethanoic acid clearly. Since I have put the answers on the table, I think that I have already answered the objective too.

The pattern that I have seen through this project is as I have repeated a few time, the more vinegar you add the more sodium hydroxide we need to pour to make it turn to pink which refers back to my hypothesis.

Evaluation

The method that my group and I used to conduct this experiment was very accurate. Since we follow the method very carefully, I believe that we have also gotten good answer from this experiment. I think the method that we followed was very clear, easy to understand and also has a lot of details. So I don't think that there is anything else we can improve. Also in my opinion I don't think that there is any weaknesses in my method. Although what could be improved from this method is, it is better if we do more than three trials for one experiment. If we have more trials, then we can get more precise and accurate information.

Since we only did three trials for each experiment, I think that our data and results were pretty accurate, however it is not 100% accurate. This experiment -with only three trials for each experiment- allows us to see the 'big picture' of the results and help us to understand more about titration. However it could not give us exact and very accurate answers.

Conclusion

In conclusion, I have learned about the scientific concept through this experiment. It has also given me a clear conclusion based on the results and data that I have gotten which is the more vinegar we used, the more sodium hydroxide we need to it to react. Throughout conducting this experiment, we did not have any difficulties or problems. The experiment went very well without any problems because we followed the method which was also written, read and followed carefully by my group and I. As I have said before the only improvement that is needed in the method is to have more than three trials for each experiment.

This experiment has also enabled me to find the molarity of CH_3COOH , even if its not that accurate. Through the result table I have also learned that there are various amounts, different amounts of molarity because of the amount of sodium hydroxide that we use were different. This happens because sometimes, when we see just a tiny hint of pink, we stop the stopcock. However, sometimes, it turns that it has not reached the endpoint enough and dissolves back to pure color. So we had to add more sodium hydroxide again.

Further Inquiry

For further inquiry, we can try to substitute the vinegar with another chemical. This way, students would be able to learn about how different chemicals react to different things and also how they react in different situations. By substiting the vinegar with another chemical, it enables the student to gain more insight on the topic that they are learning and will give them more knowlegde and understanding to go on throughout the semester.

Another thing that can be done is to do this experiment backwards. This way, students will also get more understanding and insight. Students will also be able to see that chemicals affect which chemical.

Appendix



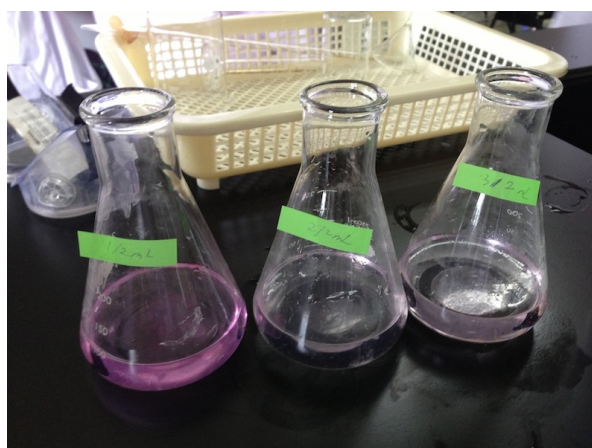
0.5 mL of vinegar.



1 mL of vinegar.



1.5 mL of vinegar.



2 mL of vinegar.



2.5 ml of vinegar.

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