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**FINDING THE UNKNOWN MOLARITY OF ETHANOIC ACID IN VINEGAR**

**Theoretical Background**

Vinegar is composed by a fermentation of an ethanol, which produces acetic acid (CH3COOH). Vinegar consists of acetic acid, water, and trace amounts of other chemicals. These other chemicals may include flavorings. The concentration of the acetic acid is varies, it is a variable.

There are two types of fermentation to form vinegar: slow and fast. The slow fermentation process takes weeks or even months. During this process they use Mother of Vinegar forms, which are non-toxic slimes. This slime consists of acetic acid bacteria and soluble cellulose. The same Mother of Vinegar is used in the fast fermentation process. It is added to the liquid from which the vinegar is to be produced. A turbine is used to provide oxygen for the mixture. This helps reduce the time needed to ferment the vinegar to anywhere between 20 hours to three days.

There are several methods to analyze the content of vinegar. However, titration is one method that is easily used and has been used a lot for this purpose. Titration is a method used to analyze the concentration of a substance by simply adding the known concentration that will be measured carefully with the unknown substance concentration until the reaction reaches the equivalent point. The equivalent point is the point where the number of moles of base is equivalent with the number of moles of acids. This does not mean that he pH will be 7. This will be indicated with the use of an indicator. An indicator is a substance that will have its color change to indicate the existence of some substance or ion. Indicators can also be used to indicate whether a chemical reaction is complete or not. The indicator which will be throughout this experiment is the phenolphthalein indicator. This will change the colour of the solution into pale pink once the reaction is complete. This stage is called the ending point. The ending point or endpoint is when the equivalent point has been reached. It is the end of a chemical reaction where no more titrant needs to be added because the solution has undergo color change and is about to neutralize.

**Objective**

The aim of this experiment is to determine the molarity of ethanoic acid in vinegar (CH3COOH) by adding a volume of sodium hydroxide (NaOH).

**Hypothesis**

The hypothesis is that the more volume of acid is added, the longer it will take to neutralize the solution. Therefore the more volume of acid (CH3COOH) is added, the more base (NaOH) will be needed too. The predicted pattern is that the more base is added to the acid, that acid will have more molarity.

**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 (CH3COOH), room temperature, pressure, the addition of phenolphthalein indicator (3 drops), the volume of distilled water into the acid (50 mL).

**Tools and Materials**

* 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 (CH3COOH)
* 600 mL of sodium hydroxide (NaOH)
* 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 colourless 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 dropwise.
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: 1mL, 1.5mL, 2mL and 2.5mL.
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**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Amount of Vinegar (CH3COOH) (mL) | Amount of distilled water in mL | Amount of NaOH | | |
| Trial 1 (mL) | Trial 2 (mL)) | Trial 3 (mL) |
| 0.5 | 50 | 2.5 | 2.4 | 2.35 |
| 1 | 50 | 4.55 | 4.5 | 4.55 |
| 1.5 | 50 | 7 | 6.8 | 6.8 |
| 2 | 50 | 9.15 | 8.95 | 9 |
| 2.5 | 50 | 11.1 | 11.2 | 11.1 |

**Data Processing**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Amount of Acid Solution (mL) | Average Amount of NaOH (mL) | Moles of Vinegar (CH3COOH) (mols) | Moles if NaOH (mols) | Molarity (M) |
| 50.5 | 2.4 | 0.0024 | 0.0024 | 0.0475 |
| 51 | 4.54 | 0.00454 | 0.00454 | 0.0890 |
| 51.5 | 6.87 | 0.00687 | 0.00687 | 0.1334 |
| 52 | 9.03 | 0.00903 | 0.00903 | 0.1737 |
| 52.5 | 11.14 | 0.01114 | 0.01114 | 0.2122 |

Chemical Equation:

CH3COOH + NaOH 🡪 CH3COONa + H20

Molarity Calculation (For the 50.5 mL acid solution) :

1. Determine the formulas

Molarity = moles/volume (dm3)

Moles = Molarity × Volume (dm3)

1. Determine the amount of moles in NaOH

1M = moles/(2.4 ÷ 1000)

0.0024 = moles in NaOH

1. Moles in NaOH is equivalent with moles in acid solution

Moles in acid = 0.0024

1. Determine the molarity considering that the volume and moles is known.

Molarity = 0.0024/ (50.5 ÷ 1000)

= 0.0024/0.0505

= 0.04752475

= 0.0475

**Data Presentation**

**Explanation**

The results from data collection have been clearly presented through these two charts. The first chart is presenting the average amount of NaOH (sodium hydroxide) needed for each acidic solution. Initially, there are three different amounts of NaOH for each acidic solution. In other words, there should have been fifteen amounts of NaOH in total. However, the numbers were averaged to have the results focused and exact. The first chart presents that more NaOH needs to be added as the amount of vinegar increases. The acidic solution with the least volume requires the least amount of NaOH and the solution with the highest volume needs the most amount of NaOH. That is the pattern from the first chart because it is clear that the amount of NaOH increases continuously starting from the 50.5 mL acidic solution, to the 52.2 mL acidic solution.

The same concept and pattern applies for the molarity chart. Since the three amounts of NaOH were averaged for each acidic solution, the same concept is applied for the molarity. The three different molarity results for each acidic solution were averaged and this chart was created. This chart presents the same pattern as the previous chart. After conducting calculations to discover the molarity of vinegar (CH3COOH) of each acidic solution, the results show that the molarity continues to increase throughout the different acidic solution volumes. It is just like the first chart, the more NaOH is required in particular acidic solution, the higher the molarity; and it is proven as the 50.5 mL solution has the least molarity while the 52.5mL solution has the highest molarity.

**Evaluation**

The two charts have clearly presented the raw data from data collection. Both charts have identical patterns. The numbers increase from the lowest acidic solution to the highest acidic solution. That is the trend of both charts, they simply have the same trend and pattern. That also makes both charts look identical since the bars are increasing in a constant pace from left to right. The increase isn’t drastic at all for both charts. This would mean that the experiment was done almost perfectly since there aren’t much flaws in the data and results. The numbers were accurate and the charts present a clear pattern. However, there is one thing that could be considered as a limitation which is the fact that the results for each acidic solution were averaged. Having more results wouldn’t be that focused and it would be more complicating, yet it would give more accuracy to the results. That is the limit, the fact that the chart results are only limited to one result per acidic solution instead of the three that was initially done.

**Conclusion**

In conclusion, the hypothesis is correct because the results are in agreement with it. The hypothesis states that the acid with more added base will have more molarity. That was the predicted pattern in the hypothesis and the results of this experiment prove that it was the right prediction because the charts clearly indicate that the solutions with more acid have more molarity; and solutions with more acid are the solutions that have more bases added. Therefore, the hypothesis of this science experiment has been proven correct.

**Evaluation**

Since the hypothesis has been proven correct, this experiment could be called a success. However, there is one improvement that could be made throughout the entire experiment which is not to start off with the 50.5mL acidic solution because that one is the hardest to reach the end point. A substantial amount of time was wasted in trying to perfectly neutralize the 50.5mL acidic solution and to get that pale pink colour. What should have been done was to skip and start with the 51mL solution because it is much easier to reach the end point. That way more time would be saved and the 50.5mL could simply be completed in the end with a better mental mind to work with. A mind that won’t be frustrated of failure. This is one improvement that would help out a lot in the future.

**Extension**

An experiment which could be done with just a slightly alternating the method of this project would be to determine the molarity of other acids such as lemon juice. Since the purpose of this experiment was to discover the molarity of vinegar. The same method, variables, and concept could be applied to have an experiment to discover the molarity of lemon juice. Lemon juice would be a suitable replacement for vinegar since their colours are pretty identical. Everything would be the same with this experiment except that lemon juice will be a replacement for vinegar.

**Reference**

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