Titrations - % acidity of vinegar

**Objective:**

Determine the concentration of acetic acid in vinegar

**Introduction:**

Neutralization is a reaction of an acid with a base to produce a salt and water. For example, the reaction of the strong acid HCl with the strong base NaOH produces the salt sodium chloride and water:

HCl(*aq*) + NaOH(*aq*)  NaCl(*aq*) + H2O(*l*)

Since the acid, base, and salt in this reaction are all strong electrolytes, the net ionic equation for this reaction is:

H+(*aq*) + OH-(*aq*)  H2O(*l*)

This same result occurs in the reaction of strong acid reacts with a weak base, or a weak acid reacts with a strong base. The acid and base react to form a salt and water. The neutralization reaction provides us with one method for determining the concentration of either the acid or the base in a solution.

The general method employed is that of titration. Titration is a procedure for determining the amount of substance A by adding a carefully measured volume of a solution with known concentration of B until the reaction between them is just complete. Titrations are not use exclusively with acids and bases but anytime you need to determine the concentration of a species in a solution.

In this lab, we will titrate a vinegar solution with a solution of sodium hydroxide, NaOH. The active ingredient in vinegar is the weak acid, acetic acid. The sodium hydroxide will neutralize the acetic acid, H C2H3O2, in the vinegar.

HC2H3O2 (*aq*) + NaOH(*aq*)   NaC2H3O2(*aq*) + H2O*(l)*

Once the neutralization reaction is complete, any additional base added will produce a basic solution. The point at which all the acetic acid has reacted with the sodium hydroxide is called the **equivalence point**. We can determine when the titration is complete by employing an acid-base indicator, which will change color in a basic solution. Phenolphthalein is an acid-base indicator that changes color from colorless to magenta. This particular indicator turns from clear to pink in basic solution. As soon as very faint pink color persist you have reached the equivalence point. At the equivalence point, the number of moles acid will equal the number of moles base, hence:

Volumeacid x Molarityacid = Volumebase x Molaritybase

Thus, we can determine the molarity of the acid by titrating a known volume of the acid solution with a known concentration and volume of a base.

**Pre-Lab: Titration of Vinegar**

For the pre-lab questions, use the following data:

A titration of 25.00 mL of an unknown HCl solution with 0.100 M NaOH starts at a buret reading for NaOH of 0.33 mL. The phenolphthalein indicator turns light pink in the acid solution for over 30 seconds at a buret reading of 24.19 mL.

* 1. What was the volume of NaOH dispensed?

* 1. How many moles of NaOH were dispensed?

* 1. Write the balanced molecular equation for the neutralization reaction:
  2. How many moles of HCl are present in the acid solution?

* 1. What is the Molarity of the unknown HCl solution?

* 1. If the density of the HCl solution is 1.097 g/mL, what is the mass of the HCl solution?

* 1. What is the % mass of HCl in the acid solution?

Procedure:

**Titration of Vinegar:**

**PREPARATION OF BURET**

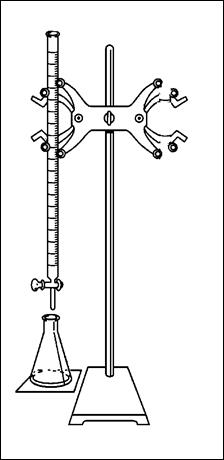
1. Clean a 50 ml buret and rinse with DI water. A clean buret will have no droplets clinging to the inside of the glass.

2. Rinse the buret with two 5 ml portions of the NaOH solution. Make sure you drain the NaOH solution through the tip of the buret.

3. Using a funnel, fill the buret with the NaOH solution. Make sure that the tip is also filled and there are no air bubbles in the tip.

4. Slowly drain the NaOH out of the buret until the buret reads 0.0 ml. Read from the bottom of the meniscus. It is sometimes helpful to hold a piece of paper with a black line behind the buret and line it up with the meniscus.

Text Box: Figure 1 - Lab Setup



**PREPARATION OF THE VINEGAR SOLUTION**

5. Pipet 5 ml of the vinegar solution into a clean 250 ml flask.

6. Add distilled water to the flask to a total solution volume of 50 mL.

7. Add two drops of phenolphthalein indicator.

**DETERMINATION OF % ACETIC ACID IN A VINEGAR SOLUTION**

8. Place a white background underneath the flask with the vinegar solution.

9. Slowly add with constant swirling the NaOH drop-wise to the vinegar solution.

10. Continue adding drop wise to the vinegar solution until the vinegar solution turns a faint shade of pink that remains for 30 seconds. This is called your endpoint.

11. Calculate the % by mass of acetic acid in the vinegar solution.

Data:

**Titration of Vinegar**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial #1 | Trial #2 | Trial #3 |
| Final Volume of NaOH (mL) |  |  |  |
| Initial Volume of NaOH (mL) |  |  |  |
| Change in Volume of NaOH (mL) |  |  |  |
| Volume of HC2H3O2 (mL) |  |  |  |

Concentration of NaOH: \_\_\_\_\_\_ M % Acid **from vinegar bottle** \_\_\_\_\_\_\_\_%

**ANALYSIS:** 1. Write the equation for the reaction between the weak acetic acid and the strong sodium hydroxide solution.

2. Determine the **average** mL of base used to neutralize 10.0 mL of diluted vinegar solution.

3. Because the sodium hydroxide and the acetic acid are in a 1:1 mole ratio, the relationship

**Ma x Va = Mb x Vb** can be used to determine the molarity of the diluted vinegar solution. Find that value.

4. Determine the grams of acetic acid, HC2H3O2, present in the 10.0 mL sample of the diluted vinegar.

vol. acid in **liters** x molarity acid x molar mass HC2H3O2 = grams acid

5. Assuming that the vinegar solution has a density of 1.0 grams/mL (actually slightly above that). Calculate the % acetic acid in the diluted vinegar solution.

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6. Remembering that the original vinegar was diluted by a factor of ten, what is the experimental % acetic acid in commercial vinegar?

% acetic acid in dilute solution x 10 =

**CONCLUSION QUESTIONS:** 1. By doing a % error calculation, compare your result with the published % on the bottle.

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2. If 35.0 mL of 0.20 M NaOH is required to neutralize 45.0 mL of HCl, what is the concentration of the acid?

(Hint: See calculation #3 above.) Show method and units.