Determination of the concentration of ethanoic acid in vinegar

Theory

Vinegar is mainly composed of water and ethanoic acid. The concentration of ethanoic acid in vinegar may be found by titrating a diluted solution of vinegar with standard sodium hydroxide solution. The equation for the titration reaction is:

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

This is a weak acid/strong base titration, and so phenolphthalein indicator is used. At the end-point, the indicator changes colour from pink to colourless.

Procedure

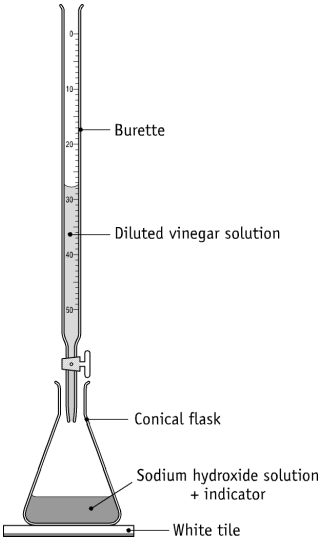
NB: Wear your safety glasses.

Place 25 cm^3 of vinegar in a 250 cm^3 volumetric flask and dilute with water to the calibration mark, mixing well.

Stopper the flask and invert several times to ensure a homogeneous solution. Label the flask.

Rinse the burette, pipette and conical flask respectively with deionised water.

Rinse the burette with diluted vinegar solution, and rinse the pipette with sodium hydroxide solution.



Place 25 cm^3 of 0.1 M sodium hydroxide solution in the conical flask, and add 3 drops of phenolphthalein indicator.

Fill the burette to the 0 cm^3 mark with diluted vinegar. Carry out one rough and three accurate titrations. Calculate the concentration of ethanoic acid in the diluted vinegar solution. Calculate the percentage (w/v) of ethanoic acid in the vinegar.

Specimen Results

Rough titration result = 30.4 cm^3
Second titre = 29.2 cm^3
Third titre = 29.2 cm^3
Average of accurate titres = 29.2 cm^3
Volume of sodium hydroxide solution used in each titration = 25.0 cm^3
Concentration of sodium hydroxide solution = 0.1 M

Specimen Calculations

(b) **Formula method**

$V_A \times M_A \times n_B = V_B \times M_B \times n_A$
$29.2 \times M_A \times 1 = 25 \times 0.1 \times 1$
$M_A = 25 \times 0.1 \times 1 / (29.2 \times 1) = 0.0856$ M

Concentration of ethanoic acid in diluted vinegar = 0.0856 M
Concentration of ethanoic acid in vinegar = 10 x 0.0856 M = 0.856 M
Percentage (w/v) of ethanoic acid in vinegar = 0.856 x 60 x 100 / 1000
= 5.14%

student questions

Why is the vinegar diluted?
To avoid a very small titre, which would reduce the accuracy of the experiment. Diluting the vinegar also reduces the amount of vinegar and the amount of sodium hydroxide solution needed in the experiment

Outline the correct procedure for bringing the solution in the volumetric flask precisely to the 250 cm^3 mark.
Fill the flask to within about 1 cm of the calibration mark, and then add the water dropwise, using a dropping pipette, until the bottom of the meniscus just rests on the calibration mark.

Outline the procedure used in preparing the burette so that it is ready for the first titration.
Rinse the burette with deionised water, and then with diluted vinegar solution. Fill the burette with diluted vinegar solution above the zero mark. Remove the funnel. Using the tap at the base of the burette, allow the acid to flow into a beaker until the level of liquid is at the zero mark. Ensure that there are no air bubbles in the nozzle of the burette.

Give two other precautions which should be taken to ensure that the burette readings are accurate.
Make sure that the burette is clamped vertically. Read the level of liquid in the burette by noting the lower level of the meniscus at eye level.

Why is phenolphthalein used as the indicator in this titration?
Because this is a weak acid/strong base titration, and phenolphthalein is the only one of the commonly used indicators that changes colour in the appropriate pH range.

Why is a rough titration carried out?
To find the approximate end-point. This information enables the subsequent titrations to be carried out more quickly.

What happens at the end point?
The indicator changes colour from pink to colourless.

Why are three accurate titrations carried out?
To reduce experimental error by calculating the average value.

Calculate the percentage (w/v) of ethanoic acid in the vinegar sample.
Multiply the concentration of ethanoic acid in moles per litre by 60 to get the concentration in grams per litre. Then divide by 10 to get the percentage (w/v) of ethanoic acid in the vinegar sample.

Extension work

Analysis of a different brand of vinegar may be done, using the same method, and the results compared.