Teacher packs in Experimental Science

CHE Pack 7

Determination of the Acid content of Vinegar (Acid-Base titration analysis)

Pack contents:

A. Teacher's Guide
B. Students Guide
C. Assessment – Student's sheet
D. Extensions to experiments
E. Links to other packs
F. Health and Safety
G. Evaluation of pack

Curriculum areas covered:

Acids, bases and salt (sources, types and examples)
Determination of amount/moles of acids/ bases in acid-base reactions
Standard solutions

Produced as part of DelPHE-funded collaboration between University of Cape Coast and The Open University, UK

Title: Determination of the Acid content of Vinegar (Acid-Base titration analysis)

Target group: DBE students

Also suitable for: SHS Students

Duration: 45 minutes plus discussion

Learning outcomes:

These are the learning outcomes expected after students have gone through this Pack

1. **Knowledge and understanding**

   KN1 explain the term, titration
   KN2 write a balanced chemical equation for the titration reaction

2. **Cognitive skills**

   CS1 demonstrate knowledge and understanding of how acid and bases react to produce salts
   CS2 able to determine the moles of NaOH required to neutralize the acetic acid in the vinegar

3. **Key Skills**

   KS1 Able to calculate the amount of NaOH needed to neutralize acetic acid (vinegar).
   KS2 Able to calculate the concentration of vinegar

4. **Practical skills**

   PS1 perform titration, using weak base and strong acid.
   PS2 record the end point and calculate the titre value.

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A. Teacher's Guide

⇒ NaOH (0.1 M) solution (NaOH is available as lye from the market and from soap makers; dissolve 4.0 g NaOH in enough distilled water to make 1.0 L of solution)
⇒ Malt vinegar can be used and can be found in the supermarket

Sample Assessment Questions

1. Give the balanced chemical equation for the titration reaction.
   (Hint: one of the products is sodium acetate.)

2. Write a conversion factor that will allow you to convert between moles of NaOH and moles of acetic acid.

3. Write a conversion factor that will allow you to convert between volume of NaOH and moles of NaOH, if the molarity of the NaOH is 0.1203 *M*.

4. Write a conversion factor that will allow you to convert between moles of acetic acid and grams of acetic acid.

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B. Student Guide

Purpose:

To determine the acid content of Vinegar using Acid-Base titration

Background to Experiment

In everyday life, we deal with many compounds that chemists classify as acids and bases. For example, orange juice and grapefruit juice contain citric acid. These juices, and others, also contain ascorbic acid, a substance more commonly known as Vitamin C. Salads are often flavoured with vinegar, which contains dilute acetic acid. Boric acid is a substance that is sometimes used to wash the eyes. Milk of magnesia (magnesium hydroxide), which is used as an antacid, is a base; lye (sodium hydroxide), which is used in the manufacture of soap, is another familiar example of base.

In any chemistry laboratory, we find acids and bases such as hydrochloric acid, sulphuric acid, potassium hydroxide, ammonia solution etc. These are called mineral acids and bases because they can be prepared from naturally occurring compounds called minerals. Mineral acids are generally stronger than household acids, and should be handled with great care because they can burn skin and clothing.

Acids and bases react in aqueous solution to form a salt and water. This reaction is known as a *neutralization* reaction, e.g. Hydrochloric acid reacts with sodium hydroxide to form sodium chloride and water acid (1); Sulphuric acid reacts with potassium hydroxide to give potassium sulphate and water (2)

$$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots....1$$

$$H_2SO_4\ (aq) + 2KOH\ (aq) \rightarrow K_2SO4\ (aq) + 2\ H_2O\ (l)\ ....2$$

Neutralization reactions are very common because there are many different acids and bases. If a neutralization reaction is run in the laboratory under controlled conditions, it can be used to determine the concentration of the acid or the base in the reaction. This procedure is known as an acid-base titration analysis and it involves accurately measuring the volume of a base that is required to neutralize a known volume of acid. In order to calculate the concentration of the acid from the laboratory data, one must also know the concentration of the base used in the titration. Thus to determine the concentration of an acid, one must have a base of known concentration and the equipment to accurately measure the volume of the acid and base reacting. The concentration of the base is given in moles of acid or base per litre of solution or *molarity (M)*.

In this experiment, we will determine the concentration of acetic acid (CH_3COOH) in household vinegar. A known volume of vinegar will be measured out with a volumetric pipette and titrated with a solution of sodium hydroxide (NaOH) of known molarity. The NaOH solution will be added from a burette until all of the acid in the

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vinegar has been neutralized. Since we need to accurately measure the volume of NaOH used in the titration, we must have a means of knowing when just enough of the base (NaOH) has been added to react with all of the acid (CH_3COOH), in the vinegar.

This point is called the *end point*. To detect the end point, an acid-base *indicator* is added to the vinegar. The indicator, phenolphthalein, is colourless in acidic solutions but turns pink in basic solution. The end point is when the vinegar turns very light pink and the colour persists even when you swirl the solution.

Equipment/ Materials

- 15ml household vinegar
- 15ml 0.1M NaOH
- Phenolphthalein indicator
- 10ml pipette / 10ml medical syringe
- 15ml burette
- 10ml Erlenmeyer flask (25ml graduated plastic cup)
- Stop cork/ cork/ rubber bung
- Retort stand
- funnel

Other requirements

- Working bench/table,
- Open space,
- Source of water supply,
- Laboratory coat, eye goggles, nose mask, hand gloves.

Pencil / pen and written exercise book

Experimental Procedure

1. Obtain a sample of vinegar from your instructor.
2. Record the sample number in the data table.
3. Obtain 100 ml of NaOH in a clean, **dry** 150 ml beaker.
4. Record the molarity of the NaOH in the data table.
5. Set up the burette using a burette clamp and ring stand.
6. Clamp your burette as shown in Figure 1.

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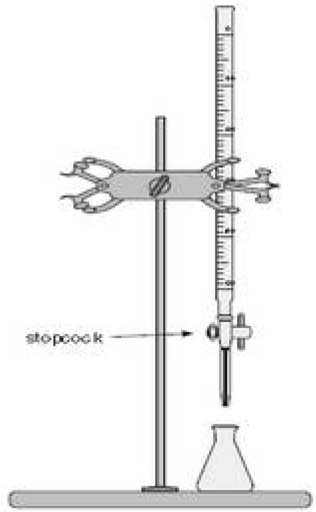

Figure 1: titration set-up

7. Using a pipette, transfer 10.00mL of vinegar into the Erlenmeyer flask. *[Note: - the flask should not be under the burette].*
8. Add 3 to 4 drops of phenolphthalein indicator to the vinegar and swirl carefully until the solution becomes colourless.
9. Rinse the burette with a little of the NaOH solution.
10. Close the stopcock and fill the burette to above the 0.00 line with NaOH using a funnel.
11. Open the stopcock and allow a little of the NaOH to run out. This is to eliminate air bubbles in the tip of the burette. Make sure you do not have an air bubble in the tip of the burette when you begin to titrate.
12. Adjust the level of the NaOH in your burette so that the bottom of the meniscus is at or below the 0.00 line.
13. Place your flask containing the 10 ml sample and the phenolphthalein under the tip of the burette and add the NaOH by quickly turning the stopcock one half turn. This allows one drop at a time to leave the burette. Swirl the contents of the Erlenmeyer as you drop the NaOH (a pink colour may be observed where the NaOH solution drops)
14. Continue adding the sodium hydroxide solution in this way, swirling the flask with every addition. As the end point is approached, the pink colour will persist for a longer time before the mixing changes the solution back to colourless. You will have reached the endpoint when the well-swirled solution in the flask remains a very pale pink and does not clear to colourless. If it remains a deeper pink colour, then you have passed the end point, and the experiment should be repeated to find the end point accurately.
15. Once you have reached the end point, read and record the volume of NaOH that you have added to your flask. Record this volume to the nearest 0.01 ml in the table below.
16. Calculate and record the titration volume. This is the volume of base required for quantitative neutralization of the acid. (Hint: $V_f - V_i = V_T$, where V_f is the final volume, V_i is the initial volume and V_T is the titration volume)

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17. Do a second titration with a fresh 10.00 mL sample of your diluted vinegar and phenolphthalein and a refilled burette. If the titration volumes for these two trials are not in good agreement, within 0.02 mL of each other, do a third titration.
18. Calculate the average titration volume. The average titration volume will be used in the calculation of the concentration of the acid.

Data table			
Burette reading	**1**	**2**	**3**
Initial (V_i)			
Final (V_f)			
Volume of NaOH (V_T)			

Reflection on the experiment

- Can the titration be done using lemon juice as the acid source?
- The acid in vinegar is acetic acid; what acid is found in lemon juice?
- Suggest another indicator which can be used in this titration.

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C. **Assessment – Student's sheet**

On completion of the experiment, you should answer the following questions:

1. Write a balanced chemical equation for the reaction between the acetic acid in vinegar and NaOH solution

2. Calculate the moles of NaOH required to neutralize the CH_3COOH in the vinegar sample (Show working).

3. Calculate the moles of CH_3COOH neutralized by the NaOH.

4. Calculate the molarity of the vinegar sample.

5. Calculate the % acetic acid in the sample.

[The density of the vinegar is 1.0002 g/mL. % acid = (mass of CH_3COOH /mass of vinegar sample) x 100%.]

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D. Extensions to experiment

- Determine the amount of NaOH in Key soap, using 0.1M hydrochloric acid (HCl)
- List some household chemicals and classify them as acids and bases.
- Discuss the properties of acids and bases

E. Useful links

http://www.ncsu.edu/sciencejunction/depot/experiments/water
http://sciencepark.etacude.com/projects/pH
http://www.chemtutor.com/acid

F. Health and Safety

Caution should be used when working with sodium hydroxide solution. It can be irritating to the skin. Goggles must be worn throughout the experiment.

Basic safety rules:

a. Do not eat, drink or chew whilst doing the experiment.

b. Keep your face at a safe distance from open flames and heated solutions. Never look into a heated solution from above.

c. Avoid breathing in dust or vapour. When smelling solutions, gently wave the air above the solution towards your nose with your hand.

d. Wash any spilled solutions from your skin with plenty of water, and notify the instructor.

e. Report any accident, no matter how minor, to the instructor/report to the nearest health post.

Compulsory rules

You will not be allowed to do the experiment unless you are wearing the following items:

a. Long-sleeved overcoat that is long enough to cover the hips, worn closed at all times.
b. Safety glasses. Please note that contact lenses do not provide eye protection and, in some cases, may complicate an emergency (caustic liquids which splash into the eye can be trapped behind the contact lens). It is recommended that you avoid wearing contact lenses in the laboratory, if possible.
c. Closed, flat-heeled shoes (no open sandals).
d. Long hair and loose scarves must be tucked away or tied up.
e. When you are using toxic or corrosive chemicals, you should wear protective gloves.

Tidy working

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Keep your working area tidy. A cluttered bench is a common contributory factor to accidents. Cleaning the glassware after use should be done immediately. This prevents the organic tarry material from attacking the surface of the glass.
Always clean up a chemical spill without delay
Clean up and dispose of your unknown substances according to your teacher's instructions.

G. Evaluation

a. Was it difficult/easy to have access to the experimental materials listed?
b. Were the experimental procedures easy to follow? Explain
c. Suggest other methods and materials which can be included in this pack

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