

Procedure

1. Obtain about 30 mL of vinegar in a clean, dry 100-mL beaker.
2. Pipet one 10.00-mL portion into a clean 100-mL volumetric flask and dilute to the mark.
3. Stopper and invert several times to mix thoroughly.
4. Obtain about 70 mL of $\text{NaOH}_{(\text{aq})}$ in a clean, dry, labelled 100-mL beaker.
5. Set up the buret with $\text{NaOH}_{(\text{aq})}$, following the accepted procedure for rinsing and clearing the air bubble.
6. Pipet a 10.00-mL sample of diluted vinegar into a clean Erlenmeyer flask.
7. Add 1 or 2 drops of phenolphthalein indicator.
8. Record the initial buret reading to the nearest 0.1 mL.
9. Titrate the sample with $\text{NaOH}_{(\text{aq})}$ until a single drop produces a permanent change from colourless to faint pink.
10. Record the final buret reading to the nearest 0.1 mL.
11. Repeat steps 6 to 10 until three consistent results are obtained.

Analysis

- (a) Answer the Question: What is the molar concentration of acetic acid in a sample of vinegar?

Evaluation

- (b) Evaluate your evidence: How confident are you that your techniques and measurements resulted in good evidence?
- (c) Evaluate the Prediction: Assuming the manufacturer's claim is accurate, is someone in the cafeteria diluting the vinegar? Include an accuracy calculation (percentage difference) in your evaluation.

Practice

Understanding Concepts

4. Briefly describe three types of characteristic reactions of acids.
5. What are the four reaction requirements in order to use a reaction in a titration in a chemical analysis?
6. What are the two reactants in a titration, and what equipment is used to contain them?
7. What is a standard solution?
8. Why are several trials usually done in a titration?

Applying Inquiry Skills

9. Analysis shows that 9.44 mL of 0.0506 mol/L $\text{KOH}_{(\text{aq})}$ is needed for the titration of 10.00 mL of a water sample taken from an acidic lake. Determine the molar concentration of acid in the lake water, assuming that the acid is sulfuric acid.

Answer

9. 0.0239 mol/L or 23.9 mmol/L

Answers

10. (b) 1.08 mol/L
 11. (b) 2.66 mol/L
 12. 0.278 mol/L

10. Solutions of oxalic acid, $\text{H}_2\text{C}_2\text{O}_4(\text{aq})$, have many applications. Like $\text{H}_2\text{SO}_4(\text{aq})$, oxalic acid reacts in a 2:1 mole ratio with sodium hydroxide. Complete the **Evidence**, **Analysis**, and **Evaluation** sections of the following investigation report.

Question

What is the concentration of oxalic acid in a rust-removing solution?

Prediction

The oxalic acid solution is labelled as 10% W/V, or 1.11 mol/L.

Experimental Design

The original oxalic acid solution (rust remover) is diluted by a factor of 100, that is, 10.00 mL to 1000 mL. The concentration of dilute oxalic acid solution is determined by titration with a sodium hydroxide solution.

Evidence

(a) Copy and complete **Table 4**.

Table 4: Volume of 0.0161 mol/L Sodium Hydroxide Required to Neutralize 10.00 mL of Diluted Oxalic Acid

Trial	1	2	3	4
Final buret reading (mL)	14.3	27.8	41.1	13.8
Initial buret reading (mL)	0.2	14.3	27.8	0.4
Volume of $\text{NaOH}_{(\text{aq})}$ used (mL)				

Analysis

(b) Using the Evidence in **Table 5**, calculate the concentration of oxalic acid in the rust remover.

Evaluation

(c) Evaluate the Prediction: Is the manufacturer's label accurate?

11. Complete the **Evidence** and **Analysis** for the following titration.

Question

What is the molar concentration of the hydrochloric acid in a solution of kettle-scale remover?

Experimental Design

The hydrochloric acid in a solution of kettle-scale remover is titrated with a standardized solution of barium hydroxide. The colour change of bromothymol blue indicator (from blue to green) is the endpoint.

Evidence

(a) Copy and complete **Table 5**.

Table 5: Titration of 10.00-mL Samples of $\text{HCl}_{(\text{aq})}$ with 0.974 mol/L $\text{Ba}(\text{OH})_{2(\text{aq})}$

Trial	1	2	3	4
final buret reading (mL)	15.6	29.3	43.0	14.8
initial buret reading (mL)	0.6	15.6	29.3	1.2
volume of $\text{Ba}(\text{OH})_{2(\text{aq})}$ added (mL)				
colour at endpoint	blue	green	green	green

Analysis

(b) Using the Evidence in **Table 5**, calculate the concentration of the hydrochloric acid in the kettle-scale remover.

12. Samples of sulfuric acid were titrated with 0.484 mol/L sodium hydroxide. The evidence is shown in **Figure 3**. Calculate the concentration of the sulfuric acid solution.

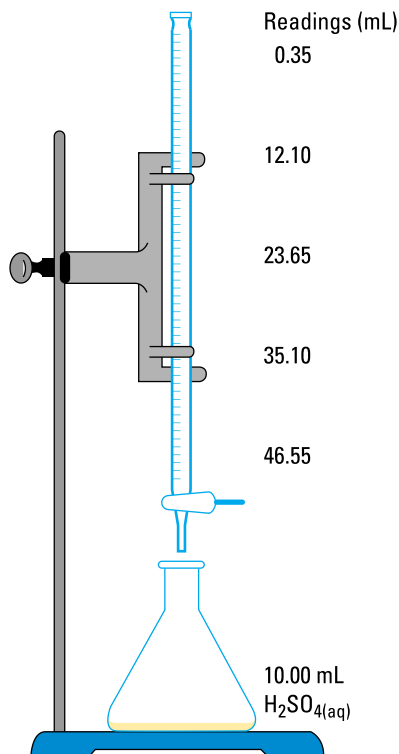


Figure 3

Sodium hydroxide titrant is added to samples of sulfuric acid in successive trials.