# 4.12 ACTIVITY: QUALITY CONTROL OF VINEGAR

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## Analysis

(a) The results are shown in **Table 1**. The concentration of $NaOH_{(aq)}$ used, after standardization with potassium hydrogen phthalate (KHP), was 0.09587 mol/L.

**Table 1** Titration of 25.0 mL Vinegar with 0.10 mol/L $NaOH_{(aq)}$

| Trial | 1 | 2 | 3 | 4 | Average |
|---|---|---|---|---|---|
| Final burette reading | 22.67 mL | 22.70 mL | 22.90 mL | 21.75 mL | |
| Initial burette reading | 0.13 mL | 0.15 mL | 0.30 mL | 0.50 mL | |
| Volume of NaOH added | 22.54 mL | 22.55 mL | 22.60 mL | 21.25 mL | 22.56 mL* |

* Average of trials 1, 2, and 3

$$v_{ave} = \frac{22.54\ \text{mL} + 22.55\ \text{mL} + 22.60\ \text{mL}}{3}$$

$$v_{ave} = 22.56\ \text{mL}$$

Thus, the average volume of 0.09587-mol/L sodium hydroxide solution required to neutralize the diluted vinegar solution is 22.56 mL.

(b) $HC_2H_3O_{2(aq)} + NaOH_{(aq)} \rightarrow NaC_2H_3CO_{2(aq)} + H_2O_{(l)}$

$$v_{HC_2H_3O_2} = 25.0\ \text{mL} = 0.0250\ \text{L}$$

$$v_{NaOH} = 22.56\ \text{mL} = 0.02256\ \text{L}$$

$$c_{NaOH} = 0.09587\ \text{mol/L}$$

$$n_{NaOH} = v_{NaOH} c_{NaOH}$$

$$= 0.02256\ \text{L} \times 0.09587\ \text{mol/L}$$

$$n_{NaOH} = 0.002163\ \text{mol}$$

$$n_{HC_3H_3O_2} = 0.002163\ \text{mol NaOH} \times \frac{1\ \text{mol}\ HC_2H_3O_2}{1\ \text{mol NaOH}}$$

$$n_{HC_2H_3O_2} = 0.002163\ \text{mol}$$

$$c_{HC_2H_3O_2} = \frac{0.002163\ \text{mol}}{0.025\ \text{L}}$$

$$c_{HC_2H_3O_2} = 0.086\ \text{mol/L} \quad \text{(diluted)}$$

$$c_{HC_2H_3O_2} = 0.086\ \text{mol/L} \times 10$$

$$c_{HC_2H_3O_2} = 0.86\ \text{mol/L} \quad \text{(original)}$$

The molar concentration of acetic acid in a sample of vinegar from the school cafeteria is 0.86 mol/L.

(c) The concentration of acetic acid given on the label is 5%, that is, 5% W/V, or 5 g of acetic acid per 100 mL of vinegar. To find the concentration of acetic acid on the label,

$m_{HC_2H_3O_2} = 5.0\ g$

$v_{HC_2H_3O_2} = 100\ mL = 0.100\ L$

$M_{HC_2H_3O_2} = 60.06\ g/mol$ (calculated from periodic table values)

$c_{HC_2H_3O_2} = ?$

$$n_{HC_2H_3O_2} = 5.0\ g\ HC_2H_3O_2 \times \frac{1\ mol\ HC_2H_3O_2}{60.06\ g\ HC_2H_3O_2}$$

$$n_{HC_2H_3O_2} = 0.083\ mol\ HC_2H_3O_2$$

$$c_{HC_2H_3O_2} = \frac{n_{HC_2H_3O_2}}{v_{HC_2H_3O_2}}$$

$$= \frac{0.083\ mol\ HC_2H_3O_2}{0.100\ L}$$

$$c_{HC_2H_3O_2} = 0.83\ mol/L$$

$$\%\ difference = \frac{|0.86\ mol/L - 0.83\ mol/L|}{0.83\ mol/L} \times 100\%$$

$$\%\ difference = 3.6\%$$

The molar concentration of acetic acid in a sample of vinegar from the school cafeteria is only about 3.6% more than the advertised value of 0.83 mol/L.

### Evaluation

(d) The observations obtained appear satisfactory because three consistent results were obtained and no unexpected or unusual observations were made. Titration is a well-known experimental technique and it appears adequate in this quality control analysis.

(e) It is unlikely that someone is diluting the vinegar. The slight difference between the experimental value and the concentration from the label can be accounted for by various experimental errors, such as measurement uncertainties in the pipette, burette, and volumetric flask, and some slight error in the given concentration of the sodium hydroxide solution.

## 4.13 ACID RAIN

### TRY THIS ACTIVITY: A MARBLE REACTION

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Observations from the activity are recorded in **Table 1.**

**Table 1** Observations of Reaction of Marble Chips with $H_2SO_{4(aq)}$

| Reactants | Initial mass of marble chips (g) | Observations of reaction | Mass of dried unreacted marble chips (g) |
|---|---|---|---|
| marble chips and dilute sulfuric acid | 5.652 | • when sulfuric acid is added, vigorous bubbling occurs<br>• bubbles form on the surfaces of the marble chips and rise to the surface of the sulfuric acid solution | 5.294 |