ACTIVITY 8.4.1 QUANTITATIVE TITRATION

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Evidence

Part I
mass $KHC_8H_4O_{4(s)}$ used: 0.400 g
average volume of $NaOH_{(aq)}$ used : 19.20 mL
Part II
2.00 mL vinegar
average volume of $NaOH_{(aq)}$ used : 17.50 mL

Analysis

(a) $$C_{NaOH(aq)} = \frac{19.6 \times 10^{-3}\ \text{mol}}{19.20 \times 10^{-3}\ \text{L}}$$
$$= 0.102\ \text{mol/L}$$

The molar concentration of the sodium hydroxide solution was 0.102 mol/L.

(b) $KHC_8H_4O_{4(s)}$ is commonly used in standardization titrations because it is a weak acid and because a known amount (in moles) of it can conveniently and accurately be determined using a balance. Furthermore, potassium hydrogen phthalate can be obtained to a high degree of purity. (The degree of purity is given on the reagent bottle.)

(c) Shaking the solution before titrating dissolves more carbon dioxide into the solution, which then produces carbonic acid. This would slightly increase the acidity of the solution—an unnecessary source of error.

(d) Boiling the water removes dissolved carbon dioxide from the solution.

(e) For the titration of vinegar:

$$HC_2H_3O_{2(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaC_2H_3O_{2(aq)}$$

$$n_{NaOH_{(aq)}} = 17.50\ \text{mL} \times 0.102\ \text{mol/L}$$
$$n_{NaOH_{(aq)}} = 1.785\ \text{mmol} \qquad \text{(extra digit carried)}$$
$$C_{HC_2H_3O_{2(aq)}} = \frac{1.785\ \text{mmol}}{2.00\ \text{mL}}$$
$$C_{HC_2H_3O_{2(aq)}} = 0.893\ \text{mol/L}$$

The molar concentration of acetic acid in vinegar is also 0.893 mol/L.

Evaluation

(g) The Procedure is judged to be adequate because the concentration of the unknown acid was determined with no obvious flaws. One minor improvement would be to use a more concentrated sodium hydroxide solution. This would allow for a larger sample of vinegar to be titrated.

INVESTIGATION 8.5.1 BUFFER ACTION

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Prediction

(a) According to the empirical definition of a buffer, the addition of small amounts of a strong acid or strong base produces only a slight change in the pH of the mixture until the capacity of the buffer is exceeded. The reasoning is that the added hydronium ion or hydroxide ion is quantitatively removed by reacting with a component of the weak acid–weak base buffer mixture, as shown below.

$$H_3O^+_{(aq)} + HPO^{2-}_{4(aq)} \rightarrow H_2O_{(l)} + H_2PO^-_{4(aq)}$$

$$OH^-_{(aq)} + H_2PO^-_{4(aq)} \rightarrow H_2O_{(l)} + HPO^{2-}_{4(aq)}$$

Both of the above reactions are predicted to be quantitative.

Experimental Design

(b) A $H_2PO^-_{4(aq)}/HPO^{2-}_{4(aq)}$ buffer is prepared and then tested by adding small amounts of $HCl_{(aq)}$ and $NaHO_{(aq)}$, one drop at a time. Indicators are used to indicate a sudden change in pH. A $NaCl_{(aq)}$ solution is tested as a control. The independent variable is the volume (number of drops) of acid or base added. The dependent variable is the colour of the