

Question Revision

1.

The concentration of hydrochloric acid in a liquid concrete cleaner was determined using the following method. A 25.00 mL sample was diluted to 250 mL in a volumetric flask. A pipette was used to transfer a 10.00 mL sample of this diluted concrete cleaner to a conical flask. An indicator was added and the sample of diluted concrete cleaner was titrated against a 0.200 M solution of sodium carbonate in a burette. The titre was found to be 23.15 mL.

2.

The contents of a laboratory reagent bottle containing solid potassium hydroxide, $\text{KOH}_{(s)}$, has been contaminated by moisture. You have been given the job of determining the extent of contamination. This is to be done by titrating a solution of this KOH with a standardised hydrochloric acid solution (HCl) of pH 1.14. You are to use the following procedure:

Step 1: Dissolve 2.80 g of the contaminated $\text{KOH}_{(s)}$ into 500.0 mL of solution.

Step 2: Fill a burette with this solution and use it to titrate a 20.00 mL sample of the $\text{HCl}_{(aq)}$ using a suitable indicator.

Step 3: Repeat the titrations until a consistent end point is obtained.

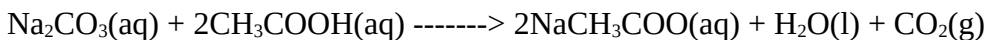
After completing the titrations, the following data is available:

- Titration end point = 15.80 mL of $\text{KOH}_{(aq)}$.
- pH of $\text{HCl}_{(aq)}$ = 1.14.

3.

A supermarket brand of vinegar is to be analysed for its ethanoic acid content by a titration technique. This requires the preparation of a $\text{Na}_2\text{CO}_3(aq)$ primary standard. The primary standard is made by dissolving 1.416 g of anhydrous $\text{Na}_2\text{CO}_3(s)$ in some distilled water and making the solution up to exactly 500.0 mL using a volumetric flask.

A 50.00 mL sample of the vinegar is diluted to exactly 1.000 L in another volumetric flask. Four 25.00 mL samples of this solution are placed into separate conical flasks and titrated with the $\text{Na}_2\text{CO}_3(aq)$ primary standard. On average 23.55 mL of the Na_2CO_3 solution was required for equivalence.

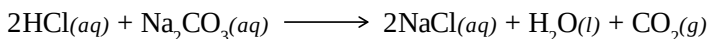
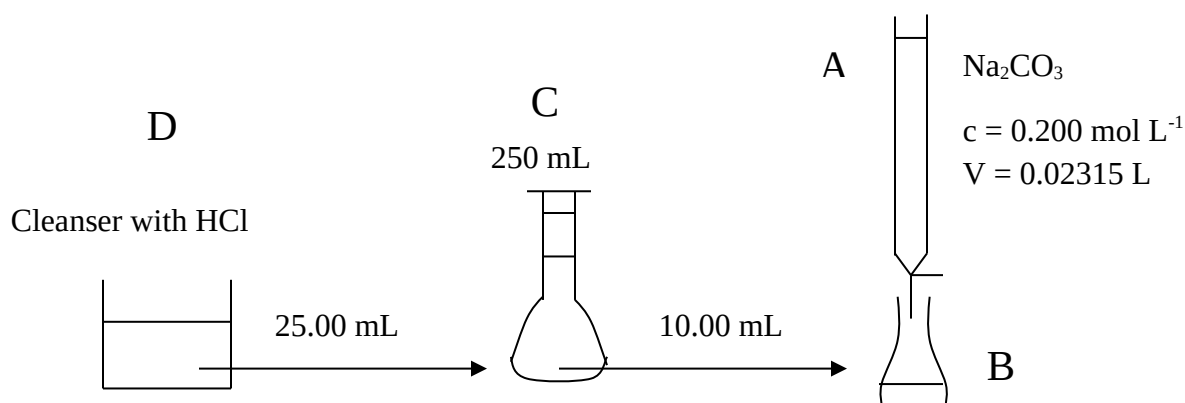


Determine the percentage by mass of ethanoic acid in the undiluted vinegar if this vinegar has a density of 1.060 g mL^{-1} .

1

The concentration of hydrochloric acid in a liquid concrete cleaner was determined using the following method. A 25.00 mL sample was diluted to 250 mL in a volumetric flask. A pipette was used to transfer a 10.00 mL sample of this diluted concrete cleaner to a conical flask. An indicator was added and the sample of diluted concrete cleaner was titrated against a 0.200 M solution of sodium carbonate in a burette. The titre was found to be 23.15 mL.

(a) Calculate the concentration of HCl in the original sample of concrete cleaner.



$$n(\text{Na}_2\text{CO}_3)_A = cV = 0.200 \times 0.02315 = 0.00463$$

$$n(\text{HCl})_B = 2 \times n(\text{Na}_2\text{CO}_3)_A = 2 \times 0.00463 = 0.00926 \text{ mol}$$

$$c(\text{HCl})_C = (n(\text{HCl})_B) / 0.0100 = 0.00926 / 0.01 = 0.926 \text{ M}$$

$$n(\text{HCl})_C = cV = 0.926 \times 0.250 = 0.2315 \text{ mol}$$

$$c(\text{HCl})_D = n/V = 0.2315 / 0.025 = \mathbf{9.26 \text{ M}}$$

2.

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Step 1: Dissolve 2.80 g of the contaminated $\text{KOH}_{(s)}$ into 500.0 mL of solution.

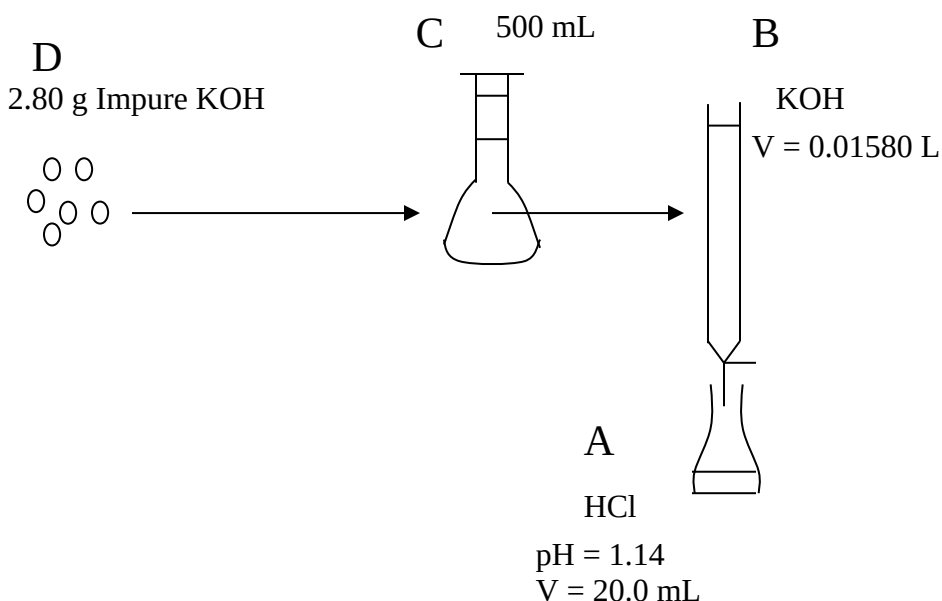
Step 2: Fill a burette with this solution and use it to titrate a 20.00 mL sample of the $\text{HCl}_{(aq)}$ using a suitable indicator.

Step 3: Repeat the titrations until a consistent end point is obtained.

After completing the titrations, the following data is available:

- Titration end point = 15.80 mL of $\text{KOH}_{(aq)}$.
- pH of $\text{HCl}_{(aq)} = 1.14$.

Calculate the percentage by mass of moisture in the contaminated KOH(s)

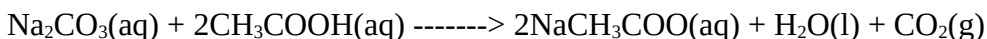


$$\begin{aligned}
 n(\text{HCl})_A &= cV = 10^{-1.14} \times 0.020 = 1.45 \times 10^{-3} \text{ mol} \\
 n(\text{KOH})_B &= n(\text{HCl})_A = 1.45 \times 10^{-3} \text{ mol} \\
 c(\text{KOH})_B &= n/V = (1.45 \times 10^{-3})/0.01580 = 9.17 \times 10^{-2} \text{ M} \\
 c(\text{KOH})_C &= 9.17 \times 10^{-2} \text{ M} \\
 n(\text{KOH})_C &= c \times V = (9.17 \times 10^{-2}) \times 0.500 = 0.0459 \\
 m(\text{NaOH})_D &= n \times M = 0.0459 \times 56.1056 = 2.58 \text{ g} \\
 \%(\text{KOH}) \text{ in impure sample} &= (2.58/2.80) \times 100 = \mathbf{92.0\%}
 \end{aligned}$$

3.

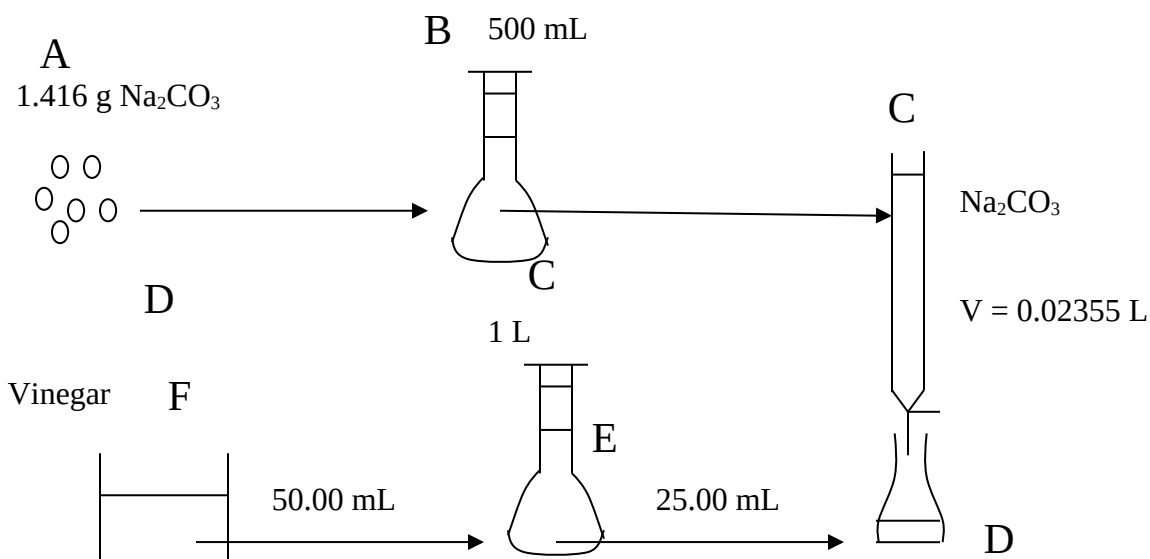
A supermarket brand of vinegar is to be analysed for its ethanoic acid content by a titration technique. This requires the preparation of a $\text{Na}_2\text{CO}_3(\text{aq})$ primary standard. The primary standard is made by dissolving 1.416 g of anhydrous $\text{Na}_2\text{CO}_3(\text{s})$ in some distilled water and making the solution up to exactly 500.0 mL using a volumetric flask.

A 50.00 mL sample of the vinegar is diluted to exactly 1.000 L in another volumetric flask. Four 25.00 mL samples of this solution are placed into separate conical flasks and titrated with the $\text{Na}_2\text{CO}_3(\text{aq})$ primary standard. On average 23.55 mL of the Na_2CO_3 solution was required for equivalence.



Determine the percentage by mass of ethanoic acid in the undiluted vinegar if this vinegar has a density of 1.060 g mL^{-1} .

[10 marks]



$$\begin{aligned}
 n(\text{Na}_2\text{CO}_3)_A &= m/M = 1.416/105.9884 = 1.336 \times 10^{-2} \text{ mol} \\
 c(\text{Na}_2\text{CO}_3)_B &= n/V = (1.336 \times 10^{-2})/0.500 = 2.67 \times 10^{-2} \text{ M} \\
 n(\text{Na}_2\text{CO}_3)_{\text{added from Burette C}} &= cV = (2.67 \times 10^{-2}) \times 0.02355 = 6.29 \times 10^{-4} \text{ mol} \\
 n(\text{CH}_3\text{COOH})_D &= 2 \times n(\text{Na}_2\text{CO}_3)_{\text{added from Burette C}} = 2 \times (6.29 \times 10^{-4}) = 1.26 \times 10^{-3} \text{ mol} \\
 c(\text{CH}_3\text{COOH})_E &= n/V = (1.26 \times 10^{-3})/0.02500 = 5.03 \times 10^{-2} \text{ M} \\
 n(\text{CH}_3\text{COOH})_E &= cV = (5.03 \times 10^{-2}) \times 1 = 5.03 \times 10^{-2} \text{ mol} \\
 c(\text{CH}_3\text{COOH})_E &= n/V = (5.03 \times 10^{-2})/0.0500 = 1.01 \text{ M}
 \end{aligned}$$

density of vinegar = 1060 g / L

therefore, mass of 1 L solution = 1060 g

number of moles CH₃COOH in 1 L = 1.01

therefore, mass of CH₃COOH in 1 L = $n \times M = 1.01 \times 60.0519 = 60.5\text{g}$

$$\begin{aligned}
 \%(\text{CH}_3\text{COOH}) &= [(\text{mass of CH}_3\text{COOH}) / (\text{mass of solution})] \times 100 \\
 &= (60.5/1060) \times 100 = \mathbf{5.7\%}
 \end{aligned}$$