

## Activity 5A: Acid-base titrations

Ans p. 22

- 10.00 mL of a standard potassium carbonate solution, concentration  $0.208 \text{ mol L}^{-1}$ , is pipetted into a flask. This sample is titrated with hydrochloric acid of unknown concentration. The indicator (methyl orange) showed that the end-point had been reached after an average titre of 21.22 mL of hydrochloric acid was added.
  - What is the function of the indicator?
  - How many moles of potassium carbonate are there in the 10.00 mL sample?
  - Write a balanced equation for the reaction between hydrochloric acid and potassium carbonate.
  - How many moles of hydrochloric acid are there in the 21.22 mL titre?
  - What is the concentration of the hydrochloric acid?
- A solution of NaOH was titrated with 15.00 mL aliquots of  $0.252 \text{ mol L}^{-1}$  ethanoic acid. An average titre of 24.96 mL of NaOH was required. Find the concentration of the NaOH.
- During the preparation of a standard solution of anhydrous sodium carbonate,  $\text{Na}_2\text{CO}_3$ , a student obtained the following results:
  - mass of beaker and anhydrous sodium carbonate = 131.10 g
  - mass of empty beaker = 128.45 g
 The student then dissolved the sodium carbonate in enough water to form 100.00 mL of solution.
  - Calculate the mass of sodium carbonate that was weighed out.
  - Calculate the concentration of the solution prepared in:
    - $\text{g L}^{-1}$
    - $\text{mol L}^{-1}$  [ $M(\text{Na}_2\text{CO}_3) = 106.0 \text{ g mol}^{-1}$ ]
  - The standard solution was then titrated against a hydrochloric acid solution of unknown concentration, using methyl orange indicator. It was found that 20.00 mL of the sodium carbonate solution was neutralised by 15.16 mL of the acid.
    - What piece of apparatus would be used to measure the 20.00 mL of standard solution into a conical flask for the titration?
    - What piece of apparatus would be used to measure the volume(s) of acid necessary to neutralise the standard solution?
    - Briefly describe how it was known when the two solutions were neutralised.
    - Write an equation for the reaction which occurred between the hydrochloric acid and sodium carbonate.
    - Calculate the concentration of the hydrochloric acid solution in  $\text{mol L}^{-1}$
- To determine the concentration of limewater,  $\text{Ca}(\text{OH})_2$ ,  $4 \times 10.00 \text{ mL}$  samples were titrated against  $0.125 \text{ mol L}^{-1}$  hydrochloric acid solution. The average volume of acid needed to reach the equivalence point was 24.02 mL.  
Write a balanced equation for the titration reaction and calculate the concentration of the limewater.

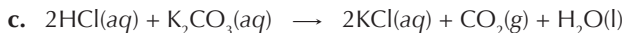
**Activity 5A: Acid-base titrations** (page 21)

1. a. To show when the equivalence point is reached.

b.  $n = cV$

$$= 0.208 \text{ mol L}^{-1} \times 0.0100 \text{ L}$$

$$= 0.00208 \text{ mol}$$



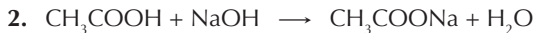
d.  $n(\text{HCl}) = 2n(\text{K}_2\text{CO}_3)$

$$= 2 \times 0.00208 \text{ mol}$$

$$= 0.00416 \text{ mol}$$

e.  $c = \frac{n}{V}$

$$= \frac{0.00416 \text{ mol}}{0.02122 \text{ L}} = 0.196 \text{ mol L}^{-1}$$

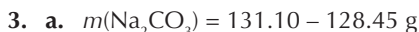


$$n(\text{CH}_3\text{COOH}) = cV = 0.252 \text{ mol L}^{-1} \times 0.01500 \text{ L}$$

$$= 0.00378 \text{ mol}$$

$$n(\text{CH}_3\text{COOH}) = n(\text{NaOH}) = 0.00378 \text{ mol}$$

$$c(\text{NaOH}) = \frac{n}{V} = \frac{0.00378 \text{ mol}}{0.02496 \text{ L}} = 0.151 \text{ mol L}^{-1}$$



$$= 2.65 \text{ g}$$

b. i.  $c = \frac{m}{V} = \frac{2.65 \text{ g}}{0.100 \text{ L}} = 26.5 \text{ g L}^{-1}$

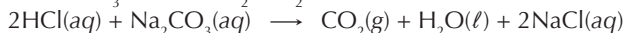
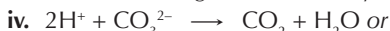
ii.  $n(\text{Na}_2\text{CO}_3) = \frac{m}{M} = \frac{2.65 \text{ g}}{106.0 \text{ g mol}^{-1}} = 0.0250 \text{ mol}$

$$c(\text{Na}_2\text{CO}_3) = \frac{n}{V} = \frac{0.025 \text{ mol}}{0.100 \text{ L}} = 0.250 \text{ mol L}^{-1}$$

c. i. 20 mL pipette.

ii. Burette.

iii. Indicator changes colour from yellow to red.



v.  $n(\text{Na}_2\text{CO}_3) = cV = 0.250 \text{ mol L}^{-1} \times 0.0200 \text{ L}$

$$= 0.00500 \text{ mol}$$

$$n(\text{HCl}) = 2n(\text{Na}_2\text{CO}_3) = 0.00500 \times 2 = 0.0100 \text{ mol}$$

$$c(\text{HCl}) = \frac{n}{V} = \frac{0.0100 \text{ mol}}{0.01516 \text{ L}} = 0.660 \text{ mol L}^{-1}$$



$$n(\text{HCl}) = c(\text{HCl}) \times V(\text{HCl}) = 0.125 \text{ mol L}^{-1} \times 0.02402 \text{ L} = 0.003003 \text{ mol}$$

From the equation:

$$n(\text{Ca}(\text{OH})_2) = \frac{1}{2}n(\text{HCl}) = \frac{1}{2} \times 0.003003 = 0.001501$$

$$c(\text{Ca}(\text{OH})_2) = \frac{n(\text{Ca}(\text{OH})_2)}{V(\text{Ca}(\text{OH})_2)} = \frac{0.001501 \text{ mol}}{0.0100 \text{ L}} = 0.150 \text{ mol L}^{-1}$$

The final answer is given to 3 significant figures since the least accurate measurement ( $c(\text{HCl})$ ) is only given to 3 significant figures.