

1 (a) A solution is made by dissolving calcium chloride in water.

11.1 g of calcium chloride are dissolved in water.

The volume of the solution is made up to 500 cm³.

Calculate the concentration, in mol dm⁻³, of calcium chloride, CaCl₂, in this solution.

(relative atomic masses: Cl = 35.5, Ca = 40.0)

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concentration = mol dm⁻³

(b) The concentration of a solution of an alkali can be determined by titration with an acid.

25.0 cm³ portions of the solution of the alkali are transferred into a conical flask and titrated with the acid solution, using a suitable indicator.

(i) Describe how you would measure out and transfer 25.0 cm³ of the solution of the alkali.

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(ii) Complete the sentence by putting a cross (☒) in the box next to your answer.

The burette readings of acid added were

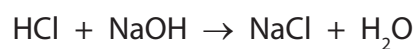
	titration 1	titration 2	titration 3
final volume / cm ³	27.20	30.10	25.35
initial volume / cm ³	2.05	5.20	0.10
volume of acid added / cm ³	25.15	24.90	25.25

The volume of acid added that should be used in the calculation is

(1)

- A** 24.90 cm³
- B** 25.00 cm³
- C** 25.10 cm³
- D** 25.20 cm³

- 2 Titration can be used to determine the exact amount of hydrochloric acid that reacts with a given amount of sodium hydroxide solution.



- (a) What type of reaction takes place when hydrochloric acid reacts with sodium hydroxide solution?

(1)

Put a cross (☒) in the box next to your answer.

- A** neutralisation
- B** oxidation
- C** precipitation
- D** reduction

- (b) Suggest why universal indicator must not be used in titration experiments.

(1)

(d) Sodium hydroxide solution is titrated with dilute hydrochloric acid.

The results of the experiment are

volume of sodium hydroxide solution = 25.0 cm³

volume of 0.100 mol dm⁻³ hydrochloric acid used

rough titration = 23.1 cm³

1st titration = 22.6 cm³

2nd titration = 22.8 cm³

(i) State the volume of hydrochloric acid that must be used to calculate the concentration of sodium hydroxide solution.

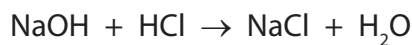
(1)

volume of hydrochloric acid = cm³

(ii) In a different experiment, 25.0 cm³ of sodium hydroxide solution reacted with 23.2 cm³ of 0.100 mol dm⁻³ hydrochloric acid, HCl.

Calculate the concentration of this sodium hydroxide solution, NaOH, in mol dm⁻³.

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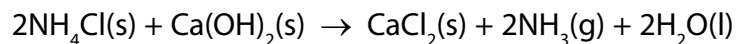
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concentration of sodium hydroxide solution = mol dm⁻³

(Total for Question 2 = 12 marks)

- 3 (a) In an experiment, ammonia gas is made by heating a mixture of ammonium chloride and calcium hydroxide.



10.0 g of ammonium chloride is added to an excess of calcium hydroxide.

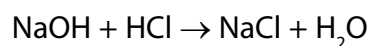
Calculate the maximum volume of ammonia gas that could be formed.

(relative atomic mass H = 1.00, N = 14.0, O = 16.0 and Ca = 40.0; one mole of any gas occupies 24 dm³ at room temperature and pressure)

(2)

volume = dm³

- (b) Sodium hydroxide solution reacts with hydrochloric acid.



- (i) 25.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide, NaOH, solution is added to 35.0 cm³ of 0.0750 mol dm⁻³ dilute hydrochloric acid, HCl.

Use the information to determine which reagent is in excess.

(3)

- (ii) To find the exact amount of dilute hydrochloric acid that reacts with 25.0 cm³ of the sodium hydroxide solution, a titration is carried out. Figure 14 shows the results for the titrations.

	1st titration	2nd titration	3rd titration	4th titration
final burette reading / cm ³	37.60	36.20	39.15	38.40
initial burette reading / cm ³	1.80	0.00	3.95	2.10
volume of acid used / cm ³	35.80	36.20	35.20	36.30

Figure 14

In this titration, the accurate volumes of acid used that are within 0.20 cm³ of each other are considered concordant volumes.

Use the concordant results to calculate the mean volume of hydrochloric acid required.

(1)

mean volume = cm³

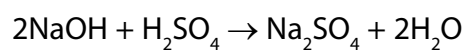
- (iii) During the titration, the indicator used changed colour at the end point.

Which of the following shows an indicator with the colour change that would be seen in this titration?

(1)

	indicator	colour in alkali	colour at end point
<input type="checkbox"/>	A phenolphthalein	colourless	pink
<input type="checkbox"/>	B phenolphthalein	pink	yellow
<input type="checkbox"/>	C methyl orange	red	yellow
<input type="checkbox"/>	D methyl orange	yellow	orange

- (c) In another titration, 25.0 cm³ of a different sodium hydroxide solution is titrated with 0.200 mol dm⁻³ sulfuric acid, H₂SO₄.



24.80 cm³ of acid are required to neutralise 25.0 cm³ of the sodium hydroxide solution.

Calculate the concentration of the sodium hydroxide solution, NaOH, in mol dm⁻³.

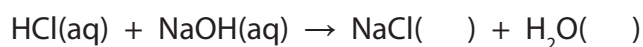
(4)

concentration = mol dm⁻³

(Total for Question 3 = 11 marks)

- 4 To make pure sodium chloride from sodium hydroxide solution and dilute hydrochloric acid, a titration has to be used.

The equation for the reaction is



- (a) Which state symbols follow NaCl and H₂O to complete the equation?

Put a cross (☒) in the box next to your answer.

(1)

	NaCl	H₂O
<input checked="" type="checkbox"/> A	s	
<input checked="" type="checkbox"/> B	aq	
<input checked="" type="checkbox"/> C	s	a
<input checked="" type="checkbox"/> D	aq	

- (b) The reaction above is a neutralisation reaction.

Write the ionic equation for the reaction.

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- (c) When sodium hydroxide solution is titrated with dilute hydrochloric acid, an acid-base indicator is used.

The hydrochloric acid is added from a burette to the sodium hydroxide solution in a conical flask.

At the end point the indicator changes colour.

- (i) Give the name of a suitable indicator to use in this titration.

(1)

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- (ii) State the colour change for this indicator at the end point.

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(d) A sodium hydroxide solution was made up by dissolving 20.0 g of sodium hydroxide in water and making the volume of the solution up to 1.00 dm³. Calculate the concentration of sodium hydroxide, NaOH, in this solution in mol dm⁻³.

(relative atomic masses: H = 1.00, O = 16.0, Na = 23.0)

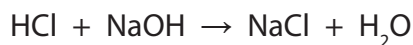
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concentration = mol dm⁻³

(e) In another experiment, a titration was carried out. 25.0 cm³ of 1.50 mol dm⁻³ sodium hydroxide solution, NaOH, was titrated with hydrochloric acid. The volume of the hydrochloric acid required to neutralise the sodium hydroxide solution was 30.0 cm³.

Calculate the concentration of the hydrochloric acid, HCl, in mol dm⁻³.



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concentration = mol dm⁻³

(Total for Question 4 = 10 marks)
