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 cm^3.

Calculate the concentration, in mol dm^{-3}, of calcium chloride, $CaCl_2$, in this solution.

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

(3)

concentration = ... mol dm^{-3}

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

25.0 cm^3 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 cm^3 of the solution of the alkali.

(2)

(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 cm^3

☒ **B** 25.00 cm^3

☒ **C** 25.10 cm^3

☒ **D** 25.20 cm^3

*(c) Some salts dissolved in water cause the water to be hard.

When mixed with a small volume of soap solution, hard water does not form a lather.

You are provided with three unlabelled samples of water.

- one is soft water
- one is permanent hard water
- one is temporary hard water

You are provided with soap solution and the usual laboratory apparatus.

Describe tests that you should carry out on each sample to identify the type of water in each sample.

(6)

(Total for Question 1 = 12 marks)

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

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(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)

.....

*(c) Sodium chloride solution can be made from dilute hydrochloric acid and sodium hydroxide solution.

Describe a titration experiment to find the exact volume of hydrochloric acid needed to neutralise 25.0 cm^3 of sodium hydroxide solution and how you would use this result to obtain pure, dry crystals of sodium chloride.

(6)

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

The results of the experiment are

volume of sodium hydroxide solution = 25.0 cm^3

volume of 0.100 mol dm^{-3} hydrochloric acid used

rough titration	= 23.1 cm^3
1st titration	= 22.6 cm^3
2nd titration	= 22.8 cm^3

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

(1)

volume of hydrochloric acid = ... cm^3

(ii) In a different experiment, 25.0 cm^3 of sodium hydroxide solution reacted with 23.2 cm^3 of 0.100 mol dm^{-3} hydrochloric acid, HCl.

Calculate the concentration of this sodium hydroxide solution, NaOH, in mol dm^{-3}.

(3)

$$NaOH + HCl \rightarrow NaCl + H_2O$$

.....

.....

.....

.....

.....

.....

.....

.....

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.

$$2NH_4Cl(s) + Ca(OH)_2(s) \rightarrow CaCl_2(s) + 2NH_3(g) + 2H_2O(l)$$

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 dm^3 at room temperature and pressure)

(2)

volume = ... dm^3

(b) Sodium hydroxide solution reacts with hydrochloric acid.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

(i) 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide, NaOH, solution is added to 35.0 cm^3 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 cm^3 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 cm^3 of each other are considered concordant volumes.

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

(1)

mean volume = ... cm^3

(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
☒	**A**	phenolphthalein	colourless	pink
☒	**B**	phenolphthalein	pink	yellow
☒	**C**	methyl orange	red	yellow
☒	**D**	methyl orange	yellow	orange

(c) In another titration, 25.0 cm^3 of a different sodium hydroxide solution is titrated with 0.200 mol dm^{-3} sulfuric acid, H_2SO_4.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

24.80 cm^3 of acid are required to neutralise 25.0 cm^3 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

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(\quad) + H_2O(\quad)$$

(a) Which state symbols follow NaCl and H_2O to complete the equation?

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

(1)

		NaCl	**$_2$O**
☒	**A**	s	
☒	**B**	aq	
☒	**C**	s	a
☒	**D**	aq	

(b) The reaction above is a neutralisation reaction.

Write the ionic equation for the reaction.

(2)

.....

(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)

.....

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

(1)

from ..... to .....

(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 dm^3. 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)

(2)

concentration = ... mol dm^{-3}

(e) In another experiment, a titration was carried out.
25.0 cm^3 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 cm^3.

Calculate the concentration of the hydrochloric acid, HCl, in mol dm^{-3}.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(3)

concentration = ... mol dm^{-3}

(Total for Question 4 = 10 marks)