C3 USING CONCENTRATIONS OF SOLUTIONS IN MOL DM3 TITRATIONS

Question Practice

Name: ____________________

Class: ____________________

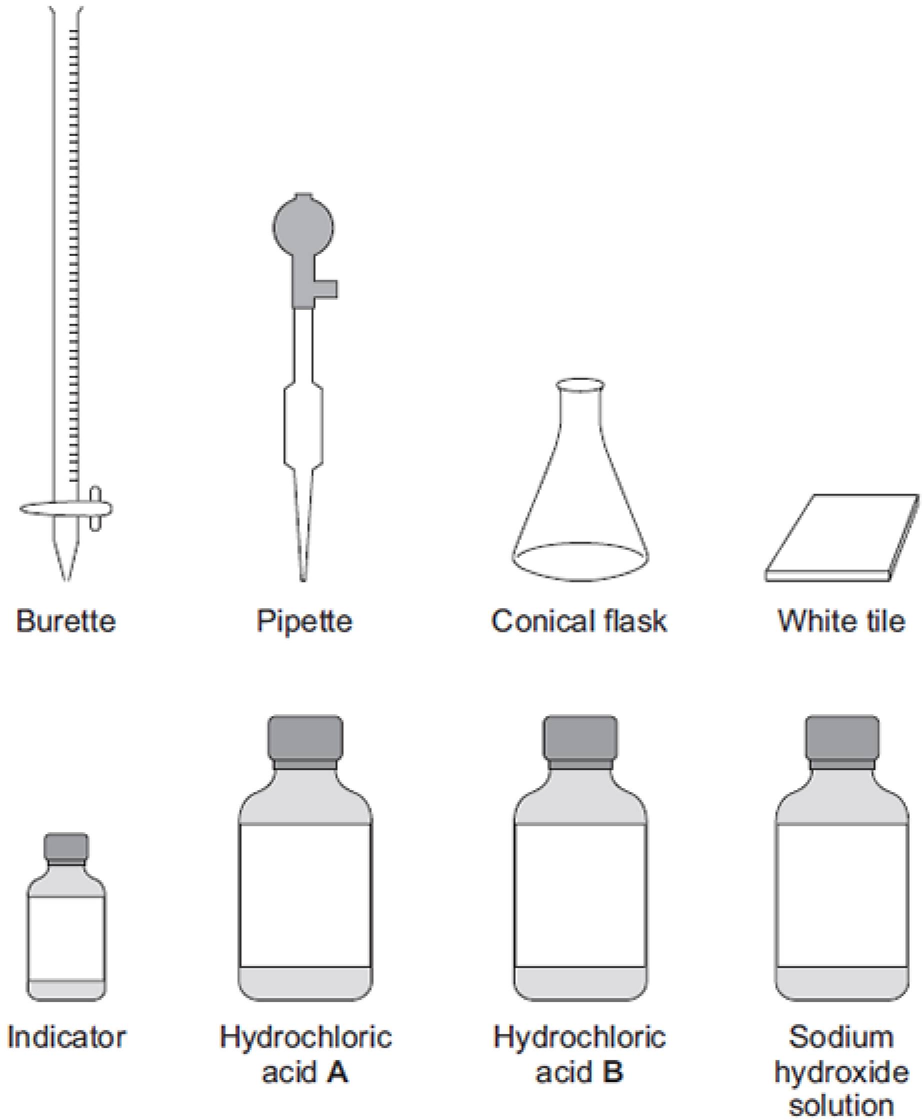
Date: ____________________

Time:	**166 minutes**
Marks:	**165 marks**
Comments:	**GCSE CHEMISTRY ONLY**

1 **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

A student has to check if two samples of hydrochloric acid, **A** and **B**, are the same concentration.

Describe how the student could use the apparatus and the solutions in the diagram below to carry out titrations.



(Total 6 marks)

2 (a) A student had a colourless solution.

The student thought the solution was dilute hydrochloric acid.

(i) The student added universal indicator to this solution.

What colour would the universal indicator change to if the solution is hydrochloric acid?

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(1)

(ii) Describe how the student could show that there are chloride ions in this solution.

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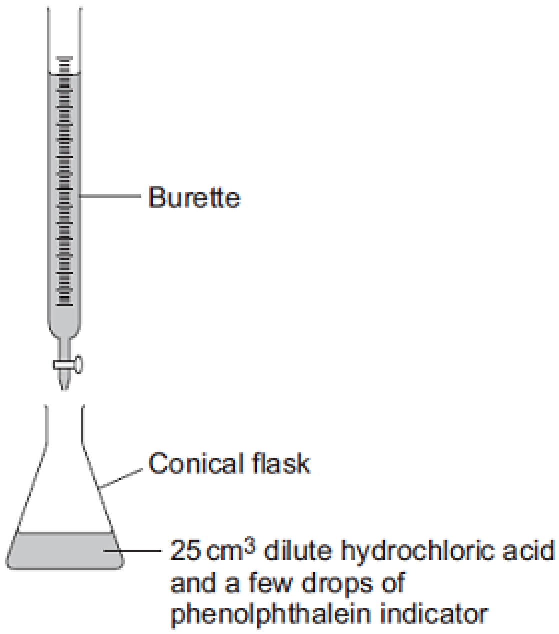
(2)

(b) The results of a titration can be used to find the concentration of an acid.



Describe how to use the apparatus to do a titration using 25 cm^3 of dilute hydrochloric acid.

In your answer you should include:

- how you will determine the end point of the titration
- how you will make sure the result obtained is accurate.

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(4)

(c) Hydrochloric acid is a strong acid.

Ethanoic acid is a *weak acid*.

What is meant by the term *weak acid*?

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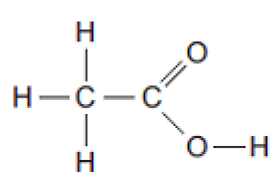
(1)

(d) The displayed formula of ethanoic acid is:



(i) On the formula, draw a circle around the functional group in ethanoic acid.

(1)

(ii) Ethanoic acid and ethanol react together to make the ester ethyl ethanoate.

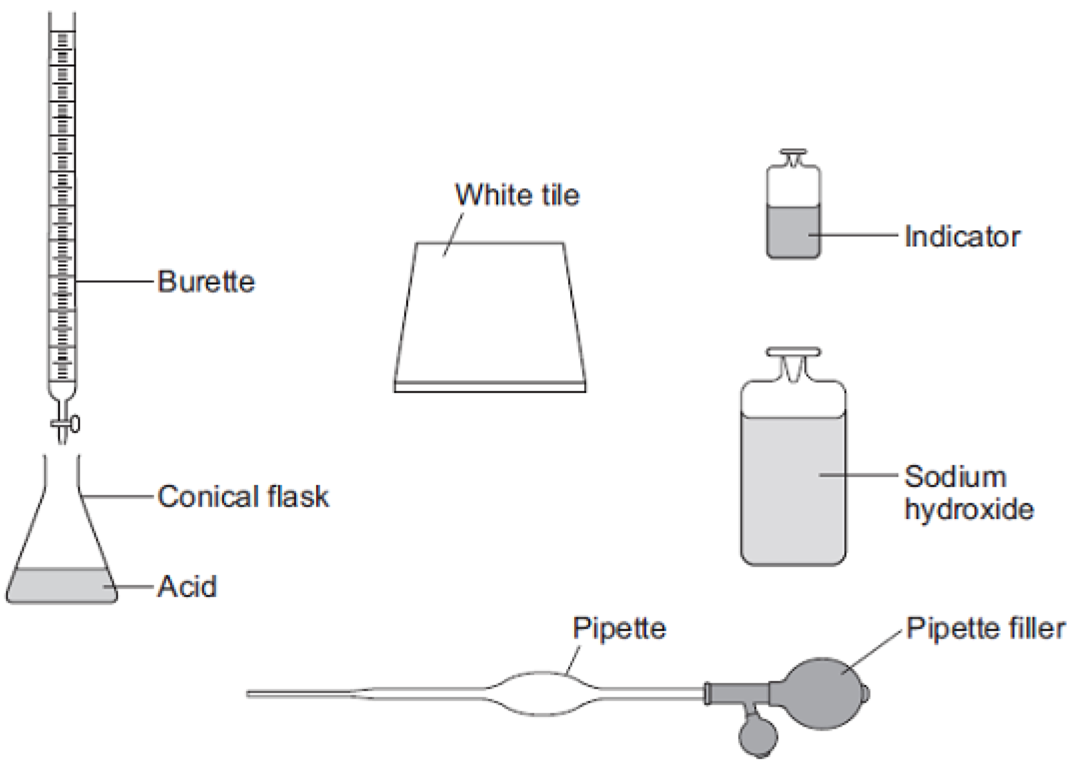
Draw the **displayed** formula of ethyl ethanoate.

(2)

(Total 11 marks)

3 *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

A student used the equipment shown to do a titration.



Describe how the student should use this equipment to find the volume of sodium hydroxide solution that reacts with a known volume of acid.
Include any measurements the student should make.

Do **not** describe how to do any calculations.

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(Total 6 marks)

4 Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

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

(a) Sulfuric acid is a strong acid.

What is meant by a strong acid?

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(2)

(b) Write the ionic equation for this neutralisation reaction. Include state symbols.

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(2)

(c) A student used a pipette to add 25.0 cm^3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol / dm^3 sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

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(4)

(d) The student carried out five titrations. Her results are shown in the table below.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of 0.100 mol / dm^3 sulfuric acid in cm^3	27.40	28.15	27.05	27.15	27.15

Concordant results are within 0.10 cm^3 of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol / dm^3 sulfuric acid added.

Mean volume = ______________________________ cm^3

(2)

(e) The equation for the reaction is:

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

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

Concentration = ________________________ mol / dm^3

(4)

(f) The student did another experiment using 20 cm^3 of sodium hydroxide solution with a concentration of 0.18 mol / dm^3.

Relative formula mass (M_r) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm^3 of this solution.

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Mass = ________________ g

(2)

(Total 16 marks)

5 Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

A student investigated the temperature change in this reaction.

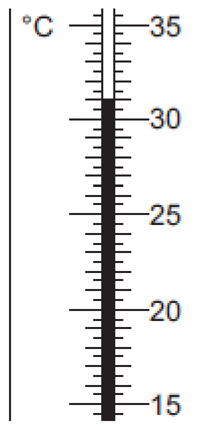
This is the method the student used.

Step 1 Put 25 cm^3 of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 cm^3 of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.
Step 5 Repeat steps 3 and 4 until 40 cm^3 of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

Figure 1



What is the temperature shown on the thermometer?

The temperature shown is ___________ °C

(1)

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

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(2)

(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

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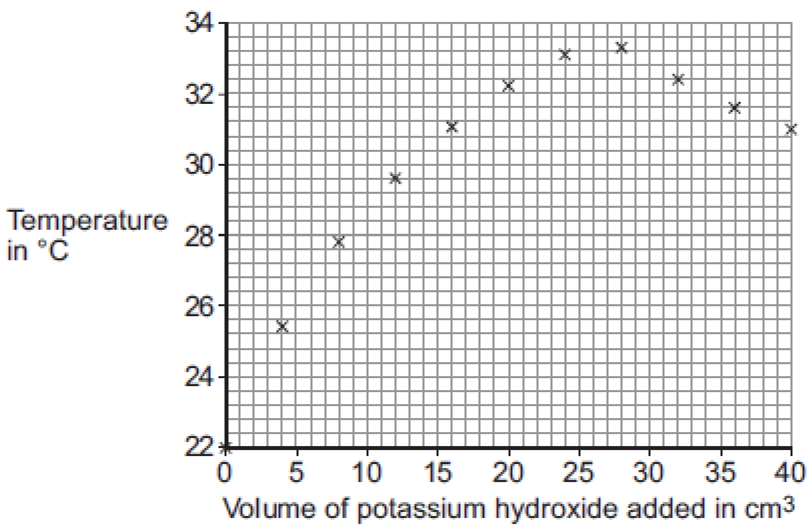
(1)

(c) The results of the student using the polystyrene cup are shown in **Figure 2**.

Figure 2



(i) How do the results in **Figure 2** show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

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(1)

(ii) Explain why the temperature readings decrease between 28 cm^3 and 40 cm^3 of potassium hydroxide solution added.

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(2)

(iii) It is difficult to use the data in **Figure 2** to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature

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(2)

(d) The student did further experimental work and found that 31.0 cm^3 of potassium hydroxide solution neutralised 25.0 cm^3 of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per dm^3.

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide solution in moles per dm^3.

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Concentration = _______________ moles per dm^3

(3)

(e) The student repeated the original experiment using 25 cm^3 of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

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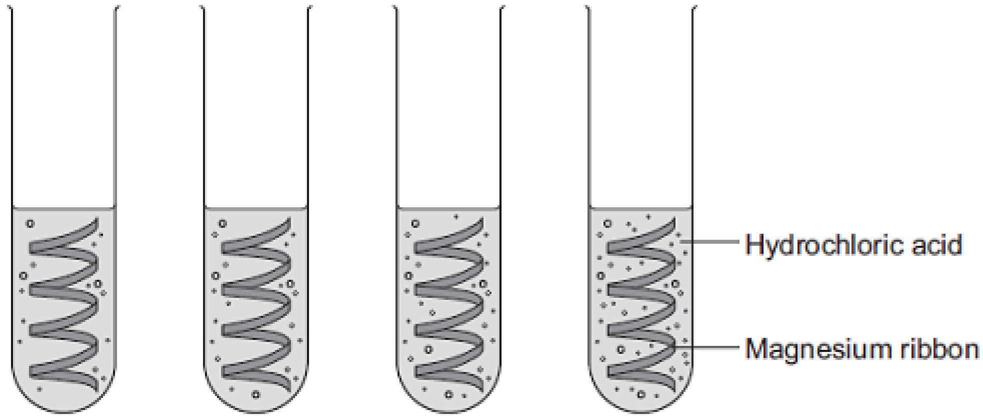
(2)
(Total 14 marks)

6 A student investigated the rate of reaction of magnesium and hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.



Concentration of hydrochloric acid in moles per dm^3	0.5	1.0	1.5	2.0

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1. ___

2. ___

(2)

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

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(2)

(ii) Explain why increasing the temperature would increase the rate of reaction.

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(3)

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm^3.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm^3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm^3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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(4)

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

The student found that 27.20 cm^3 of 0.100 moles per dm^3 sodium hydroxide neutralised 5.00 cm^3 of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm^3.

Give your answer to three significant figures.

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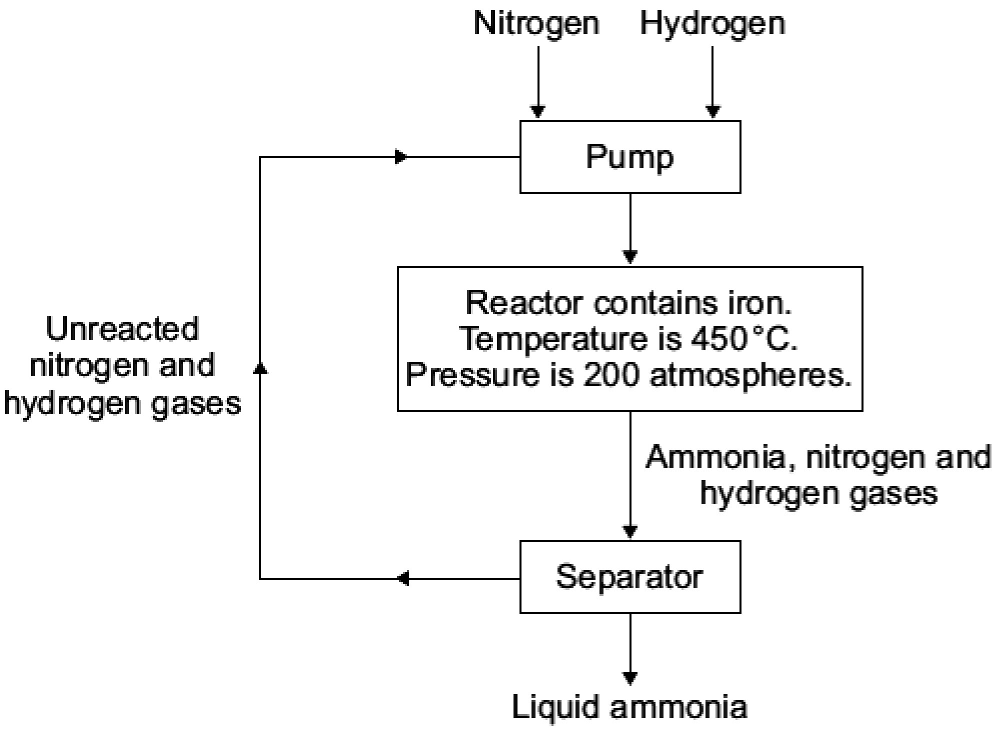
Concentration of hydrochloric acid = ________________ moles per dm^3

(3)

(Total 14 marks)

7 Ammonia is made using the Haber process.



(a) How is ammonia separated from unreacted nitrogen and hydrogen in the separator?

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(2)

(b) The equation shows the reaction which takes place in the reactor:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Why does the yield of ammonia at equilibrium increase as the temperature is decreased?

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(1)

(ii) A temperature of 450 °C is used in the reactor to make the reaction take place quickly.

Explain, in terms of particles, why increasing the temperature makes a reaction go faster.

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(2)

(iii) Why does the yield of ammonia at equilibrium increase as the pressure is increased?

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(1)

(iv) The pressure used in the reactor is 200 atmospheres.
Suggest why a much higher pressure is **not** used.

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(1)

(c) Use the equation for the reaction in the reactor to help you to answer these questions.

$$N_2(g) \quad + \quad 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) It is important to mix the correct amounts of hydrogen and nitrogen in the reactor.

20 m^3 of nitrogen is reacted with hydrogen.

What volume of hydrogen (measured at the same temperature and pressure as the nitrogen) is needed to have the correct number of molecules to react with the nitrogen?

Volume of hydrogen needed = ______________ m^3

(1)

(ii) Calculate the maximum mass of ammonia that can be made from 2 g of nitrogen.

Relative atomic masses: H = 1; N = 14.

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Maximum mass of ammonia = _______________ g

(3)

(d) The expected maximum mass of ammonia produced by the Haber process can be calculated.

(i) In one process, the maximum mass of ammonia should be 80 kg.

The actual mass of ammonia obtained was 12 kg.

Calculate the percentage yield of ammonia in this process.

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Percentage yield of ammonia = ______________ %

(1)

(ii) Give **two** reasons why it does **not** matter that the percentage yield of ammonia is low. Use the flow diagram at the start of this question to help you.

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(2)

(Total 14 marks)

8 Vinegar can be added to food. Vinegar is an aqueous solution of ethanoic acid.

Ethanoic acid is a *weak* acid.

(a) Which ion is present in aqueous solutions of all acids?

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(1)

(b) What is the difference between the pH of a *weak* acid compared to the pH of a strong acid of the same concentration?

Give a reason for your answer.

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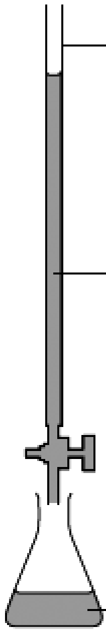
(2)

(c) The diagram shows the apparatus used to find the concentration of ethanoic acid in vinegar.



(i) Why should phenolphthalein indicator be used for this titration instead of methyl orange?

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(1)

(ii) 25.00 cm^3 of vinegar was neutralised by 30.50 cm^3 of a solution of sodium hydroxide with a concentration of 0.50 moles per cubic decimetre.

The equation for this reaction is:

$$CH_3COOH(aq) \quad + \quad NaOH(aq) \quad \rightarrow \quad CH_3COONa(aq) \quad + \quad H_2O(l)$$

Calculate the concentration of ethanoic acid in this vinegar.

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Concentration of ethanoic acid in this vinegar = ___________ moles per cubic decimetre

(2)

(d) The concentration of ethanoic acid in a different bottle of vinegar was 0.80 moles per cubic decimetre.

Calculate the mass in grams of ethanoic acid (CH_3COOH) in 250 cm^3 of this vinegar.
The relative formula mass (M_r) of ethanoic acid = 60.

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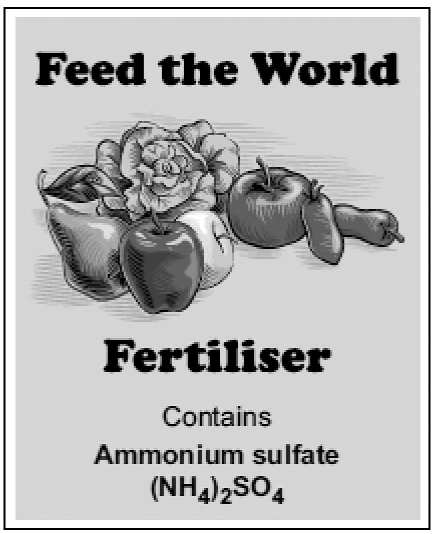
Mass of ethanoic acid = ____________________ g

(2)

(Total 8 marks)

9 Ammonium sulfate is an artificial fertiliser.



(a) (i) When this fertiliser is warmed with sodium hydroxide solution, ammonia gas is given off.
Describe and give the result of a test for ammonia gas.

Test ___

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Result ___

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(2)

(ii) Describe and give the result of a chemical test to show that this fertiliser contains sulfate ions (SO_4^{2-}).

Test ____

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Result ____

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(2)

(b) Ammonium sulfate is made by reacting sulfuric acid (a *strong* acid) with ammonia solution (a *weak* alkali).

(i) Explain the meaning of *strong* in terms of ionisation.

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(1)

(ii) A student made some ammonium sulfate in a school laboratory.

The student carried out a titration, using a suitable indicator, to find the volumes of sulfuric acid and ammonia solution that should be reacted together.

Name a suitable indicator for strong acid-weak alkali titrations.

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(1)

(iii) The student found that 25.0 cm^3 of ammonia solution reacted completely with 32.0 cm^3 of sulfuric acid of concentration 0.050 moles per cubic decimetre.

The equation that represents this reaction is:

$$2H_2SO_4(aq) \quad + \quad 2NH_3(aq) \quad \rightarrow \quad (NH_4)_2SO_4\ (aq)$$

Calculate the concentration of this ammonia solution in moles per cubic decimetre.

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Concentration = __________________ moles per cubic decimetre

(3)

(iv) Use your answer to (b)(iii) to calculate the concentration of ammonia in grams per cubic decimetre.

(If you did not answer part (b)(iii), assume that the concentration of the ammonia solution is 0.15 moles per cubic decimetre. This is **not** the correct answer to part (b)(iii).)

Relative formula mass of ammonia (NH_3) = 17.

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Concentration = __________________ grams per cubic decimetre

(2)

(Total 11 marks)

10 Chemical tests can be used to detect and identify elements and compounds.

Two jars of chemicals from 1870 are shown.

(a) One jar contains copperas. Copperas was a name used for iron(II) sulfate, $FeSO_4$ It does not contain any copper!

Describe and give the result of a chemical test to show that a solution of copperas contains:

(i) iron(II) ions, Fe^{2+}

Test ____

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Result ____

(2)

(ii) sulfate ions, SO_4^{2-}

Test ____

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Result ____

(2)

(b) The other jar contained a mixture of common salt (sodium chloride, NaCl) and washing soda (sodium carbonate, Na_2CO_3).

To show that the mixture contains chloride ions, silver nitrate solution ($AgNO_3$) and nitric acid (HNO_3) are added. A white precipitate is produced.

$$AgNO_3(aq) \quad + \quad NaCl(aq) \quad \rightarrow \quad AgCl(s) \quad + \quad NaNO_3(aq)$$

(i) The carbonate ions in the mixture will affect the test for chloride ions.

Use the equations to explain why carbonate ions affect the test for chloride ions **and** how nitric acid overcomes this problem.

AgCl (s)	+	HNO_3 (aq)	→	no reaction				
$2AgNo_3$ (aq)	+	Na_2CO_3 (aq)	→	Ag_2CO_3 (s) white	+	$2NaNO_3$ (aq)		
Ag_2CO_3 (s)	+	$2HNO_3$ (aq)	→	$2AgNO_3$ (aq)	+	H_2O (l)	+	CO_2 (g)

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(2)

(ii) Hydrochloric acid (HCl) should **not** be used instead of nitric acid when testing for chloride ions with silver nitrate solution.

Suggest why.

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(1)

(Total 7 marks)

11 In 1916, during the First World War, a German U-boat sank a Swedish ship which was carrying a cargo of champagne. The wreck was discovered in 1997 and the champagne was brought to the surface and analysed.

(a) 25.0 cm^3 of the champagne were placed in a conical flask.

Describe how the volume of sodium hydroxide solution needed to react completely with the weak acids in 25.0 cm^3 of this champagne can be found by titration, using phenolphthalein indicator.

Name any other apparatus used.

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(4)

(b) The acid in 25.0 cm^3 of the champagne reacted completely with 13.5 cm^3 of sodium hydroxide of concentration 0.10 moles per cubic decimetre.

Calculate the concentration in moles per cubic decimetre of acid in the champagne.

Assume that 1 mole of sodium hydroxide reacts completely with 1 mole of acid.

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Concentration = ______________ moles per cubic decimetre

(2)

(c) Is analysis by titration enough to decide whether this champagne is safe to drink?

Explain your answer.

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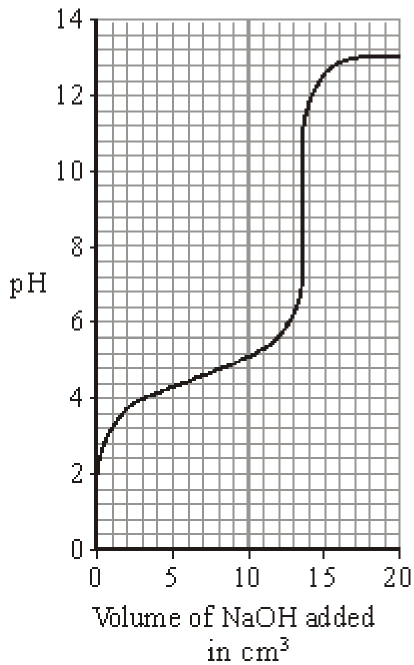
(1)

(d) The graph shows how the pH of the solution changes during this titration.



Phenolphthalein is the indicator used in this titration. It changes colour between pH 8.2 and pH 10.0.

Methyl orange is another indicator. It changes colour between pH 3.2 and pH 4.4.

Suggest why methyl orange is **not** a suitable indicator for this titration.

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(2)
(Total 9 marks)

12 Four labels have come off four bottles.

Aluminium sulphate solution $Al_2(SO_4)_3$ (aq)	Ammonium sulphate solution $(NH_4)_2SO_4$ (aq)
Magnesium sulphate solution $MgSO_4$ (aq)	Sodium sulphate solution Na_2SO_4 (aq)

Describe and give the results of the **chemical** tests that you would do to identify which bottle contained which substance.

(Total 5 marks)

13 (a) This label has been taken from a bottle of vinegar.

Vinegar is used for seasoning foods. It is a solution of ethanoic acid in water.

In an experiment, it was found that the ethanoic acid present in a 15.000 cm^3 sample of vinegar was neutralised by 45.000 cm^3 of sodium hydroxide solution, of concentration 0.20 moles per cubic decimetre (moles per litre).

The equation which represents this reaction is

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

Calculate the concentration of the ethanoic acid in this vinegar:

(i) in moles per cubic decimetre (moles per litre);

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Concentration =__________________ moles per cubic decimetre

(2)

(ii) in grams per cubic decimetre (grams per litre).

Relative atomic masses: H = 1; C = 12; O = 16.

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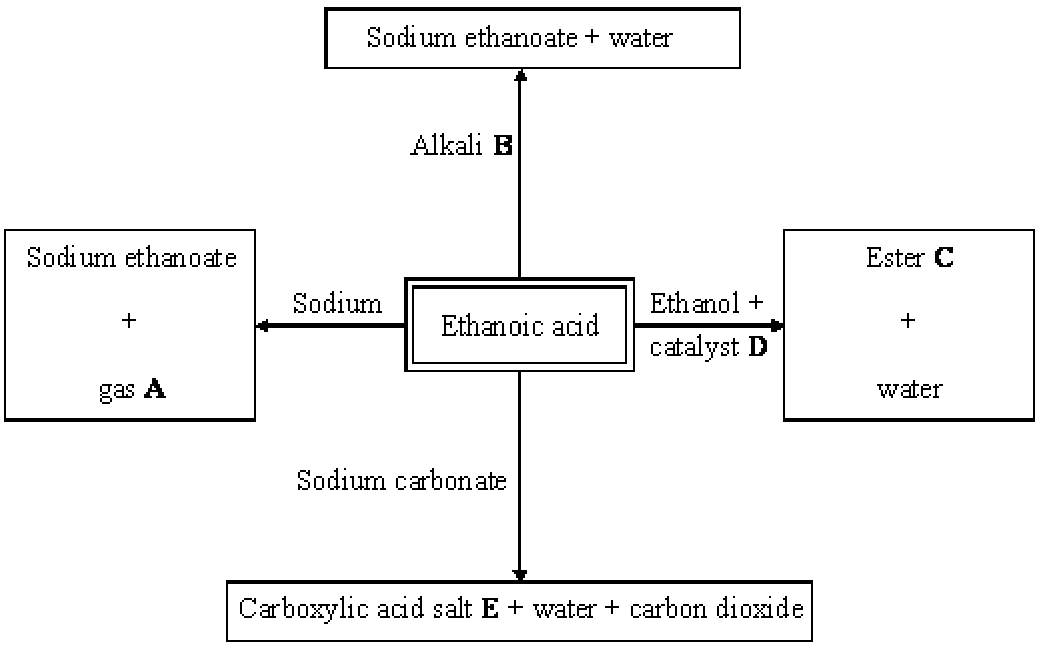
Concentration = ________________ grams per cubic decimetre

(2)

(b) The flow diagram shows some reactions of ethanoic acid.



Give the name of:

(i) gas **A**,

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(1)

(ii) alkali **B**,

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(1)

(iii) ester **C**,

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(1)

(iv) catalyst **D**,

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(1)

(v) carboxylic acid salt **E**.

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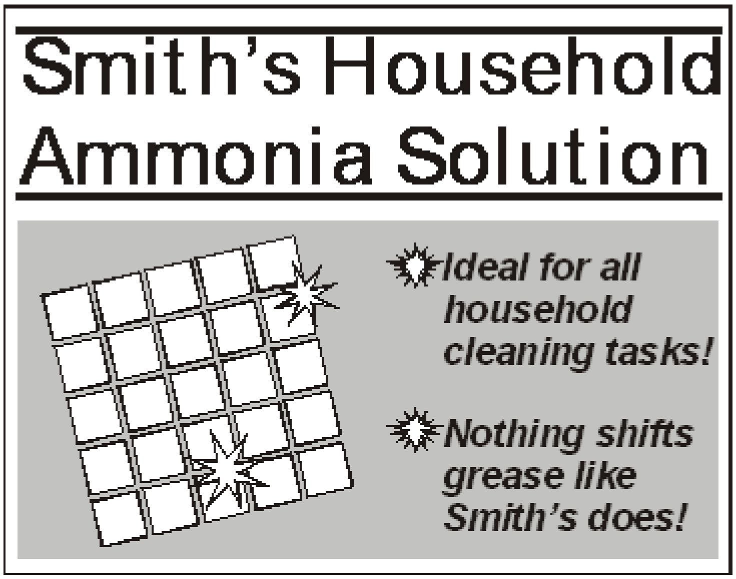
(1)

(Total 9 marks)

14 This label has been taken from a bottle of household ammonia solution.



Household ammonia is a dilute solution of ammonia in water. It is commonly used to remove grease from ovens and windows.

(a) The amount of ammonia in household ammonia can be found by titration.

25.0 cm^3 of household ammonia is placed in a conical flask. Describe how the volume of dilute nitric acid required to neutralise this amount of household ammonia can be found accurately by titration. Name any other apparatus and materials used.

To gain full marks you should write down your ideas in good English. Put them into a sensible order and use correct scientific words.

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(4)

(b) In an experiment, it was found that 25.0 cm^3 of household ammonia was neutralised by 20.0 cm^3 of dilute nitric acid with a concentration of 0.25 moles per cubic decimetre.

The balanced symbol equation which represents this reaction is

$$NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$$

Calculate the concentration of the ammonia in this household ammonia in moles per cubic decimetre.

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Concentration = _______________ moles per cubic decimetre

(2)

(c) The salt, ammonium nitrate, is formed in this reaction.

Describe, and give the result of, a chemical test which shows that ammonium nitrate contains ammonium ions.

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(2)

(Total 8 marks)

15 A student carried out a titration to find the concentration of a solution of sulphuric acid. 25.0 cm^3 of the sulphuric acid solution was neutralised exactly by 34.0 cm^3 of a potassium hydroxide solution of concentration 2.0 mol/dm^3. The equation for the reaction is:

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

(a) Describe the experimental procedure for the titration carried out by the student.

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(4)

(b) Calculate the number of moles of potassium hydroxide used.

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Number of moles = ____________________

(2)

(c) Calculate the concentration of the sulphuric acid in mol/dm^3.

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Concentration = ______________ mol/dm^3

(3)

(Total 9 marks)

16 An oven cleaner solution contained sodium hydroxide. A 25.0 cm^3 sample of the oven cleaner solution was placed in a flask. The sample was titrated with hydrochloric acid containing 73 g/dm^3 of hydrogen chloride, HCl.

(a) Describe how this titration is carried out.

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(3)

(b) Calculate the concentration of the hydrochloric acid in mol/dm^3.

Relative atomic masses: H 1; Cl 35.5

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Answer = ______________ mol/dm^3

(2)

(c) 10.0 cm^3 of hydrochloric acid were required to neutralise the 25.0 cm^3 of oven cleaner solution.

(i) Calculate the number of moles of hydrochloric acid reacting.

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Answer = ________________ mol

(2)

(ii) Calculate the concentration of sodium hydroxide in the oven cleaner solution in mol/dm^3.

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Answer = ____________________ mol/dm^3

(2)

(Total 9 marks)

17 A student carried out a titration to find the concentration of a solution of hydrochloric acid. The following paragraph was taken from the student's notebook.

> I filled a burette with hydrochloric acid. 25.0 cm^3 of 0.40 mol/dm^3 potassium hydroxide was added to a flask. 5 drops of indicator were added. I added the acid to the flask until the indicator changed colour. The volume of acid used was 35.0 cm^3.

(a) What piece of apparatus would be used to measure 25.0 cm^3 of the potassium hydroxide solution?

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(1)

(b) Name a suitable indicator that could be used.

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(1)

(c) Calculate the number of moles of potassium hydroxide used.

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Moles of potassium hydroxide = ________________________ mol

(2)

(d) Calculate the concentration of the hydrochloric acid. The equation for the reaction is:

$KOH + HCl \rightarrow KCl + H_2O$

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Concentration of hydrochloric acid = ______________________ mol/dm^3

(2)

(Total 6 marks)

Mark schemes

1 Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a ‘best-fit’ approach to the marking.

Level 3 (5 – 6 marks)
There is a description of titrations that would allow a comparison to be made between the two solutions of hydrochloric acid.

Level 2 (3 – 4 marks)
There is a description of an experimental method including addition of acid to alkali which may include an indicator or colour change and may include a measurement of volume.

Level 1 (1 – 2 marks)
There is a simple description of using some of the apparatus.

0 marks
No relevant content.

examples of chemistry points made in the response could include:

- acid in burette **or** flask
- alkali/sodium hydroxide **or** acid in burette **or** flask
- volume of acid **or** alkali measured using the pipette
- indicator in flask
- white tile under the flask
- slow addition
- swirling/mixing
- colour change of indicator
- burette volume measured

[6]

2 (a) (i) red

ignore pink

1

(ii) add silver nitrate (solution)

1

white precipitate

dependent on addition of silver nitrate

ignore addition of another acid

if hydrochloric acid added max ***1*** *mark*

1

(b) suitable named alkali / sodium hydroxide solution in burette

1

add alkali solution until (indicator) becomes pink / red

1

if acid to acid titration described, first two marking points ***not*** *available* any **two** from:

- wash / rinse equipment
- add dropwise or slowly (near end point)
- swirl / mix
- read (meniscus) at eye level
- white background
- read start and final burette levels / calculate the volume needed
- repeat

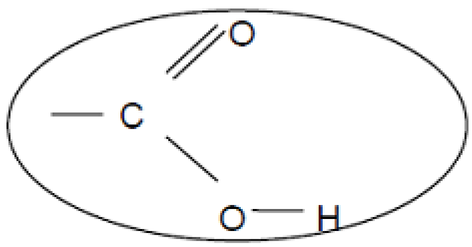
2

(c) does not ionise / dissociate completely

allow for acids of the same concentration, weak acids have a higher pH or fewer hydrogen ions

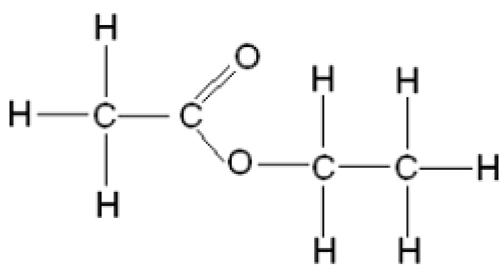
1

(d) (i) ring round COOH

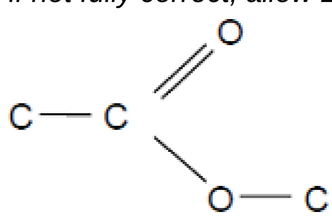


1

(ii)



*if not fully correct, allow **1** mark for correct ester group − minimum*



2

[11]

3 Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a simple description of using some of the equipment.

Level 2 (3-4 marks)
There is a description of an experimental method involving a measurement, **or** including addition of alkali to acid (or vice versa).

Level 3 (5-6 marks)
There is a description of a titration that would allow a successful result to be obtained.

Examples of chemistry points made in the response could include:

- acid in (conical) flask
- volume of acid measured using pipette
- indicator in (conical) flask
- sodium hydroxide in burette
- white tile under flask
- slow addition
- swirling
- colour change
- volume of sodium hydroxide added

Extra information

- allow acid in the burette to be added to sodium hydroxide in the (conical) flask
- allow any specified indicator

colour change need not be specified

[6]

4 (a) (sulfuric acid is) completely / fully ionised

1

In aqueous solution **or** when dissolved in water

1

(b) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

allow multiples

***1** mark for equation*

***1** mark for state symbols*

2

(c) adds indicator, eg phenolpthalein / methyl orange / litmus added to the sodium hydroxide (in the conical flask)

*do **not** accept universal indicator*

1

(adds the acid from a) burette

1

with swirling **or** dropwise towards the end point **or** until the indicator just changes colour

1

until the indicator changes from pink to colourless (for phenolphthalein) or yellow to red (for methyl orange) or blue to red (for litmus)

1

(d) titrations 3, 4 and 5

or

$$\frac{27.05 + 27.15 + 27.15}{3}$$

1

27.12 cm^3

*accept 27.12 with no working shown for **2** marks*

1

*allow 27.1166 with no working shown for **2** marks*

(e) Moles H_2SO_4 = conc × vol = 0.00271

allow ecf from 8.4

1

Ratio H_2SO_4:NaOH is 1:2

or

Moles NaOH = Moles H_2SO_4 × 2 = 0.00542

1

Concentration NaOH = mol / vol = 0.00542 / 0.025 = 0.2168

1

0.217 (mol / dm^3)

*accept 0.217 with no working for **4** marks*

1

*accept 0.2168 with no working for **3** marks*

(f) $\frac{20}{1000}$ × 0.18 = no of moles

or

0.15 × 40 g

1

0.144 (g)

1

*accept 0.144g with no working for **2** marks*

[16]

5 (a) 31

1

(b) (i) any **two** from:

- incorrect reading of thermometer / temperature
- incorrect measurement of volume of acid
- incorrect measurement of volume of alkali (burette).

2

(ii) glass is a (heat) conductor **or** polystyrene is a (heat) insulator

*answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*

accept answers based on greater thermal capacity of glass (such as “glass absorbs more heat than polystyrene”)

1

(c) (i) temperature increases

1

(ii) no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

1

cool / colder potassium hydroxide absorbs energy **or** lowers temperature

ignore idea of heat energy being lost to surroundings

1

(iii) take more readings

ignore just “repeat”

1

around the turning point **or** between 20 cm^3 and 32 cm^3

accept smaller ranges as long as no lower than 20 cm^3 and no higher than 32 cm^3

1

(d) 1.61 **or** 1.6(12903)

*correct answer with or without working scores **3***

*if answer incorrect, allow a maximum of **two** from:*

*moles nitric acid = (2 × 25 / 1000) = 0.05 for **1** mark*

*moles KOH = (moles nitric acid) = 0.05 for **1** mark*

concentration KOH = 0.05 / 0.031

answer must be correctly rounded (1.62 is incorrect)

3

(e) same amount of energy given out

1

which is used to heat a smaller total volume **or** mixture has lower thermal capacity
or
number of moles reacting is the same
but the total volume / thermal capacity is less

*if no other marks awarded award **1** mark for idea of reacting faster*

1

[14]

6 (a) any **two** from:

- temperature (of the HCl)
- mass or length of the magnesium
- surface area of the magnesium
- volume of HCl

2

(b) (i) (a greater concentration has) more particles per unit volume

allow particles are closer together

1

therefore more collisions <u>per unit time</u> **or** more frequent collisions.

1

(ii) particles move faster

allow particles have more (kinetic) energy

1

therefore more collisions <u>per unit time</u> **or** more frequent collisions

1

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

1

(c) (i) add (a few drops) of indicator to the acid in the conical flask

allow any named indicator

1

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

candidate does not have to state a colour change but penalise an incorrect colour change.

1

repeat the titration

1

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

1

(ii) **moles of NaOH**

$0.10 \times 0.0272 = 0.00272$ moles

*correct answer with or without working gains **3** marks*

1

Concentration of HCl

$0.00272 / 0.005 = 0.544$

allow ecf from mp1 to mp2

1

correct number of significant figures

1

[14]

7 (a) mixture is cooled / cooling

1

so ammonia / it condenses

or

so ammonia <u>turns into</u> a liquid (but nitrogen and hydrogen remain as gases)

1

(b) (i) exothermic reaction

accept reverse reaction is endothermic

or

equilibrium / reaction moves in the direction which raises the temperature

ignore answers based on rate or collisions

1

(ii) they / particles / molecules move faster **or** have more (kinetic) energy

allow atoms instead of particles

ignore particles move more / vibrate

*do **not** accept electrons (max1)*

1

any **one** from:

- particles / molecules collide more often / more frequently / more likely to collide

  ignore collide faster

  ignore more collisions

- more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

  accept more successful collisions

1

(iii) more molecules / particles / moles / volumes on LHS (of equation than RHS)

accept 4 molecules / particles / moles / volumes on LHS and 2 molecules / particles / moles / volumes on RHS

or
greater volume on LHS (than RHS)
or
equilibrium / reaction moves in the direction which reduces the pressure / volume

accept converse

1

(iv) cost

or
difficulty in containing such a high pressure

allow risk of explosion

ignore dangerous

1

(c) (i) 60

1

(ii) 2.4(2857….)

*correct answer gains **3** marks with or without working*

accept any answer that rounds to 2.4

ignore units

*if answer is incorrect look for evidence of correct working to a maximum of **2** marks.*

moles of N_2 = 2/28 = (0.0714)

moles of ammonia = 2 × 0.0714 = (0.1428)

mass of ammonia = 0.1428 × 17 = (2.4276)

or

28 → 34

1g →34/28

2g →2.4… ….

3

(d) (i) 15

1

(ii) unreacted gases are recycled

allow unreacted gases are reused

1

rate (of production) is fast

accept production is continuous

ignore compromise between rate and yield

1

[14]

8 (a) Hydrogen / H^+

ignore state symbols

ignore proton / H

1

(b) *it = weak acid*

pH of weak acid is higher than the pH of a strong acid

allow converse for strong acids

allow correct numerical comparison

1

any **one** from:

allow converse for strong acids

- only partially dissociated (to form ions)

  allow ionises less

- not as many hydrogen ions (in the solution)

  allow fewer H^+ released

1

(c) (i) (titration of) weak acid <u>and</u> strong base

1

(ii) 0.61

*correct answer with or without working gains **2** marks*

if the answer is incorrect:

moles of sodium hydroxide = (30.5 × 0.5)/1000 = 0.01525 moles

or

*(0.5 × 30.5/25) gains **1** mark*

2

(d) 12

*correct answer with or without working gains **2** marks or even with incorrect working.*

if the answer is incorrect:

0.8 × 60 = 48g

or

evidence of dividing 48g (or ecf) by 4

or

$\frac{0.8 \times 250}{1000} = \frac{0.8}{4} =$ *0.8 × 0.25 = 0.2 mol*

or

evidence of multiplying 0.2mol (or ecf) by 60

*would gain **1** mark*

2

[8]

9 (a) (i) *incorrect test or no test = **0** mark*

*testing the solution **or** using blue litmus = **0** mark*

(test ammonia / gas with red) litmus

accept any acid-base indicator with correct result

1

(goes) blue

OR

(conc.) HCl (1)

<u>white</u> fumes / smoke / solid (1)

allow <u>white</u> gas / vapour

OR

(test ammonia / gas with) Universal Indicator (1)

blue / purple (1)

1

(ii) *incorrect test or no test = **0** marks*

add barium chloride / $BaCl_2$ (solution)

*do **not** accept H_2SO_4 added*

or add barium nitrate / $Ba(NO_3)_2$ (solution)

allow Ba^{2+} solution / aqueous added

1

<u>white</u> precipitate / solid (formed)

allow white barium sulfate / $BaSO_4$

ignore barium sulfate / $BaSO_4$ alone

1

(b) (i) <u>fully</u> / <u>completely</u> ionised / dissociated
or hydrogen ions fully <u>dissociated</u>

accept has more ions than weaker acid / alkali of <u>same concentration</u>

ignore strongly ionised

*do **not** accept ions are fully ionised*

*ignore concentrated **or** reference to concentrations of ions*

1

(ii) methyl orange

accept correct spelling only

accept any strong acid-weak base indicator

*do **not** allow phenolphthalein / litmus / universal indicator*

1

(iii) 32 × 0.05/1000 **or** 0.0016 (mole H_2SO_4)

*accept (0.05 x 32) = (V x 25) **or** 0.05 x 32 / 25*

1

(reacts with) 2 × 0.0016 **or** 0.0032 (mole NH_3 in 25 cm^3)

*accept dividing rhs by 2 **or** multiplying lhs by 2*

1

(0.0032 × 1000/25 =) 0.128

allow ecf from previous stage

*correct answer 0.128 **or** 0.13 with or without working gains all **3** marks*

1

(iv) 2.176 **or** 2.18

correct answer with or without working

or ecf from candidate's answer to (b)(iii)

or 2.55 if 0.15 moles used

if answer incorrect or no answer

*0.128 × 17 **or** 0.13 x 17*

***or** their (b)(iii) × 17*

***or** 0.15 × 17 gains **1** mark*

2

[11]

10 (a) (i) sodium hydroxide / NaOH (solution)

accept potassium hydroxide / KOH

accept ammonia (solution) / $NH_3(aq)$ / NH_4OH

*do **not** accept limewater / calcium hydroxide*

incorrect reagent

***or** no reagent = **0** marks*

1

(pale) <u>green</u> <u>precipitate</u> / <u>solid</u>

allow iron(II) hydroxide / $Fe(OH)_2$ (formed)

*allow OH^- / hydroxide solution gives a green precipitate for **1** mark*

1

(ii) (acidified) barium chloride / $BaCl_2$ barium nitrate / $Ba(NO_3)_2$

*do **not** accept sulphuric acid*

incorrect reagent

***or** no reagent = **0** marks*

1

<u>white</u> <u>precipitate</u> / <u>solid</u>

allow barium sulfate / $BaSO_4$ (formed)

*allow a solution of barium ions / Ba^{2+} gives a white precipitate for **1** mark*

1

(b) (i) *credit can not be obtained for incorrect reactions*

carbonate (ions) give (white) ppt (with silver nitrate)

owtte

1

(nitric) acid reacts with / removes / displaces carbonate (ions)

owtte

1

(ii) hydrochloric acid is a chloride / contains chloride (ions) / Cl^-

accept hydrochloric acid reacts with silver nitrate

*do **not** accept chlorine*

1

[7]

11 (a) **must** be description of a titration no titration = no marks

NaOH in <u>burette</u>

*do **not** accept biuret etc*

1

add NaOH until (indicator) changes colour

*if specific colour change mentioned, must be correct – colourless to pink / red **or** 'goes pink / red'*

*do **not** accept 'clear' for colourless*

1

note (burette) volume used **or** final reading

accept 'work out the volume'

1

one other point: eg repeat

accept:
*(white) tile **or** add dropwise / slowly **or** white background **or** swirling / mix **or** read meniscus at eye level **or** wash apparatus*

1

(b) 0.054

*for **2** marks*

*(0.1 × 13.5)/25 for **1** mark*

(c) don't know – insufficient evidence to decide

owtte

any sensible answer

or

depends on whether acid level is considered safe or unsafe

yes, safe – acid level low / weak acids / low compared with stomach acid

owtte

any sensible answer

2

no, unsafe – acid level (too) high / other substances or bacteria may be present / insufficient evidence to decide

owtte

any sensible answer

1

(d) (methyl orange) would have changed colour (well) before the end-point / pH7 / neutral

owtte

1

weak acid present

weak acid-strong base (titration)

allow methyl orange used for strong acid-weak base titration

1

[9]

12 any series of chemical tests that work should be given credit

each mark is for test + result + inference

identifying all 4 substances unambiguously with no errors gains **5** marks

e.g.

- Flame test: yellow / orange

  ⇒ Na^+ ⇒ sodium sulphate

  ignore incorrect flame test colours for other compounds

  1

- Add NaOH to remaining 3 samples:

  no (white) ppt / ammonia ⇒

  no need to test for ammonia

  1

  NH_4^+ ⇒ ammonium sulphate (white) ppt ⇒ magnesium ions or aluminium ions

  1

- add excess NaOH to the 2 samples which gave a (white) ppt:

  ppt dissolves ⇒ aluminium sulphate

  ppt insoluble ⇒ magnesium sulphate

  2

or

- Add NaOH:

  no ppt: ammonia ⇒NH_4^+ ⇒ (1)

  ammonium sulphate

  the other one is sodium sulphate (1)

  (damp red) litmus goes blue*

  ⇒ NH_3⇒ ammonium sulphate

  the other one is sodium sulphate

- Add excess NaOH to the 2 samples which gave the white ppt (1)
  ppt dissolves ⇒ aluminium sulphate (1)
  ppt insoluble ⇒ magnesium sulphate (1)
  (*) or UI/pH indicator goes blue/purple

[5]

13 (a) (i) e.g. moles NaOH = moles of acid

or formula:

$0.2 \times \frac{45}{1000} = 0.009$

$15M_1 = 0.2 \times 45$

1

rounding to 0.01 loses mark

$= 0.009 \times \frac{1000}{15} = 0.6(M)$

$M_1 = 0.6(M)$

ecf for arithmetical error

*correct answer **2** marks*

1

(ii) 36

ecf – (a)(i) × 60

*correct answer **2** marks*

*0.6 × 60 gets **1** mark*

*relative formula mass of ethanoic acid = 60 for **1** mark*

0.6 × incorrect molar mass gains second mark only

2

(b) (i) A = hydrogen / H_2

1

B = sodium hydroxide / NaOH **or** sodium oxide / Na_2O

1

(iii) C = ethyl ethanoate (acetate) / $CH_3COOC_2H_5$ / $CH_3CO_2C_2H_5$

1

(iv) D = (concentrated) sulphuric acid /
H_2SO_4

*do **not** accept dilute sulphuric acid*

1

E = sodium ethanoate (acetate) / CH_3COONa / CH_3CO_2Na

1

[9]

14 (a)

***must** be a description of a titration no titration = **0** marks*

Quality of written communication

*for correct sequencing of 2 of first 3 bullet points i.e. 1 + 2 **or** 2 + 3 **or** 1 + 3*

1

any **three** from:

- nitric acid in burette

  *do **not** accept biuret*
  can be inferred from 3rd point

- add nitric acid until indicator changes (colour)

  can be named acid-base indicator
  colour change does not have to be correct

- note (burette) volume used **or** final reading

- accuracy: e.g. repeat

  *accept white tile **or** dropwise near end **or** white background **or** swirling the flask **or** read meniscus at eye level*

3

(b) e.g. formula method:

$25 \times M_{NH3} = 0.25 \times 20$

1

$M_{NH3} = 0.2$

*correct answer alone = **2***

OR

moles NH_3 = moles HNO_3

$= \frac{20}{1000} \times 0.25 = 0.005$ moles (1)

concentration NH3

$= \frac{0.005 \times 1000}{25} = 0.2$ (1)

1

(c) sodium hydroxide **or** potassium hydroxide **or** lithium hydroxide **or** calcium hydroxide

ignore mention of alkali

1

ammonia produced

accept gas produced turns (damp) (red) litmus blue (not blue litmus)
or *alkaline gas produced*

any suitable named indicator e.g. UI with consequential marking
white fumes / smoke with (concentrated) HCl

*do **not** accept white gas wrong test = **0** marks*

1

[8]

15 (a) any four from:

- sulphuric acid measure by pipette
  or *diagram*
- potassium hydroxide in burette
  or *diagram*
- if solutions reversed, award
- note initial reading
- use of indicator
- note final reading **or** amount used

4

(b) $\frac{34 \times 2}{1000}$ 1

= 0.068 1

(c) ½ or 0.5 moles H_2SO_4 react with 1 mole KOH 1

moles H_2SO_4 in 25.0 cm^3 = 0.068 × 0.5 1

∴ moles H_2SO_4 in 1 dm^3 = $\frac{0.068 \times 0.5 \times 1000}{25}$ = 1.36 mol/dm^3 1

[9]

16 (a) hydrochloric acid in burette 1

indicator 1

note volume at end / neutralisation point

titre must be HC1 1

(b) 1 mole HCl = 36.5g /36.5 1

∴ $\frac{73}{36.5}$ = 2 moles / dm^3

2 for correct answer 1

(c) (i) $\frac{10 \times 2}{1000}$

allow e.c.f. ie their (b) × $\frac{10}{1000}$

2 for correct answer 1

= 0.02 moles 1

(ii) $0.02 \times \frac{1000}{25} = 0.8$ mol / dm^3 1

allow e.c.f. ie their (c)(i) $\times \frac{1000}{25}$ 1

[9]

17 (a) pipette / burette 1

(b) named indicator eg methyl orange / phenolphthalein

__not__ universal
accept litmus but __not__ litmus paper 1

(c) $\frac{25 \times 0.4}{1000}$

2 for correct answer 1

= 0.01 1

(d) 1KOH ≡ 1 HCl

∴ 0.01 moles HCl in 35 cm^3 1

$\therefore \frac{0.01 \times 1000}{35} = 0.29$

2 for correct answer
0.3 = (1) (with correct working = (2)) 1

[6]