1 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.

.....

(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.

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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.

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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)

2 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.

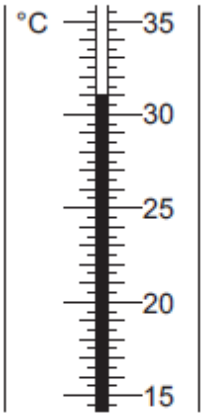
This is the method the student used.

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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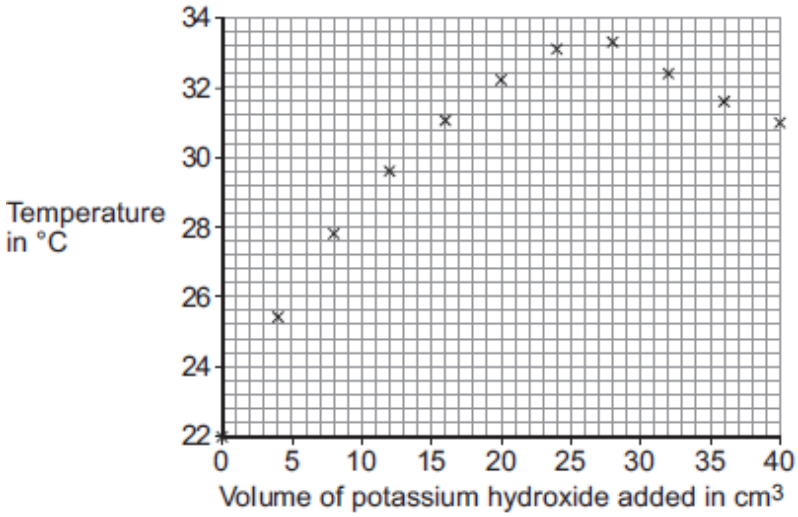
(1)

(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)

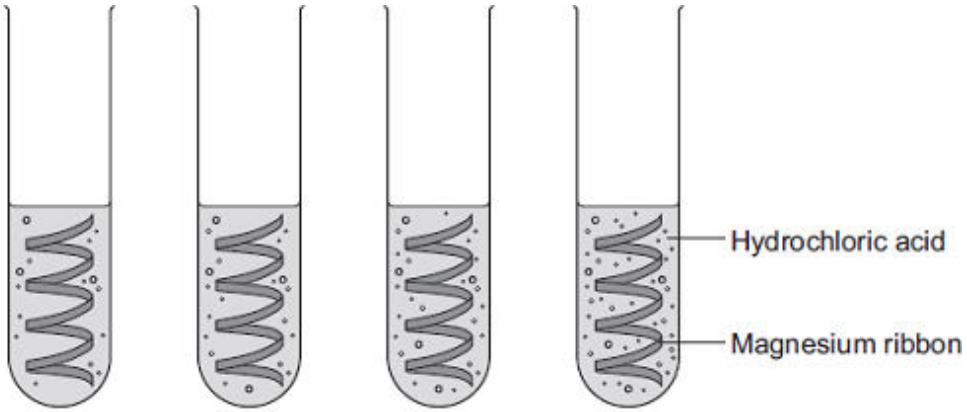
(Total 14 marks)

3 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)

4 (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?

.....

(1)

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

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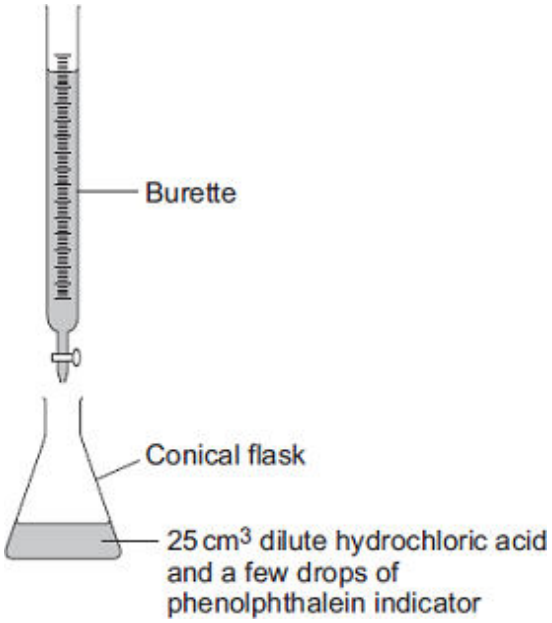
(2)

(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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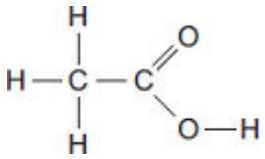
(1)

(d) The displayed formula of ethanoic acid is:



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

(1)

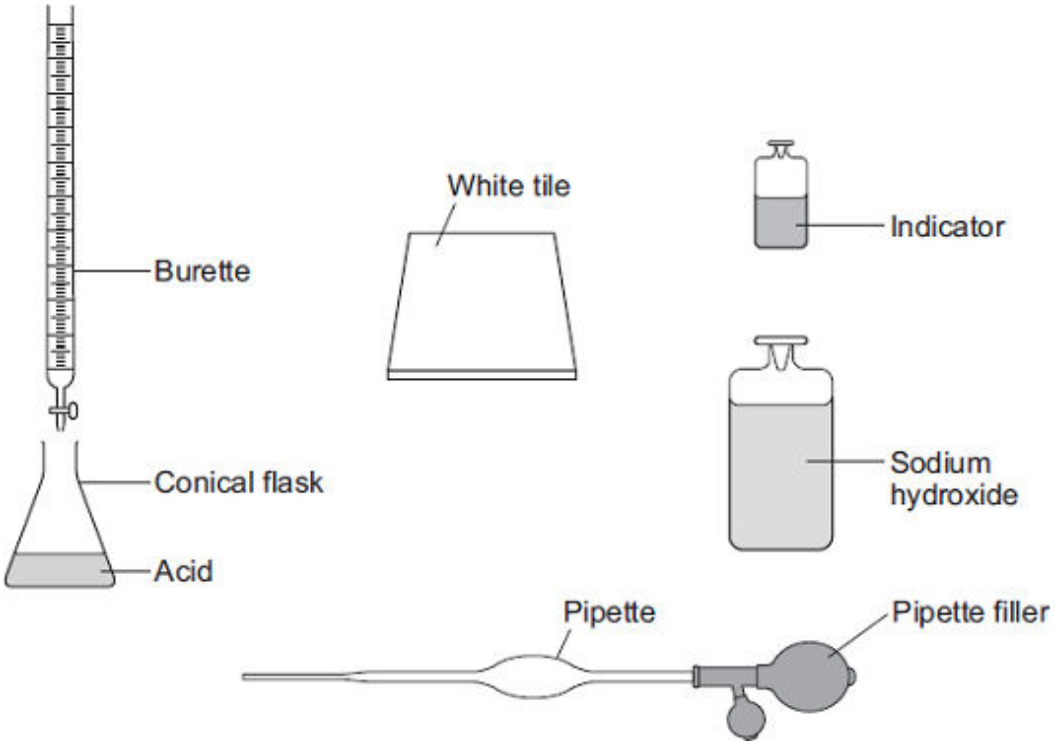
(ii) Ethanoic acid and ethanol react together to make the ester ethyl ethanoate.

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

(2)
(Total 11 marks)

5 *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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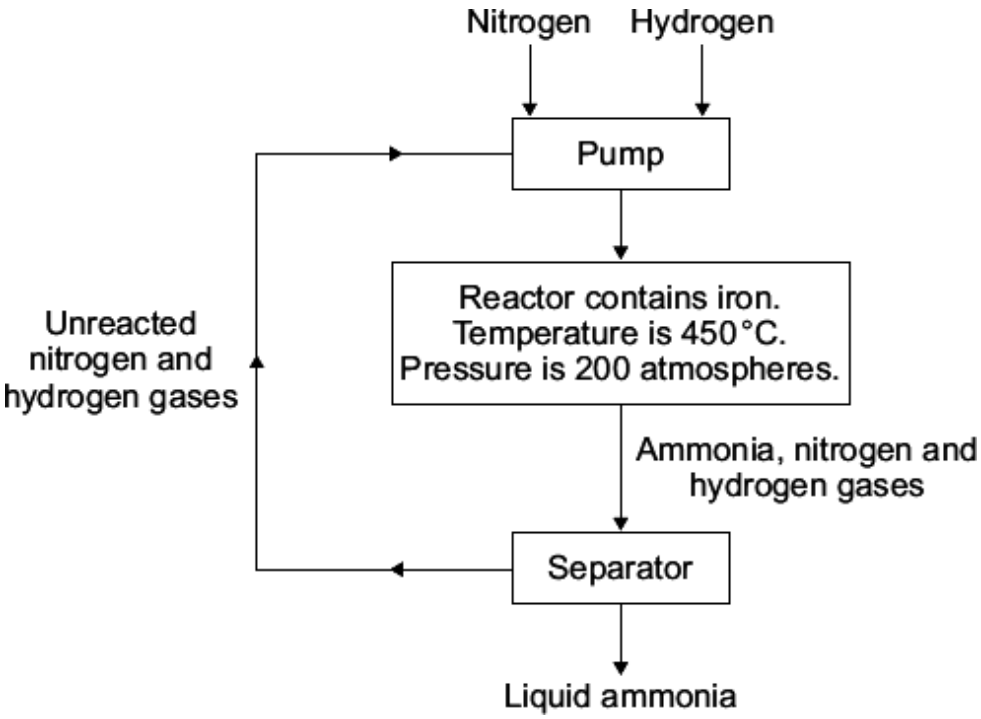
(Total 6 marks)

6 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?

.....

.....

(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?

.....

.....

(1)

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

.....

.....

(1)

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

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

(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.

.....

.....

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)

7 Vinegar can be added to food.

Vinegar is a solution of ethanoic acid in water.

(a) Ethanoic acid is a *weak* acid.

Draw a ring around the correct answer to complete each sentence.

(i) When dissolved in water, an acid forms a solution containing

carbonate ions.

hydrogen ions.

hydroxide ions.

(1)

(ii) Ethanoic acid is a *weak* acid because in water it is

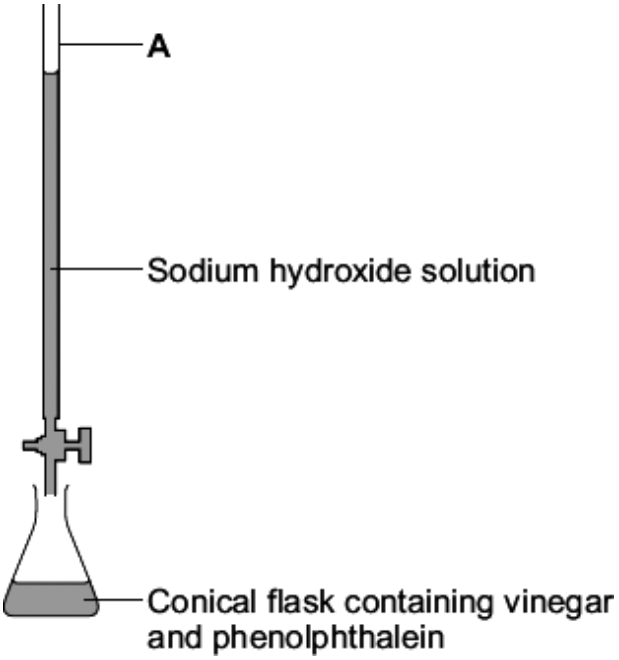
completely ionised.

not ionised.

partially ionised.

(1)

(b) The diagram shows the apparatus used to investigate the amount of ethanoic acid in vinegar.



(i) Draw a ring around the name of the piece of apparatus labelled **A** on the diagram.

burette **measuring cylinder** **pipette**

(1)

(ii) Phenolphthalein is added to the vinegar in the conical flask so that the end point of the titration can be seen.

What type of substance is phenolphthalein?

Draw a ring around the correct answer.

alkali **catalyst** **indicator**

(1)

(iii) How would you know that the end point of the titration has been reached?

.....

.....

(1)

(c) The results of the titration are shown in the table.

	Rough titration	Accurate titrations		
		1	2	3
Final reading in cm^3	22	21.30	22.50	24.40
Initial reading in cm^3	0	1.00	2.00	4.00
Volume used in cm^3	22	20.30	20.50	20.40

Calculate the best value of the mean volume from these titrations.

.....

.....

.....

Mean volume used = ... cm^3

(2)

(d) 25.0 cm^3 of this vinegar contained 1.25 g of ethanoic acid.

Calculate the mass of ethanoic acid in 1 litre (1000 cm^3) of this vinegar.

.....

.....

.....

Mass = ... g

(2)
(Total 9 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?

.....

(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.

.....

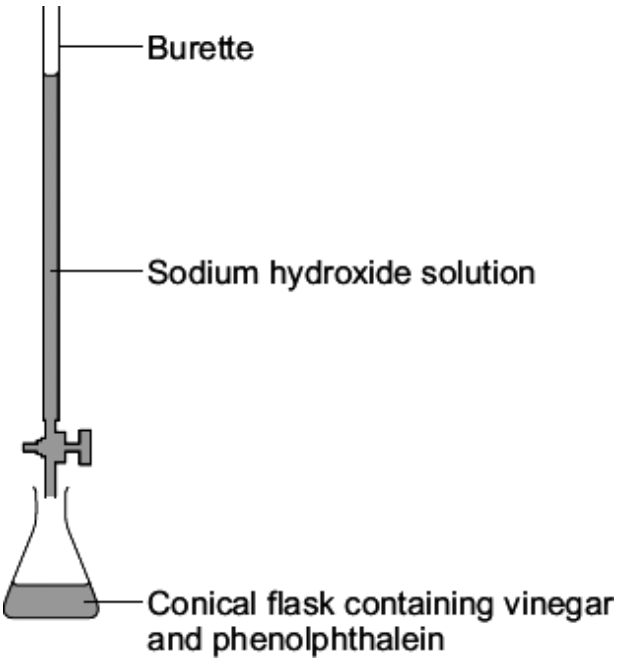
.....

.....

.....

(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?

.....

.....

(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:

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

Calculate the concentration of ethanoic acid in this vinegar.

.....

.....

.....

.....

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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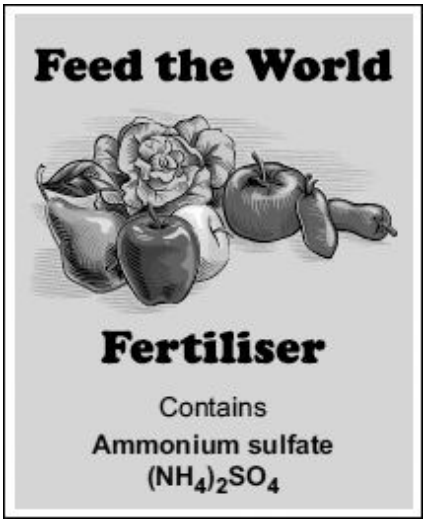
.....

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 .....

.....

Result .....

.....

(2)

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

Test .....

.....

Result .....

.....

(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.

.....

(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.

.....

(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:

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

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.

.....

.....

.....

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 .....

.....

Result .....

(2)

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

Test .....

.....

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.

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

(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.

.....

.....

.....

.....

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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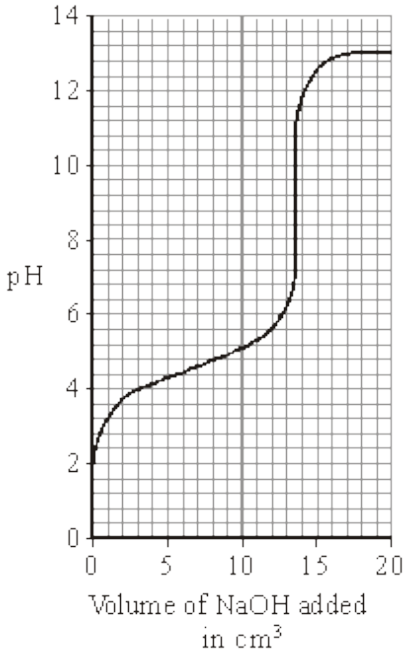
(1)

(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 Chemical tests are used to identify compounds.

(a) What colour is produced by sodium compounds in flame tests?

.....

(1)

(b) Chemical tests are carried out on these substances.

ammonium	**copper bromide**	**magnesium sulphate**
potassium nitrate	**copper nitrate**	**zinc carbonate**

Complete each sentence by choosing the correct substance from the box. You may use each substance once or not at all.

The substance which

(i) reacts with dilute hydrochloric acid to produce carbon dioxide gas is

.....

(1)

(ii) in solution reacts with sodium hydroxide solution to form a blue precipitate is

.....

(1)

(iii) in solution reacts with barium chloride solution, in the presence of dilute hydrochloric acid, to form a white precipitate is

.....

(1)

(c) State what you **see** when sodium chloride solution reacts with silver nitrate solution in the presence of dilute nitric acid.

.....

(1)

(Total 5 marks)

13 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.

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(Total 5 marks)

14 (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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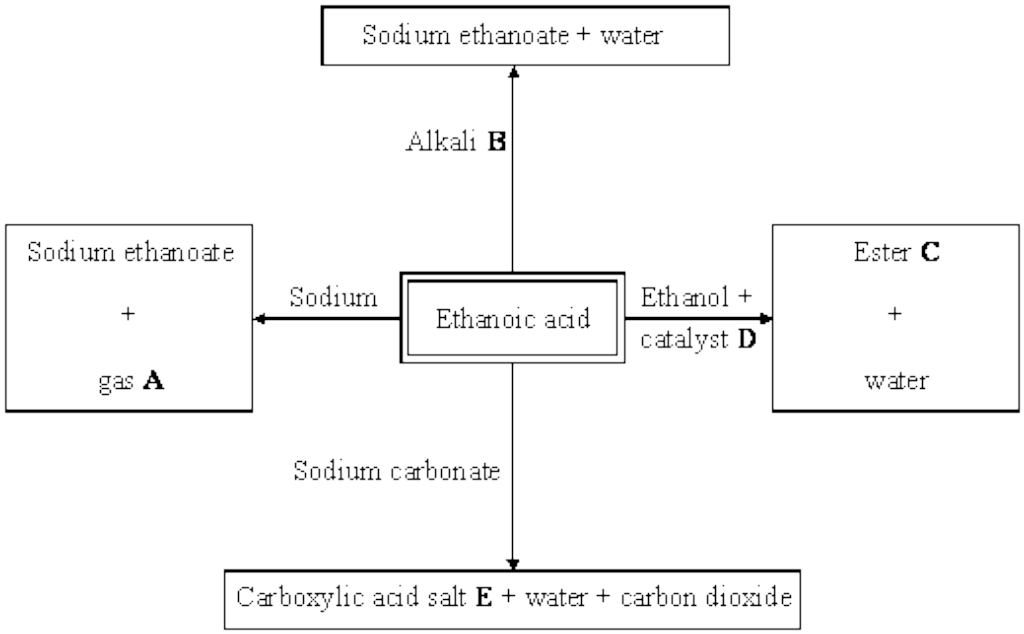
Concentration = ... grams per cubic decimetre

(2)

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



Give the name of:

(i) gas **A**,

.....

(1)

(ii) alkali **B**,

.....

(1)

(iii) ester **C**,

.....

(1)

(iv) catalyst **D**,

.....

(1)

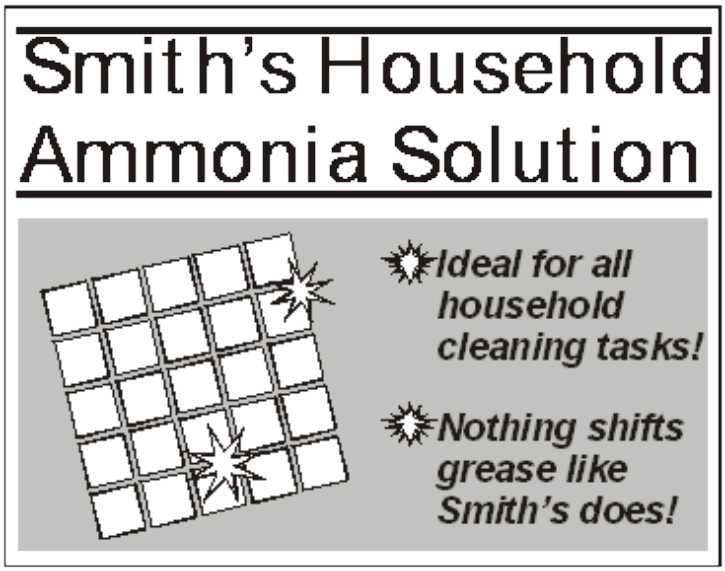
(v) carboxylic acid salt **E**.

.....

(1)

(Total 9 marks)

15 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.

.....

.....

.....

.....

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)

16 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.

.....

Number of moles = ...

(2)

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

.....

.....

.....

.....

Concentration = ... mol/dm^3

(3)

(Total 9 marks)

17 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

.....

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.

.....

Answer = ... mol

(2)

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

.....

Answer = ... mol/dm^3

(2)
(Total 9 marks)

18 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?

.....

(1)

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

.....

(1)

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

.....

.....

Moles of potassium hydroxide = ... mol

(2)

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

$KOH + HCl \rightarrow KCl + H_2O$

.....

.....

.....

Concentration of hydrochloric acid = ... mol/dm^3

(2)

(Total 6 marks)