Further Analysis and Quantitative Chemistry

Question Paper

Level	GCSE
Subject	Chemistry
Exam Board	AQA
Unit	C3
Topic	Further Analysis and Quantitative Chemistry
Difficulty Level	Gold Level
Booklet	Question Paper

Time Allowed: **161 minutes**

Score: **/161**

Percentage: **/100**

Q1. This question is about chemical analysis.

(a) A student has solutions of three compounds, **X, Y** and **Z**.

The student uses tests to identify the ions in the three compounds.

The student records the results of the tests in the table.

	Test			
Compound	**Flame test**	**Add sodium hydroxide solution**	**Add hydrochloric acid and barium chloride solution**	**Add nitric acid and silver nitrate solution**
X	no colour	green precipitate	white precipitate	no reaction
Y	yellow flame	no reaction	no reaction	yellow precipitate
Z	no colour	brown precipitate	no reaction	cream precipitate

Identify the **two** ions present in each compound, **X, Y** and **Z**.

X .....

Y .....

Z .....

(3)

(b) A chemist needs to find the concentration of a solution of barium hydroxide. Barium hydroxide solution is an alkali.

The chemist could find the concentration of the barium hydroxide solution using two different methods.

Method 1

- An excess of sodium sulfate solution is added to 25 cm^3 of the barium hydroxide solution. A precipitate of barium sulfate is formed.
- The precipitate of barium sulfate is filtered, dried and weighed.

- The concentration of the barium hydroxide solution is calculated from the mass of barium sulfate produced.

Method 2

- 25 cm^3 of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.

- The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

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(5)
(Total 8 marks)

Q2. Hard water causes scale in kettles, as shown in the figure below .

(a) Acids are used to remove scale.

(i) Give the name of a carbonate in scale.

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(1)

(ii) When acids react with scale a gas is produced.

What is the name of the gas?

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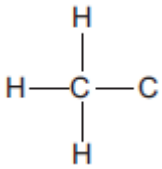
(1)

(b) Ethanoic acid is used to remove scale.

Complete the displayed structure of ethanoic acid (CH_3COOH).



(1)

(c) A student compared the rates at which ethanoic acid and hydrochloric acid react with scale.

Both acids had the same concentration.

(i) The student found that hydrochloric acid reacts faster than ethanoic acid with scale.

Explain why hydrochloric acid reacts faster than ethanoic acid.

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(2)

(ii) Hydrochloric acid should **not** be used to dissolve scale in kettles.

Suggest why.

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(1)

(d) A student does a titration to find the concentration of a solution of hydrochloric acid.

The student titrates 25.00 cm^3 of hydrochloric acid with sodium hydroxide solution of concentration 0.200 moles per dm^3. The equation for the reaction is:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

The student added 28.60 cm^3 of sodium hydroxide solution to neutralise the hydrochloric acid.

Calculate the concentration of the hydrochloric acid.

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Concentration = ... moles per dm^3

(3)
(Total 9 marks)

Q3. The colours of fireworks are produced by chemicals.

(a) Information about four chemicals is given in the table.

Complete the table below.

Chemical	Colour produced in firework
barium chloride	green
..... carbonate	crimson
sodium nitrate	.....
calcium sulfate	red

(2)

(b) Describe a test to show that barium chloride solution contains chloride ions.

Give the result of the test.

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(2)

(c) A student did two tests on a solution of compound **X**.

Test 1
Sodium hydroxide solution was added.
A blue precipitate was formed.

Test 2
Dilute hydrochloric acid was added.
Barium chloride solution was then added.
A white precipitate was formed.

The student concluded that compound **X** is iron(II) sulfate.

Is the student's conclusion correct?

Explain your answer.

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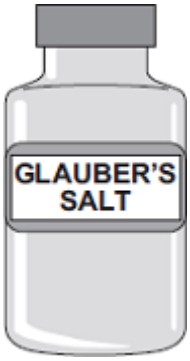
(3)
(Total 7 marks)

Q4. Four bottles of chemicals made in the 1880s were found recently in a cupboard during a Health and Safety inspection at Lovell Laboratories.

Sodium carbonate

Sodium chloride

Sodium nitrate



Sodium sulfate

The chemical names are shown below each bottle.

(a) You are provided with the following reagents:

- aluminium powder

- barium chloride solution acidified with dilute hydrochloric acid
- dilute hydrochloric acid
- silver nitrate solution acidified with dilute nitric acid
- sodium hydroxide solution.
- limewater
- red litmus paper

(i) Describe tests that you could use to show that these chemicals are correctly named.

In each case give the reagent(s) you would use **and** state the result.

Test and result for carbonate ions:

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Test and result for chloride ions:

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Test and result for nitrate ions:

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Test and result for sulfate ions:

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(4)

(ii) Suggest why a flame test would **not** distinguish between these four chemicals.

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(1)

(b) Instrumental methods of analysis linked to computers can be used to identify chemicals.

Give **two** advantages of using instrumental methods of analysis.

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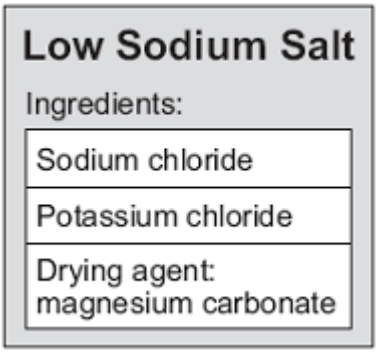
(2)
(Total 7 marks)

Q5. Low sodium salt is used on food. This label is from a packet of low sodium salt.



A student tests the low sodium salt for the substances on the label.

(a) (i) The same test can be used to identify sodium ions and potassium ions.

Describe the test.

Give the result of the test for sodium ions and for potassium ions.

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(3)

(ii) It is difficult to identify potassium ions when sodium ions are present.

Suggest why.

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(1)

(b) Describe how the student would test a solution of the low sodium salt for chloride ions.

Give the result of the test.

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(3)

(c) To test for magnesium ions, the student adds a few drops of sodium hydroxide solution to a solution of the low sodium salt.

A white precipitate is produced.

This test also gives a white precipitate with aluminium ions and calcium ions.

(i) Describe how the student could confirm that the low sodium salt contains magnesium ions and **not** aluminium ions.

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(2)

(ii) Describe a test the student could do to confirm that the low sodium salt does **not** contain calcium ions.

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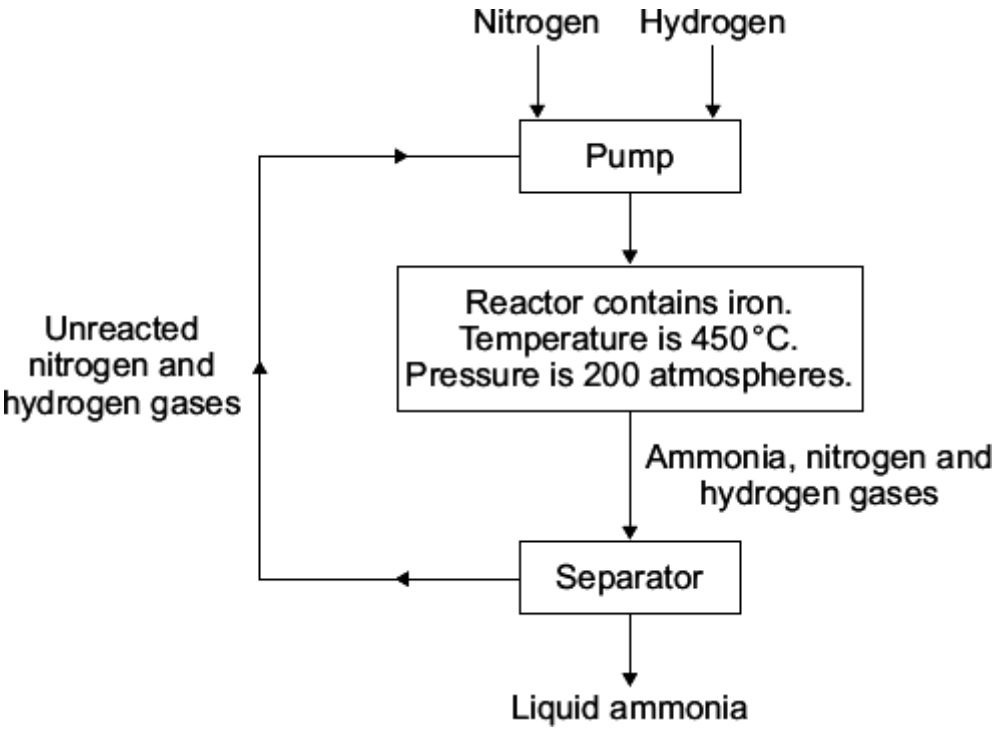
(2)

(Total 11 marks)

Q6. 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.

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

(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)

Q7. A student investigated an egg shell.

Trish Steel [CC-BY-SA-2.0], via Wikimedia Commons

(a) The student did some tests on the egg shell.

The student's results are shown in the table below.

Test		Observation
1	Dilute hydrochloric acid was added to the egg shell.	A gas was produced. The egg shell dissolved, forming a colourless solution.
2	A flame test was done on the colourless solution from test **1**.	The flame turned red.
3	Sodium hydroxide solution was added to the colourless solution from test **1**.	A white precipitate formed that did not dissolve in excess sodium hydroxide solution.
4	Silver nitrate solution was added to the colourless solution from test **1**.	A white precipitate formed.

(i) The student concluded that the egg shell contains carbonate ions.

Describe how the student could identify the gas produced in test **1**.

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(2)

(ii) The student concluded that the egg shell contains aluminium ions.

Is the student's conclusion correct? Use the student's results to justify your answer.

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(2)

(iii) The student concluded that the egg shell contains chloride ions.

Is the student's conclusion correct? Use the student's results to justify your answer.

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(2)

(b) Some scientists wanted to investigate the amount of lead found in egg shells. They used a modern instrumental method which was *more sensitive* than older methods.

(i) Name **one** modern instrumental method used to identify elements.

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(1)

(ii) What is the meaning of *more sensitive*?

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(1)
(Total 8 marks)

Q8. Read the information in the box and then answer the questions.

Seidlitz Powder is the name of a medicine.

Seidlitz Powder comes as two powders. One powder is wrapped in white paper and contains tartaric acid ($C_4H_6O_6$). The other powder is wrapped in blue paper and contains potassium sodium tartrate ($KNaC_4H_4O_6$) and sodium hydrogencarbonate ($NaHCO_3$).

The contents of the blue paper are completely dissolved in water and then the contents of the white paper are added.

The equation which represents this reaction is:

$$C_4H_6O_6\ (aq) + 2NaHCO_3\ (aq) \longrightarrow Na_2C_4H_4O_6\ (aq) + 2H_2O\ (l) + 2CO_2\ (g)$$

(a) Describe and give the result of a test to identify the gas produced in this reaction.

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(2)

(b) One of the chemicals in Seidlitz Powder is potassium sodium tartrate ($KNaC_4H_4O_6$).

Suggest why it would be difficult to identify **both** potassium ions and sodium ions in potassium sodium tartrate using a flame test.

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(1)

(c) Some Seidlitz Powder was bought on the Internet. However, when tested, it was found to be only magnesium sulfate.

(i) Describe and give the result of a chemical test to show that magnesium sulfate contains sulfate ions.

Test .....

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Result .....

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(2)

(ii) Magnesium sulfate contains magnesium ions.

Describe what you **see** when sodium hydroxide solution is added to a solution of magnesium sulfate.

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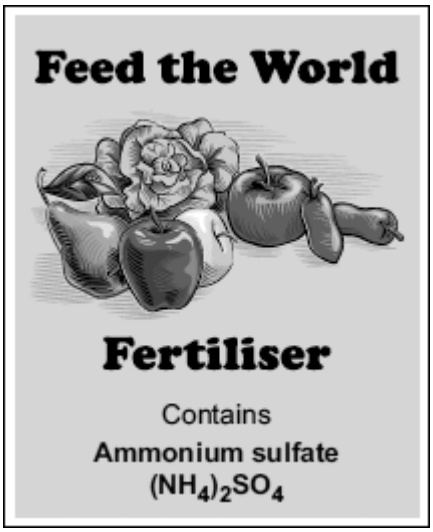
(1)
(Total 6 marks)

Q9. 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 .....

.....

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:

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

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.

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Concentration = ... grams per cubic decimetre

(2)

(Total 11 marks)

Q10. 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.

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

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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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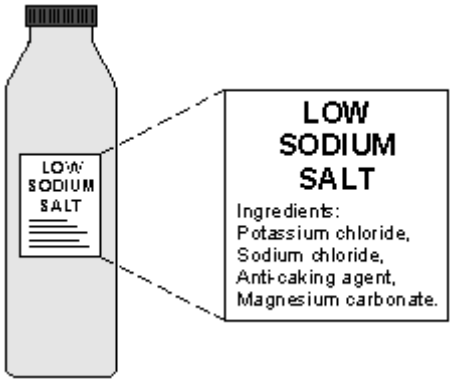
(1)

(Total 7 marks)

Q11. The use of too much common salt (sodium chloride) in our diet increases the risk of heart problems. One way to reduce sodium chloride in our diet is to use Low Sodium Salt instead of common salt.



A student tested Low Sodium Salt to find out if it contained both potassium chloride and sodium chloride and what ions were in the anti-caking agent.

(a) The student did a flame test.

The flame colour showed that there were sodium ions in the Low Sodium Salt.

The student did **not** observe the colour in the flame which would show that there were potassium ions in the Low Sodium Salt.

Suggest why.

(You will need to state the flame colours of sodium ions **and** potassium ions in your answer.)

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(3)

(b) The student did a test to find which metal ion was in the anti-caking compound.

The student had **not** seen any red colour in the flame while doing the flame test.

The student added water to make a solution of Low Sodium Salt.
The student then added sodium hydroxide solution. A white precipitate formed that was insoluble in excess sodium hydroxide solution.

Use the information to draw a ring around the name of the metal ion that is in the anti-caking agent.

aluminium **calcium** **magnesium**

(1)

(c) A student was provided with the following reagents to test for non-metal ions in the Low Sodium Salt.

- Calcium hydroxide solution
- Dilute hydrochloric acid
- Silver nitrate in solution
- Dilute nitric acid

The table shows the tests that student did and the observations that the student made.

Tests	**Observations**
Dilute nitric acid was added to Low Sodium Salt	The mixture fizzed and the gas given off turned limewater cloudy.
Excess nitric acid was added to the Low Sodium Salt, and then silver nitrate solution was added.	A white precipitate formed in the solution.

(i) From the table what conclusions can you make about the non-metal ions that are in the Low Sodium Salt?

Explain your conclusions.

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(2)

(ii) Another student used hydrochloric acid instead of nitric acid for the tests shown in the table.
Describe what this student would observe and explain why this student's conclusions would not be valid.

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(3)
(Total 9 marks)

Q12. 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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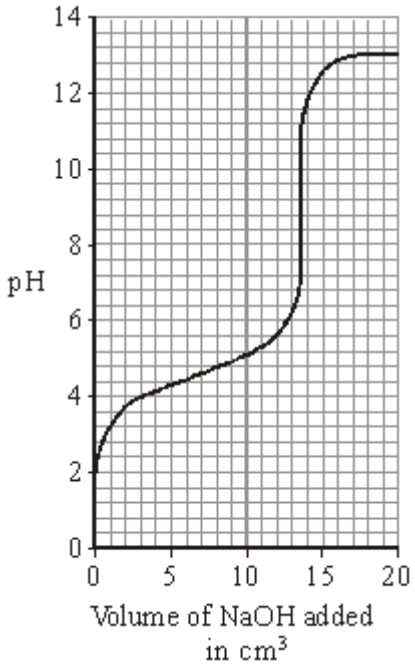
(1)

(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)

Q13. (a) Four bottles of chemicals made in the 1880s were found recently in a cupboard during a Health and Safety inspection at Lovell Laboratories.

The chemicals are correctly named.

You are provided with the following reagents:

- aluminium powder
- barium chloride solution acidified with dilute hydrochloric acid
- dilute hydrochloric acid
- silver nitrate solution acidified with dilute nitric acid
- sodium hydroxide solution.

(i) Describe tests to show that these chemicals are correctly named.

In each case give the reagent(s) you would use and state what you would see.

Test and result for carbonate ions:

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Test and result for chloride ions:

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Test and result for nitrate ions:

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Test and result for sulfate ions:

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(5)

(ii) Suggest why a flame test would **not** distinguish between these four chemicals.

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(1)

(b) Instrumental methods of analysis linked to computers can be used to identify chemicals.

Describe **two** advantages of using instrumental methods of analysis.

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(2)

(Total 8 marks)

Q14. 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)

Q15. (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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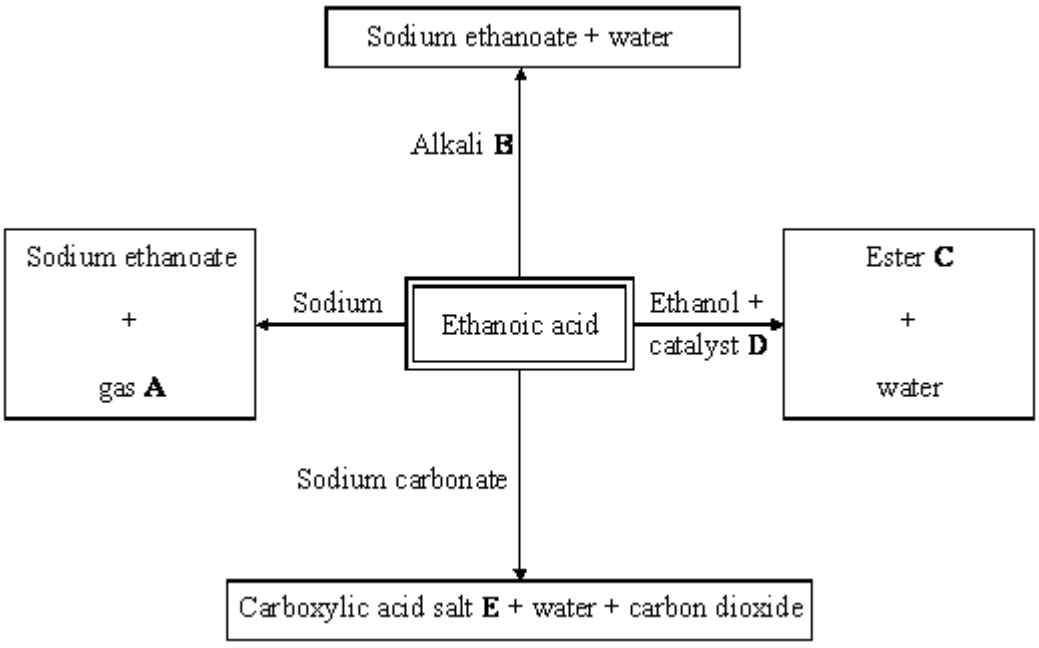
Concentration = ... grams per cubic decimetre

(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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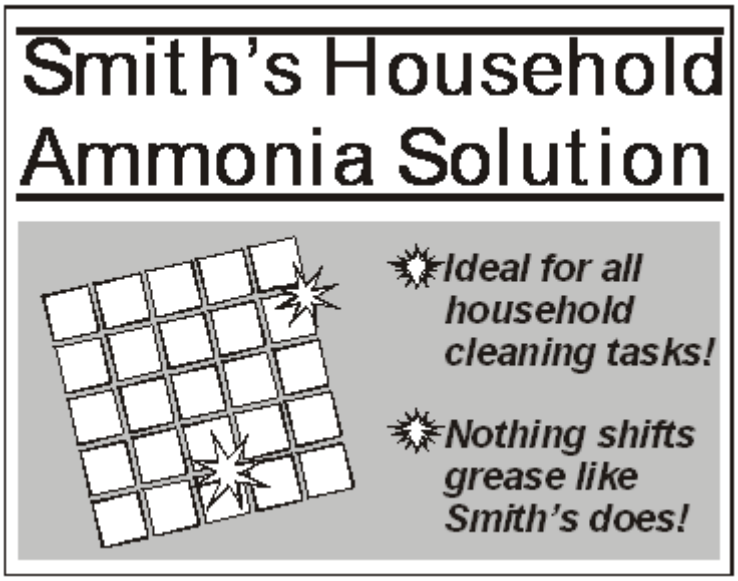
(1)

(Total 9 marks)

Q16. 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)

Q17. 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)

Q18. 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)

Q19. 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)