1 Chlorine and bromine are important Group 7 elements.

(a) Explain why chlorine is added to drinking water.

....

....

(1)

(b) Describe what you would **see** when bromine water is added to an unsaturated organic compound.

....

....

(1)

(c) Bromine can be extracted from seawater. The dissolved bromide ions are reacted with chlorine. Bromine and chloride ions are formed.

(i) Complete and balance the equation below, which represents the reaction between chlorine and bromide ions.

$Cl_2 + 2Br^- \rightarrow$ .... + ...

(1)

(ii) Describe what you **see** when chlorine is added to a solution containing bromide ions.

....

....

(1)

(d) In terms of electronic structure:

(i) state why bromine and chlorine are both in Group 7

....

....

(1)

(ii) explain why bromine is less reactive than chlorine.

....

....

....

....

....

....

....

(3)

(e) What is the result of adding acidified silver nitrate solution to a solution containing:

(i) chloride ions

....

(1)

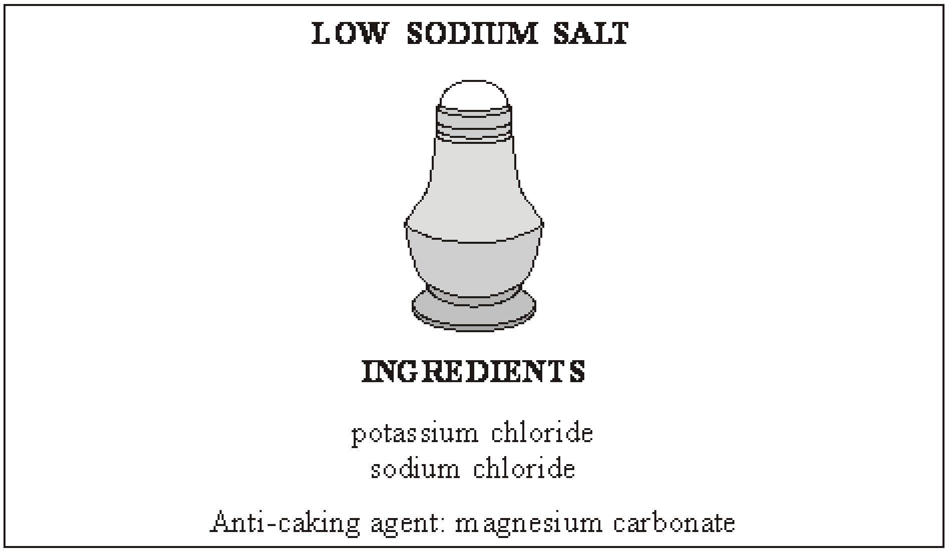
(ii) bromide ions?

....

(1)

(Total 10 marks)

2 The label is from a packet of Low Sodium Salt.



(a) A student tested some Low Sodium Salt to show that it contains carbonate ions and chloride ions.

(i) Describe and give the result of a test for carbonate ions.

....

....

....

....

(2)

(ii) A student identified chloride ions using acidified silver nitrate solution.

State what you would **see** when acidified silver nitrate solution is added to a solution of Low Sodium Salt.

....

(1)

(iii) Flame tests can be used to identify potassium ions and sodium ions.

Suggest why it is difficult to identify **both** of these ions in Low Sodium Salt using a flame test.

....

....

(1)

(b) Read the following information and then answer the questions.

Salt – friend or foe?

Sodium chloride (salt) is an essential mineral for our health. It is used to flavour and preserve foods. Too much sodium in our diet may increase the risk of high blood pressure and heart disease. Heart disease is the biggest cause of death in the United Kingdom. Some people claim that excess sodium is a poison that can cause cancer, while others say that more evidence is needed.

Many processed foods contain salt, so it is easy to exceed the recommended daily upper limit of about 5 g of salt per person. A 'healthier' amount should be about 3 g. In the United Kingdom many people consume over 10 g of salt each day.

One way to reduce sodium in our diet is to use Low Sodium Salt. This has two thirds of the sodium chloride replaced by potassium chloride.

A national newspaper asked readers for their views on two options.

Option 1: Ban the use of sodium chloride in foods.

Option 2: Reduce the amount of sodium chloride in all foods to a 'healthier' level.

(i) Suggest why Option **1** was rejected.

....

....

(1)

(ii) Suggest **two** advantages and **one** disadvantage of Option **2**.

....

....

....

....

....

....

....

(3)

(Total 8 marks)

3 Chemical tests can be used to identify ions in solutions.

(a) List **A** gives the names of two sulfates in solution.
List **B** gives the results of adding sodium hydroxide solution.

Draw a straight line from each sulfate in List **A** to its correct test result in List **B**.

List A **Name of sulfate in solution**	**List B** **Result of adding sodium hydroxide solution**
	A blue precipitate formed
Copper sulfate	A white precipitate formed
Iron(II) sulfate	A green precipitate formed

(2)

(b) Suggest why clean test tubes were used for each test.

....

....

(1)

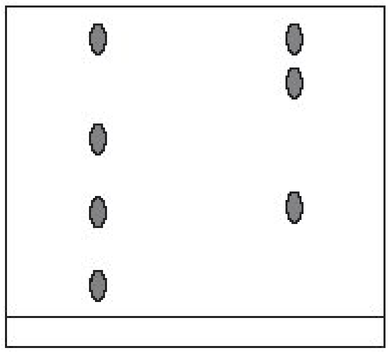
(c) Draw a ring around the correct colour to complete this sentence.

Sulfate solutions react with barium chloride solution to give a

blue green white	precipitate.

(1)
(Total 4 marks)

4 The result of a process used to detect and identify the colours in two foods, **A** and **B**, is shown.



(i) Describe the differences between the colours used in food **A** and food **B**.

....

....

....

....

(2)

(ii) Tick (✓) the name of the process used to detect and identify colours in food.

Process	**(✓)**
chromatography	
extraction	
hardening	

(1)
(Total 3 marks)

5 This question is about chemical tests.

(a) Solutions of copper(II) ions and iron(III) ions produce coloured precipitates with sodium hydroxide solution.

Draw **one** line from each metal ion to the colour of the precipitate it produces.

Metal ion	**Colour of precipitate**
	Blue
Copper(II) (Cu^{2+})	
	Brown
	Green
Iron(III) (Fe^{3+})	
	White

(2)

(b) Sodium hydroxide solution was added to a solution containing ions of a metal.

A white precipitate was produced. The white precipitate dissolved in excess sodium hydroxide solution.

Use the correct answer from the box to complete the sentence.

aluminium	**magnesium**	**potassium**

The ions in the solution were ions of ....

(1)

(c) Low sodium salt contains sodium chloride and potassium chloride.

A student used a flame test on low sodium salt.

(i) What is the colour produced by sodium ions in a flame test?

....

(1)

(ii) What is the colour produced by potassium ions in a flame test?

....

(1)

(iii) Why is it **not** possible to tell from the flame test that both ions are present in low sodium salt?

....

....

(1)

(Total 6 marks)

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

A jar of a chemical from 1870 is shown.

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

(a) A student tested solutions of copperas to show which ions it contained.

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

(i) The student tested for iron(II) ions, Fe^{2+}

The student added a solution of

barium chloride.
silver nitrate.
sodium hydroxide.

The colour of the precipitate formed was

green
red.
white

The precipitate was a

liquid.
gas.
solid

(3)

(ii) The student tested for sulfate ions, SO_4^{2-}

The student added dilute hydrochloric acid and

barium chloride
silver nitrate
sodium hydroxide

solution.

The colour of the precipitate formed was

green
red.
white

Sulfuric acid (H_2SO_4) should **not** be used instead of hydrochloric acid (HCl) when testing for sulfate ions. This is because sulfuric acid contains

chloride ions, Cl^-
nitrate ions, NO_3^-
sulfate ions, SO_4^{2-}

(3)

(b) A flame test can be used to identify the metal ions in a compound.

How do you carry out a flame test?

....

....

(1)

(c) The elements in a compound can also be detected and identified using instrumental methods of analysis.

State **one** advantage of using instrumental methods compared with chemical tests.

....

....

(1)

(Total 8 marks)

7

Alums are salts. They have been used since ancient times in dyeing and medicine and still have many uses today.

Three alums are shown in the table:

Name	Ions present
Ammonium alum	NH_4^+ Al^{3+} SO_4^{2-}
Potassium alum	K^+ Al^{3+} SO_4^{2-}
Sodium alum	Na^+ Al^{3+} SO_4^{2-}

A student tested these alums to show which ions were present.

(a) The student did a flame test on these alums. A sample of each alum was held on a wire in a colourless flame.

In (a)(i) and (a)(ii) use the correct word from the box to complete each sentence.

blue	**lilac**	**yellow**	**green**

(i) Sodium ions give a .... flame.

(1)

(ii) Potassium ions give a .... flame.

(1)

(iii) Draw a ring around the correct answer to complete the sentence.

	density.
The wire used in a flame test should have a high	electrical conductivity.
	melting point.

(1)

(b) Draw a ring around the correct word to complete the sentences.

(i) The student tested a solution of each salt for sulfate ions (SO_4^{2-}).

The student added dilute hydrochloric acid and

barium chloride
nitric acid
silver nitrate

solution and

a white

gas
liquid
solid

was formed.

(2)

(ii) The student tested a solution of each salt for aluminium ions (Al^{3+}).

The student added sodium hydroxide solution and a

green
red
white

precipitate

was formed. When excess sodium hydroxide solution was added, the

precipitate

boiled.
condensed.
dissolved.

(2)

(Total 7 marks)

8 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**.

....

....

....

....

(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.

....

....

....

....

(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.

....

....

....

....

(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.

....

....

(1)

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

....

....

(1)

(Total 8 marks)

9

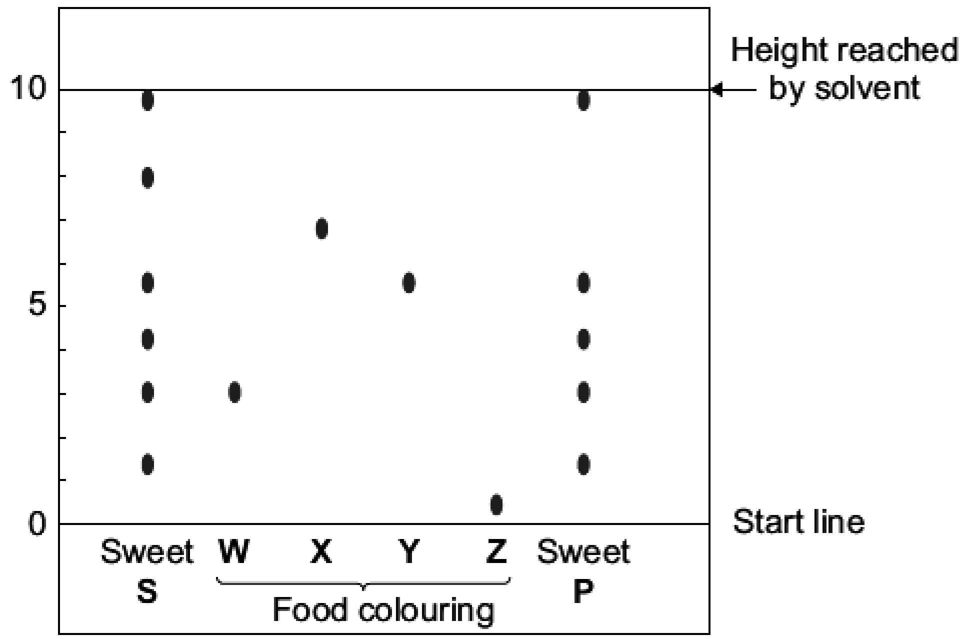
Read the article.

Problem food colourings
Scientists say they have evidence that some food colourings cause hyperactive behaviour in young children. These food colourings are added to some sweets.

W, **X**, **Y** and **Z** are food colourings that may cause hyperactive behaviour in young children.

A scientist used chromatography to see if these food colourings were used in two sweets, **S** and **P**.

The results are shown on the chromatogram.



(a) Food colourings, such as **W**, **X**, **Y** and **Z**, are added to some sweets.

Suggest **one** reason why.

....

....

(1)

(b) In chromatography, the R_f value = $\frac{\text{distance moved by the colouring}}{\text{distance moved by the solvent}}$

Use the scale on the chromatogram to help you to answer this question.

Which food colouring, **W**, **X**, **Y** or **Z**, has an R_f value of 0.7?

(1)

(c) From the chromatogram, what conclusions can the scientist make about the colourings in sweets **S** and **P**?

....

....

....

....

....

....

....

....

....

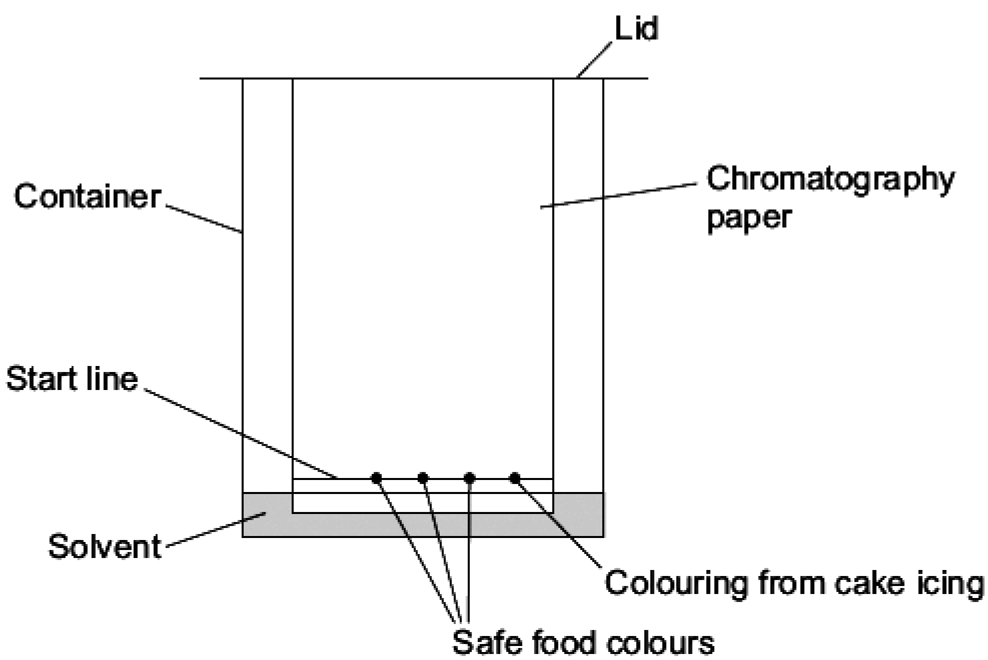
(3)

(Total 5 marks)

10 Icing on cakes is tested to check that safe colours were used when they were made.

Paper chromatography is one method of testing which colours are in cake icing.

(a) The diagram shows an experiment a student did.



(i) Suggest why there is a lid on the container.

....

....

(1)

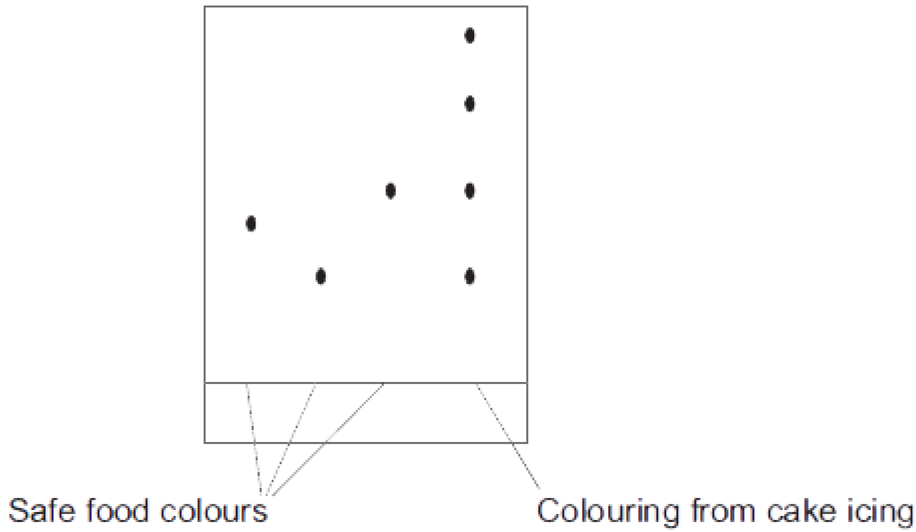
(ii) The start line should be drawn in pencil **not** in ink.
Suggest why.

....

....

(1)

(b) The diagram shows the results of the paper chromatography experiment.



(i) How many different food colours were used in the colouring from the cake icing?

....

(1)

(ii) Is the cake icing safe to eat?

Give a reason for your answer.

....

....

(1)

(c) Gas chromatography linked to mass spectroscopy is an example of an instrumental method. This method was used on a mixture of solvents.

(i) Give **two** advantages of gas chromatography compared with paper chromatography.

....

....

....

....

(2)

(ii) What does gas chromatography do to the mixture of solvents?

....

....

(1)

(iii) What information does mass spectroscopy give?

....

....

(1)

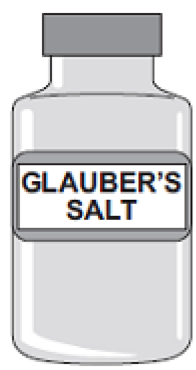
(Total 8 marks)

11 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:

....

....

....

Test and result for chloride ions:

....

....

....

Test and result for nitrate ions:

....

....

....

Test and result for sulfate ions:

....

....

....

(4)

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

....

(1)

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

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

....

....

....

....

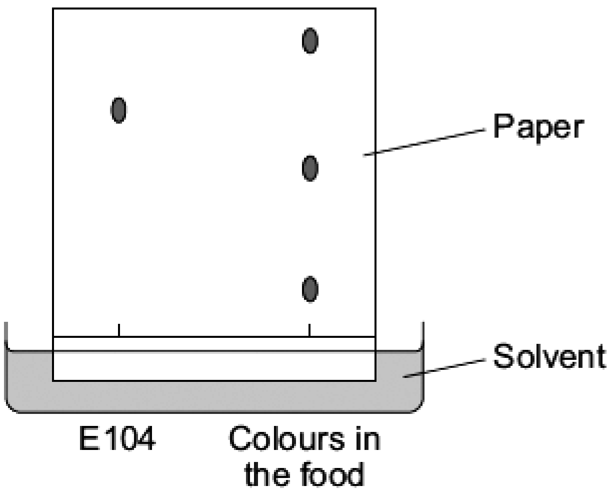
(2)

(Total 7 marks)

12 An article began:

Ban yellow additives
Quinoline yellow (E104) is suspected of causing hyperactivity, asthma and rashes in children.

(a) A student tested a food to find out if it contained quinoline yellow (E104).
The student's results are shown below.



(i) Draw a ring around the correct answer to complete the sentence.

This method of detecting and identifying colours is called

- chromatography.
- distillation.
- electrolysis.

(1)

(ii) Using the student's results, how many different colours are in the food? ......

(1)

(iii) Using the student's results, how can you tell that the food does **not** contain quinoline yellow (E104)?

....

....

(1)

(b) Quinoline yellow (E104) is used in foods such as sweets, drinks and ice cream.

(i) Give **one** reason why quinoline yellow (E104) is added to foods.

....

....

(1)

(ii) Suggest what should be done to decide if quinoline yellow (E104) should be banned.

....

....

(1)

(Total 5 marks)

13 This is part of an article about food additives.

THE PERIL OF FOOD ADDITIVES
Some orange drinks contain the additives E102 (Tartrazine), E104 (Quinoline Yellow) and E110 (Sunset Yellow).These three coloured additives are thought to cause hyperactivity in children.

(a) State **two** reasons that a manufacturer might give to justify the use of these additives.

1 ....

....

2 ....

....

(2)

(b) Some scientists asked 4000 twelve-year-old children to help them investigate if there is a link between these three coloured additives and hyperactivity.

How would the scientists use these 4000 children to investigate if there is a link between these three coloured additives and hyperactivity in children?

....

....

....

....

....

....

....

....

(4)

(c) A manufacturer used an independent scientist to show that their orange drink did not contain these three coloured additives.

(i) Suggest why the manufacturer would use a scientist who was independent instead of using their own scientist.

....

....

(1)

(ii) The scientist had samples of E102, E104 and E110 and the orange drink. The scientist used paper chromatography for the test.

Describe how the scientist could use the results to show if the orange drink contained any of these three coloured additives.

You may include a diagram of the paper chromatography results.

....

....

....

....

....

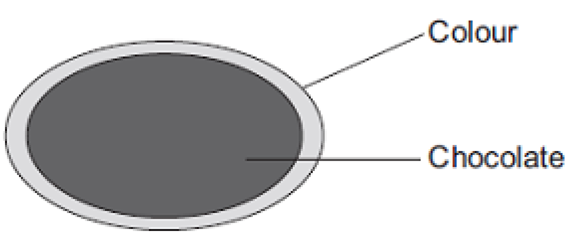
....

(2)

(Total 9 marks)

14 Colours are used to coat some chocolate sweets.

Some of these colours are given E-numbers.



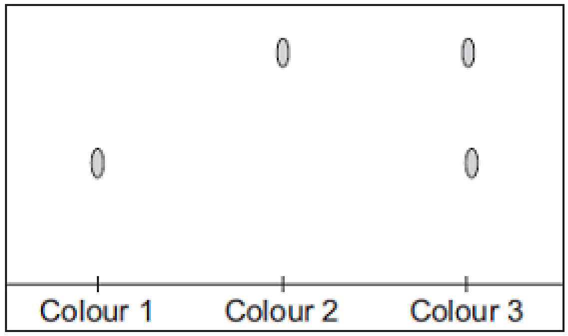
Use the correct word from the box to complete the sentence.

additive	**element**	**fuel**

An E-number is used to identify a permitted food ....

(1)

(b) Chromatography was used to compare three of the colours used to coat the chocolate sweets.



What do these results tell you about these three colours?

....

....

....

....

....

....

(3)

(Total 4 marks)

15

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.

....

....

....

....

(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.

....

....

....

....

....

....

(3)
(Total 7 marks)

16 The label shows the ingredients in a drink called Cola.

Cola
Ingredients:
Carbonated water Sugar Colouring Phosphoric acid Flavouring Caffeine

(a) (i) The pH of carbonated water is 4.5.

The pH of Cola is 2.9.

Name the ingredient on the label that lowers the pH of Cola to 2.9.

....

(1)

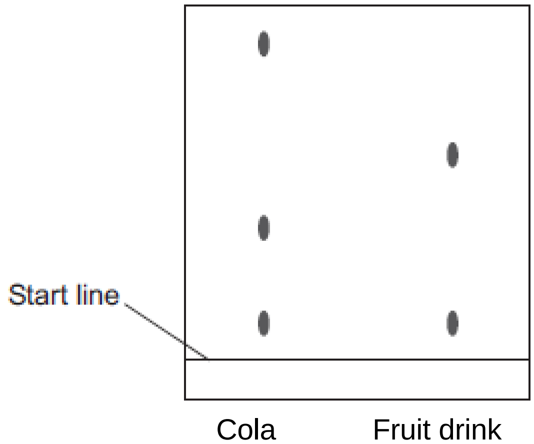
(ii) Which ion causes the pH to be 2.9?

....

(1)

(b) A student investigated the food colouring in Cola and in a fruit drink using paper chromatography.

The chromatogram in the figure below shows the student's results.



(i) Complete the sentence.

The start line should be drawn with a ruler and ....

Give a reason for your answer.

....

....

(2)

(ii) Suggest **three** conclusions you can make from the student's results.

....

....

....

....

....

....

(3)

(c) Caffeine can be separated from the other compounds in the drink by gas chromatography.

Why do different compounds separate in a gas chromatography column?

....

....

(1)

(d) Caffeine is a stimulant.

Large amounts of caffeine can be harmful.

(i) Only **one** of the questions in the table **can** be answered by science alone.

Tick (✓) **one** question.

Question	**Tick** (✓)
Should caffeine be an ingredient in drinks?	
Is there caffeine in a certain brand of drink?	
How much caffeine should people drink?	

(1)

(ii) Give **two** reasons why the other questions **cannot** be answered by science alone.

Reason 1 ....

....

Reason 2 ....

....

(2)

(Total 11 marks)

17 (a) The colours of fireworks are produced by chemicals.

Three of these chemicals are lithium sulfate, potassium chloride and sodium nitrate.

(i) A student wants to carry out flame tests on these three chemicals.

Describe how to carry out a flame test.

....

....

....

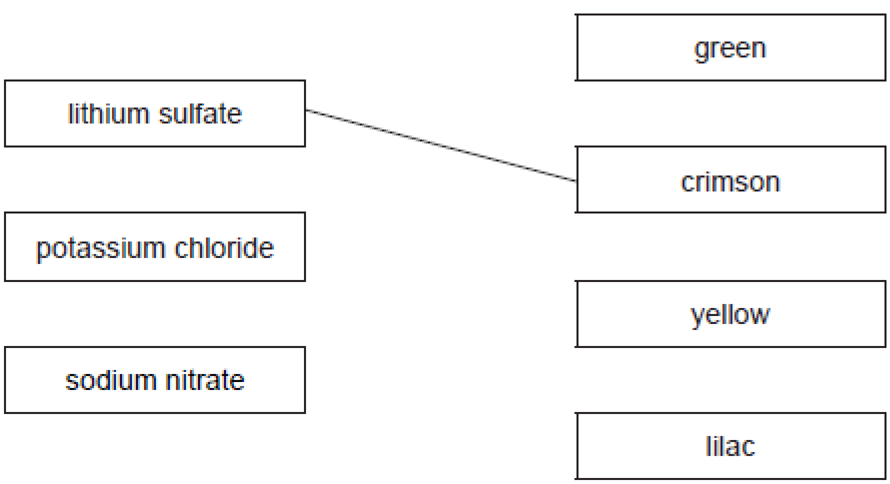
....

(2)

(ii) Draw **one** line from each chemical to the correct flame colour.

The first one has been done for you.

Chemical **Flame colour**



(2)

(iii) Dilute nitric acid and silver nitrate solution are added to solutions of the three chemicals.

A white precipitate forms in one of the solutions.

Which chemical produces the white precipitate?

....

(1)

(b) The student tests a fourth chemical, **X**.

(i) The student adds sodium hydroxide solution to a solution of chemical **X**.

A blue precipitate is formed.

Which metal ion is in chemical **X**?

....

(1)

(ii) The student adds dilute hydrochloric acid to a solution of chemical **X** and then adds barium chloride solution.

A white precipitate is formed.

Which negative ion is in chemical **X**?

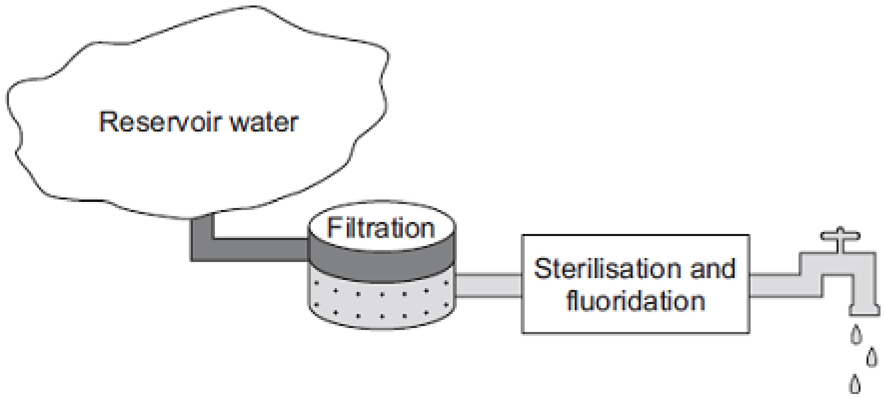
Draw a ring around the correct answer.

chloride **nitrate** **sulfate**

(1)

(Total 7 marks)

18 The diagram shows three stages in the treatment of reservoir water.



(a) (i) What is separated from the reservoir water during filtration?

Tick (✓) **one** box.

Bacteria ☐

Dissolved nitrates ☐

Solids ☐

(1)

(ii) What is added to sterilise the water?

Tick (✓) **one** box.

Calcium ☐

Chlorine ☐

Magnesium ☐

(1)

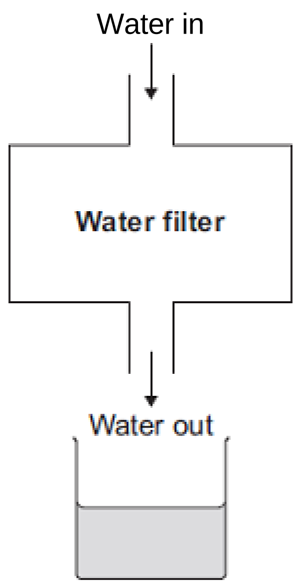
(iii) State **one** advantage of adding fluoride to drinking water.

....

....

(1)

(b) The diagram shows a water filter used in the home.



A student collected a sample of water from the filter.

The student could show that the filtered water contains dissolved salts without using a chemical test.

Describe how.

....

....

....

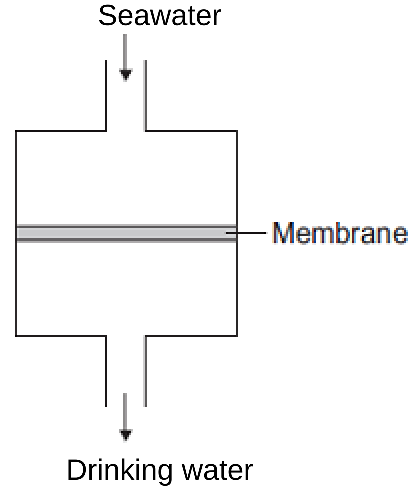
....

....

....

(2)

(c) Seawater is forced through a membrane to make drinking water.



Suggest why water molecules can pass through the membrane, but sodium ions and chloride ions cannot.

....

....

(1)
(Total 6 marks)

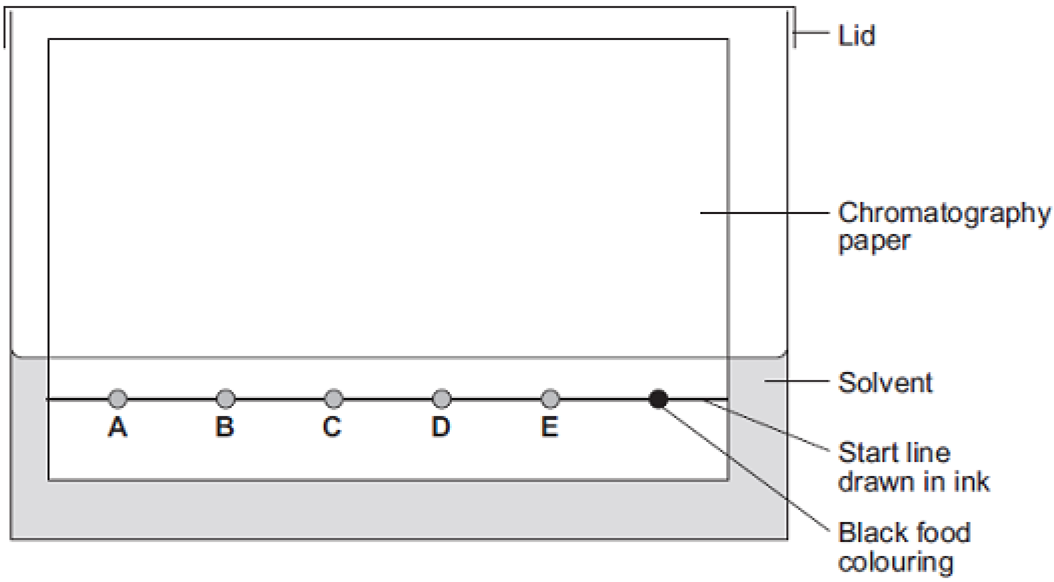
19 Chromatography can be used to separate components of a mixture.

(a) A student used paper chromatography to analyse a black food colouring.

The student placed spots of known food colours, **A**, **B**, **C**, **D** and **E**, and the black food colouring on a sheet of chromatography paper.

The student set up the apparatus as shown in **Diagram 1**.

Diagram 1



The student made **two** errors in setting up the apparatus.
Identify the **two** errors and describe the problem each error would cause.

....

....

....

....

....

....

....

....

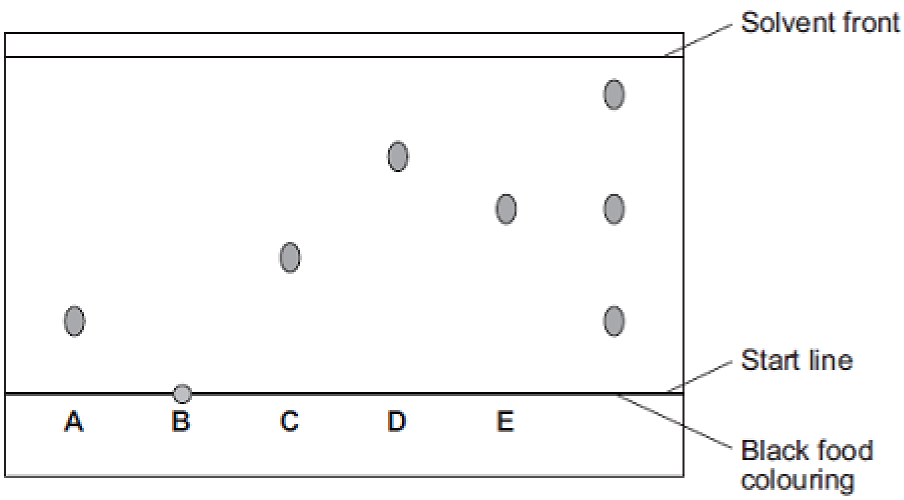
....

(4)

(b) A different student set up the apparatus without making any errors.

The chromatogram in **Diagram 2** shows the student's results.

Diagram 2



(i) What do the results tell you about the composition of the black food colouring?

....

....

....

(2)

(ii) Use **Diagram 2** to complete **Table 1**.

Table 1

	Distance in mm
Distance from start line to solvent front	....
Distance moved by food colour **C**	....

(2)

(iii) Use your answers in part **(b) (ii)** to calculate the R_f value for food colour **C**.

....

....

R_f value = ...

(1)

(c) **Table 2** gives the results of chromatography experiments that were carried out on some known food colours, using the same solvent as the students.

Table 2

Name of food colour	**Distance from start line to solvent front in mm**	**Distance moved by food colour in mm**	**R_f value**
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

Which of the food colours in **Table 2** could be food colour **C** from the chromatogram?

Give the reason for your answer.

....

....

....

(2)

(d) Two types of chromatography are gas chromatography and paper chromatography.

Give **one** advantage of gas chromatography compared with paper chromatography.

....

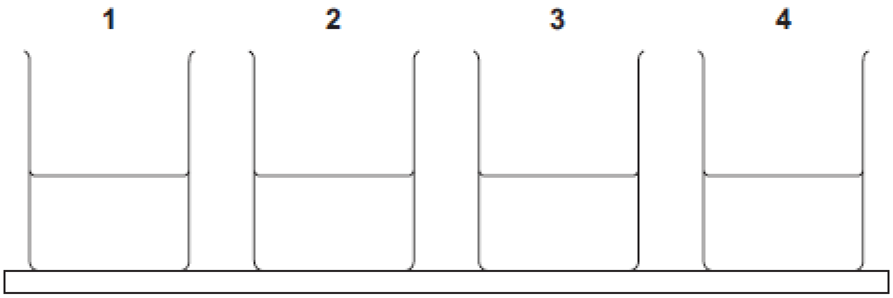
....

(1)

(Total 12 marks)

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

A group of students had four different colourless solutions in beakers **1, 2, 3** and **4**, shown in the figure below.



The students knew that the solutions were

- sodium chloride
- sodium iodide
- sodium carbonate
- potassium carbonate

but did **not** know which solution was in each beaker.

The teacher asked the class to plan a method that could be used to identify each solution.

She gave the students the following reagents to use:

- dilute nitric acid
- silver nitrate solution.

The teacher suggested using a flame test to identify the positive ions.

Outline a method the students could use to identify the four solutions.

You should include the results of the tests you describe.

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Extra space ....

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(Total 6 marks)

21 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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....

....

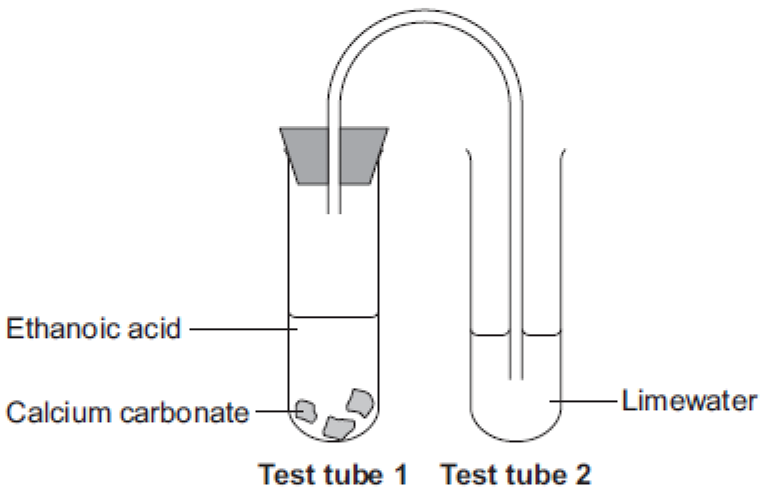
(5)

(Total 8 marks)

22 This question is about reactions of ethanoic acid and the analysis of salts.

(a) **Figure 1** shows the apparatus used to investigate the reaction of ethanoic acid with calcium carbonate.

Figure 1



(i) Describe a change that would be seen in each test tube.

Give a reason for each change.

Test tube 1...

....

....

....

Test tube 2...

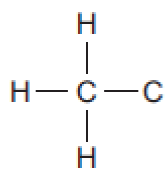
....

....

....

(4)

(ii) Complete the displayed structure of ethanoic acid.



(1)

(iii) Ethanoic acid is a carboxylic acid.
Complete the sentence.

Carboxylic acids react with alcohols in the presence of an

....

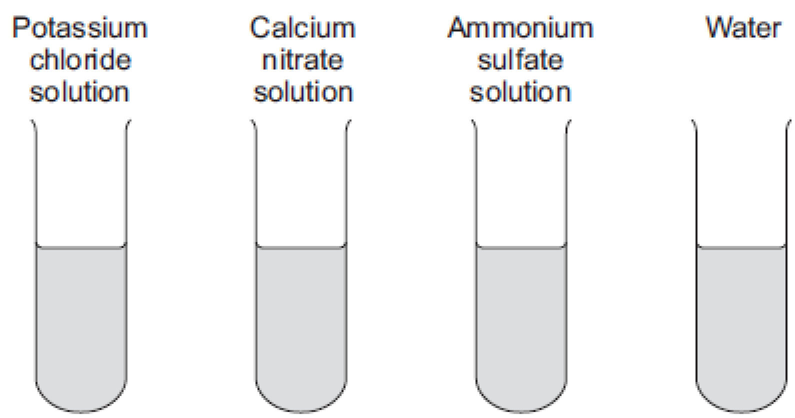
catalyst to produce pleasant-smelling compounds

called ....

(2)

(b) **Figure 2** shows four test tubes containing three different salt solutions and water.

Figure 2



Each solution and the water was tested with:

- silver nitrate in the presence of dilute nitric acid
- barium chloride in the presence of dilute hydrochloric acid.

Complete the table of results.

	Potassium chloride solution	**Calcium nitrate solution**	**Ammonium sulfate solution**	**Water**
Test with silver nitrate in the presence of dilute nitric acid			no change	no change
Test with barium chloride in the presence of dilute hydrochloric acid		no change	white precipitate	

(2)

(c) Flame tests can be used to identify metal ions.

(i) Complete the following sentences.

The flame colour for potassium ions is ....

The flame colour for calcium ions is ....

(2)

(ii) Give **one** reason why a flame test would **not** show the presence of both potassium ions and calcium ions in a mixture.

....

....

....

(1)

(Total 12 marks)

23 This question is about mixtures and analysis.

(a) Which **two** substances are mixtures?

Tick **two** boxes.

Air	☐
Carbon dioxide	☐
Graphite	☐
Sodium Chloride	☐
Steel	☐

(2)

(b) Draw **one** line from each context to the correct meaning.

Context	**Meaning**
	A substance that has had nothing added to it
Pure substance in chemistry	A single element or a single compound
	A substance containing only atoms which have different numbers of protons
Pure substance in everyday life	A substance that can be separated by filtration
	A useful product made by mixing substances

(2)

(c) What is the test for chlorine gas?

Tick **one** box.

A glowing splint relights ☐

A lighted splint gives a pop ☐

Damp litmus paper turns white ☐

Limewater turns milky ☐

(1)

(d) A student tested a metal chloride solution with sodium hydroxide solution.

A brown precipitate formed.

What was the metal ion in the metal chloride solution?

Tick **one** box.

Calcium ☐

Copper(II) ☐

Iron(II) ☐

Iron(III) ☐

(1)
(Total 6 marks)

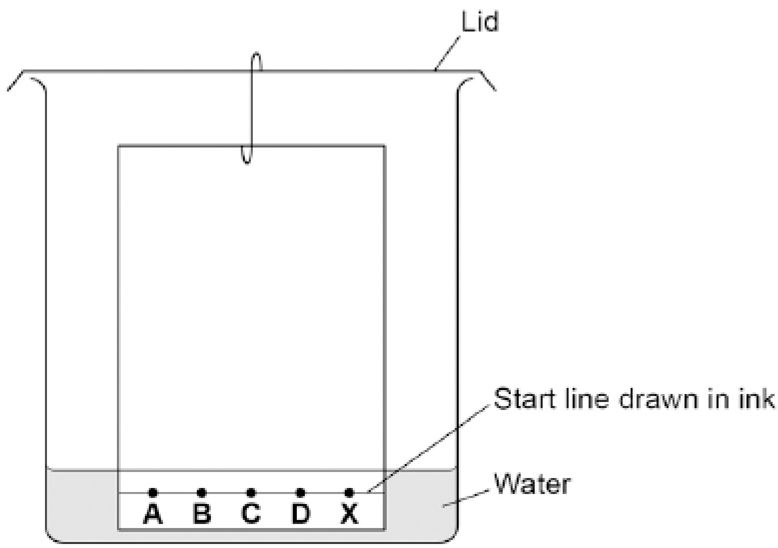
24 A student investigated food dyes using paper chromatography.

This is the method used.

1. Put a spot of food colouring **X** on the start line.
2. Put spots of four separate dyes, **A**, **B**, **C** and **D**, on the start line.
3. Place the bottom of the paper in water and leave it for several minutes.

Figure 1 shows the apparatus the student used.

Figure 1



(a) Write down **two** mistakes the student made in setting up the experiment and explain what problems one of the mistakes would cause.

....

....

....

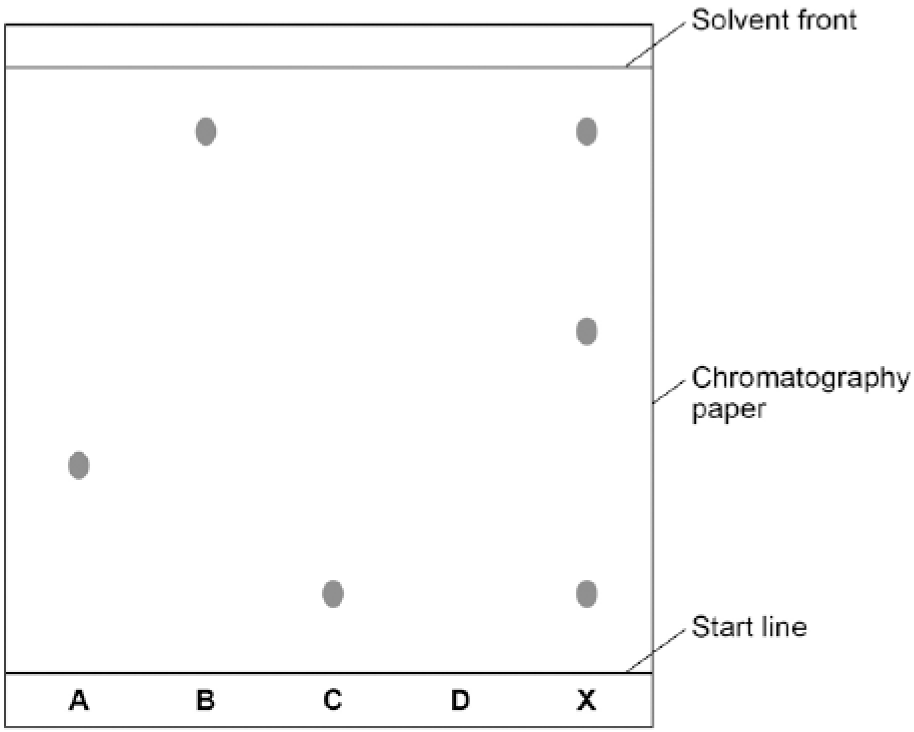
....

(2)

(b) Another student set up the apparatus correctly.

Figure 2 shows the student's results. The result for dye **D** is not shown.

Figure 2



Calculate the R_f value of dye **A**

Give your answer to two significant figures.

....

....

....

....

R_f value = ...

(3)

(c) Dye **D** has an R_f value of 0.80. Calculate the distance that dye **D** moved on the chromatography paper.

....

....

Distance moved by dye **D** = ...

(1)

(d) Explain how the different dyes in **X** are separated by paper chromatography.

....

....

....

....

....

....

....

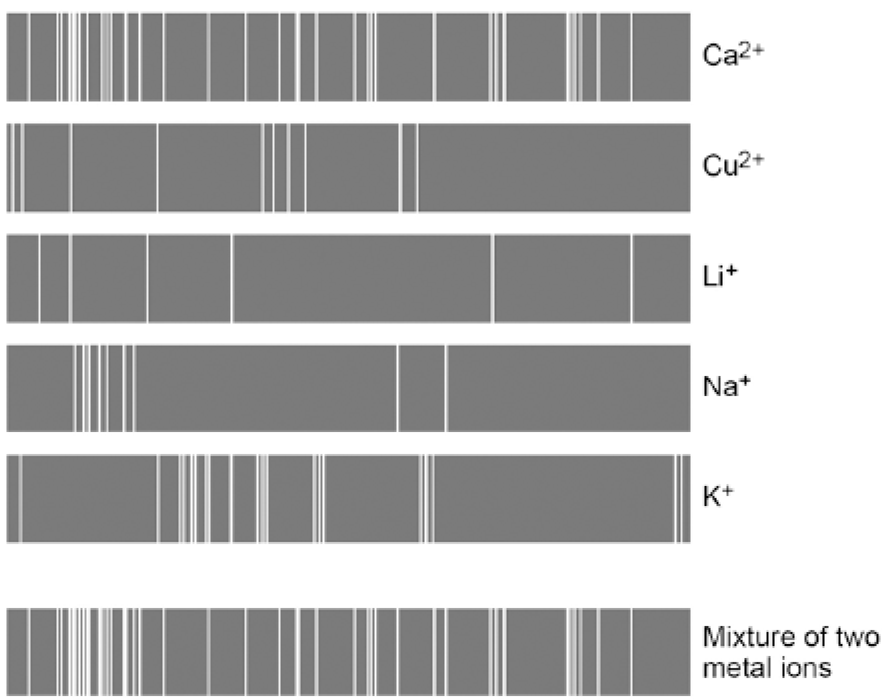
....

(4)

(e) Flame emission spectroscopy can be used to analyse metal ions in solution.

Figure 3 gives the flame emission spectra of five metal ions, and of a mixture of two metal ions.

Figure 3



Use the spectra to identify the **two** metal ions in the mixture.

....

....

(2)

(f) Explain why a flame test could **not** be used to identify the two metal ions in the mixture.

....

....

....

....

(2)

(g) Two students tested a green compound **X**.
The students added water to compound **X**.
Compound **X** did not dissolve.

The students then added a solution of ethanoic acid to compound **X**.
A gas was produced which turned limewater milky.

Student **A** concluded that compound **X** was sodium carbonate.
Student **B** concluded that compound **X** was copper chloride.

Which student, if any, was correct?

Explain your reasoning.

....

....

....

....

....

....

....

....

(4)
(Total 18 marks)

25

Water from a lake in the UK is used to produce drinking water.

(a) What are the two main steps used to treat water from lakes?

Give a reason for each step.

Step 1 ....

Reason ....

Step 2 ....

Reason ....

(2)

(b) Explain why it is more difficult to produce drinking water from waste water than from water in lakes.

....

....

....

....

....

....

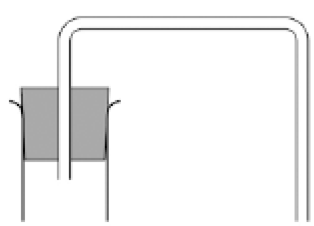
(3)

(c) Some countries make drinking water from sea water.

Complete the figure below to show how you can distil salt solution to produce and collect pure water.

Label the following:

- pure water
- salt solution



(3)

(d) How could the water be tested to show it is pure?

Give the expected result of the test for pure water.

....

....

....

....

....

(2)

(e) Why is producing drinking water from sea water expensive?

....

....

(1)

(Total 11 marks)

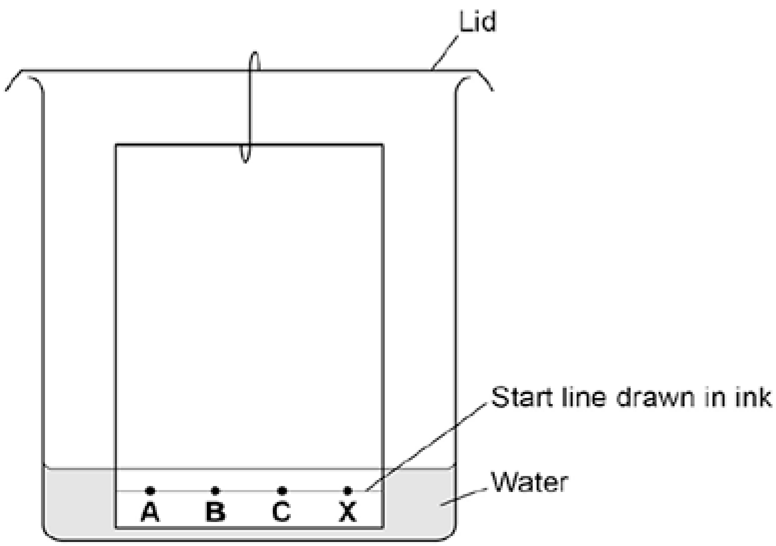
26 A student investigated a food colouring using paper chromatography.

This is the method used.

1. Put a spot of food colouring **X** on the start line.
2. Put spots of three separate dyes, **A**, **B** and **C**, on the start line.
3. Place the bottom of the paper in water and leave it for several minutes.

(a) **Figure 1** shows the apparatus the student used.

Figure 1



Give **two** mistakes the student made in setting up the experiment.

Tick **two** boxes.

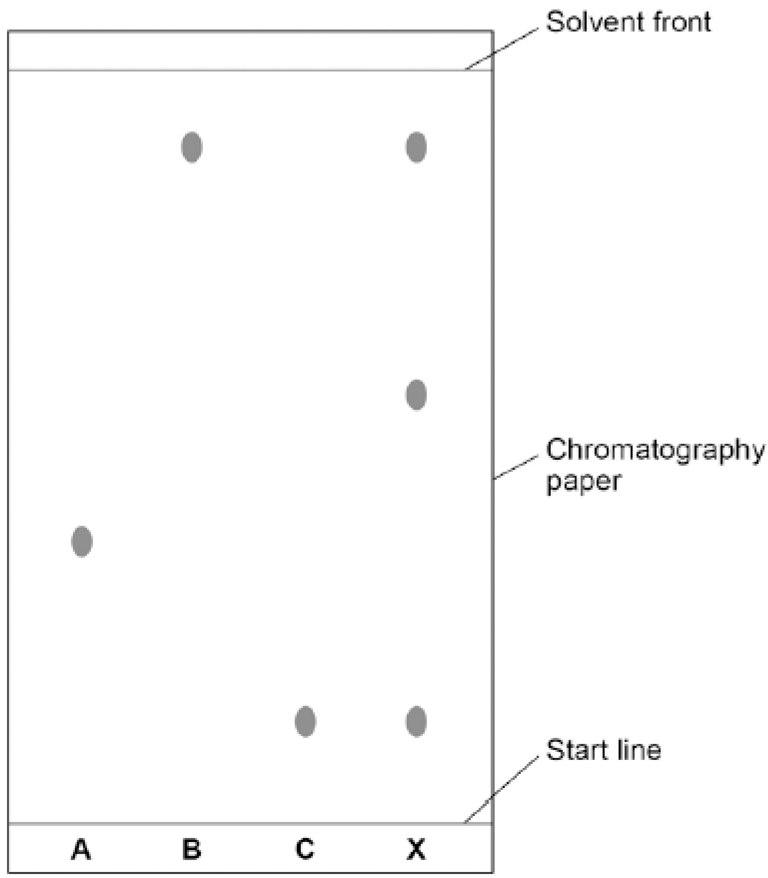
The lid was on the beaker.	☐
The paper did not touch the bottom of the beaker.	☐
The spots were too small.	☐
The start line was drawn in ink.	☐
The water level was above the spots.	☐

(2)

(b) Another student set the experiment up correctly.

Figure 2 shows the student's results.

Figure 2



How many dyes were in **X**?

Tick **one** box.

1		**3**		**4**		**6**	

(1)

(c) Which dye, **A**, **B** or **C**, is **not** in **X**?

Write your answer in the box. ☐

(1)

(d) Use **Figure 2** to complete the table below.

Calculate the value for R_f for dye **A**.

	Distance in mm
Distance moved by dye **A**	....
Distance from start line to solvent front	....

Use the equation:

$$R_f = \frac{\text{distance moved by dye } \mathbf{A}}{\text{distance moved by solvent}}$$

Give your answer to two significant figures.

....

....

....

R_f value = ...

(5)

(Total 9 marks)

1 (a) kills bacteria / sterilises (water)

allow kills microorganisms / microbes / germs

allow 'makes (water) safe (to drink)' ***or*** *disinfectant*

ignore cleans water ***or*** *removes impurities / bacteria*

1

(b) goes colourless / decolourised (from red / red-brown / brown / yellow / orange)

allow colour disappears

ignore 'goes clear' ***or*** *discoloured*

do ***not*** *accept incorrect initial colour*

do ***not*** *accept precipitate*

1

(c) (i) Br_2 **and** $2Cl^-$

allow multiples / fractions if whole equation balanced

1

(ii) changes to red / red-brown / brown / yellow / orange

do ***not*** *accept effervescence / fizzing / precipitate / gas given off*

ignore vapour / temperature changes / ignore initial colour

1

(d) (i) 7 <u>outer</u> electrons **or**

same number of <u>outer</u> electrons

allow last / final shell for outer
allow energy level / orbit / ring for shell

allow 'need to gain 1 e^- to have a full outer shell'
ignore 'similar number of outer electrons'

1

(ii) bromine / it (atom) is <u>bigger</u> **or**

must be a comparison

outer electrons (level / shell) further from nucleus **or** more shells

do ***not*** *accept more outer shells*
ignore more electrons

forces / attractions are weaker **or** more shielding **or** attracts less

do ***not*** *accept magnetic / gravitational / intermolecular forces*
allow 'electron(s) <u>attracted</u> less easily'

electron(s) gained <u>less</u> easily

"outer / last / final" must be mentioned once, otherwise max ***2*** *marks.*
accept converse for chlorine throughout where clearly stated

3

(e) (i) white precipitate **or** white solid

ignore names of chemicals

1

(ii) cream precipitate **or** cream solid

allow pale yellow / off-white precipitate / solid
ignore names of chemicals

1

[10]

2

(a) (i) hydrochloric acid / HCl

accept any (named) acid

1

carbon dioxide / CO_2

*accept bubbles / fizz / gas **or** limewater gets milky*

ignore 'add limewater'

*do **not** accept other named gases*

2nd mark dependant on first mark

*accept for this answer only heat gives CO_2 / limewater milky = **1** mark*

1

(ii) (white) precipitate / solid

ignore names of substances even if incorrect

accept white deposit / substance

*do **not** accept any coloured precipitate*

1

(iii) eg flame colour of (Na) and flame colour of (K) interfere / mask / mix with each other

*accept 'can't see the colours' **or** 'difficult to determine the colour' **or** 'both produce different colours' **or** a correct statement of colours **or** hard to distinguish*

1

(b) (i) eg essential (mineral) **or** everyone needs it / some (salt) **or** problems with health if have no salt

accept preservative / flavouring / taste

it = salt

(all) foods contain / use it / sodium chloride / salt

1

(ii)

mark positively ie no list principle

advantages

any **two** from:

ignore economic arguments throughout ***or*** *people eat less salt*

- more people will be healthier
- (should have) less heart disease
- (should have) less cancer
- (more people with) lower blood pressure

2

disadvantages

any **one** from:

ignore references to too much / too little (salt)

- not everyone affected
- not enough evidence
- does not provide choice
- undemocratic
- less taste / flavour
  ignore no flavour / taste
- shorter shelf life / not preserved (as long)
  ignore references to sell by dates
- too much potassium chloride might be bad

1

[8]

3 (a) copper sulfate → blue precipitate

1

iron(II) sulfate → green precipitate

1

(b) eg some idea of contamination

allow so you can see the colour change clearly / easily

or

give misleading / incorrect results / lead to wrong conclusion

allow to get accurate / reliable results
ignore fair test

1

(c) white

1

[4]

4

(i) any **two** from:

- **A** has four colours(*)
- **B** has three colours(*)

  (*) if first two bullets not stated
  *accept **A** has more colours (than **B**) **or B** has less colours (than **A**)*
  *for **1** mark only*

- **A / B** have two colours the same
- **B** has one different colour

2

(ii) chromatography

1

[3]

5

(a) copper (II) → blue

iron (III) → brown

more than one line from any box negates the mark

1
1

(b) aluminium

allow correct answer shown in box if answer line blank

1

(c) (i) yellow

allow orange

1

(ii) lilac

allow purple

1

(iii) one colour masks the other

allow colours mixed

1

[6]

6

(a) (i) sodium hydroxide

1

green

1

solid

1

(ii) barium chloride

1

white

1

sulfate ions, SO_4^{2-}

1

(b) some indication of contact between (colourless) flame and the chemical

ignore colour of flame

1

(c) any **one** from:

ignore reference to cost / safer

- accurate
- precise
- sensitive
- reliable
- rapid
- only small amount needed

1

[8]

7

(a) (i) yellow

1

(ii) lilac

1

(iii) melting point

1

(b) (i) barium chloride

1

solid

1

(ii) white

1

dissolved

1

[7]

8

(a) (i) (bubble gas produced through) limewater

incorrect tests = zero

1

(limewater) goes cloudy / milky

1

(ii) *ignore yes or no*

red flame indicates that calcium / lithium ions present

allow aluminium has no flame colour

or

Ca/Mg also produce a (white) precipitate with NaOH

1

the (white) precipitate formed in test 3 **or** by adding sodium hydroxide solution would dissolve (in excess) if aluminium ions were present

1

(iii) *ignore yes or no*

because a white precipitate is formed in test 4 **or** by adding silver nitrate

1

but chloride ions are in hydrochloric acid

1

(b) (i) mass spectrometry

allow MS

or

atomic absorption spectroscopy

allow AAS

spectrometry / spectroscopy alone is insufficient

1

(ii) can detect a small(er) amount of the substance

allow can detect small(er) changes

allow small(er) sample sizes

ignore references to precision / accuracy

1

[8]

9 (a) (improve) appearance

allow add colour

allow these food colourings have not been proven to cause hyperactive behaviour in young children

*do **not** accept taste / flavour / preservatives*

ignore reference to E-numbers

1

(b) X

1

(c) any **three** from:

- S contains six / 6 colourings
- P contains five / 5 colourings

  *if neither of first 2 bullet points given allow **1** mark for S contains more colours than P **or** converse*
- both S and P contain the same

  five / 5 colourings
- both contain W **and** Y
- both sweets (may) cause hyperactivity

  ignore unsafe
- neither contain X **and** Z

3

[5]

10 (a) (i) prevent evaporation of solvent

allow prevent loss of solvent

allow to support the (chromatography) paper

1

(ii) ink dissolves in the solvent

*allow ink 'runs' / spreads **or** pencil does not 'run' / spread*

allow ink would affect the result / mixes with colours

or

carbon / graphite does not dissolve in the solvent

accept pencil for carbon / graphite

1

(b) (i) 4

1

(ii) *no mark for 'no / don't know'* ,

ignore numbers

any **one** from:

- because not all colours match
- not all colours are safe
- some colours could be unsafe
- some colours travelled higher (than safe colours)

1

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

ignore reliable / precise

- rapid / quick
- accurate
- sensitive **or** detects very small quantities

accept small sample

2

(ii) separates

1

(iii) identifies solvents / compounds / substances

accept (relative) molecular mass

accept formula mass

accept M_r

accept relative mass

accept molecular ion peak

1

[8]

11 (a) (i) Na_2CO_3: HCl → gas / effervescence / bubbles (1)

CO_2 / carbon dioxide / turns lime water milky (1)

1

NaCl: $AgNO_3$ → white ppt (1)

silver chloride (1)

1

$NaNO_3$: Al + NaOH → pungent / sharp smell / choking gas (1)

NH_3 / ammonia / turns (red) litmus blue(1)

1

Na_2SO_4: $BaCl_2$ → white ppt (1)
barium sulfate (1)

1

each correct test and one result = ***1*** *mark*

one *other result for any test =* ***1*** *mark this mark can only be awarded* *<u>once</u>*

(ii) all would give a yellow / yellow-orange (flame) / same coloured (flame) / same results

allow <u>orange</u> (flame) 1

or

they all contain sodium

1

(b) any **two** from:

ignore cost/errors

- fast / quick or comment about speed
  allow precise
- small amounts/sensitive
  allow can be left to run/continuous analysis
- accurate
- ease of automation
  accept operators do not need chemical skills
- sample not used up
- reliable / efficient

2

[7]

12 (a) (i) chromatography

1

(ii) 3 / three

1

(iii) the colour / E104 is not on the same level as any of the colours in the food

accept E104 does not match

1

(b) (i) to improve the appearance of the food

ignore adds yellow / colour

ignore taste / flavour

1

(ii) further / or different tests (for harmful effects) **or** obtain more evidence (that it is harmful)

allow do a survey / study

1

[5]

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

ignore reference to taste / shelf-life / sales etc

- improve the colour / appearance
- additives are permitted / not banned / listed on the label
- link between additives and hyperactivity not proved
- maintain the low cost of the drink **or** natural colours would make the drink cost more

  allow cheaper if qualified

2

(b) have a control group / placebo **or** test children before any drink given

1

give a drink to at least 3 groups **or** give a drink at least 3 times

1

give each additive to different group / children / at different times

1

observe / monitor / compare behaviour of group / children

1

(c) (i) so that there would be trust / respect / no bias

1

(ii) compare the colours / spots from the orange drink with those of the (three) additives

accept diagram of chromatogram(s) with spots for E102, 104, 110 and sample from the orange drink

1

there should be no matching colours / spots

1

[9]

14 (a) additive

1

(b) colour 3 is a mixture of colours 1 and 2

any **two** from:

accept E-number or additive instead of colour

ignore comments about height / level

1

- colour 1 is made up of only one colour / dye
- colour 2 is made up of only one colour / dye
- colour 3 is made up of two colours / dyes
  or
  more colours (than colours 1 and 2)

2

[4]

15 (a) lithium

allow Li^+ / Li

1

yellow

allow orange

1

(b) silver nitrate (solution)

*incorrect test = **0** marks*

ignore (nitric) acid

*do **not** allow other named acids*

1

white precipitate

1

(c) blue precipitate (with sodium hydroxide) indicates copper ions

allow Cu^{2+}

1

and white precipitate (with barium chloride) indicates sulfate ions

allow SO_4^{2-}

*accept compound X is copper sulfate / $CuSO_4$ for **1** mark*

1

but iron(II) ions produce a green precipitate (with sodium hydroxide)

1

[7]

16 (a) (i) (phosphoric) acid

allow phosphoric

1

(ii) H^+ / hydrogen (ion)

if ion symbol given, charge must be correct

1

(b) (i) pencil

1

so it will not run / smudge / *dissolve*

ignore pencil will not interfere with / affect the results

or

because ink would run / smudge / *dissolve*

ignore ink will interfere with / affect the results

1

(ii) any **three** from:

*reference to spots / dots = max **2***

allow colouring for colour

- *3* colours in Cola

  *allow more colours in cola **or** fewer colours in fruit drink*
- *2* colours in Fruit drink
- one of the colours is the same
- two of the colours in Cola are different
- one of the colours in Fruit drink is different

  allow some of the colours in the drinks are different
- *one of the colours in Cola is the most soluble*

  accept one of the colours in Cola has the highest R_f value

3

(c) different substances travel at different speeds **or** have different retention times

accept different attraction to solid

ignore properties of compounds

1

(d) (i) Is there caffeine in a certain brand of drink?

1

(ii) any **two** from:

- cannot be done by experiment
- based on opinion / *lifestyle choice*
- ethical, *social* or economic issue

accept caffeine has different effects on different people

2

[11]

17 (a) (i) *method of introducing sample into flame*

e.g. wire / splint / spray

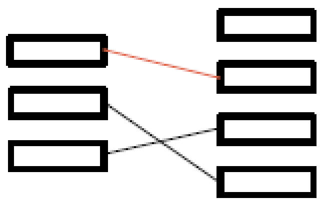
1

clean wire or colourless flame

allow blue / roaring flame

1

(ii)



1

1

(iii) (potassium) chloride

allow KCl ***or*** *Cl^-*

1

(b) (i) copper

allow Cu^{2+}

1

(ii) sulfate

1

[7]

18 (a) (i) Solids

1

(ii) Chlorine

1

(iii) improves dental health **or** reduces tooth decay

1

(b) put a sample of the filtered water in an evaporating basin **or** leave to evaporate

accept any description of evaporation (using a Bunsen or leaving on the windowsill)

1

there will be crystals of salt left

1

(c) sodium and / or chloride ions are bigger than water (molecules) **or** ions are charged **or** molecules are not charged

do ***not*** *accept sodium chloride molecules as ions is given in the question*

1

[6]

19 (a) start line drawn in ink

1

so it will run / dissolve in the solvent / split up

allow mixes with the spots

1

spots under solvent **or** solvent above spots / start line

1

so they will mix with solvent **or** wash off paper **or** colour the solvent **or** dissolve in the solvent

1

(b) (i) contains **A** and **E**

1

and one other (unknown substance)

*if no other marks awarded, an answer saying it is made up of three colours gains **1** mark*

1

(ii) 45 or 46

allow any value from 45 to 46

1

18

allow any value from 16 to 20

*award **1** mark if numbers correct but in cm*

1

(iii) 0.40

*allow ecf from **(b)(ii)***

ignore units

1

(c) fast red

*allow ecf from **(b)(iii)***

1

has same R_f value

*allow none of them, as none has the same R_f value for **2** marks*

1

(d) any **one** from:

- more accurate
- more sensitive
- uses small quantities of samples
- quicker / faster / more rapid
- can link to mass spectrometer (MS)

1

[12]

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

0 marks
No relevant content

Level 1 (1 – 2 marks)
Any description of a method used and / or a result given

Level 2 (3 – 4 marks)
Description of workable methods used, with results to identify positive **or** negative ions

Level 3 (5 – 6 marks)
Description of methods used to identify both positive **and** negative ions, with relevant results

examples of the points made in the response

extra information

Test: add (platinum / nichrome) wire (for the flame test)

accept any method of introducing the solution into the flame, eg a splint soaked in the solution or sprayed from a bottle

Result: the sodium compounds result in a yellow / orange / gold flame **or** the potassium compound results in a lilac / purple / mauve flame

student could state that potassium carbonate gives a different colour to the three sodium compounds as long as it is clear that the flame test colour comes from Na^+ *or* K^+

Test: add dilute nitric acid to all four solutions

allow any acid

Result: sodium carbonate and potassium carbonate will effervesce **or** sodium chloride and sodium iodide will not effervesce

Test: add dilute nitric acid followed by silver nitrate

Result: sodium chloride and sodium iodide produce a precipitate **or** sodium chloride produces a white precipitate and sodium iodide produces a yellow precipitate

accept sodium carbonate and potassium carbonate do not produce a precipitate

[6]

21 (a) **X:**
Fe^{2+} / iron(II), SO_4^{2-} / sulfate

allow iron(II) sulfate
or $FeSO_4$

1

Y:
Na^+ / sodium, I^- / iodide

allow sodium iodide
or *NaI*

1

Z:
Fe^{3+} / iron(III), Br^- / bromide

allow iron(III) bromide
or *$FeBr_3$*

correct identification of any two ions = one mark

correct identification of any four ions = two marks

1

(b) any **five** from:

allow converse arguments

method 1

- weighing is accurate
- not all barium sulfate may be precipitated
- precipitate may be lost
- precipitate may not be dry
- takes longer
- requires energy

allow not all the barium hydroxide has reacted

method 2

- accurate
- works for low concentrations

allow reliable / precise

5

[8]

22 (a) (i) fizz / effervescence / bubbles

allow calcium carbonate decreases in size or dissolves

1

because carbon dioxide produced / released

allow because gas produced / released

1

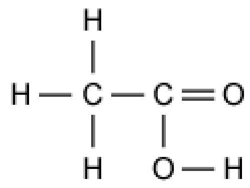
limewater turns cloudy / milky / white

1

because (a precipitate of or solid) calcium carbonate forms

allow because of carbon dioxide if not already credited

1

(ii) 

allow -OH
do not allow lower case 'h'

1

(iii) acid

must be in this order
ignore any name of an acid

1

ester(s)

1

(b) white (precipitate) no change

no change no change

all four correct 2 marks
any two correct 1 mark

2

(c) (i) lilac

allow purple

1

red

1

must be in this order

(ii) colours are masked / changed by each flame colour

1

[12]

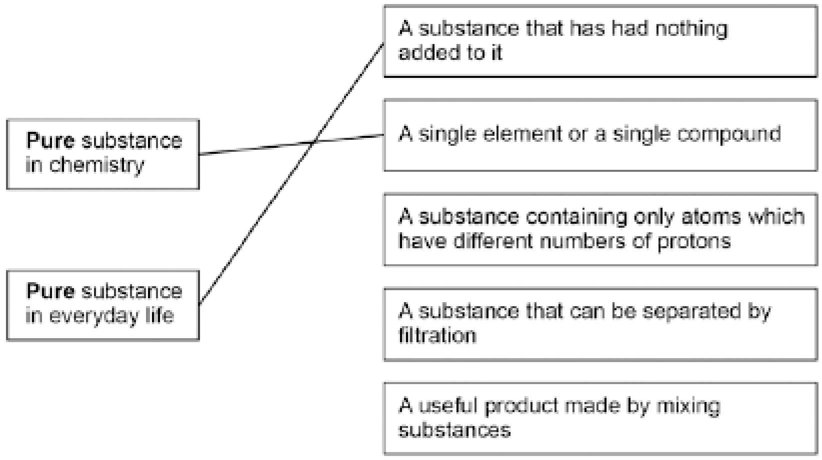
23 (a) Air

2

Steel

1

(b)



Allow **1** mark for the correct meanings linked to context but incorrect way around

1

(c) Damp litmus paper turns white

1

(d) Iron(III)

1

[6]

24

(a) water level above the start line
and
start line drawn in ink

allow water level too high

1

water level
food colours would dissolve into water
or
start line
the ink would 'run' on the paper

1

(b) (distance moved by **A**) 2.8cm **and** 8.2 cm (distance moved by solvent)

allow values in range 2.7 − 2.9 cm and 8.1 − 8.3 cm

1

$\frac{2.8}{8.2}$

1

0.34

allow 0.33 or 0.35

*allow ecf from incorrect measurement to final answer for **2** marks if given to 2 significant figures*

*accept 0.34 without working shown for **3** marks*

1

(c) 6.6 cm

allow values between 6.48 and 6.64 cm

1

(d) solvent moves through paper

1

different dyes have different solubilities in solvent

1

and different attractions for the paper

1

and so are carried different distances

1

(e) calcium ions

allow Ca^{2+}

1

sodium ions

allow Na^{+}

1

(f) two different colours

or

Ca^{2+} / one is orange-red and Na^{+} / the other is yellow

allow brick red for Ca^{2+} and / or orange for Na^{+}

*allow incorrect colours if consistent with answer to **7.5***

1

(so) colours mix

or

(so) one colour masks the other

1

(g) (Student **A** was incorrect)

because sodium compounds are white not green

or

because sodium carbonate is soluble

1

so can't contain sodium ions

1

(Student **B** was incorrect)
because adding acid to carbonate produces carbon dioxide

1

so must contain carbonate not chloride ions

1

[18]

25 (a) filtration
or
by passing through filter beds to remove solids

1

sterilisation to kill microbes

allow chlorine / ozone allow ultraviolet light

1

(b) water needs more / different processes

1

because it contains any **two** from:

- more organic matter
- more microbes
- toxic chemicals or detergents

2

(c) *(as part of glassware attached to bung)*
salt solution in (conical) flask

allow suitable alternative equipment, eg boiling tube

1

(at end of delivery tube)
pure water in test tube which must not be sealed

allow suitable alternative equipment, eg, beaker, condenser

1

heat source (to heat container holding salt solution)

1

*if no other mark obtained allow for **1** mark suitable equipment drawn as part of glassware attached to bung **and** at end of delivery tube*

(d) determine boiling point

1

should be at a fixed temperature 100°C

allow should be 100°C

allow if impure will boil at a temperature over 100°C

1

(e) high energy requirement

1

[11]

26 (a) The start line was drawn in ink

1

The water level was above the spots

1

(b) 3

1

(c) **A**

1

(d) *(distance moved by dye A)* 38 (mm)

allow values in range 36-40

1

(distance from start line to solvent front)
102 (mm)

allow values in range 101-103

1

$\frac{38}{102}$

allow ecf from Table 1

1

0.37254 …

allow values in range 0.35 − 0.39

1

0.37

1

accept 0.37 with no working shown for ***5*** *marks*

[9]

Examiner reports

1

Parts (a) and (d) were answered quite well, the other parts less so.

(a) Most candidates knew why chlorine is added to drinking water. However, candidates need to say that chlorine kills bacteria rather than just removes bacteria. Weaker candidates simply stated it was to clean the water or thought it softened the water.

(b) Less than half of the candidates knew that bromine water was decolourised. It does not go clear and neither does it become discoloured.

(c) (i) Only the best candidates were able to complete and balance the equation. Most candidates had no idea what the products of the reaction were, and charges were frequently omitted/added even when the products' formulae were correct.

(ii) The large majority of the candidates were unable to describe the effect of chlorine on bromide ions. Many candidates thought that a precipitate formed or that there was an effervescence.

(d) (i) The majority of candidates knew that these elements have the same number of outer electrons (7) or need one electron to gain a complete outer shell of electrons. Chlorine and bromine do not have a similar number of outer electrons.

(ii) An excellent discriminator as usual, and some excellent answers were seen. In a question such as this, a comparison is required so it is essential to include comparative terms such as more/most, closer/closest, stronger/strongest or easier/easiest. Simply saying easy/easily, close or strong/strongly is insufficient.

Candidates needed to mention outer electron or outer energy level or outer shell somewhere in their answer to receive full credit. Some candidates suggested that a bromine atom loses an electron less easily. Others wrote about bromine having more outer shells than chlorine. Some candidates thought that intermolecular, magnetic or gravitational forces hold the electrons to the nucleus, while others referred to the strength of the bond between electron and nucleus. The third marking point proved elusive for many who often concluded their answer with the words therefore bromine is less reactive rather than therefore bromine gains an electron less easily.

(e) A quite discriminating question.

(i) Less than half the candidates knew that a white precipitate/solid was formed when silver nitrate solution was added to a solution containing chloride ions. Simply saying that the solution goes white or milky is insufficient.

(ii) Even fewer candidates knew that a pale yellow (or cream) precipitate was formed with bromide ions. Candidates should be aware that a yellow precipitate is formed when silver nitrate solution is added to a solution containing iodide ions.

2

Foundation Tier

Part (a) was quite poorly attempted In Part (a)(i) a large number of candidates did not know the test for carbonates. Many candidates wrote 'add lime water' and 'it will go cloudy'. Some candidates even wrote 'flame test'. They seemed to know that carbon dioxide was somehow involved/evolved and simply gave the test for carbon dioxide.

A large number of candidates in Part (a)(ii) wrote 'bubbles' or 'gas' while some suggested 'there will be a colour change'. Very few candidates knew that there would be a precipitate or a solid formed. Some lost marks by giving an incorrectly coloured precipitate.

Many candidates in Part (a)(iii) lost the mark here. They could not apply their knowledge of separate flame colours to a mixture. Many candidates wrote 'they have similar coloured flames' or 'they produce same coloured flames' while others suggested that 'it is low in sodium'. Some stated wrong colours for sodium and potassium.

Part (b) was quite well attempted. The majority of the candidates were able to pick out the relevant points from the passage.

In Part (a)(i) most candidates got the mark for 'essential mineral'.

The majority of the candidates in Part (a)(ii) gave two advantages for option 2 but many found it difficult to identify a disadvantage. The most commonly seen correct responses were 'preservation', 'taste' and 'flavour'. Some candidates wrote 'it is an essential mineral' while others talked in terms of the difficulty of removing salt from food and how expensive that would be.

Higher Tier

In part (a)(i) a surprising number of candidates did not know the test for carbonates. Many used silver nitrate, sodium hydroxide or flame tests, and some thought carbon was evolved. Many candidates knew that carbon dioxide was involved in some way but too many simply added the limewater to the carbonate. Carbon dioxide forms a white precipitate with limewater.

Many candidates in part (a)(ii) lost marks by describing an incorrectly coloured precipitate – cream and yellow were common errors.

In part (a)(iii) many candidates had difficulty expressing themselves, and those candidates who stated the colours frequently gave the wrong colours. Potassium was sometimes suggested to give a red or a white flame test rather than lilac.

Both parts in (a) were well answered and it was clear that generally candidates understood the issues and gave very sensible and mature answers.

Part (b)(i) was well answered – most candidates were able to suggest a reason why Option 1 was rejected.

In part (b)(ii) the majority of the candidates could extract the information for the advantages of Option 2 from the passage. However, identifying the disadvantage was problematic for many who focused on the difficulty of removing salt from food and quoted economic factors in their response. Taste, flavour and preservation were the correct responses most often seen.

3

(a) A lot of candidates did not know the colours given by the two sulfates.

(b) This was quite well attempted although some candidates wrote so no bacteria present.

(c) This was quite poorly attempted.

4

(i) Despite the fact that the Specification includes detection and identification of artificial colours by chromatography, most candidates showed little or no understanding of the test results. These candidates often expressed their answers in terms of low = safe and high = unsafe. Candidates who gained one mark usually did so by stating that A has more colours than B.

(ii) The majority of candidates did recognise that the result shown was produced by chromatography.

5

(a) About a third of candidates knew both and a further third knew one. Iron(III) was unsurprisingly often linked to green.

(b) Less than a third of students knew this test result. Magnesium was predictably the more popular incorrect answer.

(c) (i) Slightly more than half the students scored this mark. Some students seemingly were just guessing the colour (blue, brown, white) whilst others were clearly mixed up (crimson, red).

(ii) There was evidently quite a lot of guess work.

(iii) This was very poorly attempted. Many students were unable to express themselves well. There were responses like ‘sodium is more reactive and will show its colour’, ‘the flame cannot give two separate colours’, ‘it can only produce one colour’, ‘it’s a low sodium salt’, ‘they are both the same colour’, and ‘the most reactive element’s colour is shown’.

6

(a) (i) A few candidates could not recall the test for Fe^{2+} ions but the vast majority managed to gain at least one mark here.

(ii) This was better attempted and a large number of candidates managed to gain at least two marks.

(b) Some candidates found this difficult. There were vague answers like heat the compound with a Bunsen burner or place it in a beaker and heat it. Others suggested carrying out a test for either hydrogen or oxygen gas, eg put the compound in a test tube, bring a lighted splint near the mouth of the test tube and see if there is a pop sound.

(c) Some candidates gave the names of instrumental methods eg mass spectrometry. Others gave vague answers such as it will be fairer or there will not be much wastage of the sample while some candidates made references to cost and safety.

7

(a) (i) More than half of the candidates got this wrong. They could not identify the correct colour of the flame given by the sodium ion.

(ii) Almost half of the candidates were unable to identify the correct colour of the flame given by the potassium ion.

(iii) A large majority of candidates gained a mark here as they were able to recall the fact that the wire used in a flame test should have a high melting point.

(b) (i) Many candidates could not recall the test for the sulfate ion.

(ii) While most of the candidates gained some credit, about a third gained both marks.

8

(a) (i) Most students correctly described the limewater test for carbon dioxide and gave the correct result. A very small number mentioned limewater but omitted the result. A common error was to fail to notice that the question specifically asked students how to identify the gas produced from the addition of acid to a carbonate. As a result, many described tests for other gases such as for hydrogen or ammonia.

(ii) Many students knew that test 3 was for aluminium but there was some confusion over whether the insolubility of the precipitate in excess sodium hydroxide argued in favour of or against aluminium ions. Of those who did score the mark relatively few went on to say that test three indicated magnesium or calcium ions to gain a second mark. The flame test was often cited, but usually incorrectly. Quite a few said that aluminium produces a red flame; others that it does not, but only a few gained a mark by correctly attributing the red flame to calcium (or lithium) or by indicating that aluminium produces no flame colour (which is not the same as 'not red'). A few were incorrectly drawn to the test for nitrates by the mention of aluminium.

(iii) There was some confusion with other tests but most identified test 4 as indicating the presence of chloride ions. Far fewer realised that the test was rendered invalid by the prior addition of hydrochloric acid and most of those who did unfortunately omitted to mention the test so that very few gained both marks.

(b) (i) Just over half of students answered correctly, mass spectrometry proving slightly more popular than atomic absorption spectroscopy. Wrong answers included incorrect instrumental methods such as nmr or uv but some gave wet chemistry answers such as flame tests. A few simply answered 'spectroscopy' without further elucidation. There is still confusion between spectroscopy and spectrometry along with much misspelling of these terms, but these were not penalised.

(ii) Responses to this question were disappointing, with just under half of students being awarded a mark. Students frequently mentioned or described accuracy and, especially, precision. Such references did not gain a mark but, where cited in addition to a correct response, nor were they penalised.

9

(a) Surprisingly, only about half of the students gave the correct reason that colourings are added to improve the appearance of the sweets. Many students thought that the colouring was added to improve the taste of the sweets or to provide an energy boost or even to preserve the sweets. Several students also thought that it was a good idea to add colourings because it would make children hyperactive.

(b) About half of the students correctly identified X.

(c) There were very few answers that earned all three marks. Most students had difficulty interpreting the chromatogram. Many students incorrectly thought that W, X, Y and Z were also sweets. A comparison of the number of colourings and the types of colourings in each sweet was required. The most common marks awarded were for ‘the sweets may cause hyperactivity’, ‘both sweets contain W and Y’ and ‘sweet S contains more colourings than sweet P’. Very few students mentioned the actual number of colourings in each sweet or mentioned that both sweets did not contain X and Z.

10 This question involving chromatography was generally not well answered. It appeared that many students had not had practical experience of carrying out paper chromatography.

(a) (i) The vast majority of answers were incorrect. Many responses referred to the function of the lid as to preventing substances such as gases, oxygen and bacteria getting into the container. Vague references to contamination and preventing the escape of toxins/poisons and the colours were prevalent. The idea of preventing the loss/evaporation of solvent was rarely seen.

(ii) Generally well answered. A lack of knowledge and understanding was evident when some students discussed the problems of removing the ink compared to rubbing out a pencil mark if a mistake were made.

(b) (i) A surprising number of students were unable to deduce that four different colours were present in the cake icing. Seven, three and two were common incorrect answers.

(ii) Many students thought that the cake icing was safe because they identified the two safe colours and ignored the others. Answers that detailed that all the cake colours were safe showed a lack of understanding.

(c) Only the more able students had any knowledge and understanding of gas chromatography.

(i) This was the best attempted part of the question. Confusion between accuracy and reliability and precision was evident. Vague references to better results, the cost and 'easier to do' were common.

(ii) The idea of separating the mixture was the correct answer. Poor responses referred to evaporation and the mixing of solvents.

(iii) Very few students scored credit here. Those who did implied that the identity of the solvents could be realised. Many vague answers such as 'something to do with weight/mass' showed no knowledge of molecular mass.

11 (a) (i) This question clearly divided the students into those who had learned the tests and those who had not. Approximately one quarter answered well, gaining four or five marks, but well over half scored one or zero. Most knew that the test for the carbonate ion involved carbon dioxide but many incorrectly suggested adding sodium carbonate directly to limewater. Of the remaining three tests, that for sulfate ions was by far the best known, and that for nitrates the least. A frequent mistake in the latter was to omit either sodium hydroxide or aluminium powder from the test. Many students believed that test for ions required the use of those ions in the test; for example by adding silver nitrate to test for nitrate ions or barium chloride to test for chloride ions.

(ii) About half of students answered correctly. A major source of confusion was the belief that only anions, which would have no flame colour, were being tested. Others failed to recognise that all the compounds contained sodium and therefore wrote of the difficulty of recognising individual colours within a mixture.

(b) Most students managed to score a mark, with the majority gaining both. The most frequent answers identified accuracy or precision, speed, or a small sample size.

12

(a) (i) The majority of students gained credit for knowing that chromatography is the method used to detect and identify colours in food.

(ii) Most students understood that the food contained three different colours.

(iii) Many students had difficulty describing the positions of the colours on the chromatogram. A comparison of levels is the probably the clearest way. There were still far too many vague descriptions of what was happening or comparisons of the number of colours on each columns.

(b) (i) Surprisingly, less than half of the students could give the correct reason that colours, such as quinoline yellow (E104), are added to improve the appearance of the food. Many students thoughtthat the colouring was added to improve the taste of the food or to make food sweeter or to provide an energy boost or even to preserve the food. Several students also thought that it was a good idea to add E104 because it would make people hyperactive

(ii) Most of the students managed to get the idea that further or different tests were needed. There were a few students who incorrectly wanted to use chromatography again, use a different colouring or simply ban E104.

13

(a) There were lots of good reasons given as to why a manufacturer might justify the use of additives in orange drinks. However, there was a large minority who felt that the possibility of the additives causing hyperactivity might be a good selling point as an energy drink.

(b) There were many good answers as to how scientists could use 4000 children to investigate if there is a link between three coloured additives and hyperactivity in children. The most common error was to have just two groups of children: a control group and another group that were given all three coloured additives.

(c) (i) This was very well answered; most students understood that the company's own scientists might be biased.

(ii) Chromatography was less well known. There were few correct descriptions of how to use paper chromatography for the test. Very few students said how the results could be used to show if the orange drink contained any of the three coloured additives.

14

(a) Most students did know that an E-number is used to identify a permitted food additive.

(b) There were very few answers that earned all three marks. Most students had difficulty interpreting the simple chromatogram. Many students incorrectly thought that the height of the dots represented the level of hyperactivity the colour causes or that the number of dots represented the number of tests done. Few students mentioned the actual number of colourings in each colour or mentioned that colour 3 is a mixture of colour 1 and colour 2.

15

(a) Part a was done well; students seemed reasonably secure in their knowledge of flame colours. Where an error was made it was usually in identifying lithium.

(b) This part was much less well done than part (a), with just over a third gaining both marks. Few scored a single mark; most who knew the test also knew the correct result. There were several common errors. Many added hydrochloric acid as a reagent, perhaps associating it with barium chloride in the test for sulfate ions. Many suggested a flame test, often giving green as the expected colour, which would be the correct test for barium but which did not answer the question. A few stated that a green flame colour would be caused by the presence of chlorine. Finally, a significant number of students gave incorrect or spurious tests, many of which were claimed to give a white precipitate, although no mark was awarded for this.

(c) Part b produced a good spread of marks. The best students were able to gain all three marks with clear and thorough answers. Marks were usually lost by omission; students should take note of the number of marks achievable on this type of question. Some less able students confined themselves to reiterating the information in the question without adding anything significant, for example, ‘Yes, because it produced a white precipitate with barium chloride’.

16 (a) (i) The majority of students correctly named the ingredient as phosphoric acid recognising that a pH of 2.9 indicated acidity.

(ii) The correct response was hydrogen ion. Only a few students read the question and were able to give an ion. Most chose an incorrect answer from the list of ingredients for Cola. The most popular answers were phosphoric acid, carbonated water and sugar.

(b) (i) Most students scored a mark for using a pencil. To gain the second mark the idea was needed that the pencil was insoluble and that ink was soluble with the appropriate consequences for the chromatogram. Answers scoring no further credit included the line being straight, being able to erase the line if an error occurred and vague answers that ink interfered with the results of the separation.

(ii) This question discriminated well with the full range of marks awarded. Many students were poor at expressing their ideas. The most common answer quoted the cola as having the most colours with the fruit juice having fewer colours. Good answers showed students had analysed the chromatogram and referred to the number of colours in each drink and deduced that one of the colours was the same. Misconceptions were often in terms of the speed of dots rising up the paper. There were several incorrect conclusions about the similarity and differences of the dots.

(c) This was poorly answered. Reference to substances travelling at different speeds was rare. Common incorrect answers involved boiling point or pH. Several answers confused gas chromatography with mass spectrometry thinking that the speed through the column was related to the mass of the molecule.

(d) (i) About half of students chose the correct answer, ‘Is there caffeine in a certain brand of drink?’

(ii) Common correct responses were concerned with opinion or choice or ethical / moral reasons followed by words to the effect that caffeine has different effects on different people. Answers involving the inability to do an experiment were less frequent. Lots of confused responses discussed the labels on the drinks at length.

17 (a) (i) Many students did not know how to carry out the flame test in any detail, although a majority gained at least one mark. A large number of students did not mention a colourless flame or cleaning of the wire. A fair number specifically stated that the safety flame should be used. Some just added the substance to the flame without being in any way specific about how this should be achieved. Others suggested adding the chemical to water, perhaps confusing a flame test with the reactions of alkali metals with water.

(ii) Most students managed to gain both marks although a significant number failed to gain any marks.

(iii) As in previous years, students do not seem to have learned chemical tests. Only a small minority correctly identified potassium chloride. Many students did not appear to realise that their answer should be limited to the three given chemicals, with many random guesses attempted. Students should be encouraged to see questions as a whole rather than as a sequence of unrelated parts.

(b) (i) Despite not having a restricted choice of answers as in part (a)(iii), students fared better in this question, with more than twice as many successfully identifying copper, perhaps due to a familiarity with the blue colour of copper sulfate.

(ii) Again, with only three answers to choose from, less than a third of students did so correctly. The most popular answer was chloride. A knowledge of the chemical tests in the specification is an area that needs attention.

20 This question produced a wide range of responses; some very clearly expressed, others suggesting that the student had not done any practical chemistry of this sort. Nearly half of the responses, however, achieved Level 3 with five or six marks.

There were several routes to identifying the ions and substances. The most popular route was to use the flame test to differentiate the potassium ion (and hence potassium carbonate) from the three sodium compounds, then to carry out the halide test, using nitric acid and silver nitrate, to identify sodium chloride and iodide. Students then assumed that the remaining chemical, which would not produce a precipitate, was sodium carbonate. Some students identified the carbonates as well, using nitric or hydrochloric acid and passing the gas released through limewater.

Most of the other methods chosen were similar, some students starting with the halide test, others with identification of the two carbonates.

Some descriptions were very detailed, explaining why nitric acid was used before adding silver nitrate, while others confused the halide test with that for a sulfate.

The method used for the flame test varied considerably. The most common methods included spraying the solutions in the flame, soaking spills in the solutions before placing in the flame and using nichrome wire or glass rods that had been dipped in the solutions. Some students evaporated the water from the solutions to gain a solid version of the substance. Others just stated that the flame test should be used but did not give a method, which limited their mark to four.

21 (a) A wide spread of responses was seen, as might be expected. In general, the cation tests were better known than the anion tests. Sulfate was the least well known of all. Some students spoiled their halide ion answers by naming them iodine and bromine. Fewer than a quarter knew all six ion results.

(b) The responses to this question were generally poor. A large number of students considered how difficult it would be for them to do the experiments rather than compare the two methods being done by a competent chemist. Therefore they frequently stated that the titration would take a long time and the results would be inaccurate due to the difficulty of recognising the end point in a titration. Students also considered the calculation (instead of the actual method) and gave the response that a titration calculation would be difficult to do and was prone to mistakes, whereas the calculation for the precipitation reaction would be very easy to do. Even students who recognised that some of the precipitate would be lost then sometimes went on to state that this method is more accurate than the titration. In general, the greater speed and accuracy of the titration were the two marks most frequently awarded, with loss of precipitate also mentioned by some students. The other marking points were seldom seen and in general the award of four marks was uncommon and of five marks extremely rare. As with question 4(b), students need to be careful that their responses in respect of each method do not contradict each other.

22 **Foundation**

(a) (i) Reasonably well answered by the majority, with three marks being the most common score. Many students described either effervescence or reduction in size of calcium carbonate in the first test tube and some went on to link this with the evolution of carbon dioxide. More often, though, credit was given for carbon dioxide when it was used as an explanation for the formation of cloudy limewater in the second tube. The least well known feature was that the cloudy observation is caused by a precipitate of calcium carbonate. Some students thought that the limewater would be drawn back into the first tube. A significant minority wrote their responses for the two tubes in the wrong spaces but were given credit if it was clear what was meant.

(ii) Fewer than one in ten of the students could draw the structure of ethanoic acid. Incorrect responses included completion with hydrogen atoms to show ethane, or something completely infeasible.

(iii) Most students had no idea what the catalyst was, so chose a substance they knew was a catalyst from other parts of the specification – usually iron, sometimes nickel. However, ester was known by more, even if often spelled like the female name. ‘Perfume’ and ‘fragrance’ were commonly seen. No credit was available for ether.

(b) Poorly attempted by many. It is clear that students do not know or understand these anion tests. Often a random scatter of white, cream and yellow precipitates were seen, and even flame colour precipitates like lilac and crimson. However, some students at least recognised that water would do nothing in either test.

(c) (i) Nearly one-third of students knew both flame colours.

(ii) This question stretched the powers of expression of many students to the limit. Many inadequate statements such as ‘you can’t see two colours at once’ or ‘only one colour can be seen at a time’ were seen. However, credit was given to those students who thought the colours would mix or blend.

Higher

(a) (i) Reasonably well answered by the majority, with three marks being the most common score. Many students described either effervescence or reduction in size of calcium carbonate in the first test tube and some went on to link this with the evolution of carbon dioxide. More often, though, credit was given for carbon dioxide when it was used as an explanation for the formation of cloudy limewater in the second tube. The least well known feature was that the cloudy observation is caused by a precipitate of calcium carbonate. Some students thought that the limewater would be drawn back into the first tube. A significant minority wrote their responses for the two tubes in the wrong spaces but were given credit if it was clear what was meant.

(ii) Fewer than half of the students could draw the structure of ethanoic acid. A small minority extended the diagram and drew propanoic acid instead. The weaker responses involved completion with hydrogen atoms to show ethane.

(iii) Most students had no idea what the catalyst was, so chose a substance they knew was a catalyst from other parts of the specification – usually iron, sometimes nickel. However, ester was well known, even if often spelled like the female name. No credit was available for ether.

(b) Quite poorly attempted by many. It is clear that students do not know or understand these anion tests. Often a random scatter of white, cream and yellow precipitates were seen, and even flame colour precipitates like lilac and crimson. However, most students recognised that water would do nothing in either test.

(c) (i) Nearly three-quarters of students knew both flame colours.

(ii) This question stretched the powers of expression of many students to the limit. Many inadequate statements such as ‘you can’t see two colours at once’ or ‘only one colour can be seen at a time’ were seen. However, credit was given to those candidates who thought the colours would mix or blend.