C8: Chemical Analysis 1

ANSWER KEY

19.1	In everyday language what is a “pure” substance?	A substance that has had nothing added to it and is in its “natural” state
19.2	In chemistry what is a “pure” substance?	A substance made of a single element or compound
19.3	**How can pure substances be distinguished from impure ones?**	**By their melting/boiling points**
19.4	**Describe the melting and boiling points of pure substances**	**Melt and boil at one very specific temperature e.g. pure water melts at 0°C and boils at 100°C**
19.5	Describe the melting and boiling points of impure substances	They change state over a range of temperatures
19.6	**What is a formulation?**	**A mixture designed as a useful product**
19.7	Give three examples of formulations	Petrol, toothpaste, paints, medicines, alloys, fertilisers and chocolate biscuits
19.8	What is chromatography?	A process to separate the substances in a mixture like coloured inks or dyes
19.9	**In paper chromatography, what is the stationary phase and what is the mobile phase?**	• **paper is the stationary phase** • **solvent (eg. water or ethanol) is the mobile phase**
19.10	**How can chromatography show the difference between pure and impure substances?**	**Pure substances will only show 1 spot**
19.11	**How can you tell how many different substances are in the mixture?**	**Count the number of spots arranged vertically**
19.12	**How is the Rf value calculated?**	**Rf = distance moved by spot / distance moved by solvent**

C8: Chemistry Analysis 2

ANSWER KEY

20.1	What does a substance's Rf value depend on?	How soluble it is in the solvent – more soluble substances move further and have larger Rf values
20.2	**In chromatography, why must the start line be drawn in pencil?**	**Pencil will not dissolve in the solvent**
20.3	Why must the solvent height be below the pencil line?	So that the substances do not dissolve into the solvent without moving up the paper
20.4	**Why might a spot not move from the start line when a solvent is added?**	**It doesn't dissolve in the solvent**
20.5	If a substance is more attracted to the mobile phase, where will it be on the paper?	Further up
20.6	If a substance is more attracted to the stationary phase, where will it be on the paper?	Lower down
20.7	**How can hydrogen be tested for, and what is the correct observation?**	**Test = lit splint Observation = squeaky pop**
20.8	**How can oxygen be tested for, and what is the correct observation?**	**Test = glowing splint Observation = relights**
20.9	**How can carbon dioxide be tested for, and what is the correct observation?**	**Test = bubble through limewater Observation = turns milky/cloudy**
20.10	**How can chlorine be tested for, and what is the correct observation?**	**Test = damp blue litmus paper Observation = bleached white**

C8: Identification of Ions (Triple Content)

ANSWER KEY

1	What is a flame test?	A test to identify metal ions (cations)
2	**How do you carry out a flame test?**	• **dip a metal loop or a wooden splint into the compound** • **place in the blue (hot) flame of a Bunsen** • **observe colour of flame**
3	**What is the colour of the flame produced from compounds containing: lithium, sodium, potassium, calcium, copper**	• **lithium = crimson (deep red)** • **sodium = yellow** • **potassium = lilac (pink)** • **calcium = orange-red** • **copper = green**
4	**Why is it difficult to identify the ions in a mixture using a flame test?**	• **different metals give different colours** • **colours mix and one will mask the other**
5	How is flame emission spectroscopy carried out?	• sample placed in a flame • light emitted is passed through a spectroscope • spectrum is compared to a reference
6	**What are the pros and cons of flame emission spectroscopy over flame tests?**	**Pros = more accurate, more sensitive** **Cons = need specialist equipment**
7	Which solutions produce white precipitates on addition of sodium hydroxide?	Solutions containing aluminium, magnesium or calcium ions
8	**How can a solution of aluminium ions be distinguished from calcium and magnesium ions?**	**Aluminium's precipitate will re-dissolve in excess sodium hydroxide**
9	**What is the colour of the precipitate formed from the addition of sodium hydroxide to a solution containing:** • **copper (II) ions?** • **iron (II) ions?** • **iron (III) ions?**	• **copper (II) ions = blue ppt** • **iron (II) ions = green ppt** • **iron (III) ions = brown ppt**
10	**What is the test for carbonates?**	• **add acid to generate CO_2 gas** • **bubble gas through limewater** • **limewater should go milky/cloudy**

11	**What is the test for halides (group 7 ions)?**	• **add nitric acid then silver nitrate** • **a silver halide precipitate forms**
12	**What are the colours of the silver halide precipitates?**	• **silver chloride = white ppt** • **silver bromide = cream ppt** • **silver iodide = yellow ppt**
13	**What is the test for sulfate ions?**	• **add hydrochloric acid then barium chloride** • **forms white precipitate of barium sulfate**

FOUNDATION TIER

Q1. This question is about mixtures.

(a) Which substance is a mixture? Tick (✓) **one** box.

Air ☐ Gold ☐ Methane ☐ Nitrogen ☐

(1)

(b) Food colourings are often mixtures of dyes.

What name is given to mixtures that are designed as useful products?

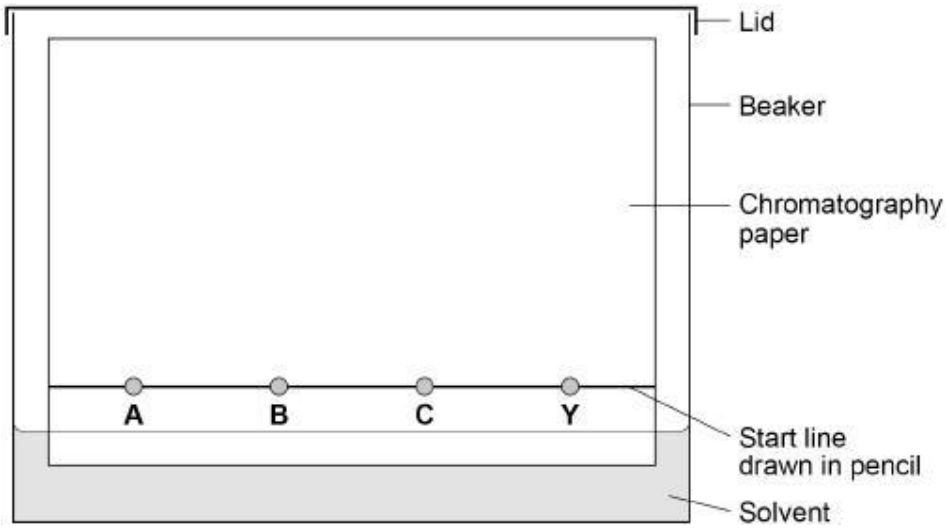
_____

(1)

A student investigated a purple food colouring, **Y**, using chromatography.

The student compares **Y** with dyes **A**, **B** and **C**.

(c) **Figure 1** shows the apparatus used.



Chromatography involves a stationary phase and a mobile phase.

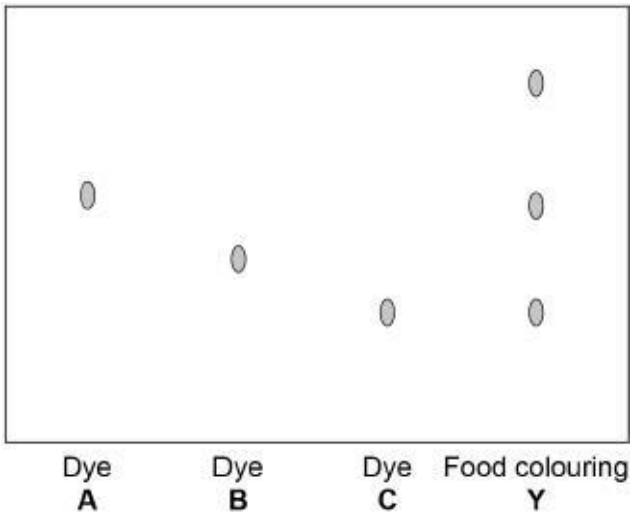
Draw **one** line from each phase to what is used for that phase. Use **Figure 1**.

Phase	What is used
	Beaker
Mobile phase	Chromatography paper
	Food colouring
Stationary phase	Pencil line
	Solvent

(2)

Figure 2 shows the student's results.

Figure 2



(d) What **three** conclusions can you make about the dyes in food colouring **Y**?

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(e) In a different experiment a student recorded these results:

Distance moved by dye **G** = 60 mm
Distance moved by solvent = 80 mm

Calculate the R_f value of dye **G**.

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

_____

_____

_____

_____

R_f = _____

(2)

(Total 9 marks)

Q2. This question is about the Earth's resources.

When most fuels burn carbon dioxide is produced.

Propane (C_3H_8) is a fuel.

(a) Balance the equation for the combustion of propane.

$$C_3H_8 + \_\_\_\_\_ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

(1)

(b) Describe the test for carbon dioxide.

Give the result of the test.

Test _____

Result _____

_____

(2)

(c) Propane can be cracked to produce propene and hydrogen.

Complete the symbol equation for the reaction.

$$\underset{\text{propane}}{C_3H_8} \rightarrow \underline{\qquad\qquad} + \underset{\text{hydrogen}}{H_2}$$

propene

(1)

(d) Describe the test for hydrogen.

Give the result of the test.

Test _____

Result _____

_____

(2)

(e) Propene is an alkene.

Describe the test for alkenes.

Give the colour change in the test.

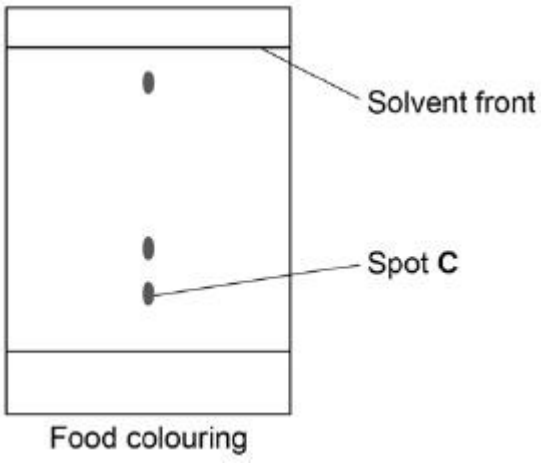
Test _____

Colour change _____ to _____

(3)

(Total 9 marks)

Q3. The diagram shows a chromatogram for a food colouring.



(a) How does the chromatogram show that the food colouring is a mixture?

_____

_____

(1)

(b) A student makes measurements for spot **C**.

The table shows the results.

	Distance in mm
Distance moved by spot **C**	7
Distance moved by solvent	39

Calculate the R_f value for spot **C**.

Give your answer to 2 significant figures.

Use the results in the table.

R_f value = _____

(3)

(c) Plan a chromatography experiment to investigate the colours in an ink.

(6)

(Total 10 marks)

HIGHER TIER

Q4. This question is about chromatography of food colouring.

(a) Food colouring is a formulation.

What is a formulation?

_____

_____

(1)

(b) Explain how paper chromatography separates the dyes in a food colouring.

Do **not** give details of how to do the experiment.

_____

_____

_____

_____

(2)

(c) Explain how the student could tell from the chromatogram that the food colouring contained more than one dye.

_____

_____

_____

_____

(2)

(d) Explain how the student could use chromatography to identify unknown dyes in the food colouring.

_____

_____

_____

_____

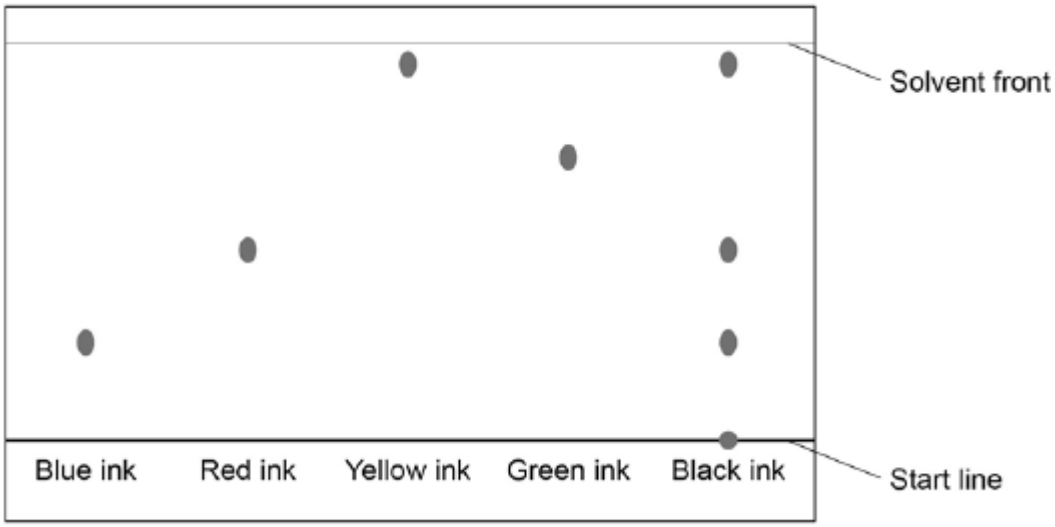
_____

_____

(3)

(Total 8 marks)

Q5. The figure below shows a paper chromatogram of five different inks.



(a) Explain how paper chromatography separates substances.

(3)

(b) Analyse the chromatogram. Describe and explain the result for black ink.

(4)

(c) Use the figure above to calculate the R_f value of the blue ink.

_____

_____

_____

_____

R_f value = _____

(3)

(Total 10 marks)

SEPARATE SCIENCE

Q6. This question is about chemical analysis.

A student tested copper sulfate solution and calcium iodide solution using flame tests.

This is the method used.

1. Dip a metal wire in copper sulfate solution.
2. Put the metal wire in a blue Bunsen burner flame.
3. Record the flame colour produced.
4. Repeat steps 1 to 3 using the same metal wire but using calcium iodide solution.

(a) What flame colour is produced by copper sulfate solution?

_____

(1)

(b) Calcium compounds produce an orange-red flame colour.

The student left out an important step before reusing the metal wire.

The student's method did **not** produce a distinct orange-red flame colour using calcium iodide solution.

Explain why.

_____

_____

_____

_____

(2)

(c) The student added sodium hydroxide solution to:

- copper sulfate solution
- calcium iodide solution.

Give the results of the tests.

Copper sulfate solution _____

_____

Calcium iodide solution _____

_____

(2)

(d) To test for sulfate ions the student added dilute hydrochloric acid to copper sulfate solution.

Name the solution that would show the presence of sulfate ions when added to this mixture.

_____

(1)

(e) To test for iodide ions the student added dilute nitric acid to calcium iodide solution.

Name the solution that would show the presence of iodide ions when added to this mixture.

Give the result of the test.

Solution _____

Result _____

_____

(2)

(Total 8 marks)

Q7. This question is about lithium carbonate. Lithium carbonate is used in medicines.

The figure shows a tablet containing lithium carbonate.

(a) Lithium carbonate contains lithium ions and carbonate ions.

A student tested the tablet for lithium ions and for carbonate ions.

The student used:

- a metal wire
- dilute hydrochloric acid
- limewater.

Plan an investigation to show the presence of lithium ions and of carbonate ions in the tablet.

You should include the results of the tests for the ions.

(6)

(b) The tablet also contains other substances.

The substances in tablets are present in fixed amounts.

What name is given to mixtures like tablets?

_____

(1)

(c) The tablet has a mass of 1.20 g and contains 700 mg of lithium carbonate.

Calculate the percentage by mass of lithium carbonate in this tablet.

_____

_____

_____

_____

Percentage by mass of lithium carbonate = _____%

(3)

(Total 10 marks)

Q8. Potash alum is a chemical compound.

The formula of potash alum is $KAl(SO_4)_2$

(a) Give a test to identify the Group 1 metal ion in potash alum.

You should include the result of the test.

Test _____

_____

Result _____

_____

(2)

(b) Name **one** instrumental method that could identify the Group 1 metal ion **and** show the concentration of the ion in a solution of potash alum.

_____

_____

(1)

A student identifies the other metal ion in potash alum.

The student tests a solution of potash alum by adding sodium hydroxide solution until a change is seen.

(c) Give the result of this test.

_____

_____

(1)

(d) This test gives the same result for several metal ions.

What additional step is needed so that the other metal ion in potash alum can be identified?

Give the result of this additional step.

Additional step _____

_____

Result _____

_____

(2)

(e) Describe a test to identify the presence of sulfate ions in a solution of potash alum.

Give the result of the test.

Test _____

_____

_____

Result _____

_____

_____

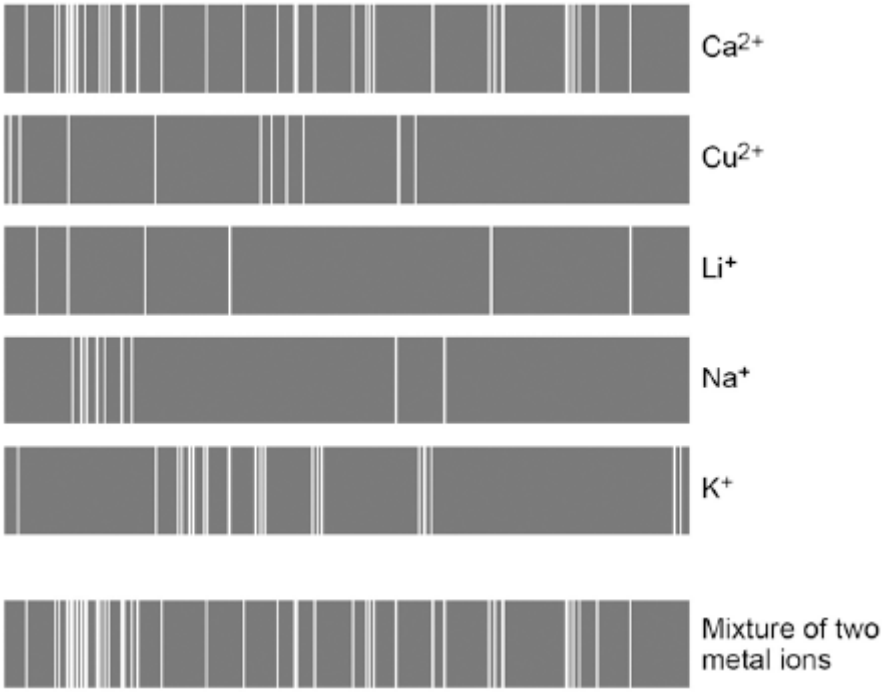
(3)

(Total 9 marks)

Q9. 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



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

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(c) 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 8 marks)

Mark schemes

Q1.

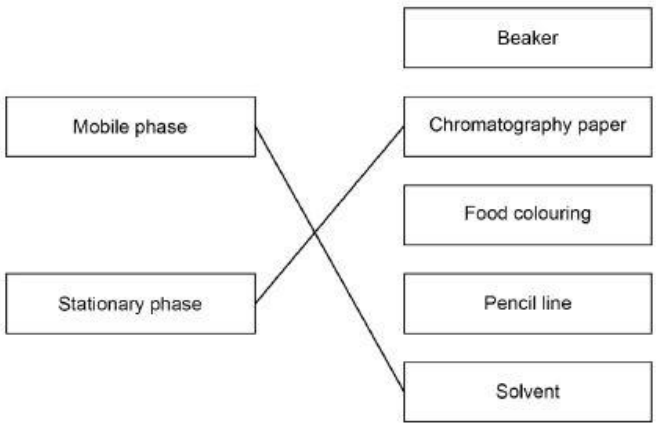
(a) air

1

(b) formulation(s)

1

(c)



1

additional line from a box on the left negates the mark for that box

1

(d) *allow colour for dyes*

Y contains 3 dyes

1

Y contains 2 known dyes

*allow **Y** contains **A** and **C***

1

Y contains an unknown dye

*allow **Y** does not contain dye **B***

1

alternative approach:

Y contains 3 dyes (1)

Y contains 1 known dye (1)

*allow **Y** contains dye **C***

Y contains 2 unknown dyes (1)

*allow **Y** does not contain dyes **A** and **B***

(e)

$(R_f =) \frac{60}{80}$

1

= 0.75

ignore units

1

[9]

Q2.

(a) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

allow multiples

1

(b) *MP2 is dependent upon correct response in MP1*

(bubble gas through) lime water

allow (bubble gas through) calcium hydroxide (solution)

1

turns milky / cloudy / white **or** white precipitate forms

1

(c) C_3H_6

1

(d) *MP2 is dependent upon correct response in MP1*

burning / lit splint

*allow flame but do **not** accept **glowing** splint*

1

burns with a (squeaky) pop sound

allow pops

1

(e) bromine (water)

*do **not** accept bromide*

1

(colour change) orange*

1

(to) colourless*

**allow 1 mark for colourless (to) orange*

ignore clear

1

[9]

Q3.

(a) more than 1 dot in a vertical line

1

(b) correct equation and substitution 7/39

accept R_f = distance moved by spot C / distance moved by solvent

1

calculation and answer 0.1795

1

answer to 2 significant figures 0.18

1

(c)

Level 3: The plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5-6
Level 2: The plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3-4
Level 1: The plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1-2
No relevant content	0
Indicative content • put dots of known colours, and a dot of the ink on a pencil line on the chromatography paper.	

• place the bottom of the paper in water, making sure the start line is above the water • leave for solvent to rise up through paper. • when solvent near top of paper, remove and leave to dry. • compare positions of dots for known colours with those from ink	

6

[10]

Q4.

(a) a mixture designed as a useful product

1

(b) dyes distributed differently between the stationary and mobile phase

allow dyes have different solubilities

allow dyes have different forces of attraction for stationary phase

allow dyes have different forces of attraction for mobile phase

allow dyes have different forces of attraction to the paper

allow dyes have different forces of attraction to the solvent

1

(so dyes) move up the paper at different speeds / rates

allow (so dyes) move different distances up the paper

ignore references to time

1

(c) (because chromatogram has) different dots / colours

1

in a (vertical) column

allow above the (original) spot

1

(d) run known dyes and food colouring (as a chromatogram)

1

compare distances moved **or** compare R_f values

(so) can identify those that move the same distance as known dyes

allow (so) can identify those that move different distances as unknown dyes

or

(so) can identify those that have the same R_f values as known dyes

allow (so) can identify those that have different R_f values as unknown dyes

1

[8]

Q5.

(a) mobile phase / solvent moves through paper

1

and carries substances different distances

1

which depend on their attraction for paper and solvent

allow which depend on solubility in solvent and attraction to paper

1

(b) **Level 2 (3–4 marks):**
A relevant and coherent description which provides a clear analysis of the chromatogram. The response makes logical links between the points raised and uses sufficient examples
to support these links.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic attempt to analyse the chromatogram. The response may fail to make logical links between the points raised.

0 marks:
No relevant content

Indicative content

- black ink is a mixture
- because more than one spot
- contains blue, red and yellow
- because Rf values / positions match
- does not contain green
- contains an unknown
- which is insoluble
- yellow is most soluble or has highest Rf value, blue is least

4

(c) both measurements from artwork for **1** mark (1.3 ± 0.1 cm and 5.3 ± 0.1 cm)

1

correct equation used for **1** mark

1

0.25 ± 0.02

1

*accept 0.25 ± 0.02 without working shown for **3** marks*
*allow ecf from incorrect measurement to final answer for **2** marks*

[10]

Q6.

(a) green

allow blue-green

1

(b) did not clean the metal wire (between tests)

or
copper sulfate (solution) is still present

1

(so) colours are mixed / blended / masked

1

(c) (copper sulfate solution) blue precipitate
allow blue solid

1

(calcium iodide solution) white precipitate
allow white solid

1

(d) barium chloride (solution)
allow barium nitrate (solution)

1

(e) silver nitrate (solution)

1

yellow precipitate
allow yellow solid
allow pale yellow precipitate / solid

1

[8]

Q7.

(a) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

lithium:
- crush tablets or dissolve tablet (in water or acid)
- clean wire
- place on wire
- place in (roaring / blue / non-luminous) flame
- observe flame colour
- crimson flame

carbonate:
- add hydrochloric acid
- effervescence / fizzing

- bubble gas through limewater
- limewater becomes cloudy

(b) formulation(s)

1

(c)

*an answer of 58.3333333 (%) correctly rounded to at least 2 significant figures scores **3** marks*

1.20 g = 1200 mg
or
700 mg = 0.700 g

1

$\frac{700}{1200} \times 100$ **or** $\frac{0.700}{1.20} \times 100$

allow correct use of incorrectly or not converted values from step1

1

= 58.3 (%)

allow 58.3333333 (%) correctly rounded to at least 2 significant figures

1

[10]

Q8.

(a) flame test

allow description of flame test

1

lilac (flame)

1

(b) flame emission spectroscopy

1

(c) white precipitate

ignore precipitate dissolves

1

(d) (add) excess sodium hydroxide (solution)

allow (add) more sodium hydroxide (solution)

1

precipitate dissolves

1

(e) add barium chloride (solution)

allow add barium nitrate (solution)

1

add (dilute) hydrochloric acid

allow add (dilute) nitric acid

1

white precipitate

dependent on MP1 being awarded

1

[9]

Q9.

(a) calcium ions *allow Ca^{2+}*

1

sodium ions *allow Na^{+}*

1

(b) 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

(c) (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

[8]