1. Rachael has some solids without labels.

Rachael does some tests to find out what ions the solids contain.

She thinks the solids contain copper ions and chloride ions.

Draw straight lines to connect each **ion** with the correct **test and result.**

Ion	Test and result
	dilute sodium hydroxide gives a brown precipitate
chloride	dilute sodium hydroxide gives a green precipitate
copper	dilute sodium hydroxide gives a blue precipitate
	dilute silver nitrate gives a white precipitate
	dilute barium nitrate gives a yellow precipitate
	dilute barium sulfate gives carbon dioxide gas

[2]

2. Abi does some tests to find out which metal ions are in some other samples of mining waste, samples **A, B** and **C**.

She adds dilute sodium hydroxide, NaOH, to a solution of the metal ions.

These are her results.

Mining waste sample	After adding a few drops of NaOH	After adding excess NaOH
A	white precipitate	precipitate dissolves
B	blue precipitate	no further change.
C	no precipitate	

What conclusions can Abi make about the metal ions in the mining waste?

---

[3]

3. Joe collects some samples of three minerals, **A**, **B** and **C**.

He thinks the minerals contain compounds of Group 1 elements.

He looks up the flame colours for some Group 1 elements.

Element	Flame colour
lithium	red
sodium	yellow-orange
potassium	pale purple
rubidium	purple

He does a flame test on each mineral.

These are his results.

Mineral	Flame colour
A	yellow-orange
B	purple
C	green

Write down what conclusions you can make about which elements each mineral contains and explain why there is not enough information to identify all of the elements in the minerals.

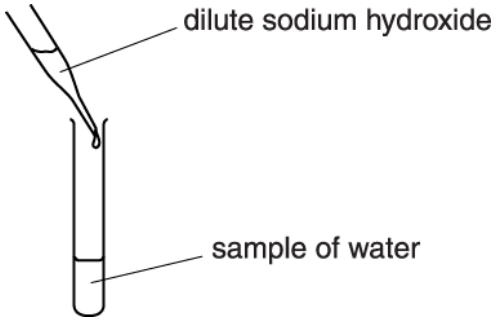
The quality of written communication will be assessed in your answer.

[6]

4(a). Joe investigates water that contains calcium ions.

Joe knows that dilute sodium hydroxide can be used to show if water contains calcium ions.

He tests a sample of pure water and a sample of water that contains calcium ions.



Describe what Joe sees when he adds excess sodium hydroxide to each sample of water.

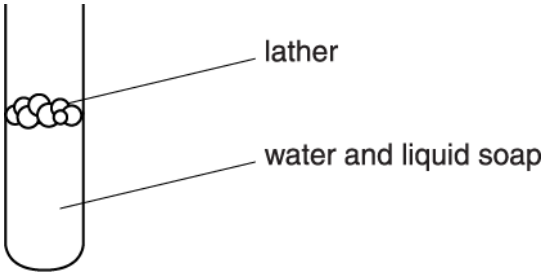
Use the data sheet on page 2 to help you.

---

[3]

(b). Joe finds out that adding liquid soap to water gives a 'lather'.

A lather is a layer of bubbles on the water.



Joe counts how many drops of soap he needs to make a lather with pure water and with water that contains calcium ions.
He also tests samples of water from different places.

(i) What must Joe keep the same to make his experiment a fair test?

---

[1]

(ii) These are Joe's results.

Type of water	Pure water	Water containing calcium ions	Water from London	Water from Birmingham	Water from Plymouth
Number of drops of soap to make a lather	3	18	17	11	4

What conclusions can Joe make from his results?

The quality of written communication will be assessed in your answer.

---

[6]

5(a). Alex plans to write an article about flame colours for a school science magazine.

He researches the flame colours of some compounds of metals from Group 1 in the Periodic Table.
He talks about his findings with other science students in an internet chat room.

Alex Hi everyone. Have any of you done any research into flame test colours for Group 1? I have found out that potassium and rubidium both give purple flames. I think that each group has its own flame colour.

Bea I've checked out your research and I agree about the flame colours for potassium and rubidium. I just looked up caesium and that's purple too!

Carl I flame-tested some Group 2 elements, none of them were purple. They were all different colours.

Dan Sodium is in Group 1 and gives a yellow flame.

Elly I've looked on the internet and I can't find any elements that give purple flame colours except the ones in Group 1.

Fay Lithium doesn't have a purple flame.

Why is it a good idea for Alex to chat to other students about his work before he writes his article?

---

[2]

(b). Alex's ideas are that in flame tests:

- all the elements in a group of the Periodic Table have the same flame colour
- each group has its own flame colour.

Explain how each piece of evidence in the chat **supports** or **does not support** Alex's ideas.

The quality of written communication will be assessed in your answer.

[6]

6(a). Caesium is an element. Compounds of caesium are found in some minerals.

Ben looks at a table of flame colours for different elements.

Element	Flame colour
caesium	blue
barium	green
calcium	red
copper	blue
potassium	purple
sodium	yellow

Ben does a flame test on a mineral to find out if it contains caesium.

Describe how to do a flame test.

--- [2]

(b). After doing his test, Ben writes this note.

> The flame colour was blue.
>
> I am sure that the mineral does not contain calcium or sodium.
>
> I am not sure whether it contains caesium.

(i) Explain why Ben is sure that the mineral does **not** contain calcium or sodium.

--- [2]

(ii) From his results, Ben cannot be sure whether the mineral contains caesium.

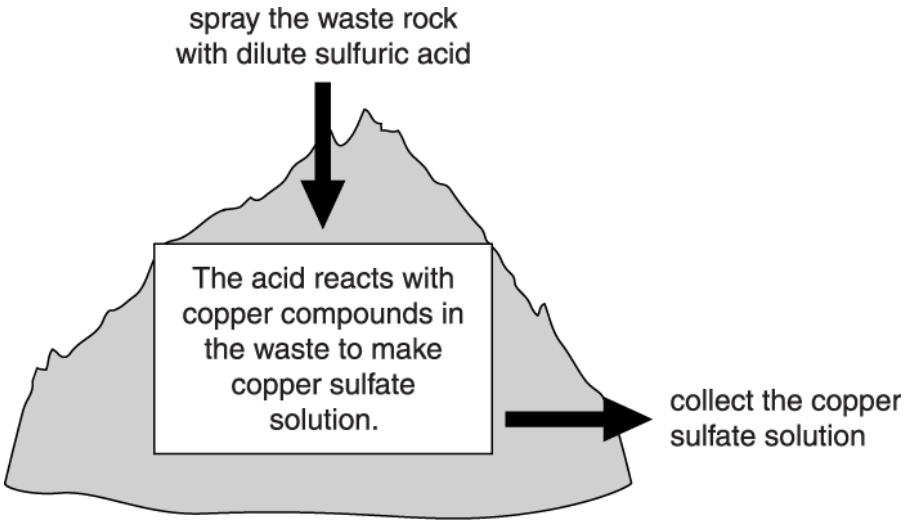
Explain why.

--- [2]

7. Mining copper produces large amounts of waste rock.

The waste rock still contains some copper.

A new process uses dilute sulfuric acid to extract this copper from the waste rock.



Use the data sheet on page 2 to help you answer these questions.

A scientist tests the solution to check that it contains copper sulfate.

(i) He adds dilute sodium hydroxide to test for copper ions.

What does the scientist see if the solution contains copper ions?

_____

_____ [2]

(ii) What does the scientist add to test for sulfate ions?

What result does he expect?

test _____

result _____

[2]

8. Alex has a solution of ammonium sulfate.

(i) Alex uses barium chloride solution to show that the solution contains sulfate ions.

Describe what Alex sees **and** name the substance formed.

Alex sees ----------

Name of substance formed ----------

[3]

(ii) Alex wants to make **solid** ammonium sulfate from the solution of ammonium sulfate.

What would Alex do first?

Tick (✓) **one** box.

Distil the solution. ☐

Evaporate the solution. ☐

Filter the solution. ☐

Use chromatography. ☐

[1]

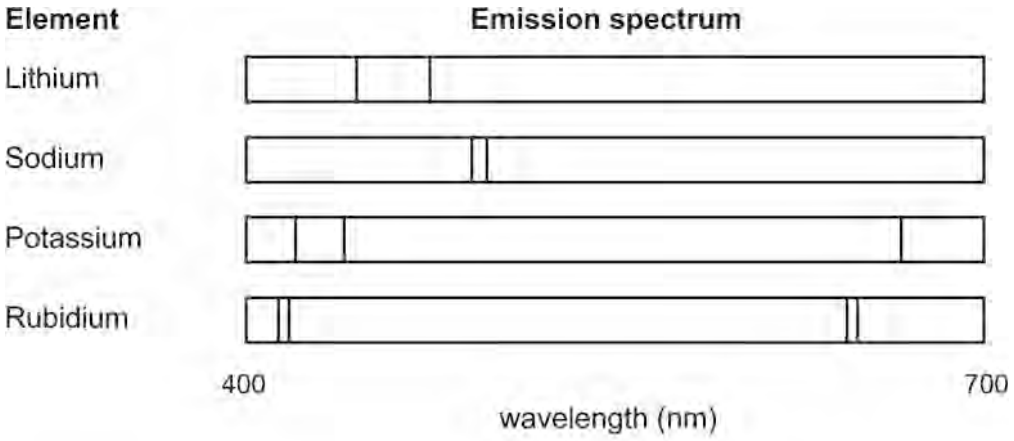
9(a). Salt that is used for food contains compounds of Group 1 elements.
One type of food salt is called 'Healthy salt'.

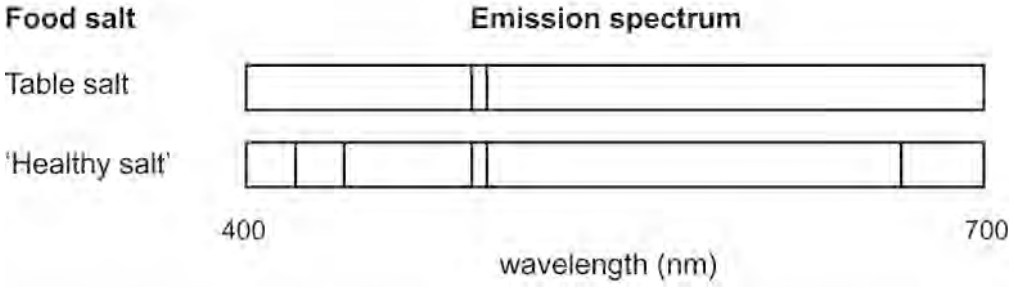
Ben wants to find out what the difference is between table salt and 'Healthy salt'.

He does some experiments to find the emission spectra of some Group 1 elements. He also does experiments to find the emission spectra of table salt and 'Healthy salt'.

He puts small samples of each element and salt in a spectroscopy machine and looks at the printout of results.

Here are Ben's results.





What conclusions can you make about the elements that table salt and 'Healthy salt' do and do not contain? Explain how the lines in both emission spectra support your conclusions.

[6]

(b). Elements in salts can also be identified using chemical tests.

Each test involves adding chemicals to the salts and looking for colour changes or reactions.

Ben thinks that spectroscopy is a better method to use to identify the elements.

What are the **advantages** and **disadvantages** of using spectroscopy rather than chemical tests to identify elements?

[3]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			copper → dilute sodium hydroxide gives a blue precipitate ✓ chloride → dilute silver nitrate gives a white precipitate ✓	2	
			Total	2	
2			A contains zinc (ions) ✓ B contains copper (ions) ✓ C does not contain any (identifiable) metal ions ✓	3	
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
3			[Level 3] Makes correct statements about **all** three minerals AND explains why there is not enough information to identify B/C. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Makes correct statements about **all** three minerals OR Explains why B/C cannot be identified Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Makes a correct statement about the element in **two** minerals. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to E Indicative scientific points may include: Statements about elements in the minerals • A contains sodium • B contains potassium/rubidium • C – can't tell idea/other metal ion suggested • None of the minerals contain lithium • green colour may indicate copper/barium • C is not a group 1 element Explanation • potassium and rubidium have the same colour flame/can't tell the difference • Green colour is not in table • Idea of needs a reference for the green colour Use the L1, L2, L3 annotations in RM Assessor; do not use ticks. Examiner's Comments Most candidates who attempted the extended writing question 2 were able to identify sodium and rubidium in minerals A and B although some concentrated only on reasons for not being able to identify the elements, frequently not referring to the flame colours at all. There were some good responses that went on to explain the problems with identifying the element in mineral C due to the absence of a green flame in the table although some thought that a green flame must mean chlorine or a mixture of two other flame colours.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
4	a		(water containing calcium ions) gives a white precipitate (1) which does not re-dissolve / doesn't dissolve (1) pure water does not give a precipitate / no change (1)	3	Examiner's Comments Few candidates gained all three marks, but most were able to select the correct result of a test for calcium ions. Most candidates failed to explain that pure water would show no change.
	b	i	volume / amount of water / temperature of water / type of soap / concentration of soap solution / drop size	1	Apply list principle **ignore** references to time Examiner's Comments This was generally answered well, with many candidates offering a number of good responses such as type of soap and size of drops. Number of drops of soap was the most common incorrect response.
		ii	**Level 3 (5–6 marks)** Makes a comparison that links cities with concentration / amount of calcium ions OR makes a comparison that links the concentration of calcium ions to how much soap is needed. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Makes a simple conclusion. Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** Selects information from the table. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to E** **Indicative scientific points may include:** **Makes comparisons** • The higher the concentration of calcium ions the more soap needed • London water contains **more** calcium ions • Birmingham does not contain as many calcium ions as London / more than Plymouth • Plymouth water contains few calcium ions (**allow** no calcium ions) **Makes simple conclusions** • Water with calcium ions needs a lot of soap to make a lather • Pure water needs a little soap to make a lather • Birmingham / London need a lot of soap to make a lather • Plymouth water only needs a small amount of soap • Different waters need different

Question			Answer/Indicative content	Marks	Guidance
					amounts of soap • London water needs similar amount of soap to water that contains calcium ions Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This six-mark extended-writing question was well-answered by many who achieved at least four marks demonstrating the ability to draw conclusions. The best responses were those that linked the concentration of calcium ions to the number of drops of soap. Weaker responses linked purity to geographical location – purer the further south you go or the nearer the sea / or related to the dirt and pollution of big cities. A few candidates lost marks because they discussed time taken to lather as opposed to number of soap drops.
			Total	10	

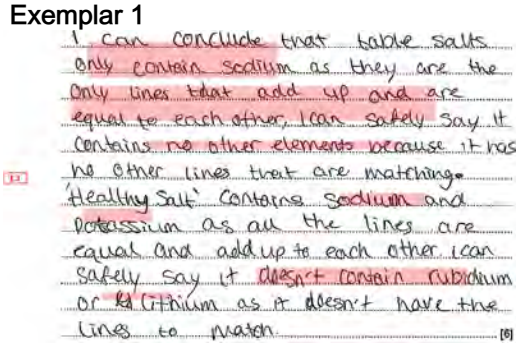
Question			Answer/Indicative content	Marks	Guidance
5	a		getting more data / information (1) checking Alex's results / peer assessment / comparing results / idea that other people may or may not agree / if others agree it is more likely that he is right (1)	2	Examiner's Comments Very few candidates were able to achieve both marks for this question; most got a mark for the idea of comparing results, or checking results, but most did not appreciate the idea of more data.

Question			Answer/Indicative content	Marks	Guidance
	b		**Level 3 (5–6 marks)** Explains points linked to support and a point linked to lack of support for Alex's idea OR a point linked to support and points linked to lack of support for Alex's idea. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Identifies a point linked to support AND a point linked to lack of support for Alex's idea. Points may be identified by person's name only. Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** Identifies a point linked to support or lack of support for Alex's idea. Points may be identified by person's name only. Links may not be emphatically stated. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted at grades up to C Indicative scientific points may include: Points that support Alex's Ideas • K and Rb give purple flames (Bea) / two people have got the same colours for K and Rb (Alex and Bea) • Cs also gives a purple flame (Bea) / Cs is also in Group 1 • Group 2 elements don't give purple flames (Carl) • No other elements except group 1 have purple flames (Elly) • Bea / Elly / (partly) Carl support Alex's ideas (insufficient at level 3) Points that do not support Alex's ideas • Na gives a yellow flame / not a purple flame / Na is in group 1 (Dan) • Li does not give a purple flame (Fay) / Li is in group 1 • Elements in Group 2 all have different coloured flames (Carl) • Fay / Dan / (partly) Carl do not support Alex (insufficient at level 3) Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This six-mark extended-writing question was well answered by many candidates, and even those who struggled with extended writing were prepared to attempt the question; often achieving over three marks. The best responses were those where candidates had clearly stated the evidence supporting or not supporting Alex, and also the name of those students who had found the evidence for their claims. Some only achieved level 1 marks because their evidence only supported or disagreed with Alex without balance to the discussion.

Question			Answer/Indicative content	Marks	Guidance
			Total	8	
6	a		heat / use a (Bunsen) flame (1) *Plus one from:* (mineral) on a wire / spill / spray etc; (1) use a small amount; (1) Look at the colour / compare the colour / see if it's blue (1)	2	Examiner's Comments There was occasional confusion with putting the element in water rather than putting the mineral into a flame and looking at flame colour. A few candidates suggested using flame for pop test (hydrogen) but generally they had the right idea.
	b	i	calcium would give a red flame; (1) sodium would give a yellow flame (1)	2	**allow** flame is not red or yellow for 2 marks **allow** flame would not be blue for 1 mark Examiner's Comments 2 marks were often achieved. The answer 'flame would be a different colour' was insufficient but quite often seen as a response. The flame colours needed to be specific for calcium and sodium.
		ii	*any two from:* blue flame could mean caesium; (1) other metals give blue colour / copper gives blue colour; (1) some other colours difficult to see / difficult to tell green or purple from blue. (1)	2	**allow** caesium and copper would give the same colour for 1 mark Examiner's Comments Candidates generally had the idea that both caesium and copper 'flames ' were blue but did not always say it; responses often referred to elements giving the same colours. A few appreciated that it may be difficult to determine flame colour.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
7		i	blue precipitate; which does not dissolve in excess NaOH;	2	ALLOW blue solid Must be clear that excess NaOH has been used Mark independently Examiner's Comments Most candidates were able to use the data sheet to select appropriate the observations or tests for ions required. Some responses did not give full responses e.g. did not include that the blue precipitate would not dissolve in excess sodium hydroxide and others did not use the data sheet at all.
		ii	(add dilute acid and then) barium chloride / barium nitrate; white precipitate forms;	2	REJECT use of sulphuric acid ALLOW white solid IGNORE cloudy / milky Mark independently
			Total	4	
8		i	White ✓ precipitate/solid ✓ Barium sulfate ✓	3 (AO 1.2 × 2) (AO 2.1)	IGNORE reference to ammonium chloride Examiner's Comments Few candidates appeared to recognise this test. Those candidates who did gain credit often did so by recognising that barium sulfate would be formed.
		ii	Evaporate the solution ✓	1 (AO 1.2)	Examiner's Comments Filter or distil were chosen more frequently than the correct response, evaporate.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
9	a		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Identifies all elements present and not present in both salts and justifies their answer. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Identifies element(s) present in Table Salt and Healthy Salt and identifies at least one element that is absent. OR Identifies element(s) present in Table Salt and Healthy Salt and justifies their answer. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Identifies element(s) present in Table Salt or Healthy Salt OR identifies element(s) not present. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO 4× 3.2b) (AO 2× 3.1b)	**AO3.2b Identifies elements in Table and Healthy Salt** • Healthy salt contains sodium and potassium • Table salt contains sodium • Elements identified quantifiably **AO3.2b Identify elements that Table Salt and Healthy salt do not contain.** • Table salt does not contain potassium • Both salts do not contain lithium • Both salts do not contain rubidium • Healthy salt <u>only</u> contains sodium and potassium • Table salt <u>only</u> contains sodium **AO3.1b Justifies their answer.** • If elements are present lines ‘match’. • Lines are in same pattern / position / wavelength • If element is absent there are no lines matching **Ignore** any comments about how reactive the elements are – or their suitability to be used in food. <u>Examiner’s Comments</u> A good number of candidates showed that they understood how to process the data from the spectra and so identified sodium in table salt and both sodium and potassium in the “healthy salt”. Although it was sometimes implied, many did not state which elements were <u>not present</u> in each. Explanations of how the elements were identified from the spectra were highly variable. Although the question mentions that the salts contain “compounds of group 1 elements” a significant minority of candidates turned to their understanding of the reactivity of each alkali metal element. They then deduced that “healthy salt” was

Question			Answer/Indicative content	Marks	Guidance
					actually very dangerous as potassium was more reactive than sodium. Exemplar 1  I can conclude that table salts only contain sodium as they are the only lines that add up and are equal to each other, I can safely say it contains no other elements because it has no other lines that are matching. 'Healthy salt' contains sodium and potassium as all the lines are equal and add up to each other I can safely say it doesn't contain rubidium or lithium as it doesn't have the lines to match. [6] This answer identifies that 'table salt' contains just sodium and 'Healthy salt' contains sodium and potassium. It also identifies that lithium and rubidium are not present. The answer justifies the claims by saying that the lines of the spectra match up to sodium and potassium but not to lithium and rubidium which shows an understanding of how to identify elements from emission spectra. This answer was Level 3 and credited 6 marks.
	b		**Any three from:** Advantages: automated idea ✓ does not rely on colour / judgement / less human error idea ✓ does not involve handling hazardous chemicals ✓ tests for multiple ions at the same time ✓ Disadvantages: Needs an (expensive) machine ✓ More difficult to interpret lines ✓	3 (AO 1.1) (AO 2.1 ×2)	**For 3 marks must have both advantages and disadvantages** **ALLOW** more accurate / reliable **IGNORE** "quicker" **IGNORE** expensive" by itself Examiner's Comments Even the higher ability candidates found it difficult to compare the two approaches to analysis.

Question			Answer/Indicative content	Marks	Guidance
			Total	9	