1. Metal extraction produces a lot of waste. The zinc ions from this waste could leak into watercourses and contaminate soil. This plant, Alpine Penny-cress, grows on waste heaps that contain toxic zinc ions.

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?

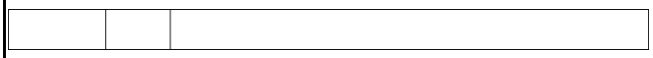
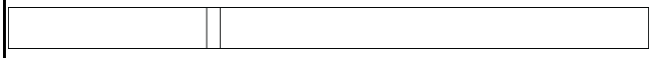
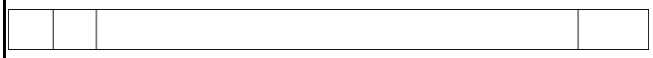
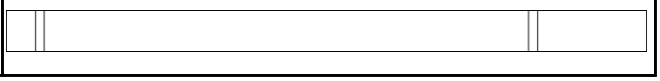
---

[3]

2. Joe collects some samples of a mineral.

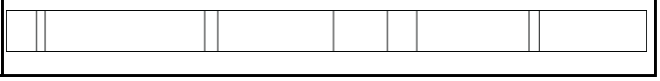
He thinks the mineral contains Group 1 elements.

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

Element	Flame colour	Emission spectrum
lithium	red	
sodium	very strong yellow-orange	
potassium	pale purple	
rubidium	purple	

He does a flame test and records the emission spectrum produced by the mineral.

These are his results.

	Flame colour	Emission spectrum
mineral	yellow-orange	

What conclusions can you make about which elements the mineral **does** and **does not** contain?
Give your reasons and explain why neither the flame test nor the emission spectra data can be used to identify **all** of the elements in the mineral.

[6]

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

3(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.

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]

(b). The students' chat is **not** an example of peer review.

Explain why.

---

[2]

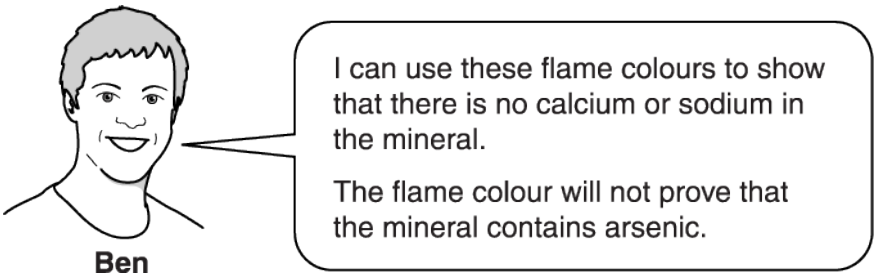
4(a). Arsenic can be used to treat some cancers.

Ben wants to analyse a mineral to see if it contains arsenic.

He looks at a table of flame colours for some elements.

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

Ben talks about what a flame test could show.



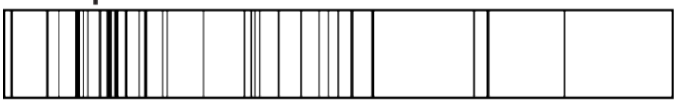
Explain why what Ben says is true.

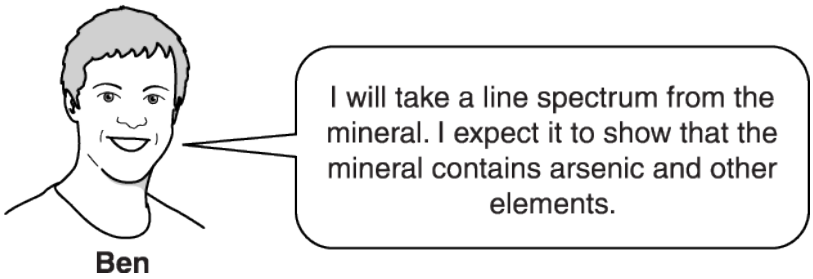
---

[3]

(b). Ben finds an image of the line spectrum of arsenic.

Line spectrum of arsenic





How can Ben use a line spectrum to show that the mineral contains arsenic **and** other elements?

---

[2]

5. People living near a copper mine are worried about the water that runs out of the mine.

They think that the water might contain copper ions or other metal ions.

A scientist tests for metal ions by adding dilute sodium hydroxide to the water.

Why is dilute sodium hydroxide used to test for metal ions?

Put ticks (?) in the boxes next to the **two** correct answers.

Many metal hydroxides are insoluble.	☐
The metals can be identified by the gases given off in the reactions.	☐
Different metal ions react at different rates with sodium hydroxide.	☐
Dilute sodium hydroxide is neutralised by the metal ions.	☐
Precipitates of metal compounds have characteristic colours.	☐

[2]

6. Eve does tests **A**, **B**, **C** and **D** on both dilute hydrochloric acid and dilute sulphuric acid.

1 test pH using a pH meter
2 add magnesium ribbon
3 add a few drops of dilute silver nitrate (see data sheet page 2)
4 add a few drops of dilute barium chloride (see data sheet page 2)

(i) Two tests give the **same** result with both hydrochloric acid and sulfuric acid.

Which two tests give the same result?

What will she **see** when she does each of these tests?

test _____

result _____

---

test _____

result _____

---

[3]

(ii) Two tests give a **different** result with hydrochloric acid and sulfuric acid.

Which two tests give a different result?

What will she **see** when she does each test?

test _____

result for each acid _____

---

test _____

result for each acid _____

_____

[3]

7(a). Jane has a sample of a white powder, compound **A**.

Jane carries out a flame test on compound **A** and sees a lilac flame.

What can Jane conclude about compound **A**?

---

[1]

(b). Jane has a solution of compound **B**, sodium sulfate, Na_2SO_4.

She adds acidified barium chloride solution, $BaCl_2$, to a solution of compound **B**.

(i) What does she **see** when she does this?

---

[1]

(ii) Write a **balanced chemical** equation for the reaction that occurs.

---

[2]

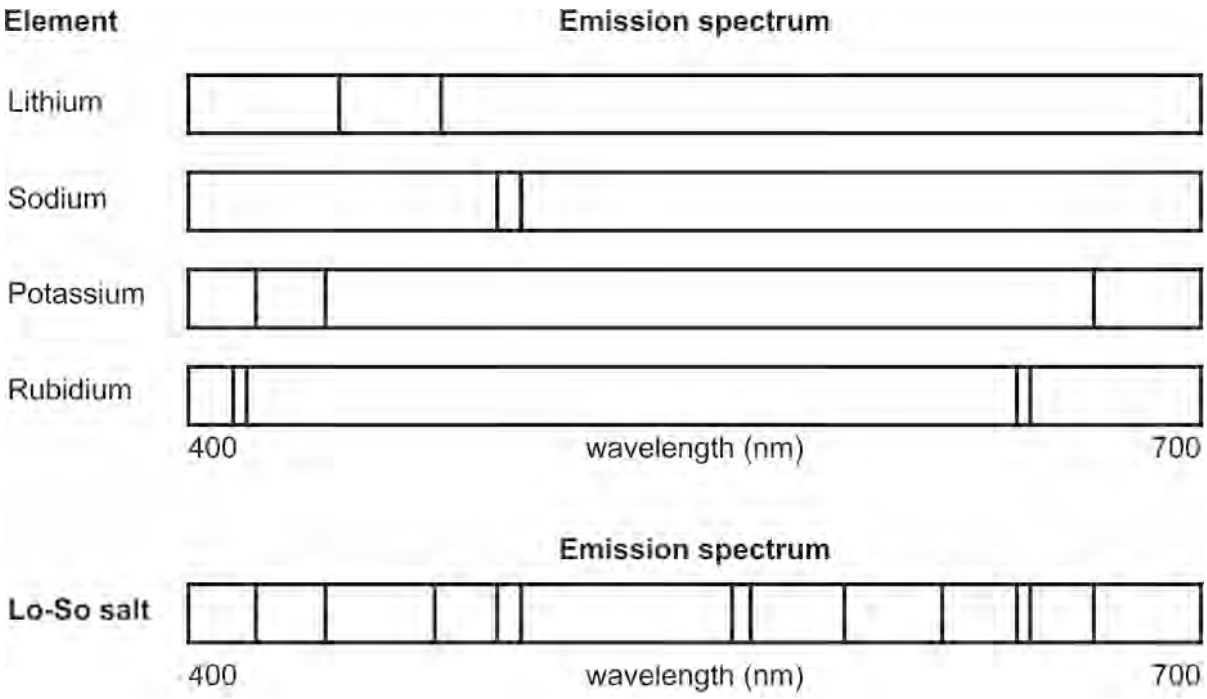
8. A new type of salt for using on food is called ‘Lo-So salt’.

Nina wants to find out what elements ‘Lo-So salt’ contains.

She does some experiments to find the emission spectra of some compounds of Group 1 elements. She also does an experiment to find the emission spectrum of ‘Lo-So salt’.

She puts small samples of each element and the salt in a spectroscopy machine and looks at the print-out of results.

Here are Nina’s results.



Nina says that she thinks she needs to do further experiments to identify all the elements in ‘Lo-So salt’.

State which elements ‘Lo-So salt’ does and does not contain, giving your reasons, and describe what further experiments Nina needs to do to identify all the elements in ‘Lo-So salt’.

---

[6]

9.

Jane has a sample of a white powder, compound **A**.

Jane looks at the emission spectrum of compound **A**.

(i) Describe what an emission spectrum looks like.

---

[2]

(ii) Describe how Jane could use the spectrum to confirm her answer to **(a)**.

---

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			A contains zinc (ions) ✓ B contains copper (ions) ✓ C does not contain any (identifyable) metal ions ✓	3	
			Total	3	
2			[Level 3] Identifies all elements present and absent, with a reason for each and discusses spectrum/ flame test linked to unknown elements. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Identifies whether all four named elements are present/absent in mineral and states some reasons. OR Correctly identifies whether 2 elements are present/absent with reasons and discusses spectrum/flame test linked to unknown element(s). OR Identifies whether all four named elements are present/absent in mineral and discusses spectrum/flame test linked to unknown element(s). Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Correctly identifies whether 2 elements are present/absent with reasons OR identifies whether all four named elements are present or absent with no reasons. OR discusses spectrum/flame test linked to unknown element(s). Quality of written communication impedes communication of the science at this level.	6	This question is targeted at grades up to A/A* Indicative scientific points may include: Elements • mineral contains sodium • mineral contains rubidium • mineral contains other unidentified element(s) • mineral does not contain lithium • mineral does not contain potassium Reasons • Lines/wavelength/frequency/line spectra match for sodium • Lines/wavelength/frequency/line spectra match for rubidium (**Ignore** 'spectrum matches' alone) • No lines/AW match for lithium • No lines/AW match for potassium • sodium colour only shown in flame test Unknown elements • Flame test: other elements 'masked' by strong colour / can't see other colours • Spectrum: Some extra lines indicate unknown element • need spectra of other unknown elements to identify Use the L1, L2, L3 annotations in RM Assessor; do not use ticks. Examiner's Comments This level of response question was not well answered. This was mainly because the question asked for conclusions and explanations. In most cases neither were

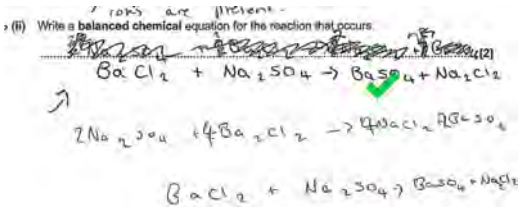
Question			Answer/Indicative content	Marks	Guidance
			(1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)		given fully. The question asked for 'elements the mineral does and does not contain'. Many candidates did not discuss any evidence or conclusions for those elements which were absent. In addition, although most referred in vague terms to 'the spectra' for the elements, the discussion was often only in vague terms. The best answers discussed the relative position of lines in the spectrum. Many candidates did not complete the task; many omitted any discussion of why the spectra data cannot be used to identify all of the elements in the mineral.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
3	a		**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-marks extended-writing question also appeared on the foundation tier paper. Higher tier candidates attempted this question well with the majority of candidates gaining a Level 2 mark or above. Most classified the views of the students correctly as ‘support’ or ‘do not support’ statements. However, the question asked candidates to ‘Explain….’. The most common reason for a lower score was that some candidates listed the statements by the student's name only, rather than explain how the evidence supported Alex's views.

Question			Answer/Indicative content	Marks	Guidance
	b		**Any 2 from:** (Peer review involves…) scientists; checking data / checking results ; checking or repeating methods / experiments / tests ; evaluation of the work / judgment of the work / assessment of the work / checking claims made ; publication / post publication	2	**Allow** reverse argument **Look for idea** of repeating / checking / judging Alex's work **Ignore** answers which refer to looking at 'each other's' work **Ignore** answers which imply checking information from internet or other secondary sources. **Ignore** 'see if they are right' / 'see if they agree' alone **Examiner's Comments** Candidates were very confused about the peer review process. Many implied collegiate work such as people 'doing the same experiment' or 'working together to check findings'. Few candidates clearly expressed the idea that peer review is a formal process carried out by scientists on research that has been made public, for example by publication.
			Total	8	

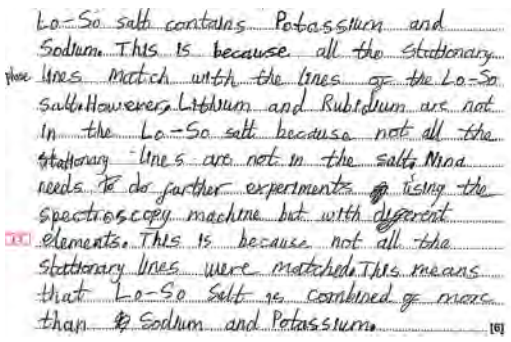
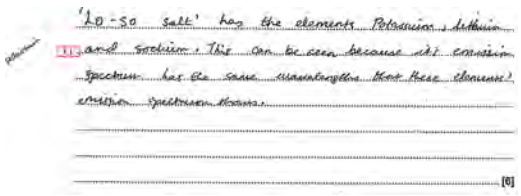
Question			Answer/Indicative content	Marks	Guidance
4	a		**Any 3 from:** idea that if colour is missing then that element is not present / not red then doesn't contain calcium / not yellow doesn't contain sodium; if the flame is blue it might contain arsenic; copper (also) gives blue colour; other elements have similar colours / difficult to tell colours apart idea;	3	**Examiner's Comments** An even spread of marks from 0 to 3 were seen for the question, showing skill at extracting and processing information. The table gave the colours for the flame tests. The skill that was being tested was that candidates needed to show that they could use the information to explain why the statement made by Ben was true. Some candidates copied out relevant information from the table, but did not explain why it supported Ben. So, for example, a list of elements and their flame colours was insufficient to access the available marks.
	b		(If mineral contains arsenic) lines are in the same place / line up / same pattern / each element has its own (unique) spectrum (1) extra lines mean other elements in the mineral (1)	2	**accept** 'lines match' **allow** 'others show different lines' for 'extra lines' **Examiner's Comments** Over half of the candidates did not score any marks here. This was usually due to answers being pitched at too low a level for a higher tier paper. Answers saying that 'the spectrum would look the same as arsenic' were not given credit. The mark scheme demanded that candidates recognised that spectra are compared by the position of their lines or by patterns. Some candidates thought that each element gives a single line in a spectrum, so that each line represents a different element.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
5			Many metal hydroxides are insoluble; (1) Precipitates of metal compounds have characteristics colours; (1)	2	Examiner's Comments Most knew that precipitates have characteristic colours. A common error was to think that the metal ions neutralise the sodium hydroxide.
			Total	2	
6		i	Test A and B; (1) (both) give a low value for pH / pH below 7; (1) (both) react with magnesium ribbon / ribbon 'disappears' / fizz / see a gas; (1)	3	Accept 'hydrogen forms' Examiner's Comments Both parts were poorly answered. Candidates did not seem to know that the pH of all acids are similar or that they would both react with magnesium. Those who did select the correct tests in the correct places usually gained all three marks.
		ii	(Test C and D) because (test C silver nitrate) white precipitate (with HCl or chloride); (1) (test D barium chloride) white precipitate (with H_2SO_4 or sulfate); (1) no precipitate with 'other' acid stated for at least one of the tests / use of the word 'only'; (1)	3	e.g. 'test C gives white ppt with HCl only' = (2) Examiner's Comments For correctly describing the changes they would see. However, over 75% of candidates failed to score in both question parts.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
7	a		(contains) potassium / K ✓	1 (AO 1.2)	
	b	i	White precipitate	1 (AO 1.2)	IGNORE cream
		ii	$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$ correct formula for one product $BaSO_4$/NaCl✓ fully correct equation with balancing ✓	2 (AO 2 × 1.2)	<u>Examiner's Comments</u> Most gave a correct formula for one of the products. **Misconception** Some candidates changed the formula of sodium chloride (which is very familiar to most candidates) in order to balance the equation. Exemplar 5  (ii) Write a balanced chemical equation for the reaction that occurs $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + Na_2Cl_2$ $2Na_2SO_4 + 4BaCl_2 \rightarrow 4NaCl_2 + 2BaSO_4$ $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + NaCl_2$ This answer gains one mark for a correct formula of a product ($BaSO_4$). However, the candidate has attempted to balance the equation by changing the formula of NaCl to Na_2Cl_2. This was a common error. Clearly the candidate knows the formula of sodium chloride, but is not sure how to show that there are two relative formula mass units in the equation.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
8			*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 element(s) present and not present, explains reasons and describes further experiments *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 <u>and</u> not present, and explains reasons *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 <u>and</u> 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× 3.3a)	**AO3.2b Analyses information and ideas to draw conclusions and identify elements in salt** • Present: sodium, potassium and unknown(s) • Not present: lithium, rubidium IGNORE elements incorrectly identified as present or not present at L1 and L2 only **AO3.2b Analyses information and ideas to draw conclusions and explains how they identified elements in salt** • For elements present lines are in same pattern / position / spectra 'match' or 'fit'. • Absent elements there is no match/(only) partial match. • Unknown elements: some lines do not match elements given **AO3.3a Analyses information and ideas to make judgements to describe what further experiments are needed** • Need to find spectra for other elements • Need to match new spectra to spectrum of salt idea • Add sodium hydroxide to test for metal cations / add silver nitrate to test for chlorides / add barium salt to test for sulfate / add acid to test for carbonate / <u>ion</u> chromatography IGNORE elements incorrectly identified as present or not present at L1 and L2 only <u>Examiner's Comments</u> This question has two parts to it. Firstly, candidates need to identify which elements are and are not present. Secondly they have to describe further experiments to show this. As this is a higher demand question, the spectrum was not straightforward. The lines in the spectrum were similar, but not identical to those in

Question	Answer/Indicative content	Marks	Guidance
			lithium. The spectrum had some, but not all of the lines present in rubidium. Most able candidates fully addressed the question, taking care to analyse the spectrum carefully to list the elements present (sodium and potassium) and those absent (lithium and rubidium). They then went on to develop the second part of the task by stating that there are extra, unidentified lines. To identify these elements it would be necessary to do further spectra of known elements to look for a match. Credit was given to candidates who described chemical ion tests rather than using spectroscopy to identify the unknown elements. Candidates who did not reach Level 3 omitted parts of their answer or misinterpreted the spectrum. Some did not describe further experiment. Some did not match the spectra carefully, leading to a statement that either or both lithium and rubidium were present. A relatively common error was to say that, as only some of the lines for lithium and rubidium match, this indicates only small amounts of these elements in the mixture.  **AfL** Candidates should be advised to look carefully at the information given. For a higher tier Level of Response differences in information are likely to be subtle and need careful consideration. Secondly, candidates should take great care to answer all parts of the task for a Level of Response question.

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 8  Lo-So salt contains Potassium and Sodium. This is because all the stationary lines match with the lines of the Lo-So salt. However, Lithium and Rubidium are not in the Lo-So salt because not all the stationary lines are not in the salt. Mina needs to do farther experiments using the spectroscopy machine but with different elements. This is because not all the stationary lines were matched. This means that Lo-So Salt is combined of more than Sodium and Potassium. [6] This answer fully addresses both parts of the question. Although not a 'perfect' answer, (more explanation about how to compare the unknown lines with known spectra could have been added) notice how succinctly and clearly the candidate has addressed the points. 6 marks. Exemplar 9  'Lo-So salt' has the elements Potassium, Lithium and Sodium. This can be seen because the emission spectrum has the same wavelengths that these elements' emission spectrums have. [6] This answer only answers one part of the question (elements present). No elements are identified as absent and no further experiments are described. Also notice the error in identifying lithium as present. However, two elements are correctly identified. This is not a secure match to the Level 1 description; 1 marks.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
9		i	lines ✓ (lines are) coloured / (lines are) on a dark/black background ✓	2 (AO 2 × 1.1)	ALLOW 'series/range of colours' IGNORE 'on a white background'
		ii	Compare/match the spectrum with the known spectrum (of potassium/(ECF answer to (a)) / AW✓	1 (AO 1.2)	Examiner's Comments In both these part questions, candidates knew that colours are seen. Some answers described 'looking at colours' but did not make it clear how emission spectra are different from looking at colours in a flame test. So such answers state 'you would see colours' in (i) and 'you need to match colours' in (ii). Higher ability candidates described how emission spectra show (coloured) lines which can be matched up to reference samples to identify the components of a mixture or element.
			Total	3	