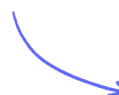


Methods of Identifying Ions

Flame Tests / Metal Hydroxides / Carbonates / Halides / Sulfates / Required
Practical: Identifying Ions / Instrumental Methods / Flame Emission
Spectroscopy

Easy (6 questions)	/35
Medium (7 questions)	/39
Hard (5 questions)	/47
Total Marks	/121

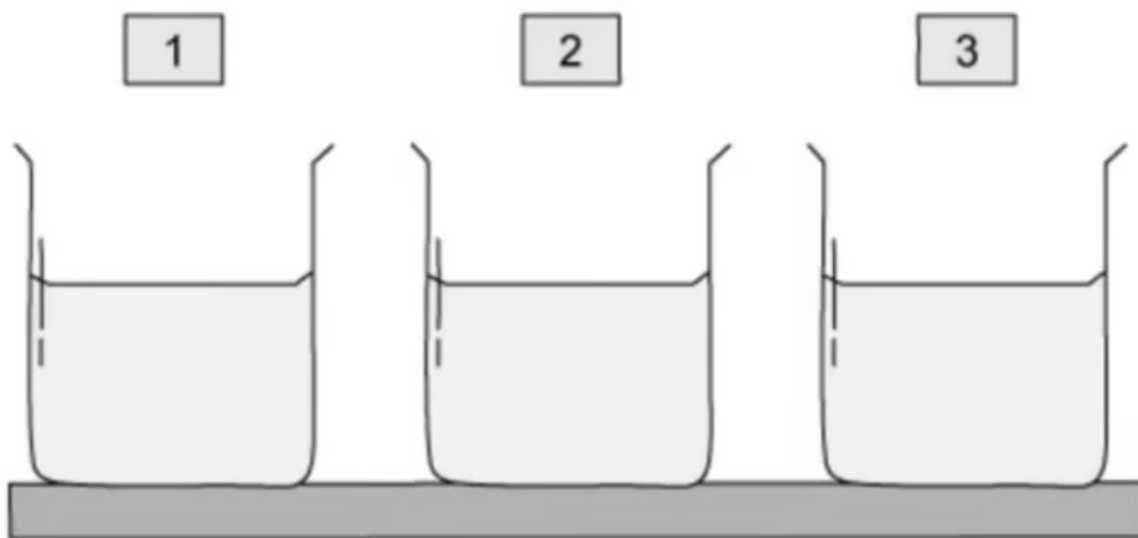
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Easy Questions

1 (a) A student had three different solutions in beakers 1, 2 & 3 as shown in **Figure 1**.

Figure 1



The beakers contained one of the following solutions but the student did **not** know which beaker contained each solution.

- potassium bromide
- calcium sulfate
- copper nitrate

To identify the solutions, the student performed a flame test.

Describe how to carry out a flame test.

.....
..... (2 marks)

(b) The student recorded the flame colour that was observed with the solutions in beakers 1, 2 and 3.

Draw **one** line from each solution to the colour of the flame that it would produce.

Solution	Flame colour
Potassium bromide	Green
Calcium sulfate	Orange-red
Copper nitrate	Lilac
	Yellow
	Crimson

(3 marks)

- (c) The student wanted to confirm the identity of the solutions in beakers **1**, **2** and **3** so performed further tests on the solutions.

They added dilute nitric acid followed by barium nitrate solution to each of the solutions.

Which of the solutions would produce a white precipitate?

Tick (✓) **one** box.

Potassium bromide	
Calcium sulfate	
Copper nitrate	

..... (1 mark)

- (d) The student added dilute nitric acid and silver nitrate solution to each of the solutions.

Which solution would produce a cream precipitate?

Tick (✓) **one** box.

Potassium bromide	
Calcium sulfate	
Copper nitrate	

(1 mark)

- (e) Finally, the student added a few drops of sodium hydroxide solution to each of the solutions.

Which solution would form a white precipitate?

Tick (✓) **one** box.

Potassium bromide	
Calcium sulfate	
Copper nitrate	

..... (1 mark)

- 2 (a)** Solutions containing iron(II) ions, Fe^{2+} , and iron(III) ions, Fe^{3+} , will produce precipitates when sodium hydroxide solution is added to them.

Draw **one** line from the iron ion to the colour of the precipitate formed.

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

(2 marks)

- (b)** Sodium hydroxide solution was added to another solution which contained metal ions.

A white precipitate was formed.

Which of the following ions could **not** be the metal ion.

Tick (✓) **one** box.

Copper	
Magnesium	
Aluminium	
Calcium	

..... (1 mark)

- (c) An excess of sodium hydroxide was added to the solution part b) and the white precipitate dissolved.

Which of the ions is the metal ion in solution?

Tick (✓) **one** box,

Copper	
Magnesium	
Aluminium	
Calcium	

(1 mark)

- (d) More than one metal ion produces a white precipitate that does not dissolve when sodium hydroxide is added in excess.

Suggest a method of distinguishing between these ions.

..... (1 mark)

3 (a) A student wanted to find the identity of different chemical compounds in solution.

Draw **one** line from each of the compounds they tested to the test and corresponding result.

Name of compound in solution	Test and test result
Lithium carbonate	Add dilute hydrochloric acid and barium chloride. A white precipitate forms
Potassium nitrate	Perform a flame test. A lilac flame is produced.
Calcium sulfate	Add dilute nitric acid and silver nitrate. A yellow precipitate forms.
Magnesium iodide	Add hydrochloric acid. Carbon dioxide gas is produced.
	Add an excess of sodium hydroxide solution. Any precipitate formed dissolves.

(4 marks)

(b) The presence of carbon dioxide gas can be determined by a test.

Circle **one** word/ phrase from each box to complete the sentences.

Bubble the gas through

barium chloride. dilute hydrochloric acid. limewater.

If carbon dioxide is present it will

form a yellow precipitate. turn cloudy. form a blue solution.

(2 marks)

(c) Another solution containing copper ions was tested using a flame test.

What colour flame would you expect to see?

..... (1 mark)

4 (a) A student had the three potassium halide solutions shown below:

- potassium chloride
- potassium bromide
- potassium iodide

What should they add to the solutions to identify each of these solutions?

Tick (✓) **one** box.

Dilute hydrochloric acid followed by barium chloride	
Dilute nitric acid followed by barium nitrate	
Dilute hydrochloric acid followed by silver nitrate	
Dilute nitric acid followed by silver nitrate	

(1 mark)

(b) When tested with the correct reagent, halides produce distinctive coloured precipitates which can be used to distinguish them from each other.

Draw **one** line from each of the potassium halide solutions to the colour of the precipitate it forms.

Solution	Precipitate colour
Potassium chloride	Green
Potassium bromide	White
Potassium iodide	Blue
	Yellow
	Cream

(3 marks)

(c) The student also had a solution of potassium carbonate.

What could they add to this solution to identify the carbonate ion?

What would they observe?

They should add _____.

They would observe _____.

(2 marks)

(d) The student could perform a flame test to confirm the presence of potassium ions in the solution in part c).

What colour flame would be seen?

Tick (✓) **one** box.

Orange-red	
Blue	
Lilac	
Yellow	

..... (1 mark)

5 (a) Instrumental analysis can be used to analyse elements and compounds.

Give **two** advantages of using instrumental analysis over chemical tests.

.....
..... (2 marks)

(b) Flame emission spectroscopy is an example of an instrumental method that can be used to analyse metal ions in solution.

Circle a word/phrase in each box to complete the sentences below.

The sample to be tested is put into a

flame.
solution.
beaker.

The light given out is put through a

mass spectrometer.
spectroscope.
coloured filter.

The output is called a line

graph.
chromatogram.
spectrum.

..... (3 marks)

(c) In addition to being able to identify the metal ions in solution, what other piece of information can flame emission spectroscopy tell us about the sample?

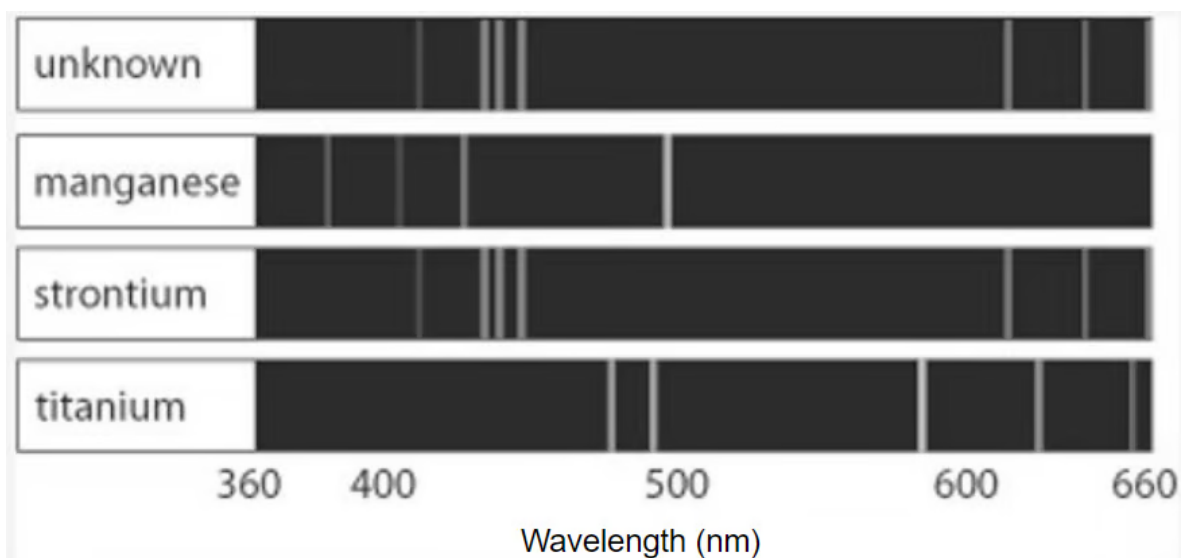
..... (1 mark)

(d) The resulting output from a flame emission spectrometer can be compared against those of known metals.

Figure 1 shows the output for manganese, strontium, titanium and an unidentified solution.

Using the output in **Figure 1**, identify which metal ion is present in the unidentified solution.

Figure 1



(1 mark)

6 Which is **not** an advantage of using instrumental methods rather than small-scale lab methods for identifying ions?

- A. Instrumental methods are more accurate
- B. Instrumental methods are faster
- C. Instrumental methods are cheaper
- D. Instrumental methods are more sensitive

(1 mark)

Medium Questions

- 1 (a) This question is about the chemicals that are used to make fireworks.

The metal ions present in the chemicals of fireworks are what produce coloured flames.

What colour flame is produced by sodium ions?

..... (1 mark)

- (b) Name a metal ion that produces a green flame.

..... (1 mark)

- (c) A company wanted to produce fireworks with a bright red colour.

Which metal would be most suitable?

..... (1 mark)

- (d) The same company also wanted to produce fireworks with a lilac colour to mimic a flower.

Which metal would be most suitable?

..... (1 mark)

- (e) Complete **Table 1** below about four chemicals.

Table 1

Chemical	Colour produced in firework
barium chloride	green
_____ carbonate	crimson
_____ sulfate	orange-red
sodium nitrate	_____

(3 marks)

- (f) Some fireworks contain a mixture of two or more metal ions.

Why is it difficult to identify the metal ions using a flame test?

.....

.....

.....

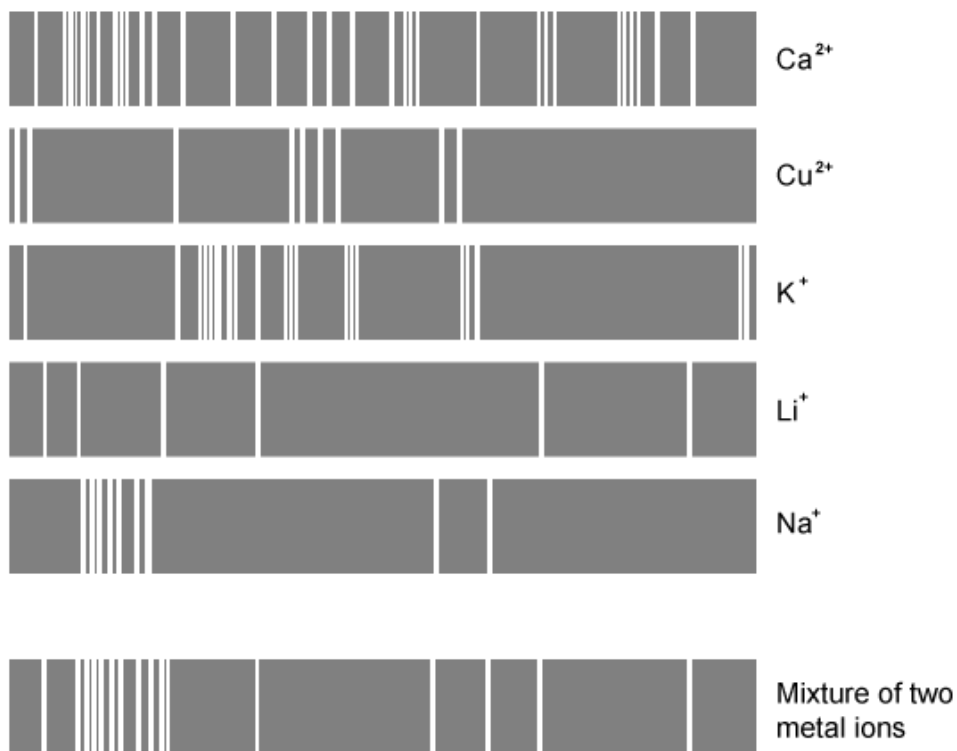
(3 marks)

- (g) Flame emission spectroscopy can be used instead of flame tests to identify metal ions in a firework.

Figure 1 shows the results of flame emission spectra of five individual metal ions.

It also shows a flame emission spectrum for a mixture of two different metal ions.

Figure 1



Identify **two** metal ions that are in the mixture?

Tick **two** boxes.

Li^+	
Cu^{2+}	
Na^+	
Fe^{2+}	
K^+	

(2 marks)

- (h) Typically, the compounds used in fireworks also contain non-metal ions.

A scientist tests a sample from a batch of fireworks.

Silver nitrate and dilute nitric acid are added to a solution of the sample and a cream precipitate is formed.

Identify the ion present.

(1 mark)

- (i) Describe a test to detect the presence of sulfate ions in the solution and the result you would expect to see if they were present.

(3 marks)

2 Scientists test a solution of compound X.

Table 1 shows their results.

Table 1

Test	Result
Add dilute nitric acid followed by silver nitrate solution	White precipitate
Add sodium hydroxide solution	Green precipitate

Which two ions are present in compound X?

- A. Fe^{3+} and Cl^-
- B. Fe^{3+} and SO_4^{2-}
- C. Fe^{2+} and Cl^-
- D. Fe^{2+} and SO_4^{2-}

(1 mark)

3 Scientists test a solution from a bottle that is known to contain a copper (II) compound.

Table 1 shows their results.

Table 1

Test	Result
Flame test	Yellow flame
Add sodium hydroxide solution	Blue precipitate formed
Add dilute nitric acid followed by silver nitrate solution	Yellow precipitate formed

Which statement below is **true**?

- A. The flame test was performed incorrectly
- B. Bromide ions are present, so the compound is CuBr_2

- C.** The test tube was contaminated for the sodium hydroxide test
- D.** The copper compound in the bottle was contaminated with another metal compound
(1 mark)

4 (a) A student investigated the composition of an egg shell as part of a wider study.

The student performed some tests on the egg shell and recorded the results as shown in **Table 2** below.

Table 2

	Test	Observation
1	Dilute HCl was added to the shell	A gas was produced. The egg shell dissolved and formed a colourless solution.
2	A flame test was done on the colourless solution from test 1 .	The flame turned red.
3	NaOH solution was added to the colourless solution from test 1 .	A white precipitate formed that did not dissolve in excess NaOH solution.
4	AgNO ₃ solution was added to the colourless solution from test 1 .	A white precipitate formed.

The student concluded that there were carbonate ions present in the egg shell.

Describe a test the student could use to identify the gas produced in test **1**.

.....

..... (2 marks)

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

Is this conclusion correct?

Use the results in the table to justify your answer.

.....

.....

.....

..... (4 marks)

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

Is this conclusion correct?

Use the results in the table to justify your answer.

.....

.....

..... (3 marks)

(d) A group of scientists working on a similar project as the student wanted to investigate the amount of lead found in egg shells.

Instead of using older methods, they used a modern instrumental method which was *more sensitive*.

Name **one** modern instrument which is used to identify elements.

..... (1 mark)

(e) What does the term *more sensitive* mean?

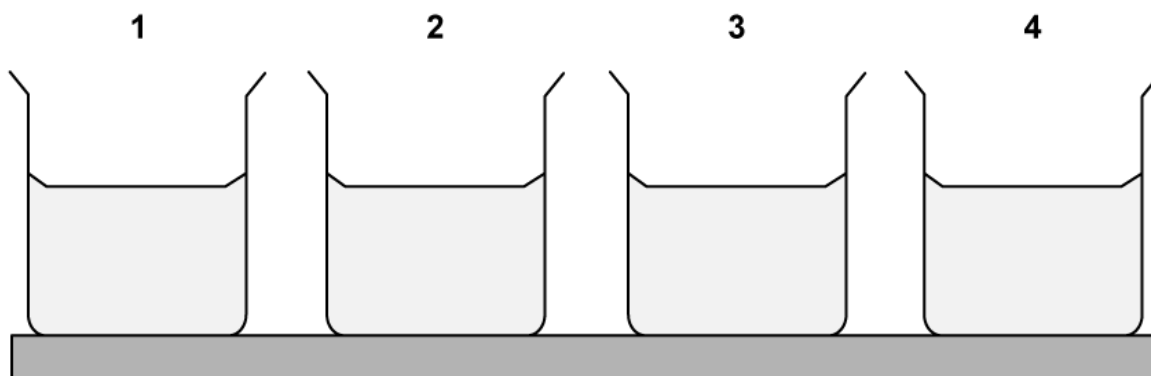
..... (1 mark)

(f) State **two** other advantages of modern instrumental methods over older methods?

(2 marks)

- 5 Four different colourless solutions were given to a group of students in beakers **1**, **2**, **3** and **4**, shown in **Figure 3**.

Figure 3



The students knew that the solutions were

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

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

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

The teacher suggested using a flame test to identify the positive ions and provided them with the following reagents only:

- silver nitrate solution
- dilute nitric acid

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

You should include the results of the tests you describe.

(6 marks)

- 6 A compound is suspected of containing calcium ions, Ca^{2+} .

Which test would **not** help to positively identify calcium?

	Test	Result
A	Flame test	Orange-red flame
B	Add sodium hydroxide solution	White precipitate forms
C	Add nitric acid and silver nitrate	White precipitate forms
D	Flame emission spectroscopy	Characteristic lines match the reference spectrum

(1 mark)

- 7 Calcium carbonate can react with hydrochloric acid by the following equation:



Which observation does **not** tell you that this reaction has occurred?

	Test	Result
A	Add dilute nitric acid then by silver nitrate solution	White precipitate forms
B	Bubble any gases present through limewater	Limewater turns cloudy
C	Observe the solutions when they are mixed	Solutions bubble and fizz upon mixing
D	Test pH of the solution at the start and after 30 s	pH increases

(1 mark)

Hard Questions

- 1 (a) A student was asked to identify the ions present in three different solutions of compounds, **A**, **B** and **C**.

The student's results from a series of tests on each solution are shown in **Table 1**.

Table 1

Compound	Test				
	Flame Test	Add dilute hydrochloric acid	Add sodium hydroxide solution	Add dilute hydrochloric acid and barium chloride	Add dilute nitric acid and silver nitrate
A	green flame	fizzing	blue precipitate	fizzing, no precipitate	no reaction
B	red flame	no reaction	white precipitate	no reaction	cream precipitate
C	yellow flame	no reaction	no reaction	white precipitate	no reaction

Identify the **two** ions present in each of the compounds **A**, **B**, and **C**.

A: _____ and _____

B: _____ and _____

C: _____ and _____

(3 marks)

..... (1 mark)

..... (1 mark)

2 (a) A student had a solution of an unknown compound, **Y**.

They performed the following tests on fresh samples of the solution and recorded their observations:

Test 1:	Add sodium hydroxide solution
Observation:	Green precipitate formed
Test 2:	Add dilute nitric acid followed by silver nitrate solution
Observation:	Yellow precipitate formed

The student concluded that the formula of compound **Y** was FeI_3 ,

Is the student's conclusion correct?

Explain your answer.

.....

.....

.....

.....

(4 marks)

(b) The student repeated **Test 1** on a solution of another compound, **Z**.

A white precipitate formed.

The student concluded that magnesium ions were present.

Explain why the student cannot make that conclusion based on the test results.

Give details of how they could use other tests to identify the metal ion present in compound **Z**.

.....

.....

.....

.....

(4 marks)

(c) The student wanted to further identify compound **Z**.

They added dilute nitric acid followed by silver nitrate solution.

Explain how the observation of a cream precipitate helps confirm the presence of bromide ions in compound **Z**

.....

.....

(2 marks)

3 (a) Minerals from a quarry were taken to a laboratory for analysis.

Four samples of minerals, **A**, **B**, **C** and **D** were submitted for identification of their ions.

In the laboratory, water is added to each mineral to form solutions and further tests are carried out.

The results of these tests are shown in **Table 1**.

Table 1

Test	A	B	C	D
Add sodium hydroxide solution	blue precipitate	no change	white precipitate	green precipitate
Add dilute hydrochloric acid	fizzed	fizzed	no change	no change
Add dilute hydrochloric acid and barium chloride	no change	no change	white precipitate	no change
Add dilute nitric acid and silver nitrate	no change	yellow precipitate	no change	cream precipitate

It was concluded that mineral **B** contained two negative ions and the positive ion was unidentified.

How do the results show this?

.....

.....

..... (3 marks)

- (b) It was believed that the positive ion present in mineral **B** was potassium.

Describe a further test, including the expected result, that could be used to confirm the presence of potassium ions.

.....
..... (2 marks)

- (c) Mineral **C** formed a white precipitate with sodium hydroxide solution.

One metal ion that gives a white precipitate with sodium hydroxide solution is aluminium.

Name **two** other metal ions that would also produce a white precipitate.

..... (1 mark)

- (d) State an instrumental method that could be used to distinguish between the three metal ions from part (c).

..... (1 mark)

- (e) Identify the ions in minerals **A** and **D**.

.....
..... (2 marks)

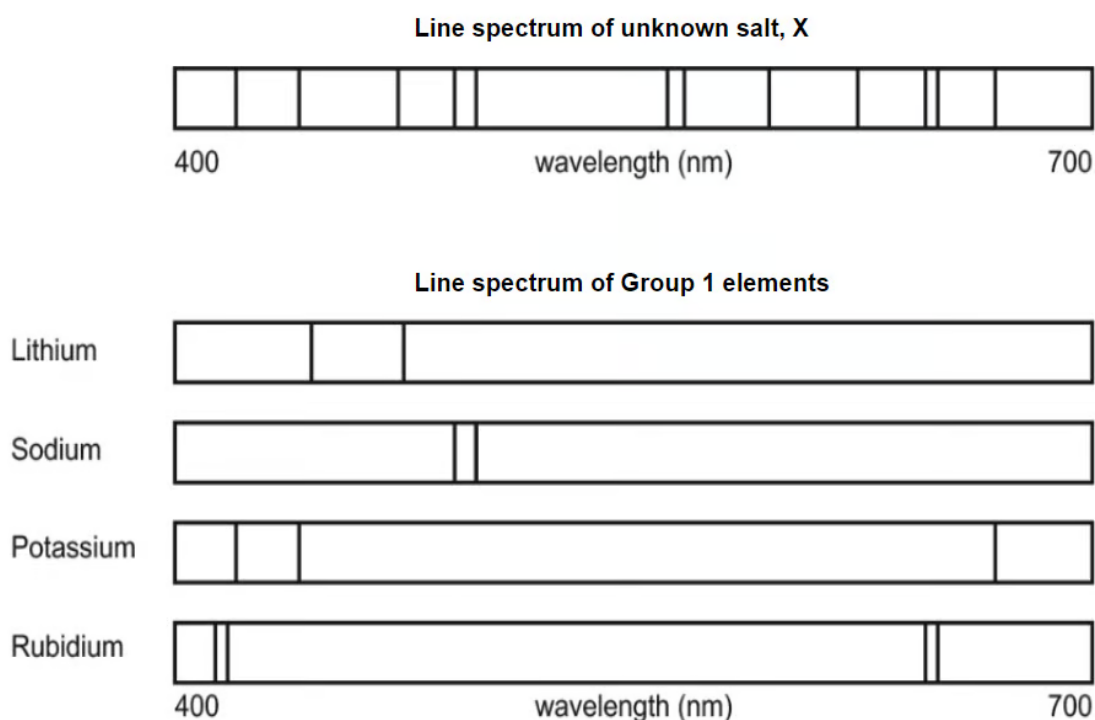
4 (a) An unknown salt sample, **X**, has been sent off for analysis for identification.

A small sample of the unknown salt, **X**, is put into a flame emission spectroscope and its line spectrum is generated.

The line spectrum is compared to the line spectrum of Group 1 elements to see if the metal ion present in **X** can be identified.

The line spectra are shown in **Figure 1**.

Figure 1



State which elements are or are not present in the unknown salt sample, **X**.

Give reasons for your answers.

.....
(5 marks)

- (b) Other than using flame emission spectroscopy, give details of any further tests that could be carried out to identify any unidentified elements.

.....
(2 marks)

- (c) Explain how flame emission spectroscopy produces a line spectrum.

.....
(2 marks)

- (d) Give **two** advantages of using a flame emission spectroscopy machine, rather than chemical tests, to identify samples.

.....
(2 marks)

- 5 (a)** Various barium compounds are used as medicines by doctors. They can be used to help diagnose problems in the stomach and bowels or for treating irregularities with the heart beating.

A medical student has a sample that they believe to be a barium compound but wants to perform some tests on the solution to confirm its identity.

They perform a flame test and a green colour flame is observed.

Table 1 shows flame colours for some other elements.

Table 1

Element	Flame colour
Barium	Green
Calcium	Orange-red
Copper	Green
Phosphorus	Blue-green
Potassium	Lilac
Sodium	Yellow

The student concluded that the solution did not contain calcium, potassium or sodium ions.

Explain why this is correct and give any other conclusions that the student could make from this test, giving your reasons.

..... (3 marks)

- (b) The student obtained an emission spectrum of barium.

How could this be used to show that the solution contains barium or any other elements?

..... (2 marks)

- (c) The student noticed that the lines produced in the spectrum did not produce the same level of light intensity.

Explain what information this gives about the elements in the sample?

..... (2 marks)

- (d) The student identified that iodide ions were present from the emission spectrum of the solution and confirmed their presence by adding dilute nitric acid and silver nitrate to the solution in question.

A yellow precipitate was formed.

Give the ionic equation, including state symbols, which shows the formation of the yellow precipitate.

..... (2 marks)