Identifying ions

Practical video

Supporting resources

Registered charity number: 207890

Contents

Teacher notes

These resources support the practical video Identifying ions, available here: rsc.li/3dhnn5B

The value of experiencing live practical work cannot be overstated. Numerous studies provide evidence of its value in terms of learner engagement, understanding, results and the likelihood of continuing to study chemistry or work in a related field. This video can be used to complement live practical work, as well as helping learners to understand the methods, equipment and skills when they cannot access the lab.

How to use this video

The video and additional resources are designed to be used flexibly, but some suggestions follow.

Flipped learning

Learners view the video ahead of the live practical lesson to help it run more smoothly and keep objectives in focus. This may also help build confidence for some learners and improve their outcomes in the lesson. Use questions from the set provided as part of the preparation task.

Consolidation and revision

Learners view the video after the practical – this may be directly after the lesson or learners can return to it as part of revision for examinations.

Revisiting a practical with a different focus

A practical experiment can support many learning outcomes. Focussing on just one or two of those in a lesson will help ensure that the aims are achieved. The video could be used to revisit the experiment with a different focus.

Home learning

Whether it is remote teaching, homework, or individual learner absence, the video provides an opportunity to engage with a practical experiment and the associated skills when learners are not in the lab.

Other tips

- **Provide your own commentary**

  Mute the voice over and provide your own commentary. This will allow you to better engage with learners and adapt to the needs and objectives of your lesson.
- **Use questions**

  A set of pause-and-think questions are provided in two formats, one for teacher-led questions and discussion and a student worksheet which can be used independently by learners. Select from these or create your own questions to help engage learners and target specific aims.

Notes on running the practical experiment

Technician notes including the equipment list and safety notes are available as a separate document here: rsc.li/3dhnn5B. If you are planning to carry out the practical in the classroom, you will need to carry out your own risk assessment.

The flame tests (wooded splint method) take about 10 minutes to carry out and it is safe for learners to work in pairs.

The microscale sodium hydroxide test for positive ions reaction takes around 10 minutes and it is safe for learners to work in pairs. This should be carried out on either the printable sheet (in this booklet) or on the integrated instruction sheet. In both cases you will need to either put the printed sheet into a plastic wallet or laminate it.

TIP: ***Printing the microscale sheet/integrated instructions onto buff coloured paper will make it easier to see when a white precipitate has been formed.***

TIP: ***Once completed learners can take a photo of their results using a mobile phone or tablet; so that they can clear away immediately. This will help avoid learners spilling chemicals on their results table.***

Allow 30 minutes for the testing of negative ions, 10 minutes for each test. You may wish to carry out this experiment in a separate lesson. This will give you time to go over the theory in the same lesson.

Once all the tests have been completed, provide the class with an unknown solution X and ask the students to identify either the positive ion present, the negative ion present or both.

Further practical activities and context

Details of alternative methods to carry out the flame tests can be accessed from rsc.li/2ZpnROO. This activity makes a good plenary or starter; asking students to name the metal ion as they see the different flame colours. The flame tests infographics is a great reference sheet and also explains the chemistry behind the flame colours. The chemistry of fireworks infographic and sparklers infographic provides a nice teaching context. You may also be interested in the Exhibition Chemistry video Rainbow flame demonstration, which provides a wonderful display of colours as well as further details of the chemistry of flame tests.

Integrated instructions

Printable integrated instructions are provided for learners. These are available as a separate download here: rsc.li/3dhnn5B.

Integrated instructions use clear numbering, arrows and simple pictograms, like an eye to show where observations are required. These have been developed using cognitive load theory. Integrated instructions remove unnecessary information, and therefore reduce extraneous load on students, which increases their working memory capacity to think about what they are doing and why. Read more about the use of integrated instructions here: rsc.li/2SdSqkQ.

Results tables

Printable results tables have been provided for the three sets of tests. For the microscale tests for metal ions there is a table to perform the experiment on and one to record results.

Key terms

Learners will need to have a clear understanding of the following scientific terminology:

Ion – a positively or negatively charged particle.

Metal halide – general term used to describe the group of ionic compounds that form when a metal reacts with a halogen.

Ionic compound – a compound made up of oppositely charged ions. Ionic compounds are held together by strong electrostatic forces between oppositely charged ions. These forces are called ionic bonds.

Aqueous solution – a solution where the solvent is water. So an aqueous solution of sodium hydroxide contains Na^+ ions, OH^- ions and H_2O molecules.

Precipitate – a solid that forms from ions in an aqueous solution. The precipitate is insoluble in water.

Ionic equation – a symbol equation which focuses on the ions that react together and ignore the ones that do not take part in the reaction (spectator ions).

Prior knowledge

Learners should be able to recall:

- Particles can be atoms, molecules or ions.
- An ion is a positively or negatively charged particle.
- An atom or a molecule can lose or gain electron(s) to form an ion.
- When an atom/molecule gains negatively charged electron(s), a negative ion is formed. When an atom/molecule loses negatively charged electron(s), a positive ion is formed.
- A solution is formed when a solute (salt) is dissolved in a solvent (water).

Learners should be confident writing word and symbol equations

There are some questions included which ask learners to balance symbol equations and write ionic equations. Depending on where the identification of ions comes in your scheme of work your learners may not have come across this yet. Adapt the questions to make them relevant to the stage and level that you are at. Some of the challenge tasks require learners to use and apply their knowledge from other topics.

Common misconceptions

1. When an atom/molecule loses negatively charged electron(s), a positive ion is formed. This is something learners often struggle with later on in their studies. Introducing the electron now, before learners meet the other sub-atomic particles, can help to embed the idea that the loss of electrons results in a positively charged ion, and may help reduce confusion later on.
2. As learners develop their understanding of chemical bonding further, it is common for students to refer to ionic compounds as molecules or to refer to intermolecular forces when explaining properties of ionic compounds. To avoid these misconceptions introduce and emphasise the correct use of the terms 'ion' and 'molecule' from the outset.
3. Learners often find solution chemistry challenging as they fail to appreciate that as well as the ions taking place in the precipitate reaction, both water molecules and spectator ions are also present.

Diagnostic multiple-choice questions are a great way to explore learners' reasoning behind their answers. You can read more about diagnostic questioning here: rsc.li/3u1kED3.

Intended outcomes

It is important that the purpose of each practical is clear from the outset, defining the intended learning outcomes helps to consolidate this. Outcomes can be categorised as hands on, what learners are going to do with objects, and minds on, what learners are going to do with ideas to show their understanding. We have offered some differentiated suggestions for this practical. You may wish to focus on just one or two, or make amendments based your learners' own needs. (Read more at rsc.li/2JMvKa5.)

Consider how you can share outcomes and evaluation with learners, empowering them to direct their own learning.

	Hands on	Minds on
Effective at a lower level	**Students correctly:** • Follow instructions • Make careful observations • Carry out a flame test • Carry out tests for negative ions • Carry out the sodium hydroxide test for positive ions	**Students can:** • Correctly record test results in a table • Use the results to identify an unknown sample
Effective at a higher level	**Students correctly:** • Plan and carry out a series of tests to identify an unknown sample	**Students can:** • Explain why different metals have different flame colours • Write ionic equations for the sodium hydroxide tests and halide tests

How to use the additional resources

Using the pause-and-think questions

Pause-and-think questions are supplied in two formats: a teacher version for 'live' questioning and a student version which can be used during independent study. The time stamps allow you to pause the video when presenting to a class, or learners to use for active revision.

The questions have been put into four sections: general questions, flame tests, testing for positive ions and testing for negative ions.

Teacher version

The questions are presented in a table and you can choose to use as many as appropriate for your class and the learning objectives.

Some questions have two timestamps to allow you to adapt the questions for different classes or scenarios. Pause the videos at the earlier timestamp to ask a question before the answer is given, useful for revision or to challenge learners. Pause at the later timestamp to ask a question reflectively and assess whether learners have understood what they have just heard or seen. This would be useful when introducing a topic, in a flipped learning scenario or when additional support and encouragement is needed.

Think about how you will ask for responses. Variation may help to increase engagement – learners could write and hold up short answers; more complex questions could be discussed in groups.

Not all answers to questions are included in the video. Some of the questions will draw on prior learning or extend learners' thinking beyond the video content.

Student version

The same questions are offered as a printable worksheet for learners. Use in situations where there is not a teacher present to guide discussion during the video, for example homework, revision or remote learning.

Using the structure strips

Writing about chemistry encourages learners to reflect on their understanding, formulate new ideas and make links between ideas in new ways. Learners also need to practice for longer-answer questions in examinations. Structure strips provide scaffolded prompts and help overcome 'fear of the blank page'. The learner sticks the strip into the margin of their exercise book or onto an A4 sheet of paper and writes alongside it. Use this long-answer question to consolidate learning after the practical and/or for revision. (Read more at rsc.li/2P0JDlW.)

Long-answer question:

A sample of an unknown ionic solution has been collected for analysis. The sample is colourless.

Describe a series of qualitative tests that could be used to identify the unknown ions in the sample.

In your plan you must include instructions for carrying out the tests and the expected results.

Using Johnstone's triangle

Johnstone's triangle helps learners to understand what going on in a chemical reaction and gain a deeper understanding. It does this by helping learners to make links between three different levels of representation: the macroscopic, symbolic and sub-microscopic levels. The macroscopic is the 'seen' level, e.g. practical investigation or observations, which can be described. The symbolic level is the unseen: how we represent the macroscopic through word or symbol equation. The sub-microscopic is unseen, at the atomic level, and includes explanatory models. (Read more at rsc.li/2XhYN9Q.)

As part of the additional resources we have included a completed example of Johnstone's triangle for the sodium hydroxide test for iron(III); an example for learners to work through for copper(II), and a template so you can set your own questions (editable file at rsc.li/3dhnn5B).

In the example provided we have used a very simple model at the sub-microscopic level. When discussing this model with your learners, you could ask them how to improve it, for example, by showing the water molecules present and the spectator ions.

If your learners are not familiar with using Johnstone's triangle, then it is recommended that you take the approach 'I try' to introduce the triangle; 'let's try' to work through an example together. Finally, 'you try' where learners work through an example on their own. When completing the 'sub-microscopic' level it is helpful if learners have access to modelling resources such as molymods, modelling clay, ionic jigsaw etc.

Using the follow-up worksheet

A practical skills worksheet has been included as part of the additional resources. The first section provides structured questions at a support level for learners, the second section provides more challenging applied questions. This worksheet could be used to follow up the practical activity, for example as homework or a revision exercise.

Pause-and-think questions

Teacher version

Timestamp(s)		Question	Answer/discussion points
00:22		What is the difference between qualitative analysis and quantitative analysis? Give examples of each.	Qualitative analysis is where we can only identify which ions or molecules are present in an unknown sample. Chemical tests are an example of qualitative analysis. Quantitative analysis is where we can identify the amount of the substance present, eg the actual concentration of an ion. Titrations are an example of quantitative analysis.
00:33	00:45	What is an ion? Describe how a positive and negative ion is formed.	A positively or negatively charged particle. A positive ion is formed when a particle loses electrons. A negative ion is formed when a particle gains electrons.
01:12		What will we be looking for during the chemical tests? How will you know if a test has a positive result?	Signs that a chemical change has taken place, eg colour change, formation of a gas, temperature change, formation of a solid or a precipitate. Consider the observed result. If there is only one possible ion with this result then the result will be positive, eg a blue precipitate with sodium hydroxide indicates the presence of the copper ion. However if there are several possibilities, eg a white precipitate is formed with sodium hydroxide then you will need to do further tests until there is only one possible answer.
		Flame tests	
01:22	01:29	What are flame tests used to identify?	Metal ions.
01:57		Why can't we use a dry splint for a flame test?	A dry splint itself will burn and affect the colour that we see. A soaked splint will not burn immediately so we will only see the flame colour associated with the metal ions initially.
02:32		Why do we test distilled water first. What does this show?	This is a control. It shows that the distilled water that the splints were soaked in does not affect the flame colour.
02:52	02:58	Record the flame colour for lithium in the table provided.	Lithium Li^{+} crimson
03:09	03:15	Record the flame colour for potassium in the table provided.	Potassium K^{+} lilac
03:30	03:42	Record the flame colour for calcium in the table provided.	Calcium Ca^{2+} orange-red
03:52	03:56	Record the flame colour for copper in the table provided.	Copper Cu^{2+} green
04:11	04:14	Record the flame colour for copper in the table provided.	Sodium Na^{+} yellow-orange

04:25		Check your results or, if you haven't yet done so, record the flame colours in your results table.	Lithium Li^{+} crimson Potassium K^{+} lilac Calcium Ca^{2+} orange-red Copper Cu^{2+} green Sodium Na^{+} yellow-orange
04:36		*Challenge: Suggest a reason why different metals have different flame colours.*	*They have different electronic configurations. For more information, see the links in the teacher notes.*
		Testing for positive ions	
04:55		What are the benefits of microscale chemistry?	Benefits include: • sustainability • safety • more careful observations can be made Read more about the benefits of microscale: rsc.li/2ZtlkTM.
05:17		What colour is sodium hydroxide?	Colourless
05:30		Name the ions present in sodium hydroxide solution.	Sodium ion, Na^{+} Hydroxide ion, OH^{-} (*also some H^{+} and OH^{-} from the water*)
05:47	06:00	Name the green precipitate formed when sodium hydroxide is added to iron (II) ions.	Iron(II) hydroxide
06:04	06:58	Record the results shown with each metal ion in your results table.	Iron(II) Fe^{2+} green precipitate Iron(III) Fe^{3+} rust precipitate Copper(II) Cu^{2+} blue precipitate Aluminium Al^{3+} white precipitate Calcium Ca^{2+} white precipitate Magnesium Mg^{2+} white precipitate
06:58		Name the products formed in the reactions and write the ionic equations.	Iron(III) hydroxide $Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow Fe(OH)_3(s)$ Copper(II) hydroxide $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$ Aluminium hydroxide $Al^{3+}(aq) + 3OH^{-}(aq) \rightarrow Al(OH)_3(s)$ Calcium hydroxide $Ca^{2+}(aq) + 2OH^{-}(aq) \rightarrow Ca(OH)_2(s)$ Magnesium hydroxide $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$
07:43		Describe the test for aluminium. What does a positive result look like?	Add excess sodium hydroxide to the white precipitate. If the solid disappears then the aluminium ion is present.
07:50		Both magnesium ions and calcium ions form a white precipitate with sodium hydroxide. Suggest a further test you could do to distinguish between the two metal ions.	Carry out a flame test. If an orange-red flame is observed then the calcium ion is present. (Magnesium has no flame colour in a flame test.)

		Testing for negative ions	
08:28		Why do you think that the limewater is put into a separate test tube at the start of the carbonate test?	The lime water is to test the gas being produced. If it was mixed with the original solution you may not be able to observe any colour change taking place.
08:34		What does limewater test for?	Carbon dioxide.
09:10		Why does the gas not escape the test tube to the surroundings?	Carbon dioxide is more dense than air. Therefore most of it remains in the test tube because diffusion will be slow.
09:29	09:33	What has happened to the limewater? Name the gas being produced.	The limewater has gone cloudy. Carbon dioxide gas is being produced.
09:37	09:43	What is the test for carbonate ions? What does a positive result look like?	Add hydrochloric acid and test any gas being produced by bubbling it through limewater. If the limewater goes cloudy it is a carbonate.
09:37	09:50	Write a word and symbol equation for the reaction of sodium carbonate with hydrochloric acid. What type of reaction is this?	Sodium carbonate + hydrochloric acid → Sodium chloride + water + carbon dioxide $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ A neutralisation reaction.
10:00	10:10	Why do you think dilute acid is added at the start of the sulfate test?	To remove any ions that might interfere with a positive result.
10:25	10:28	Write a word and symbol equation for the reaction of sodium sulfate with barium chloride. What type of reaction is this?	Sodium sulfate + barium chloride → sodium chloride + barium sulfate $Na_2SO_4(aq) + BaCl_2(aq) \rightarrow 2NaCl(aq) + BaSO_4(s)$ A double displacement reaction.
10:25	10:34	What is the test for sulfate ions? What does a positive result look like?	Add a few drops of hydrochloric acid and barium chloride to the sample. If a white precipitate forms then a sulfate is present.
10:40	10:46	Write the symbols for the halide ions in your results table: Chloride Bromide Iodide	Cl^- Br^- I^-
11:03		What was added to the test tube to test for the presence of halides?	Nitric acid and sliver nitrate solution.
11:28	11:47	Record the results in your results table.	Cl^- white precipitate is formed Br^- cream precipitate is formed I^- yellow precipitate is formed
11:40		Write the ionic equations for the formation of silver bromide and silver iodide.	$Br^-(aq) + Ag^+(aq) \rightarrow AgBr(s)$ $I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$
12:08	12:15	Unknown solution B, shown in the video, is blue. What test would you use to confirm the identity of the positive ion?	Since the solution is blue, I would suspect that a copper ion was present so I would do either the sodium hydroxide test or the flame test first.

Pause-and-think questions

Student version

Pause the video at the time stated to test or revise your knowledge of these practical experiments.

Time **Question**

00:22 What is the difference between qualitative analysis and quantitative analysis?

00:33 What is an ion?

Describe how a positive and negative ion are formed.

01:12 What will we be looking for during the chemical tests?

How will you know if a test has a positive result?

Flame tests

01:22 What are flame tests used to identify?

02:32 Why do we test distilled water first? What does this show?

Record the symbol and flame colours for each metal ion in the table below:

Metal ion	Symbol	Observation: flame colour
Lithium		
Potassium		
Calcium		
Copper		
Sodium		

02:58 Lithium.

03:09 Potassium.

03:30 Calcium.

03:52 Copper.

04:11 Sodium.

Testing for positive ions

05:17 What colour is sodium hydroxide?

____

05:30 Name the ions present in sodium hydroxide solutions.

____

____

05:47 Name the green precipitate formed when sodium hydroxide is added to iron (II) ions

____

06:04 Record the results shown with each metal ion in the results table below:

Positive ion	Symbol	Observation when added to sodium hydroxide solution	Observation with excess sodium hydroxide solution
Iron(II)			
Iron(III)			
Copper(II)			
Aluminium			
Calcium			
Magnesium			

06:58 Name the products formed in the reactions and complete the ionic equations:

Iron(III) hydroxide: $Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow$ _______________

Copper(II) hydroxide: _________ + $2OH^{-}(aq) \rightarrow$ ____________

__________________: $Al^{3+}(aq) + 3OH^{-}(aq) \rightarrow$ ________________

__________________: $Ca^{2+}(aq)$ + ________ $\rightarrow$ ______________

Magnesium hydroxide: _________ + _________ $\rightarrow$ ___________

07:43 Describe the test for aluminium. What does a positive test look like?

____

____

____

07:50 Both magnesium ions and calcium ions form a white precipitate with sodium hydroxide. Suggest a further test you could do to distinguish between the two metal ions.

____

____

Testing for negative ions

Negative ion	Symbol	Test	Observation
Carbonate			
Sulfate			

08:28 Why do you think that the limewater is put into a separate test tube at the start of the carbonate test?

____

____

08:34 What does limewater test for?

____

09:29 What has happened to the limewater?

____

09:33 Name the gas produced.

____

09:37 Complete the word and symbol equation:

Sodium carbonate + hydrochloric acid → ______________ + ____________ + ______________

$Na_2CO_3(aq)$ + __________ → __________ + $H_2O(l)$ + __________

What type of reaction is this?

____

09:43 Complete the table above with the test and positive result for carbonate ions.

09:58 Why do you think dilute acid is added at the start of the sulfate test?

____

____

10:25 Complete the table above with the test and positive result for sulfate ions.

10:25 Complete the word and symbol equation:

Sodium sulfate + barium chloride → ____________ + ____________

$Na_2SO_4(aq) + BaCl_2(aq)$ → __________ + __________

10:28 What type of reaction is this?

____

10:38 Add the symbols for the halide ions to the results table below.

11:28 Record the results for the halide tests in the results table.

Negative ion		Symbol	Test	Observation
Halide	Chloride			
	Bromide			
	Iodide			

11:40 Write the ionic equations for the formation of silver bromide and silver iodide.

________ + ________ → ________

________ + ________ → ________

12:08 Unknown solution B is blue. Which metal ion would you expect it to contain? Which test would you do use to confirm you prediction?

____

____

____

Identifying ions Structure strip	Identifying ions Structure strip	Identifying ions Structure strip	Identifying ions Structure strip	Identifying ions Structure strip
What is a qualitative test and what is it used for?	What is a qualitative test and what is it used for?	What is a qualitative test and what is it used for?	What is a qualitative test and what is it used for?	What is a qualitative test and what is it used for?
Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.	Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.	Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.	Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.	Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.
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Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?	Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?	Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?	Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?	Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?

Structure strip: suggested answer content

Identifying ions Structure strip	
What is a qualitative test and what is it used for?	A qualitative test is used to identify the chemical composition of an unknown sample. A positive test result, such as a colour change, will confirm that a particular substance is present. The unknown colourless sample is an ionic solution, so we are going to use a series of qualitative tests to identify the positive and negative ions.
Describe the hydroxide test for positive ions. What would a positive test result look like? Give an example.	There are two tests that can be used to determine the positive ion. One of these tests is the hydroxide test: • Add 2 drops of sodium hydroxide to 2 drops of the unknown solution. • A coloured precipitate will form. • Observe the colour of the precipitate. This will identify the possible positive metal ion in the unknown solution. For example, a rust coloured precipitate would be a positive result for iron(III) ions.
What is the limitation of the sodium hydroxide test?	There is more than one metal ion that will produce a white precipitate. If a white precipitate is formed and it does not dissolve in excess sodium hydroxide then further tests will need to be carried out to determine whether the unknown solution contains calcium or magnesium.
Describe the flame test to confirm the positive ion. What would a positive test result look like? Give an example.	A further test to confirm the positive ion present is a flame test. The flame test could also be used to distinguish between calcium and magnesium. • Dip a pre-soaked splint in the unknown solution. • Hold it in a roaring blue Bunsen flame. • Observe the colour of the flame. The flame colour will identify the positive metal ion present in the unknown solution. For example, a lilac flame would be a positive result for potassium.
Describe the series of tests used for negative ions. Describe the carbonate test. What would a positive test result look like?	Now, we will use a series of tests to identify the negative ion. The carbonate test • Put 1 cm^3 of the unknown solution into a test tube. • Put 1 cm^3 of limewater into a separate test tube. • Add a few drops of hydrochloric acid (HCl). If it fizzes then the carbonate ion is present. • Confirm the presence of carbonate by bubbling the gas through the limewater. If a carbonate ion is present the limewater will turn cloudy.
Describe the sulfate test. What would a positive test result look like?	The sulfate test • Put 1 cm^3 of the unknown solution into a test tube. • Add a few drops of hydrochloric acid HCl and then add barium chloride ($BaCl_2$). • If a white precipitate appears, then the sulfate ion is present.
Describe the halide test. What would a positive test result look like for chloride, bromide and iodide?	The halide test • Put 1 cm^3 of the unknown solution into a test tube. • Add a few drops of nitric acid (HNO_3) and silver nitrate ($AgNO_3$). • If a white precipitate forms then the chloride ion is present. If the precipitate is cream, then the bromide ion is present, if it is yellow then the iodide ion is present.

Follow-up worksheet

1. A student carried out some flame tests.

Complete the flame test results table. The first row has been done for you.

Metal ion	Symbol	Observation: flame colour
Potassium	K^+	Lilac
Sodium		
	Li^+	Crimson
Calcium		
	Cu^{2+}	Green
Unknown solution X ____________________		Yellow

2. Describe how you would test for positive ions using the sodium hydroxide chemical test.

____

____

____

3. Complete the sodium hydroxide test results table.

Positive ion	Symbol	Observation when added to sodium hydroxide solution
Iron(II)	Fe^{2+}	
		Brown precipitate
Copper(II)		Blue precipitate

4. Complete the equations, using the example to help.

Iron(II) + hydroxide → iron(II) hydroxide

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

(a) Iron(III) + hydroxide → ___________________________

$Fe^{3+}(aq)$ + __$OH^-(aq) \rightarrow Fe(OH)_3$(__)

(b) Copper(II) + hydroxide → ________________ (II) hydroxide

$Cu^{2+}(aq)$ + __$OH^-(aq) \rightarrow Cu(OH)_2$(__)

5. A student carried out some tests to identify the ions present in an unknown solution. After adding a few drops of dilute nitric acid and silver nitrate to the sample, a cream coloured precipitate appeared.

The student concluded that a ___________________________ ion was present in the solution.

Challenge

6. A student was asked to identify an unknown sample. She carried out some tests and here are the results.

(a) Complete the table.

Test	Result	Conclusion
Add 2 drops of sodium hydroxide to 2 drops of solution	A white precipitate is formed	
Add excess sodium hydroxide to the drop	No change to the white precipitate	
Flame test	An orange-red flame is observed	
Add a few drops of hydrochloric acid to sample	No changes observed	
Add a few drops of hydrochloric acid then a few drops of barium chloride to sample	No change observed	
Add a few drops of nitric acid then a few drops of silver nitrate to sample	A white precipitate is formed	

(b) The unknown sample is

____

(c) Complete the ionic equations for the positive results.

________( ) + ______ OH^-(aq) → _______( )

Ag^+(aq) + __________ ( ) → ___________( )

7. A sample of an unknown ionic solution has been collected for analysis. The sample is colourless.

Describe a series of qualitative tests that could be used to identify the unknown ions in the sample.

In your plan you must include instructions for carrying out the tests and the expected results.

This question has a structure strip to support your written answer. Find more resources to support you here rsc.li/3a7LS37.

Follow-up worksheet: answers

1. A student carried out some flame tests.

   Complete the flame test results table. The first row has been done for you.

Metal ion	Symbol	Observation: flame colour
Potassium	K^{+}	Lilac
Sodium	**Na^{+}**	**Yellow**
Lithium	Li^{+}	Crimson
Calcium	**Ca^{2+}**	**Orange-red**
Copper	Cu^{2+}	Green
Unknown solution X **Sodium**	**Na^{+}**	Yellow

2. Describe how you would test for positive ions using the sodium hydroxide chemical test.

   Add 2 drops of sodium hydroxide to 2 drops of an unknown solution and observe.

3. Complete the sodium hydroxide test results table.

Positive ion	Symbol	Observation when added to sodium hydroxide solution
Iron(II)	Fe^{2+}	**Green precipitate**
Iron(III)	**Fe^{3+}**	Brown precipitate
Copper(II)	**Cu^{2+}**	Blue precipitate

4. Complete the equations, using the example to help.

   Iron(II) + hydroxide → iron(II) hydroxide

   $Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$

(a) Iron(III) + hydroxide → **iron(III) hydroxide**

   $Fe^{3+}(aq) + \mathbf{3}OH^{-}(aq) \rightarrow Fe(OH)_3(\mathbf{s})$

(b) Copper(II) + hydroxide → **copper**(II) hydroxide

   $Cu^{2+}(aq) + \mathbf{2}OH^{-}(aq) \rightarrow Cu(OH)_2(\mathbf{s})$

5. A student carried out some tests to identify the ions present in an unknown solution. After adding a few drops of dilute nitric acid and silver nitrate to the sample, a cream coloured precipitate appeared.

   The student concluded that a **Chloride (or Cl^{-})** ion was present in the solution.

Challenge

6. A student was asked to identify an unknown sample. She carried out some tests and here are the results.

(a) Complete the table.

Test	Result	Conclusion
Add 2 drops of sodium hydroxide to 2 drops of solution	A white precipitate is formed	**Al^{3+}, Ca^{2+} or Mg^{2+} ions could be present**
Add excess sodium hydroxide to the drop	No change to the white precipitate	**Ca^{2+} or Mg^{2+} ions could be present**
Flame test	An orange-red flame is observed	**Ca^{2+} ion is present**
Add a few drops of hydrochloric acid to sample	No changes observed	**The carbonate or CO_3^{2-} ion is not present**
Add a few drops of hydrochloric acid then a few drops of barium chloride to sample	No change observed	**The sulfate or SO_4^{2-} ion is not present**
Add a few drops of nitric acid then a few drops of silver nitrate to sample	A white precipitate is formed	**The chloride or Cl^- ion is present**

(b) The unknown sample is

Calcium chloride (or $CaCl_2$)

(c) Complete the ionic equations for the positive results.

$\mathbf{Ca^{2+}(aq)} + \mathbf{2}OH^-(aq) \rightarrow \mathbf{Ca(OH)_2(s)}$

$Ag^+(aq) + \mathbf{Cl^-(aq)} \rightarrow \mathbf{AgCl(s)}$

7. A sample of an unknown ionic solution has been collected for analysis. The sample is colourless.

Describe a series of qualitative tests that could be used to identify the unknown ions in the sample.

In your plan you must include instructions for carrying out the tests and the expected results.

This question has a structure strip see 'suggested answer content' (rsc.li/3a7LS37).

Results tables for flame tests

Metal ion	Symbol	Observation: flame colour
Lithium		
Potassium		
Calcium		
Copper		
Sodium		

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Calcium		
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Sodium		

Microscale reactions of positive ions with sodium hydroxide

Positive ion	Symbol	Positive ion solution and sodium hydroxide solution
Iron(II)	Fe^{2+}	
Iron(III)	Fe^{3+}	
Copper(II)	Cu^{2+}	
Aluminium	Al^{3+}	
Calcium	Ca^{2+}	
Magnesium	Mg^{2+}	

Results table for positve ion tests

Positive ion	Symbol	Observation when added to sodium hydroxide solution	Observation with excess sodium hydroxide solution
Iron(II)			
Iron(III)			
Copper(II)			
Aluminium			
Calcium			
Magnesium			

Positive ion	Symbol	Observation when added to sodium hydroxide solution	Observation with excess sodium hydroxide solution
Iron(II)			
Iron(III)			
Copper(II)			
Aluminium			
Calcium			
Magnesium			

Results tables for negative ion tests

Negative ion		Symbol	Test	Observation
Carbonate				
Sulfate				
Halide	Chloride			
	Bromide			
	Iodide			

Negative ion		Symbol	Test	Observation
Carbonate				
Sulfate				
Halide	Chloride			
	Bromide			
	Iodide			