

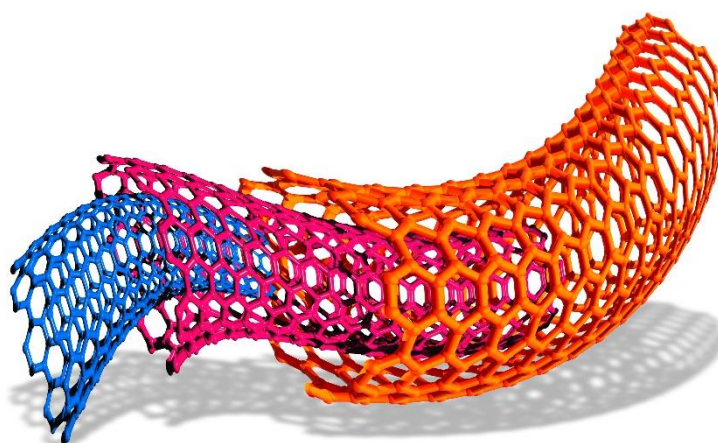
Teaching Pack

The identification of unknown compounds **C and D**

Cambridge IGCSE™ Chemistry 0620

This *Teaching Pack* can also be used with the following syllabuses:

- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge IGCSE™ Chemistry (US) **0439**
- Cambridge IGCSE™ Combined Science **0653**
- Cambridge IGCSE™ Co-ordinated Sciences (Double Award) **0654**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge O Level Chemistry **5070**



® IGCSE is a registered trademark

Copyright © UCLES 2023

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

UCLES retains the copyright on all its publications. Registered Centres are permitted to copy material from this booklet for their own internal use. However, we cannot give permission to Centres to photocopy any material that is acknowledged to a third party, even for internal use within a Centre.

Contents

Introduction	4
Experiment: The identification of unknown solids C and D	5
Briefing lesson: What is qualitative analysis?	6
Lab lesson: Option 1 – run the experiment	7
Teacher notes	8
Teacher method	12
Lab lesson: Option 2 – virtual experiment	16
Debriefing lesson: Good observations	18
Worksheets	21
Answers	29

Icons used in this pack:



Briefing lesson



Lab option 1: *Run the experiment*



Lab option 2: *Virtual experiment*



Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note

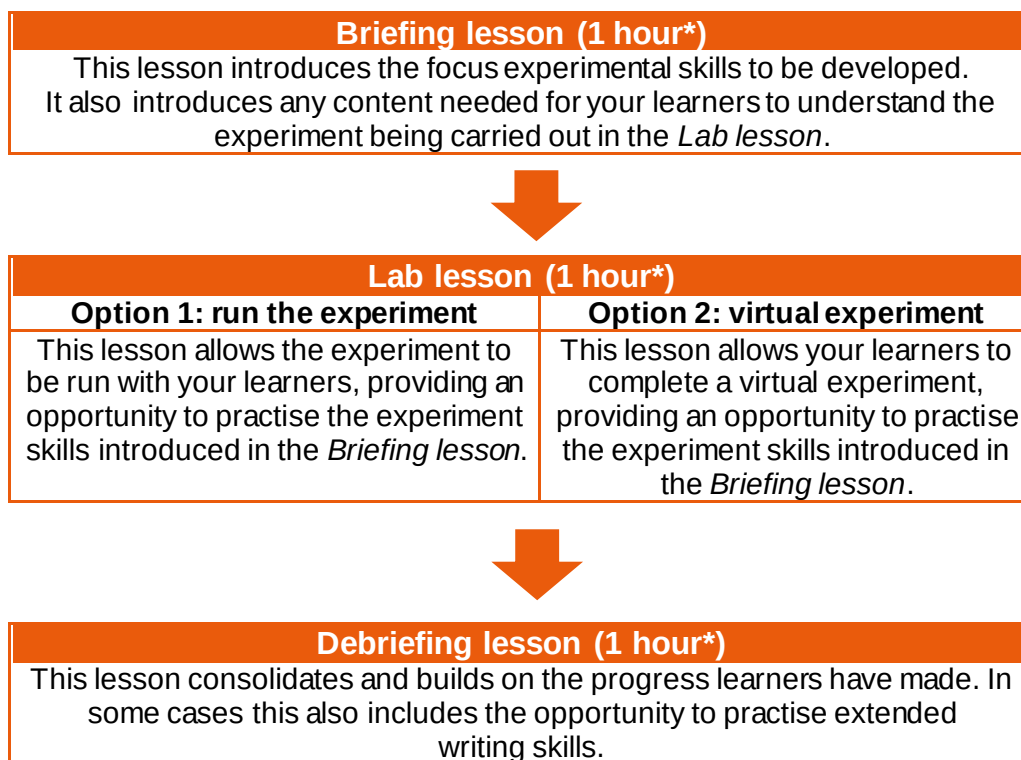
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:



** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: The identification of unknown compounds **C** and **D**

This *Teaching Pack* focuses on qualitative analysis (the identification of ions and gases).

Qualitative analysis is commonly used to identify ionic substances by analysing their component anions and cations.

This experiment has links to the following syllabus content (see syllabus for detail):

- 12.5 Identification of ions and gases

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations**:

- make and record observations
- interpret and evaluate experimental observations.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 2.4 Ions and ionic bonds
- 7.1 The characteristic properties of acids and bases
- 8.4 Transition elements

Going forward

The awareness and skill of making careful and accurate observations in this pack will assist learners in all areas of lab work. Learners could be encouraged to try to write balanced equations for some of the simpler chemical reactions that occur in this topic. Learners may be curious about any qualitative analysis tests for non-ionic compounds. Refer them to the bromine water test for unsaturation for alkenes. The chemical tests for water could also be discussed.

Briefing lesson: What is qualitative analysis?



Resources	• A range of white compounds (corn starch, sugar, baking powder, table salt) • Vinegar • Copper(II) sulfate pentahydrate (in a beaker) • Videos for qualitative analysis (cations, anions and flame tests) • Worksheets A and B
Learning objectives	By the end of the lesson: • all learners should be able to explain that specific chemical tests enable you to identify unknown substances and that there are specific tests for identifying anions and cations. • most learners should be able to highlight good lab technique and safety issues. • some learners should be able to explain that the basis of many of the tests used in qualitative analysis depends on the varying solubility of ionic substances.
Timings	Activity
 15 min	Starter/Introduction Gather the learners around a demonstration bench to look at a number of white compounds (corn starch and sugar, baking powder and table salt). The demonstration details can be found in the Teacher notes section of the pack. The aim of this activity is to relate some everyday events and/or experiments, done in earlier years, to the idea of why we need to perform chemical tests to identify substances.
 30 min	Main lesson The aim of this part of the lesson is to demonstrate the safety and good practice aspects of doing qualitative analysis. Hand out Worksheet A to each learner for reference and spend five minutes skimming through the main areas of the sheet – they will need to be familiar with this sheet when doing either of the lab lessons. Explain that each unknown substance they test will consist of anion tests and cation tests, which may include a flame test. In addition, alert them to the fact, that they will be analysing gases produced in certain reactions. Give learners Worksheet B and show the unedited versions of the qualitative analysis videos. Play each of the videos in full. Pause at relevant points so that your learners can answer the questions on the sheet. Also remind learners of the safety aspects associated with the tests as you go.
 15 min	Plenary Show the learners a sample of copper(II) sulfate pentahydrate in a small beaker (or show an image of these blue crystals). • Ask the learners to tell you which ion is the cation and which ion is the anion. • Ask the learners to write down the chemical formula. • Using their qualitative analysis sheets, ask the learners which tests could be performed to show the presence of the cation and the anion. Explain that in future sessions they will be given unknown samples and they will have to carry out the various tests to confirm what their unknown samples are.

Lab lesson: Option 1 – run the experiment



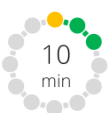
Resources

- Teacher notes
- *Teacher walkthrough* video
- Worksheets A, C and D
- Equipment as outlined in the notes

Learning objectives

By the end of the lesson:

- **all** learners should be able to perform the relevant tests on the unknown compounds.
- **most** learners should be able to identify compounds **C** and **D**.
- **some** learners will be able to evaluate and interpret their results.

Timings	Activity
 10 min	Starter/Introduction Show the two unknown compounds, C and D. Tell the learners they will try to find out what they are using the qualitative analysis tests. Safety Ensure that all learners are wearing fastened lab coats. Make sure that they wear goggles throughout and that learners with long hair tie it up safely. Remind learners about spillages. Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe. Ask the learners a few warm-up questions: What type of chemical bonding do compounds C and D have? Does the appearance of the compounds tell us anything about their identity?
 30 min	Main lesson Learners should work in pairs. Learners should already have a copy of Worksheet A. Give each pair Worksheet C detailing the method for this experiment and Worksheet D to record their results. Safety Ideally, to minimise movement around the room, each pair of learners should have the chemical solutions placed in front of them. Additionally: 1. Each bench should have a small beaker labelled 'chemical waste' on it. The learners should be encouraged to use this for the disposal of solutions after each test. They should also be shown where the large bottle labelled 'chemical waste' is for the end of the lesson, into which they will empty the contents of their beakers. 2. Bunsen burners: indicate to the learners the position of the lit Bunsen burner and that they are burning with a yellow safety flame. Remind them that this must be changed to a blue flame when doing the test and then returned to a yellow safety flame afterwards.
 5 min	Compound C = CaCO_3 Compound D = CuCl_2 Make sure that the learners tidy up after themselves, clean up any bench spills, empty the contents of their test-tubes and empty their 'chemical waste' into the main 'chemical waste' bottle. Finally, they should wash their hands.
 15 min	Plenary Discuss each result with the learners using the answers for Worksheet D.



Teacher notes

Watch the *Teacher walkthrough* video for unknown compounds **C** and **D** and read these notes.

Briefing lesson method

Corn starch and sugar:

1. Place a spatula full of each of the white powders into two separate small beakers. Tell the learners that one of them is corn starch and that the other is sugar. Ask the learners to tell you which is sugar and which is corn starch. How do they know this?
2. Remind the learners of the test for starch with iodine solution and the test for sugar with Benedict's solution. Ask the learners if they can remember the outcomes for the tests – if not, remind them using a video.

Baking powder and table salt:

1. Add a little vinegar to both substances and note the outcome.
2. Get the learners to identify the baking powder (it fizzes and bubbles).
3. Discuss with learners how they know that the other sample is table salt.
4. Lead them to the idea that a negative test does not mean that the sample is table salt and that a huge number of chemicals look just the same.
5. Make sure that you have a discussion about safety and that under no circumstances should learners taste the powders.

For the main practical lesson, each pair will require:

- stoppered vials (or test-tubes) containing the following compounds:
 - calcium carbonate (1 g, fresh sample, labelled 'Compound **C**')
 - copper(II) chloride dihydrate (1 g, labelled 'Compound **D**')
- a test-tube rack
- access to clean and dry test-tubes
- access to small, clean, dry spatulas
- distilled water (bottle)
- a loop of flame test wire attached to a suitable rod
- a Bunsen burner
- dilute hydrochloric acid [0.5 mol/dm^3]
- hydrochloric acid [5 mol/dm^3]
- fresh saturated limewater solution
- dilute nitric acid solution [0.5 mol/dm^3]
- silver nitrate solution
- sodium hydroxide solution [1 mol/dm^3]
- aqueous ammonia solution [1 mol/dm^3]

Each bench should have a beaker labelled 'chemical waste' on it so that learners do not tip chemicals down the sink. Even though the quantities of waste should be minimal, it is good practice to encourage environmental awareness.

Additionally, a large bottle (in a central location) labelled 'chemical waste' should be made known to the learners so that at the end of the experiment, before they wash their hands and take their lab coats off, they tip the contents of their beakers into it.

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Copper(II) chloride dihydrate (solid)	 GHS07 (<i>moderate hazard MH</i>)  GHS09 (<i>hazardous to the aquatic environment N</i>)	In the eye: flood the eye with gently-running tap water for at least 10 min. See a doctor. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Dust breathed in: remove the casualty to fresh air. See a doctor if breathing becomes difficult. Spilt on the skin or clothing: remove contaminated clothing and rinse it. Wash off the skin with plenty of water. Spilt on the floor, bench, etc.: scoop up compound (take care not to raise dust). Wipe up small solution spills or any traces of compound with cloth; for larger spills use a mineral absorbent (e.g. cat litter).
Calcium carbonate (solid)	LOW HAZARD	In the eye: flood the eye with gently-running tap water for at least 10 min. See a doctor. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: brush compound off contaminated clothing. Rinse clothing or the skin as necessary Spilt on the floor, bench, etc.: brush up compound spills, trying to avoid raising dust, then wipe with a damp cloth.
Dilute hydrochloric acid [0.5 mol/dm ³]	 GHS07 (<i>moderate hazard MH</i>) [below a concentration of 2.7 mol/dm ³]	In the eye: flood the eye with gently-running tap water for 10 min. See a doctor. Vapour breathed in: remove to fresh air. See a doctor if breathing becomes difficult. Swallowed: do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: remove contaminated clothing, then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Spilt on the floor, bench, etc.: for release of gas, consider the need to evacuate the lab and open all windows. For large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.

Substance	Hazard	First aid
Hydrochloric acid [2 mol/dm ³]	 GHS07 (<i>moderate hazard MH</i>)	In the eye: flood the eye with gently-running tap water for 10 min. See a doctor. Vapour breathed in: Remove to fresh air. See a doctor if breathing becomes difficult. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: remove contaminated clothing, then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Spilt on the floor, bench, etc.: for release of gas, consider the need to evacuate the lab and open all windows. For large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.
Dilute nitric acid [0.5 mol/dm ³]	 GHS05 (<i>corrosive C</i>)	In the eye: flood the eye with gently-running tap water for 10 min. See a doctor. Fumes breathed in: remove the casualty to fresh air. Keep them warm. If more than a 'sniff' is inhaled, see a doctor even if no symptoms are apparent. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: quickly use a dry cloth or paper towel to wipe as much liquid off the skin as possible. Then drench with plenty of water. If a large area is affected or blistering occurs, see a doctor. Remove contaminated clothing and rinse it well. Spilt on the floor, bench, etc.: wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated acid, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water.
Limewater solution [a saturated solution of calcium hydroxide, less than 0.02 mol/dm ³]	 GHS07 (<i>moderate hazard MH</i>)	In the eye: limewater is unlikely to cause serious problems; flood the eye with gently-running tap water for at least 10 min. See a doctor if there are any concerns. Swallowed: limewater is unlikely to cause serious problems. Wash out the mouth. See a doctor if there are any concerns. Spilt on the skin or clothing: wash with water. Spilt on the floor, bench, etc.: wipe up limewater or small amounts of compound with a damp cloth and rinse it well. For larger amounts of compound, scoop into a bucket, add water to the area followed by mineral absorbent (e.g. cat litter).

Substance	Hazard	First aid
Barium nitrate solution	LOW HAZARD	In the eye: flood the eye with gently-running tap water for at least 10 min. See a doctor. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: brush off any compound. Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Rinse contaminated clothing with water. Spilt on the floor, bench, etc.: scoop up any compound. Rinse the area with water, diluting greatly. Solutions should be treated with mineral absorbent (e.g. cat litter).
Ammonia solution [1 mol/dm ³]	 GHS05 (<i>corrosive C</i>)  GHS07 (<i>moderate hazard MH</i>)  GHS09 (<i>hazardous to the aquatic environment N</i>)	In the eye: flood the eye with gently-running tap water for at least 20 min (for alkalis). See a doctor. If it is necessary to go to hospital, continue washing the eye during the journey in an ambulance. Vapour breathed in: remove the casualty to fresh air. Call a doctor if breathing becomes difficult. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Spilt on the floor, bench, etc.: consider the need to evacuate the lab and open windows if large amounts are spilt and especially for (moderately) concentrated solutions. Cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.
Sodium hydroxide solution [1 mol/dm ³]	 GHS05 (<i>corrosive C</i>)	In the eye: flood the eye with gently-running tap water for at least 20 min. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance. Swallowed: wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. Spilt on the skin or clothing: remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Spilt on the floor, bench, etc.: wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated solutions, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water.

Teacher method



This is your version of the method for this experiment.

Do not share this method with learners. Give them [Worksheet C](#) and [Worksheet D](#).

Before you begin

Plan how you will group your learners during the experiment.

Think about:

- the number of pairs of learners you will need to cater for
- the amount of equipment/chemicals required
- where the chemicals will be placed in the lab
- the waste protocol for the lab
- the appropriate risk assessments and ensure they have been carried out.

Experiment

Circulate during the experiment in case learners encounter any difficulties.

Steps

Notes

1. Check that learners have all the chemicals they need in front of them.

If this is not possible because of space in the lab, set the chemicals out safely for easy access.

2. Check that the learners have **Worksheets A, C and D**.

3. Show the unknown samples labelled as 'C' and 'D' in vials or test-tubes.

Here is where you can ask:
1. What type of chemical bonding do compounds **C** and **D** have?
2. Does the appearance of the compounds tell us anything about their identity?

4. Before they start, warn the learners about safety and good practice for this experiment.

Always monitor learners doing the flame tests. Check that they use the blue flame for the test and return the Bunsen burner back to the safety flame afterwards.

5. Get the learners to perform each test and write their answers on **Worksheet D**.

Check to make sure that every learner is recording each observation as soon as they have completed each test.

Also ensure that both learners in the pair are taking an active role in the experiment.

Clean-up

After the practical learners should:

- empty their chemical waste into the main chemical waste bottle in a central location
- tidy up their work space and put things away as instructed
- ensure any spillages have been mopped up
- wash their hands with soap and water.

Details of the tests

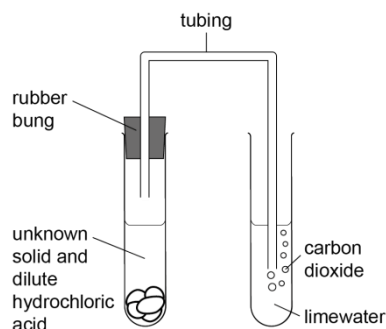
Here are the details of how to carry out each of the tests for the anions, cations and flame tests used in qualitative analysis. Before allowing your learners to do these tests, familiarise yourself with them.

*Anions***1. Test for carbonate ions in solution:**

- Add dilute hydrochloric acid (1 cm³).
- If effervescence/fizzing/bubbles are observed, the gas should be tested with limewater solution to confirm that it is carbon dioxide.
- To test with limewater, you will require two test-tubes, a rubber bung and some tubing.
- Set-up the apparatus as shown below:

Safety

Ensure learners use a light twisting action to place the bung in the mouth of the test-tube so that the gas cannot escape. Tell them to not press too hard as the glass tubing is easily broken.



- The limewater will go cloudy as the CO₂ is bubbled through it.

2. Test for chloride/bromide/iodide ions in solution:

- Acidify a solution containing the chloride/bromide/iodide ions (1 cm³) by adding dilute nitric acid (5 drops).
- Add aqueous silver nitrate solution (10 drops) and shake gently.
 - If chloride ions are present, a white precipitate will form.
 - If bromide ions are present, a cream precipitate will form.
 - If iodide ions are present, a yellow precipitate will form.

Note: this is a very sensitive test and deionised water should be used.

3. Test for nitrate ions in solution:

Safety

Do this test in the fume cupboard.

- (a) Add dilute sodium hydroxide solution (10 drops) to a solution containing nitrate ions (1 cm^3) and gently shake the mixture.
- (b) Add a small piece of aluminium foil to the tube.
- (c) Heat the tube gently for a few seconds only, ensuring that the mouth of the test-tube is facing away from yourself (and the learners). Then remove from the source of heat. Nothing much may appear to happen initially, but once the reaction starts it is very exothermic and can occasionally cause the contents of the tube to erupt out.
- (d) After gentle heating, the aluminium will be seen to be reacting vigorously and there is therefore no need for further heating.
- (e) At this point you should cautiously test for the presence of ammonia gas by placing a piece of damp red litmus paper close to the mouth of the test-tube.
A common cause of error is the learner touching the litmus paper against the inside of the test-tube making contact with the sodium hydroxide. This should be avoided, since it gives a false result.

4. Test for sulfate ions in solution:

- (a) Acidify a solution containing the sulfate ions (1 cm^3) by adding dilute nitric acid (5 drops).
- (b) Add aqueous barium nitrate solution (10 drops) and shake gently.
- (c) If sulfate ions are present, a white precipitate will form.

5. Test for sulfite ions in solution:

This test must be conducted carefully in a fume cupboard. If no fume cupboard is available, then use the video to show this test.

Safety

Sulfur dioxide is a pungent, toxic gas, and is particularly harmful to people with respiratory problems. Therefore, learners with such conditions should take extra care and not stand right next to the fume cupboard or smell the contents of the test-tube themselves.

- (a) Add a small volume of hydrochloric acid to the test sample and shake gently.
- (b) Warm gently and remove from the source of heat.
- (c) Immediately test for the presence of sulfur dioxide gas using potassium manganate(VII) solution.
- (d) Place a drop of acidified potassium manganate(VII) solution onto a strip of filter paper.
- (e) If sulfur dioxide gas is present, the purple-stained filter paper will become colourless.

Cations**1. Adding aqueous sodium hydroxide:**

- (a) Make a solution of the unknown and put 1 cm³ (max.) into a test-tube.
- (b) Add 1 cm³ (max.) sodium hydroxide solution and shake carefully.
- (c) Record the appearance of any precipitate formed.
- (d) Continue to add sodium hydroxide solution and shake – is the precipitate soluble or insoluble in excess?

2. Adding aqueous ammonia:

- (a) Make a solution of the unknown and put 1 cm³ (max.) into a test-tube.
- (b) Add 1 cm³ (max.) ammonia solution and shake carefully.
- (c) Record the appearance of any precipitate formed.
- (d) Continue to add ammonia solution and shake – is the precipitate soluble or insoluble in excess?

3. Test for ammonium ions in solution:

- (a) Add sodium hydroxide solution (1 cm³).
- (b) Warm the mixture gently in a Bunsen flame and then remove from the heat.
- (c) Moisten a piece of red litmus paper and hold it near the mouth of the test-tube. If the paper turns blue, this indicates that ammonia gas is present which confirms the presence of ammonium ions.
A common cause of error is the learner touching the litmus paper against the inside of the test-tube making contact with the sodium hydroxide. This should be avoided, since it gives a false result.

4. Flame tests*

- (a) Dip the flame test wire into a test-tube containing a small amount of hydrochloric acid [5 mol/dm³].
- (b) Heat the wire for a few seconds in the blue flame of the Bunsen burner.
- (c) Dip the wire into a solution of the test substance.
- (d) Observe and record the flame colour.
- (e) If multiple-flame tests are being performed make sure that the wire is cleaned by dipping it into the hydrochloric acid and heating in the blue flame, repeating this process until there is no positive flame test colour.

**Learners do not need to know the flame colour for calcium.*

Lab lesson: Option 2 – virtual experiment



Resources	• <i>Virtual experiment</i> video for unknown C and D • Worksheets A, C and D
------------------	--

Learning objectives	By the end of the lesson: • all learners should be able to make relevant observations based on the tests on the unknown compounds. • most learners should be able to identify compounds C and D. • some learners will be able to evaluate and interpret their results.
----------------------------	--

Timings	Activity
 10 min	Starter/Introduction Gather the learners around the screen and ensure they have the relevant worksheets (Worksheet A, Worksheet C and Worksheet D). Introduce the virtual practical. Tell the learners they will try to find out the cations and anions present in two compounds, C and D. Show them the start of the <i>Virtual Experiment</i> video for the two unknown compounds. What do they observe from just looking at them? The first thing the learners need to do on Worksheet D is to describe the appearance of compounds C and D. (Point them in the direction that it is the colour, not the texture that is important.)
 20 min	Main lesson Tests on compound C Focus on the tests and the observations at this stage. Allow the learners to work out what each observation or observations indicate. 1. Show the video for the test for a carbonate including the limewater test and then stop the video. Allow the learners to discuss and write down their observations. 2. Restart the video and show the flame test for compound C, not forgetting to discuss which flame to use and safety issues. Stop the video after the flame test. Allow the learners to discuss and write down their observations. The learners should now be able to decide what compound C is. Compound C is CaCO_3. Weaker learners may need help with writing down the chemical formula. Have a discussion with the learners about how the determination of compound C was an easy example to get them started, and that in fact, a confirmatory test for the presence of calcium ions using aqueous sodium hydroxide and aqueous ammonia solution would have been better. <i>Continues on next page ...</i>

Timings	Activity
 20 min	Tests on compound D Again, focus on the execution of the tests and the observations. 1. Explain that compound D was dissolved in distilled water and divided into three equal portions. 2. Part (c) on Worksheet D. Show the test for chloride ions on compound D. Some learners might wrongly think that the precipitate is light blue. The precipitate is actually white silver chloride; it only appears slightly blue due to the presence of unreacted copper chloride still in the test-tube. 3. Show the test with sodium hydroxide and then in excess. Stop the video after this test and ask the learners what 'in excess' means. 4. Show the test with ammonia solution and then in excess. Then stop the video. Finally, for compound D, the learners should now be able to decide what the compound is. Compound D is CuCl_2. Weaker learners may need help with writing down the chemical formula.
 10 min	Plenary Discuss each result with the learners using the suggested answers for Worksheet D.



Debriefing lesson: Good observations

Resources

- Worksheets D and E

Learning objectives

By the end of the lesson:

- **all** learners should be able to identify how we observe safely in the lab.
- **most** learners should be able to improve their observations from the lab lesson.
- **some** learners will be able to improve and evaluate others' observations based on their own understanding.

Timings	Activity
 10 min	Starter/Introduction Ask the learners: 1. Which of our senses can we use to observe safely in the lab? 2. Which of these senses do we most frequently use in qualitative analysis? Explain to the learners that good observations are the key to success in chemistry and also that these observations must be recorded fully and accurately. Give learners the following example. A learner has written the following response for the test for a sulfate: <i>'goes white'</i> What is wrong with this response and how could it be improved? Discuss with your learners and then write a more correct response on the board.
 20 min	Main lesson 1. Get learners to look back at what they have written on their results sheet (Worksheet D) for each test. 2. In their notebooks, ask them to re-write their observation(s) in full sentences as accurately as possible. Also get them to write a conclusion from that specific test. Ask learners to think about which scientific words they could have used and to incorporate them into their sentences.
 15 min	3. Next, ask the learners to swap sheets and discuss each other's answers. 4. Ask for example answers from the learners to show how, with the extra effort taken, fuller and more accurate responses can be achieved.
 15 min	Plenary Work through Worksheet E . Learners should match the right-hand column with the left-hand column. An example is given as a starting point. Learners should do this individually and then swap with another learner for checking.

Worksheets and answers

	Worksheets	Answers
For use in the <i>Briefing lesson</i>:		
A: Notes for use in qualitative analysis	20–21	—
B: Performing qualitative analysis tests	22–23	29–30
For use in <i>Lab lesson: Option 1</i>:		
A: Notes for use in qualitative analysis	20–21	—
C: Method	24–25	—
D: Results	26–27	31–32
For use in <i>Lab lesson: Option 2</i>:		
A: Notes for use in qualitative analysis	20–21	—
C: Method	24–25	—
D: Results	26–27	31–32
For use in the <i>Debriefing lesson</i>:		
E: Observation match	28	33



Worksheet A: Notes for use in qualitative analysis

Tests for anions

Anion	Test	Test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium nitrate	white ppt.
sulfite (SO_3^{2-})	add dilute hydrochloric acid, warm gently and test for the presence of sulfur dioxide	sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless

Tests for aqueous cations

Cation	Effect of aqueous sodium hydroxide	Effect of aqueous ammonia
aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	—
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt., or very slight white ppt.
chromium(III) (Cr^{3+})	green ppt., soluble in excess	grey-green ppt., insoluble in excess
copper (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Worksheet A: Notes for use in qualitative analysis



Tests for gases

gas	test and result
ammonia (NH_3)	turns damp, red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	'pops' with a lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns acidified aqueous potassium manganate(VII) from purple to colourless

Flame test for metal ions

metal ion	flame colour
lithium (Li^+)	red
sodium (Na^+)	yellow
potassium (K^+)	lilac
copper(II) (Cu^{2+})	blue-green

Solubility rules

These are a guide to help you appreciate qualitative analysis more fully.

Ion [solubility in water]	Exceptions
All nitrates (NO_3^-) are soluble	None
All halides (Cl^- , Br^- and I^-) are soluble	Silver (Ag^+) and lead (Pb^{2+})
All sulfates (SO_4^{2-}) are soluble	Lead (Pb^{2+}), barium (Ba^{2+}) and calcium (Ca^{2+})
All carbonates (CO_3^{2-}) are insoluble	Sodium (Na^+), potassium (K^+) and ammonium (NH_4^+)

Worksheet B: Performing qualitative analysis tests



Answer these questions which are based on the qualitative analysis tests you have just seen in the video(s).

Test for carbonate anion

(a) What do you observe when dilute hydrochloric acid is added to a carbonate?

.....

(b) Which reagent is used for testing the gas produced and what is the result?

.....

.....

(c) Explain why it is very important to keep the stopper kept on a freshly made up bottle of limewater.

.....

.....

Test for halide anion (chloride, bromide and iodide)

(a) What is the name of the reagent used to test for the presence of halide ions?

.....

(b) Define the term precipitate.

.....

.....

(c) Why is it very important to use distilled water in the test for chloride ions?

.....

.....

Test for sulfite anion

(a) Which gas is produced during a positive test for a sulfite?

.....

(b) What safety precautions need to be taken when performing this test?

.....

.....



Worksheet B: Performing qualitative analysis tests

Test for chromium(III) cation

(a) What does 'in excess' mean?

.....

.....

(b) What are the main differences in the results obtained when using aqueous sodium hydroxide, compared with using aqueous ammonia?

.....

.....

.....

Test for aluminium cation

(a) What is the result obtained, when a small amount of aqueous sodium hydroxide is added to aqueous aluminium ions?

.....

.....

(b) What happens when you add an excess of this reagent?

.....

.....

(c) How is the result of this test different to that obtained with aqueous ammonia?

.....

.....

Flame tests

(a) What do you need in order to perform a typical flame test?

.....

.....

(b) What safety precautions should be taken?

.....

.....

.....

Worksheet C: Method

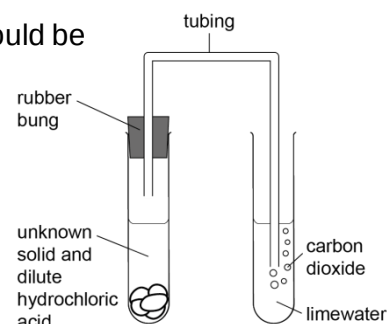


This sheet is to support you in understanding the tests used to identify your unknown substances.

Anions

1. Test for carbonate

- Add dilute acid (1 cm^3) to your unknown compound.
- If effervescence/fizzing/bubbles are observed, the gas should be tested with limewater solution. This will confirm the presence of carbon dioxide.
- To test with limewater, you will require two test-tubes, a rubber bung and some tubing.
- The set-up of the apparatus is shown opposite:
- The limewater will go cloudy as the carbon dioxide is bubbled through it.



Safety

Use a light twisting action to place the bung in the mouth of the test-tube so that the gas cannot escape. Be careful not to press too hard, else you might break the glass. Ask your teacher for help if you are unsure.

2. Test for chloride/bromide/iodide

- Acidify a solution of your unknown (1 cm^3) by adding dilute nitric acid (5 drops).
- Add aqueous silver nitrate solution (10 drops) and shake gently.
 - If chloride ions are present, a white precipitate will form.
 - If bromide ions are present, a cream precipitate will form.
 - If iodide ions are present, a yellow precipitate will form.

Note: this is a very sensitive test and deionised water should be used.

3. Test for nitrate (do this test in a fume cupboard)

- Add dilute sodium hydroxide solution (10 drops) to a solution of your unknown (1 cm^3) and gently shake the mixture.
- Add a small piece of aluminium foil to the tube.
- Heat the tube gently for a few seconds only, ensuring that the mouth of the test-tube is facing away from yourself. Then remove from the source of heat.
- After gentle heating, the aluminium will be seen to be reacting vigorously and there is therefore no need for further heating.
- At this point you should cautiously test for the presence of ammonia gas by placing a piece of damp red litmus paper close to the mouth of the test-tube.
Make sure you don't touch the inside of the test-tube with the litmus paper!

4. Test for sulfate

- Acidify a solution containing your unknown (1 cm^3) by adding dilute nitric acid (5 drops).
- Add aqueous barium nitrate solution (10 drops) and shake gently.
- If sulfate ions are present, a white precipitate will form.



Worksheet C: Method

5. Test for sulfite (do this test in a fume cupboard)

- (a) Add a small volume of hydrochloric acid to your unknown in a test-tube and shake gently.
- (b) Warm gently and remove from the source of heat.
- (c) Immediately test for the presence of sulfur dioxide gas.
- (d) Place a drop of acidified potassium(VII) manganate solution onto a strip of filter paper and place in the neck of the test-tube.
- (e) If sulfur dioxide gas is present, the purple-stained filter paper will become colourless.

Cations

1. Adding aqueous sodium hydroxide:

- (a) Make a solution of the unknown and put 1 cm³ (max.) into a test-tube.
- (b) Add 1 cm³ (max.) sodium hydroxide solution and shake carefully.
- (c) Record the appearance of any precipitate formed.
- (d) Continue to add sodium hydroxide solution and shake – is the precipitate soluble or insoluble in excess?

2. Adding aqueous ammonia:

- (a) Make a solution of the unknown and put 1 cm³ (max.) into a test-tube.
- (b) Add 1 cm³ (max.) ammonia solution and shake carefully.
- (c) Record the appearance of any precipitate formed.
- (d) Continue to add ammonia solution and shake – is the precipitate soluble or insoluble in excess?

3. Test for ammonium

- (a) Make a solution of the unknown and put 1 cm³ (max.) into a test-tube.
- (b) Add sodium hydroxide solution (1 cm³) to the unknown solution.
- (c) Warm the mixture gently in a Bunsen flame and then remove from the heat.
- (d) Moisten a piece of red litmus paper and hold it near the mouth of the test-tube. If the paper turns blue, this indicates that ammonia gas is present which confirms the presence of ammonium ions. Make sure you don't touch the inside of the test-tube with the litmus paper!

Flame tests

- (a) Dip the flame test wire into a test-tube containing a small amount of hydrochloric acid [5 mol/dm³].
- (b) Heat the wire for a few seconds in the blue flame of the Bunsen burner.
- (c) Dip the wire into a solution of the unknown.
- (d) Place the wire in the centre of the flame.
- (e) Observe and record the flame colour.

Worksheet D: Results



You have been provided with two compounds, labelled **C** and **D**.

Carry out the following tests on the compounds, entering your results and conclusions in the table.

Tests on compound C	
tests	observations
(a) Describe the appearance of the compound	
(b) Place a very small amount of the compound in a test-tube. Add dilute acid to it carefully. Keep this solution for test (c). Test the gas with limewater solution.	(i) (ii)
(c) Perform a flame test on the solution from (b) above. To do this, dip a clean flame test wire into the solution, and hold the wire into the blue Bunsen flame. Observe and record any flame colour produced.	(i)
Conclusion - Write down the name and formula of the cation and anion that you have identified above: - cation: anion: - Name of compound C: - Chemical formula of compound C:	

Worksheet D: Results



Tests on compound D	
tests	observations
(a) Describe the appearance of the compound	
(b) Dissolve compound D (one small spatula full) in distilled water (4 cm ³) with stirring until a solution is formed. (Do not worry if a very small amount of undissolved compound remains.) Divide this solution equally into four portions in four separate test-tubes.	
(c) To the second portion, acidify with dilute nitric acid (2 drops) add a solution of silver nitrate (5 drops).	
(d) To the third portion, add aqueous sodium hydroxide (10 drops) Now add an excess of aqueous sodium hydroxide noting any changes.	
(e) To the final portion, add aqueous ammonia solution (10 drops)	
- Write down the name and formula of the cation and anion that you have identified above: - cation: anion: - Name of compound D: - Chemical formula of compound D:	



Worksheet E: Observation match

Match the left-hand column with the right-hand column. One has been done for you.

Sugar in water.	colourless solutions
A precipitate is	adding much more than is needed for complete reaction
A solution	a compound that is formed when two solutions react together
White compounds dissolve to give	soluble
In excess means	dissolves
All common nitrates are in water.	is formed when a solute dissolves in a solvent
Transition metal compounds often have	coloured compounds
Effervescence means	fizzing and bubbling
A was observed when an excess of aqueous ammonia solution was added to a solution containing copper(II) ions.	potassium manganate(VII)
..... goes cloudy if you do not put the stopper back in.	limewater
..... changes colour from purple to colourless when testing for sulfur dioxide.	a deep blue solution

Worksheet B: answers



Answer these questions which are based on the qualitative analysis tests you have just seen in the video(s).

Test for carbonate anion

- (a) What do you observe when dilute hydrochloric acid is added to a carbonate?

effervescence / bubbling / fizzing

- (b) Which reagent is used for testing the gas produced and what is the result?

Limewater solution; the solution will turn cloudy/milky in the presence of carbon dioxide

- (c) Explain why it is very important to keep the stopper kept on a freshly made up bottle of limewater.

So the carbon dioxide in the air does not turn the limewater solution cloudy/milky

Test for halide anion (chloride, bromide and iodide)

- (a) What is the name of the reagent used to test for the presence of halide ions?

Silver nitrate solution

- (b) Explain the term precipitate.

A precipitate is formed when two solutions react together producing a solid substance that may or may not be dissolved in excess.

- (c) Why is it very important to use distilled water in the test for chloride ions?

The test for chloride is a very sensitive test and as tap water contains chloride ions, these will cause a precipitate to form and give a false result.

Test for sulfite anion

- (a) Which gas is produced during a positive test for a sulfite?

sulfur dioxide (SO_2) gas

- (b) What safety precautions need to be taken when performing this test?

The test must be done in a fume cupboard as sulfur dioxide is a toxic gas.

Worksheet B: answers



Test for chromium(III) cation

(a) What does 'in excess' mean?

In excess means adding much more of one reagent than is needed for complete reaction

(b) What are the main differences in the results obtained when using aqueous sodium hydroxide, compared with using aqueous ammonia?

One difference is in the solubility of the precipitate. With ammonia solution, the precipitate is insoluble in excess. Additionally, the colour of the precipitate is a grey-green colour compared to the green colour obtained with sodium hydroxide solution.

Test for aluminium cation

(a) What is the result obtained when a small amount of aqueous sodium hydroxide is added to aqueous aluminium ions?

A white precipitate is formed

(b) What happens when you add an excess of this reagent?

The precipitate dissolves to produce a colourless solution

(c) How is the result of this test different to that obtained with aqueous ammonia?

The precipitate formed is insoluble in excess reagent

Flame tests

(c) What do you need in order to perform a typical flame test?

The most important piece of equipment is a flame test wire made from an inert material that does not produce a flame colour itself. You also need concentrated hydrochloric acid to clean the wire in between tests and a Bunsen burner.

(d) What safety precautions should be taken?

Between the tests, and after use, the Bunsen burner should be left on a yellow safety flame. Long hair should be tied up and a lab coat and safety goggles must be worn. Care should be taken when using concentrated hydrochloric acid so that it does not splash.

Worksheet **D**: answers

Tests on sample C	
tests	observations
(a) Describe the appearance of the compound	<i>a white powder</i>
(b) Place a very small amount of the compound in a test-tube. Add dilute hydrochloric acid to it carefully. Keep this solution for test (c). Test the gas with limewater solution.	(i) <i>bubbles produced/ fizzing/ effervescence</i> (ii) <i>limewater solution changes milky/cloudy from a colourless solution</i>
Perform a flame test on the solution from (b) above. To do this, dip a clean flame test wire into the solution, and hold the wire into the blue Bunsen flame. Observe and record any flame colour produced.	(i) <i>a brick-red flame observed</i>
- Write down the name and formula of the cation and anion that you have identified above: cation: <i>calcium ion (Ca^{2+})</i> anion: <i>carbonate ion (CO_3^{2-})</i> - Name of compound C: <i>calcium carbonate</i> - Chemical formula of compound C: <i>CaCO_3</i>	

Worksheet **D**: answers

Tests on sample D	
tests	observations
(a) Describe the appearance of the compound	<i>green/blue crystals</i>
(b) Dissolve compound D (one small spatula full) in distilled water (4 cm ³) with stirring until a solution is formed. (Do not worry if a very small amount of undissolved compound remains.) Divide this solution equally into four portions in four separate test-tubes and place them in your test-tube rack.	
(c) To the second portion, acidify with dilute nitric acid (2 drops) add a solution of silver nitrate (5 drops).	<i>a white precipitate produced</i>
(d) To the third portion, add aqueous sodium hydroxide (10 drops) Now add an excess of aqueous sodium hydroxide noting any changes.	<i>a light-blue precipitate formed</i> <i>the precipitate does not dissolve</i>
(e) To the final portion, add aqueous ammonia solution (10 drops) Now add an excess of aqueous ammonia noting any changes	<i>a light-blue precipitate formed</i> <i>the precipitate dissolves giving a deep-blue solution</i>
- Write down the name and formula of the cation and anion that you have identified above: Cation: <i>copper(II) ion (Cu²⁺)</i> Anion: <i>chloride ion (Cl⁻)</i> - Name of compound D: <i>copper(II) chloride</i> - Chemical formula of compound D: <i>CuCl₂</i>	

Worksheet E: answers



Match the left-hand column with the right-hand column. One has been done for you.

Sugar in water.	colourless solutions
A precipitate is	adding much more than is needed for complete reaction
A solution	a compound that is formed when two solutions react together
White compounds dissolve to give	soluble
In excess means	dissolves
All common nitrates are in water.	is formed when a solute dissolves in a solvent
Transition metal compounds often have	coloured compounds
Effervescence means	fizzing and bubbling
A was observed when an excess of aqueous ammonia solution was added to a solution containing copper(II) ions.	potassium manganate(VII)
..... goes cloudy if you do not put the stopper back in.	limewater
..... changes colour from purple to colourless when testing for sulfur dioxide.	a deep blue solution

Cambridge Assessment International Education
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
t: +44 1223 553554 f: +44 1223 553558
e: info@cambridgeinternational.org www.cambridgeinternational.org

Copyright © UCLES 2023