Cambridge Assessment International Education

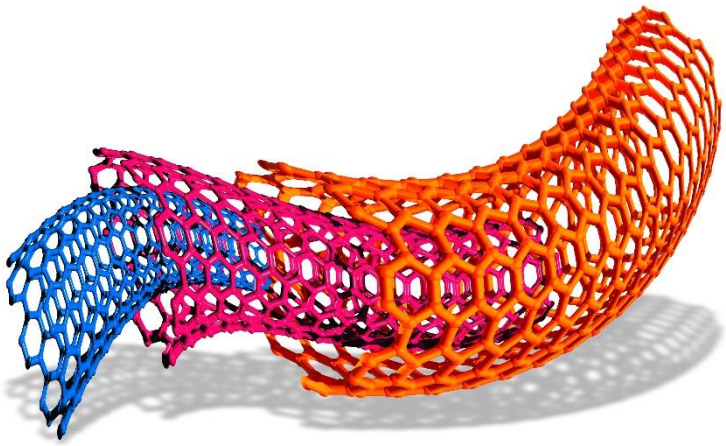
Teaching Pack

The distillation of a carbonated drink

Cambridge IGCSE™

Combined Science 0653

This *Teaching Pack* can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge IGCSE™ Chemistry (US) **0439**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge O Level Chemistry **5070**
- Cambridge O Level Combined Science **5129**



Version 2.0

Cambridge Pathway

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Briefing lesson

Lab option 1 – run the experiment

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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:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

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Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases this also includes the opportunity to practise extended writing skills.

** 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 distillation of a carbonated drink

This *Teaching Pack* focuses on a distillation experiment.

Distillation is a widely used method for separating mixtures. Here, you will distil a carbonated drink by heating it and separating out the substances based on their boiling points.

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

- C2.3 Methods of purification

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- make and record observations
- interpretation of experimental observations
- plan experiments and investigations, including equipment selection.

Prior knowledge

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

- C2.2 Criteria for purity
- C11 Air and water

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about fractional distillation.

Briefing lesson: Making observations and planning

Resources	• A box, about the size of a shoe box • 10 everyday items to fit in the shoe box • Worksheets A and B
Learning objectives	By the end of the lesson: • ***all*** learners should know what an observation is and be able to select appropriate equipment. • ***most*** learners should be able to suggest how we can make scientific observations and what equipment can be used to make it. • ***some*** learners will be able to evaluate the quality of observations made and be able to suggest improvements.

Timings	Activity
15 min	**Starter/Introduction** Fill a box with 10 everyday items, for example stationery (pens, erasers or pencil case); household items (books or cooking utensils) or classroom items (scissors, glue or textbook). Ask your learners, in small groups, to come and observe the contents of the box. When learners return to their desk, give them a short quiz (10 questions max.) on the contents of the box. The questions should require them to give detailed observational information about the items. For example: 1. What colour was the pencil? 2. Who was the author of the textbook? Try to make the questions specific – the aim of the activity is to get learners to understand that observation must be an active and detailed process.
10 min 10 min 20 min	**Main lesson** Ask learners to look at the statements given on Worksheet A. They need to work out which statements are observations and which are not. They also need to rewrite each statement to either make it an observation or improve it. Two examples are given. Ask learners to design the equipment set-up for a distillation experiment. Give them the following information: • We have a liquid (carbonated drink) that is made up of one or more substances. We are going to heat the liquid to separate it out into its different constituent parts. Your job is to design the equipment set-up for this. Remember to think about the substances you might collect and how you might test for them. Ask learners to discuss what equipment they would choose and how they would set it up with the person next to them. They should use Worksheet B to help with this. Remind them they will not need to use all of the equipment, and they need to think about reagents and other tests that might be needed. Learners should use the space on the reverse of Worksheet B to accurately draw their equipment set-up. Their design should be annotated so that their decisions are explained.
5 min	**Plenary** Now they have drawn their equipment, ask learners to write out a safety briefing that would explain to others how to use their equipment safely. Remind learners to also include general good practice in the lab.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • *Teacher Walkthrough video* • Worksheets C, D, E, G and H • Equipment as outlined in the notes
Learning objectives	By the end of the lesson: • ***all*** learners should understand how a distillation experiment works. • ***most*** learners should be able to gather data for the distillation experiment. • ***some*** learners will be able to start to evaluate and interpret the data collected.

Timings	Activity
10 min	**Starter/Introduction** Show learners the correct experimental set-up for the distillation experiment (Worksheet C). Ask learners to compare the correct set-up with their illustrations from the previous lesson and get them to identify any similarities or differences in approach.
	Main lesson Arrange learners in groups of 2–4.
5 min	Before they begin the experiment, make sure learners are aware of how often they should make their observations. This could be every 2 min or for every 10 °C change in temperature, for example. They can use Worksheet D to record their observations, or they can copy it into their lab books. Some learners might even wish to create their own table.
5 min	Learners should collect and set-up their distillation experiment following the diagram provided (Worksheet C). Make sure you draw their attention to specific things they should take care of, for example, the careful handling of glassware or the care needed when measuring out the limewater to prevent it from clouding.
20 min	When you have checked all of the equipment is set up correctly and safely, learners should begin the experiment. They should follow the method shown on Worksheet C and make careful records of their observations/findings as the experiment progresses. **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.
10 min	Once the experiment is complete, ask learners to interpret their results using the table on Worksheet E. You may want them to work on their own initially, and then join with a partner to check and refine their ideas.
10 min	**Plenary** Ask learners to complete Worksheet G, which summarises the experiment using the word grid on Worksheet H.

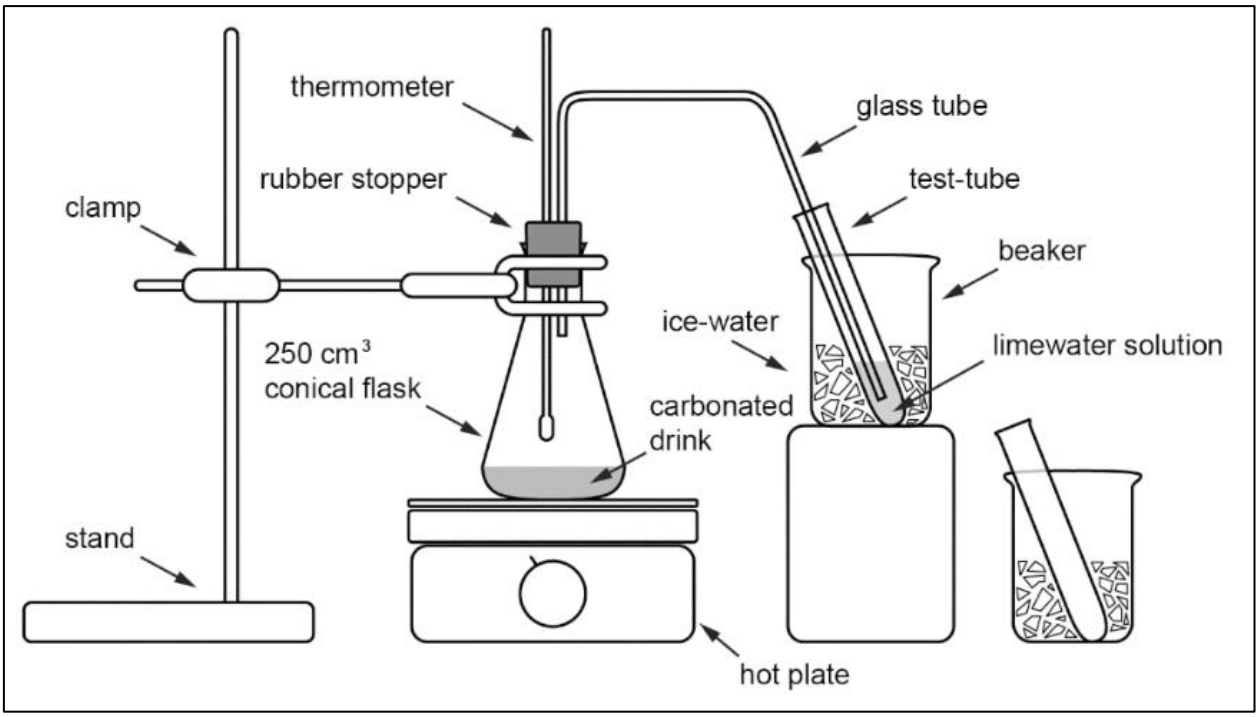
Teacher notes

Watch the *Teacher Walkthrough video* for distillation of a carbonated drink and read these notes.

Each group will require:

- access to water
- ice (enough to make two ice-water baths in 250 cm^3 beakers)
- limewater (saturated calcium hydroxide solution, less than 0.02 M). To prepare this add an excess of calcium hydroxide (or oxide) to water.
- carbonated drink(s)
- distillation equipment:
    - a clamp stand
    - a boss and clamp
    - one 250 cm^3 conical flask
    - a rubber stopper with two holes in it
    - a thermometer
    - a hot plate
    - glass tubing (but rubber tubing would also work)
    - two test-tubes
    - two 250 cm^3 beakers.

Experiment set-up



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
Limewater solution [a saturated solution of calcium hydroxide, less than 0.02 mol/dm^3]	 GHS07 (*moderate hazard* **MH**)	**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).
	Burns	Flood burnt area with water for at least 10 min. For serious injuries see a doctor.
Food	Allergies	Do not consume any foodstuffs in the labs. If discomfort persists see a doctor.

Teacher method

This is your version of the method for this experiment.

Do not share this method with learners. Give them Worksheet C.

Before you begin
Plan how you will group your learners during the experiment.

Think about:
- the number of groups you will need (group size 2–4 learners)
- the amount of equipment/chemicals required
- whether you are testing more than one carbonated drink.

Experiment
Circulate during the experiment in case learners encounter any difficulties.

Steps

1. Learners should collect all the equipment they need from the front of the class.

Notes

2. Learners should first prepare two ice-water baths.

Learners should not get any water inside their test-tubes. They should put the test-tube in the beaker first, pack with ice (carefully) and then make a slurry.

3. To one of the test-tubes, learners will add limewater (about two-thirds of the tube).

Remind learners not to disturb the limewater as it can easily become cloudy.

4. To their 250 cm^3 conical flask, the learners will add 100 cm^3 of the carbonated drink.

You could pre-prepare the 100 cm^3 of carbonated drink ahead of the experiment. Remind learners not to drink any of the carbonated drinks used.

5. Learners should place the flask on a hot plate.

Learners should not turn the hot plate on yet.

6. Learners will now assemble their distillation apparatus. They should fix the thermometer and the glass (or other) tubing to the rubber stopper.

Make sure learners are supplied with the correct sized stopper with two holes in it.

7. They will then fix the rubber stopper in the conical flask.

Watch learners carefully when they are fixing their distillation apparatus as glassware can break easily.
Be prepared for breakages and have a sharps bin nearby. Learners should not handle broken glassware.

8. Learners should now add the test-tube with the limewater in it to the end of the glass tubing.

Depending on the set-up, learners might need to support the beaker with blocks.

9. Learners should check that they are happy with their set-up before starting.

Make sure learners check their connectors. Are they secure?

10. Learners should now turn on their hot plates. They should record the temperature and start the stop clock.

Before they start, ensure learners are happy with what they are recording and how often.

11. Learners observe the carbonated drink and the test-tube.

Learners should observe that the carbonated drink bubbles, and that the gas escapes through the glass tubing into the limewater solution.
Learners should observe that the limewater goes cloudy – this is due to the formation of a precipitate from the reaction of calcium hydroxide with carbon dioxide producing calcium carbonate and water.

If learners do not observe this change, there could be a leak in their set-up or they might have over agitated their limewater. Ask them to check all connectors and tubing for any potential leaks. Ask them to show you how they added the limewater to the test-tube. You may need to provide them with the observations.

12. They should record any observations they notice based on their recording parameters (e.g. every 2 min or every 10 °C).

13. Once the limewater has changed and the rate of bubbles produced has slowed, leaners should remove the test-tube and water bath.

14. Quickly replace this with the second test-tube and water bath.

Watch out for any accidents at this stage. Whilst it should be done quickly, learners should still be careful with the glassware.

15. Learners should continue to heat the carbonated drink until it boils.

16. Whilst heating, learners should perform a waft test every minute until the mixture boils and record their observations, remembering to note the time/temperature as well as a description of the observation.

Demonstrate the proper technique for wafting hot vapours. Learners should not actively inhale them.

17. When the carbonated drink begins to boil, learners should observe the test-tube and record any observations.

Learners should see a clear liquid in their test-tubes, which is water. Learners could test this with cobalt(II) chloride.

18. Learners should continue to heat the carbonated drink until no further liquid is coming out of the tube.

If time permits, otherwise this stage could be omitted.

19. As a final observation, learners should look at the mixture that is left in the conical flask and record any observations.

If all the water has evaporated from the carbonated drink, the solution left over should be syrup.

20. Once finished, the learners should look at their recorded observations and start to evaluate their findings.

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment and any unused chemicals to you.

The carbonated drink and limewater solution should be flushed down the sink with plenty of water.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual experiment* video for distillation of a carbonated drink • Worksheets C, E, F, G and H
Learning objectives	By the end of the lesson: • ***all*** learners should understand how a distillation experiment works. • ***most*** learners should be able to gather data for the distillation experiment. • ***some*** learners will be able to start to evaluate the data collected.

Timings	Activity
10 min	**Starter/Introduction** Show learners the correct experimental set-up for the distillation experiment (Worksheet C). Ask learners to compare the correct set-up with their illustrations from the previous lesson and get them to identify any similarities or differences in approach.
15 min	**Main lesson** Ask learners to consider why the experiment is set up the way it is by watching the start of the *Virtual experiment* video and get them to answer **Q1–Q4**. Learners can answer as a whole class, or be asked to think about it in pairs or groups before sharing answers. When you click on the 'Question' buttons, the video will pause and a popup will appear. The video automatically pauses after the safety warning. Ask learners to consider what safety precautions they would need to take then get them to answer **Q5**. Make sure you discuss the incorrect options too. Explain that the distillation experiment would take about 20 min. Discuss how often they should make observations if they were doing the experiment themselves. This might be every minute, every 2 min or every time the temperature increases by 5 °C or 10 °C. Ask them what they think is appropriate.
5 min	Resume play on the video. Explain that they will now watch the distillation experiment and you want them to write down anything they think is important about the method, and any observations. The video will pause automatically at the end; do **not** answer the onscreen questions at this point. Learners should try to focus on what they think is important, rather than write down everything.
10 min	Hand out Worksheet F and ask learners to answer each question using the notes they made from the video. Have a discussion about if they were able to answer all the questions; are there differences/similarities between their notes; does this say something about their observation skills or understanding of the method; what was difficult about the task? Play the video again and get learners to answer **Q6–Q8**. They can also fill in any gaps on their sheet.
10 min	Answer **Q9** and **Q10**. Then let the video finish. Now ask learners to interpret the results of the experiment using the table on Worksheet E. You may want them to work on their own initially, and then join with a partner to check and refine their ideas.
10 min	**Plenary** Ask learners to complete Worksheet G, which summarises the experiment using the word grid on Worksheet H.

Debriefing lesson: Extended writing skills

Resources	• Data collected from distillation of a carbonated drink experiment • Worksheets E, I and J
Learning objectives	By the end of the lesson: • ***all*** learners should have been able to summarise their findings • ***most*** learners should be able to review their work, improving it in line with the success criteria • ***some*** learners will be able to evaluate the quality of the observations made in their experiment and be able to suggest improvements.

Timings	Activity
5 min	**Starter/Introduction** Ask learners to review their findings from the experiment – you may want to encourage them to share their findings with other learners. If you did the virtual experiment, ask learners to complete Worksheet E using their knowledge and notes they collected from the video.
10 min	Following this, ask pairs of learners to discuss what characteristics a good science write-up has. They are likely to suggest things like: explains processes, uses clear language; writing is concise, uses technical language or presents data clearly. Show them Worksheet I, which provides suggestions for learners to help them write scientifically.
20 min	**Main lesson** Learners need to write up the distillation experiment. To do this they can use **Worksheet I** to scaffold their writing. This sheet shows the points that learners need to include. They also show learners the success criteria for the task. Before they begin, you might want to use Worksheet J to discuss strategies learners can use to improve their extended writing.
10 min	Now they have written up their experiment, learners are going to formatively assess their work. They should swap their write-up with the person next to them. Using the success criteria, they should give each other feedback. There is a section on **Worksheet I** that has space for them to identify **three** things their partner has done well and **one** thing they need to improve. They can cut this out and glue it in, or write the feedback straight into their partner's lab book.
10 min	Learners should return the work to their partner. Each learner should read the feedback given by their partners. They need to act on the feedback by rewriting a section of their work, building in the improvements that their partner has suggested.
5 min	**Plenary** Ask learners to share the improvements they suggested in their evaluations. Ask them to critique each other's suggestions.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson*:		
A: What can we observe?	**16**	**30**
B: Drawing your experiment set-up	**17–18**	**—**
For use in *Lab lesson: Option 1*:		
C: Method	**19**	**—**
D: Equipment set-up/results	**20–21**	**—**
E: Explaining your results	**22**	**31**
For use in *Lab lesson: Option 2*:		
D: Equipment set-up/results	**20–21**	**—**
F: Observations	**23–24**	**—**
G: Summary	**25**	**32**
H: Word grid	**26**	**—**
For use in the *Debriefing lesson*:		
I: Interpretation and evaluation	**27–28**	**—**
J: Key ideas and literary techniques	**29**	**—**

Worksheet A: What can we observe?

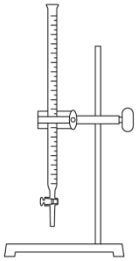
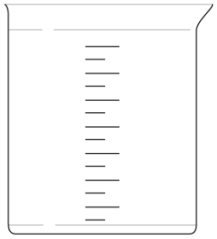
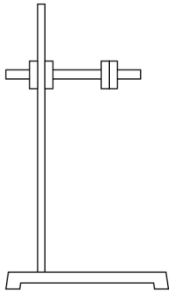
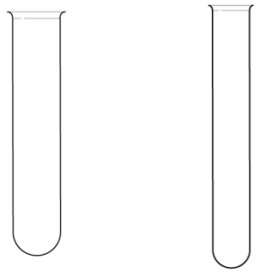
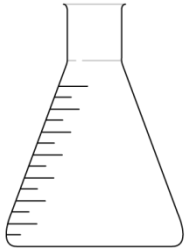
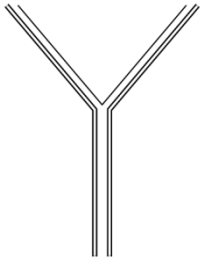
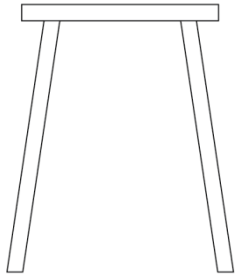
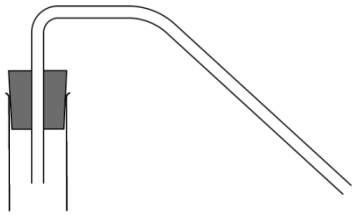
1. Look at the statements below.
2. Work out which statements are observations.
3. If the statement is not an observation, change it so that it is.
4. If the statement is an observation, see if you can change it to make it a better observation.

Two examples have been done for you.

Statement	Observation? Yes or No	Improved statement
A learner sees bubbles escaping from a liquid. Their observation is: Carbon dioxide is released.	*No*	*You cannot tell just by looking what gas the bubbles are. A better observation would be: Gas bubbles are released from the liquid.*
The temperature rises.	*Yes*	*The temperature rose rapidly by 10 °C in a minute.*
The solid is a powder.		
When the solid is added to the liquid it fizzes.		
When the reagent was added a solid formed in the test-tube.		
The limewater shows carbon dioxide was given off.		
The smell of the gas given off was pungent.		
The reaction is endothermic.		
The smell of the gas produced from the reaction was ammonia.		
The pH was low.		

Worksheet B: Drawing your experiment set-up

Here is a range of some common lab equipment.

			
burette	**beaker**	**boss, clamp and stand**	**boiling-tube and test-tube**
			
conical flask	**filter funnel**	**measuring cylinder**	**tripod**
			
bung and delivery tube	**thermometer**	**a heat source**	**pipette**

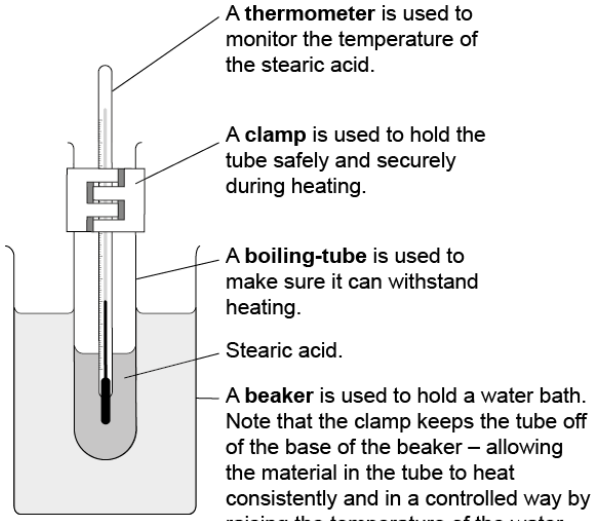
Worksheet B: Drawing your experiment set-up

In the space below, draw your experiment set-up.

Make sure you annotate your diagram showing the decisions you have made.

An example from a **different** experiment is shown.

Example:



Your experiment set-up:

Worksheet C: Method

1. Collect all your equipment from the front of the class.
2. Prepare two ice–water baths.
   - **(a)** Add two empty test-tubes into two beakers.
   - **(b)** Pack ice around each test-tube. Be careful not to get any ice in the test-tubes!
   - **(c)** Add water to the ice to make a slurry, again being careful not to get any water inside the test-tubes.
3. To one of the test-tubes, add limewater to fill about two-thirds of the tube. Try not to disturb the limewater as it can easily become cloudy when agitated.
4. To a 250 cm^3 conical flask, add 100 cm^3 of the carbonated drink supplied to you.
5. Place the flask on a hot plate (keep the hot plate turned off).
6. Fix a thermometer and glass tubing to a rubber stopper if these are not already set-up.
7. Secure the rubber stopper in the conical flask.
8. Place the end of the glass tubing into the test-tube containing the limewater. (You may need to support the water bath with blocks.)
9. Check that you are happy with the set-up and that everything is secure – does it match the diagram provided to you?
10. Turn on the hot plate and start heating the carbonated drink. Record the starting temperature and start the timer/stop clock.
11. Observe the carbonated drink and the test-tube.
12. Record any observations you notice, remembering to record the time/temperature of any observations.

You should notice a change in the limewater and that bubbles are released from the tube.

13. When the limewater has changed and the rate of bubbles produced has slowed, remove the test-tube and water bath.
14. Quickly replace this with the second (empty) test-tube and water bath.
15. Increase the heat.
16. Perform a waft test every minute until the mixture boils and record your observations, remembering to note the time/temperature as well as a description of the observation.

You may notice different smells coming from the test-tube. Gently waft the vapours towards you. Do not inhale the hot vapours!

17. When the carbonated drink begins to boil, observe the test-tube and record any observations.

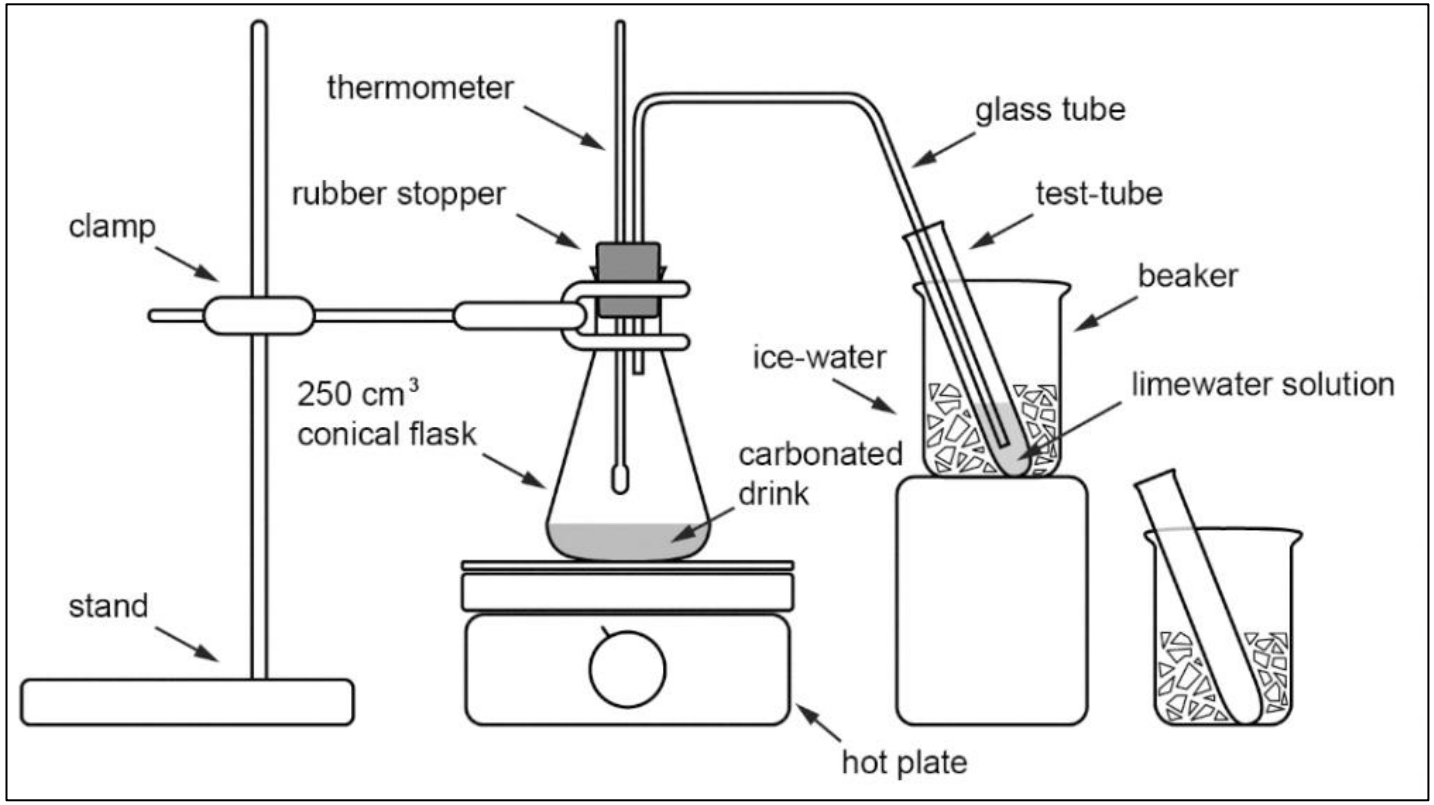
You should see a clear liquid in the bottom of the test-tube. Do you know what this is?

18. Continue heating until no further liquid is coming out of the tube from the carbonated drink.
19. Look at the mixture still in the conical flask and record any observations.
20. Look over your observations and data from the experiment and start to evaluate your findings.

Worksheet D: Equipment set-up

Make sure that you follow the diagram carefully.

Take particular care with any glassware and check that the rubber stopper completely seals the conical flask.



Worksheet D: Results

Time (s)	Temperature (ºC)	Observations
0	25	Bubbles being released naturally because the drink is carbonated. No other observations.

Worksheet E: Explaining your results

The table below shows observations that have been made during a distillation experiment.
Complete the table by interpreting the observations using your scientific knowledge.
The first one has been done for you.

Stage in experiment	Observations	Explanation
Mixture is below 30 °C	Nothing is happening. No vapours are visible, no smells have been produced.	*The substances in the mixture have not passed their boiling points.*
Mixture is above 30 °C	Small gas bubbles are beginning to form in the mixture of liquids. The gas bubbles are tested by passing them through limewater, and the limewater begins to turn cloudy.	
Mixture is between 40 °C and 50 °C	Bubbles are observed in the mixture that is being heated. When tested by wafting, the vapour produced smells of flavouring (for example, vanilla and cherry).	
Mixture is above 100 °C	The vapour passing through the tube is condensed and forms a colourless and odourless liquid. When tested with cobalt(II) chloride the colour of the cobalt chloride(II) changes from blue to pink.	

Worksheet F: Observations

Question	Observation
What is the first thing that you need to do?	
What volume of limewater is used?	
Why should you be careful not to disturb the limewater solution?	
What volume of carbonated drink is used?	
Why do the stopper and tubing need to be fastened tightly?	
What is the observation that indicates the presence of carbon dioxide? At what temperature does this happen?	**Test for carbon dioxide:** **Occurs at temperature:**

Worksheet F: Observations

Question	Observation
After the carbon dioxide is released, how long should the solution be heated for and at what temperature?	**Length of time:** **Temperature:**
How does the scientist test for the vapours? What would he have observed? What should he note down about his observations?	**Test for vapours:** **Observation:** **What the scientist needs to note down:**
At what temperature does a liquid start to appear?	
How much liquid should you allow to collect?	
What has been achieved by the end of the distillation?	

Worksheet G: Summary

Fill in the gaps in the passage below. Use the words on **Worksheet H**. Be aware that:

- some words appear more than once in the list
- each word can only be used once
- not all words will be used.

A carbonated drink is a mixture of different ingredients. ……..……..…….. can be used to separate the ingredients by their ……..……..…….. .

The ingredient with the ……..……..……..……..…… will boil off first and the ingredient with the ……..……..……..……..….. will boil off last.

The distillation apparatus is set-up so that the carbonated drink is heated and any vapours given off are funnelled into a glass tube.

To test for carbon dioxide, the glass tube is fed into a test-tube of ……..……..……... This goes cloudy due to the formation of a ……..……..…… from the reaction of calcium hydroxide with carbon dioxide to produce ……..……..……..…….. and water.

To test for food flavourings, the glass tube is fed into an empty test-tube and the vapours are wafted; they are detected as smells.

To test for water, the glass tube is fed into an empty test-tube. The test-tube is in an ice-water bath and the vapour condenses into a liquid. The resulting liquid is the ……..……..…… .

Any ingredients with a temperature too ……..……..…… to reach using the apparatus in a classroom will be left in the conical flask at the end of the experiment. This solution is called the ……..…… .

Worksheet H: Word grid

Fill in the gaps on **Worksheet G** using these words. Be aware that:

- some words appear more than once in the list
- each word can only be used once
- not all words will be used.

distillate	calcium carbonate	residue
highest boiling point	boiling point	precipitate
lowest boiling point	limewater	distillation
melting point	boiling point	carbon dioxide

Worksheet I: Interpretation and evaluation

Use this sheet to help you to write up your interpretations and evaluation for the distillation experiment.

Interpretation

Use this section to explain each of the observations made. Make sure you support this with the data collected. You should refer to:

- the temperatures the different stages of the experiment were carried out at
- the effect of the changing temperatures
- what you saw
- the substances that were collected and how you tested them.

Evaluation

Use this section to describe the strengths of the experiment and what you could do to make it better. You should refer to:

- what went well and the reasons for this
- what problems you experienced and why
- how you could solve the problems if you did the experiment again.

Writing check

1. Have you explained each of your observations, supported by data collected?

2. Have you identified what worked well and where improvements were needed?

3. Have you used a range of linking words (e.g. next, because) to extend your writing?

Check it

Read your partner's work and look back at the success criteria.

Record **three** things they have done well and **one** thing they need to improve.

Cut along the dashed line above and give this back to your partner.

The three things you have done well are:

1 ……

2 ……

3 ……

To improve, you need to:

……

……

Worksheet I: Interpretation and evaluation

This sheet shows some ideas and techniques you might want to use when writing up your experiments.

Section	What to include
Plan	This section should explain the processes involved in your experiment. You might also need to explain a theory or concept linked to your experiment. • Begin with general statements to introduce the background, e.g. 'Alkali metals are in Group 1 of the Periodic Table. This means that …' • Your vocabulary should be precise and you should use relevant technical words. • Your language should be impersonal. Do not use words like 'I' or 'we'.
Instructions or method	This section should have a sequence of steps that show how a task should be carried out. • State what you want to achieve, e.g. 'How to reduce copper oxide'. • Make sure you explain (or draw) the equipment and materials needed. • Explain clearly what steps should be taken to achieve the goal, e.g. 'Mix copper(II) oxide with carbon powder thoroughly'. • You should use imperatives like 'Measure 3 g of carbon powder.' Your instructions should be like a series of commands. • Use numbers or temporal connectives to show the stages involved. • Your language should be clear so that someone could repeat the experiment without mistakes.
Observations	This section should be made up of what you have been able to measure or observe. • Only record what can be seen or measured – do not make guesses about what the products of an experiment are without testing them, e.g. if you see bubbles, this is all you can say (unless you have tested the gas produced). • Your observations need to be as accurate as possible. Make sure you record them using the correct units. You may need to repeat observations.
Interpretations	This is where you need to make sense of the observations you have collected. • Now you can use your scientific knowledge to explain your observations. • Support points made with evidence from your observations, e.g. 'The bubbles observed turned the limewater cloudy, therefore it is clear these were carbon dioxide.'
Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. • Point out both the strengths and weaknesses of the experiment. • Avoid meaningless comments like 'It did not work very well.' Be specific and explain why the experiment did not work well and how you could improve it. • Use connectives to balance the strengths and weaknesses, e.g. 'although' or 'however'; or to give evidence, e.g. 'This is because …' or 'this shows that'.

Worksheet J: Key ideas and literary technique

Connectives help to develop your extended writing by allowing you to link ideas. This means that you can show how parts of the experiment link or how your observations might be supported by evidence.

In the table below there are examples of connectives you could use in your writing.

Useful connectives and where you might use them	
These connectives help you to show how time progresses. They are very useful in the planning and instruction sections.	• next • after • first, second, third etc. • 20 minutes later • meanwhile
These connectives help you to show cause and effect. They are very useful in the interpretation and evaluation sections.	• because • so • since • therefore • as a result
These connectives help you to show links and connections. They are very useful in the interpretation and evaluation sections.	• therefore • this shows • because • in fact • for example • furthermore • in conclusion
These help you to give comparisons, or to show differences. They are very useful in the interpretation and evaluation sections.	• although • while • similarly • equally • unless • whereas
These connectives help you to add evidence in your writing. They are very useful in the interpretation section.	• this shows that • as can be seen • as suggested by

Worksheet A: Answers

Statement	Observation? Yes or No	Improved Statement
A learner sees bubbles escaping from a liquid. Their observation is: Carbon dioxide is released.	No	You cannot tell just by looking what gas the bubbles are. A better observation would be: Gas bubbles are released from the liquid.
The temperature rises.	Yes	The temperature rose rapidly by 10 °C in a minute.
The solid is a powder.	Yes	A better observation could be that the powder is fine or coarse. Learners could also be specific about colour.
When the solid is added to the liquid it fizzes.	Yes	You could encourage learners to use more specific terms like effervesce.
When the reagent was added a solid formed in the test-tube.	Yes	Learners can be specific about the colour of the solid. They should also be encouraged to use the word precipitate.
The limewater shows carbon dioxide was given off.	No	Learners must explain what they observed to know that the limewater was indicating the presence of CO_2. For example, they should state the limewater turned cloudy or a white precipitate formed, due to bubbles of CO_2 coming from the carbonated drink, turning the limewater cloudy.
The smell of the gas given off was pungent.	Yes	Pungent is a good word for learners to use. They might also describe it as acidic or make use of any other relevant descriptive words.
The reaction is endothermic.	No	Learners must state that the temperature of the reagents fell and provide specific temperature information. This observation indicates the reaction is endothermic.
The smell of the gas produced from the reaction was ammonia.	No	The observation here would be that the smell of the gas is pungent. They would need to use wet red litmus paper to test for the presence of ammonia.
The pH was low.	No	Learners would need to carry out tests to identify the specific pH. Being able to give the precise pH would improve this observation.

Worksheet E: Answers

Stage in experiment	Observations	Explanation
Mixture is below 30 °C	Nothing yet is happening. No vapours are visible, no smells have been produced.	*All of the substances in the mixture have not passed their boiling points.*
Mixture is above 30 °C	Small gas bubbles are beginning to form in the mixture of liquids. If these gas bubbles are tested by passing them through limewater, the limewater begins to turn cloudy.	The small bubbles beginning to form are due to the gas in the liquid passing its boiling point. The gas can be identified as CO_2 as when bubbled through limewater, CO_2 reacts with the limewater ($Ca(OH)_2$) creating a white precipitate ($CaCO_3$), turning the limewater cloudy.
Mixture is between 40 °C and 50 °C	Bubbles are observed in the mixture that is being heated. When tested by wafting, the vapour produced smells of flavouring (for example, vanilla and cherry).	The bubbles forming at this stage are due to the flavourings in the drink passing their boiling points. We can identify these flavourings by wafting the vapours released. These should be characteristic of the carbonated drink being distilled.
Mixture is above 100 °C	The vapour passing through the tube is condensed and forms a colourless and odourless liquid. When tested with cobalt(II) chloride the colour of the cobalt(II) chloride changes from blue to pink.	The colourless liquid only begins to form once the temperature of the carbonated drink passes 100°C. This would lead us to believe that the colourless liquid formed is water as this boils at this temperature. By using the cobalt(II) chloride test, the presence of water is confirmed as the reagent turns from blue to pink.

Worksheet G: Answers

A carbonated drink is a mixture of different ingredients. *Distillation* can be used to separate the ingredients by their *boiling point*.

The ingredient with the *lowest boiling point* will boil off first and the ingredient with the *highest boiling point* will boil off last.

The distillation apparatus is set-up so that the carbonated drink is heated and any vapours given off are funnelled into a glass tube.

To test for carbon dioxide, the glass tube is fed into a test-tube of *limewater*. This goes cloudy due to the formation of a *precipitate* from the reaction of calcium hydroxide with carbon dioxide to produce *calcium carbonate* and water.

To test for food flavourings, the glass tube is fed into an empty test-tube and the vapours are wafted; they are detected as smells.

To test for water, the glass tube is fed into an empty test-tube. The test-tube is in an ice-water bath and the vapour condenses into a liquid. The resulting liquid is the *distillate*.

Any ingredients with a temperature too *high* to reach using the apparatus in a classroom will be left in the conical flask at the end of the experiment. This solution is called the *residue*.

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