

Is the secretary guilty?

This resource accompanies the article **Cold case chemistry** in *Education in Chemistry* which can be viewed at: <https://rsc.li/3XpQUNS>. Using this resource, your learners become chemical detectives by designing and carrying out their own forensic investigation using separation techniques.

Learning objectives

- 1 Use your knowledge of physical and chemical changes to design an experiment to analyse a sugar sample.
- 2 Collect your evidence by making careful observations while carrying out your experiment.
- 3 Write an investigation report including what you did, your results and conclusion.

Planning

Time	75 minutes – this time can be split into a 25-minute scene-setting and planning lesson, where learners have all the apparatus available to look at and a 50-minute practical session. In this time frame, many groups will complete the written report but others may require additional homework time. The exam-style question would be suitable for learners who finish early or as a homework activity. 15 minutes – meeting time where learners present their reports and arguments to the rest of the class (optional).
Group size	2–3
Curriculum links	Dissolving, filtration, evaporation, crystallisation, physical and chemical changes.

Possible approaches – scene-setting and planning

Start the lesson by showing a short video clip of a forensic science lab featuring in a TV crime drama or film. Discuss the role chemistry plays in helping to solve crimes, both past and present. You may wish to use an example from the accompanying *Education in Chemistry* article **Cold case chemistry**. Finish the discussion by emphasising that chemistry can only help to establish the facts. On its own, chemistry can't apportion blame – that job is left for someone else.

Next introduce the scenario to the class via the headteacher's email and explain the task. It would also be courteous to let the school secretary know what you are doing!

As outlined by the three learning objectives, this activity falls into three parts: planning, carrying out the investigation and report writing. It fits nicely into the curriculum where students learn about separating mixtures using techniques such as dissolving and solubility, filtration, evaporation and crystallisation. In order to design their own experiments, learners need to be familiar with these techniques as well as being aware of the differences between physical and chemical changes. During the planning stage, you may wish to have the equipment available for learners to look at. To increase challenge, include some equipment such as distillation apparatus as a distractor.

One approach is for learners to work in small groups through all three parts from start to finish. It is advisable to check each group's plan before they start on the practical work to make sure that they are on the right track. You may need to encourage them to modify their plans as they go along if they run into any difficulties such as caramelising the sugar content by overheating.

Depending on time constraints and the ability of your learners, you may wish to present all or some groups with a method to follow. In which case, the lesson would only focus on learning objectives 2 and 3.

Possible approaches – practical work

The first part of the experiment, to find out if there are 'glass shavings' or any other sharp materials in the sugar bowl, is straightforward. Most groups should be able to use prior knowledge to work out that we can dissolve the sugar in water and then filter the solution to remove any insoluble impurities. Any impurities can be dried and examined using a magnifying glass or under a microscope.

The second part of the experiment (getting the sugar back) is more difficult. It might be useful to stop the class and discuss how to 'get rid of the water quickly' without chemically changing the sugar. For example, using a naked Bunsen flame to heat the sugar solution will not work. At high temperatures sugar changes chemically as it starts to decompose.

Some groups may choose to concentrate the sugar solution using a water bath then leave this solution to evaporate naturally. Sugar is very soluble in water and will not crystallise unless most of the water is removed. So, the problem here is time. It can take a couple of weeks for a large quantity of water to evaporate. Some groups may realise that sugar is very soluble and only a small amount of water is needed to dissolve the sugar initially. This in turn means that the evaporation stage will be much quicker.

Alternative uses of the resource

This resource is suitable for high attaining learners aged 11–14 as the practical skills are of relatively low demand. However, in the planning stage they will have to apply their understanding of those practical skills to a new situation, which learners often find demanding and may need further support.

The resource is also suitable to be used with a STEM club with 11–14 or 14–16 learners. It could be run over several sessions. To increase the challenge for 14–16 learners, add some powdered chalk (calcium carbonate) into the 'sample from the head's sugar bowl' so that when the solution is filtered, an additional insoluble white solid is also left on the filter paper. The STEM club could then be asked to carry out some chemical tests to identify the white powder: eg a flame test, metal hydroxide precipitate test and tests for negative ions.

Full details, including videos, additional resources, teacher notes and technician notes of how to carry out the chemical tests used to identify both positive and negative ions can be accessed here: <https://rsc.li/3dhnn5B>.

Setting up the experiment

Refer to the technician notes for the equipment list, safety notes and preparation and disposal advice. Ensure learners are reminded that eating and drinking is never allowed in the lab.

[Read our standard health and safety guidance](#) and carry out a risk assessment before running any live practical.

Write up and assessment

Suggested write up

Learners should produce a group report using the headings:

- Problem
- Method
- Results
- Conclusion

Members of the group could be responsible for a section. Encourage the use of diagrams and photographs. Small sample bottles or plastic bags could also be available for learners to submit their actual evidence with the final report.

Evaluation of task

Here are some suggestions:

1. Judge against criteria for success. For example, use the learning objectives and the introduction to the learner task. You may wish to agree the success criteria with the learners at the start of the lesson.
2. Assess the task as a group activity, rather than as individuals.
3. Award marks for the following:
 - i. Experiment design – did the method work in the time available? Is it repeatable?
 - ii. Collecting evidence – was an ‘insoluble solid’ removed from the mixture? Was the sugar successfully recovered? What was the quality (shape and colour) of the recrystallised sugar crystals like?
 - iii. The investigation report contains a method, results and conclusion as to whether the secretary is guilty. Assess the conclusion on the quality of the arguments put forward and any questions that the chemistry couldn’t answer. For example, who else had access to the headteacher’s office?

Exam-style question

An optional exam-style question, with a structure strip, is included at the end of the student sheet. This question gives learners an opportunity to further demonstrate their knowledge and understanding of how chemical tests can be used to identify an unknown sample.

Answers

Structure strip Chemical tests to identify ions	Model answer
Write down the chemical formula for table salt.	Sodium chloride, NaCl.
Identify the positive and negative ions present in table salt.	The positive ion is sodium, Na ⁺ . The negative ion is chloride, Cl ⁻ .
Describe a chemical test that could be used to identify the positive ion. Write down the expected result.	Carry out a flame test by either method: Method 1 <ul style="list-style-type: none"> • Dip a clean nichrome wire loop into the solid sample. • Put the loop into a blue Bunsen flame. • Observe and record the flame colour produced.

	<p>Method 2</p> <ul style="list-style-type: none"> Using a test tube, dissolve the solid sample in water. Dip a soaked splint into the solution. Put the splint into a blue Bunsen flame. Observe and record the flame colour produced. <p>The expected flame colour for Na⁺ is yellow.</p> <p>Note – the sodium hydroxide test cannot be used to test for sodium ions because sodium ions are added to the sample.</p>
<p>Describe a chemical test that could be used to identify the negative ion.</p> <p>Write down the expected result.</p>	<p>The method for testing for chloride ions:</p> <ul style="list-style-type: none"> Using a test tube, dissolve the solid sample in water. Add a few drops of nitric acid to the sample. Add a few drops of silver nitrate. Carefully observe and note down any changes. <p>The expected result for chloride ions is that a white precipitate of silver chloride is formed.</p>
<p>State your overall conclusion.</p>	<p>If the results of all the ion tests are positive, then we can conclude that the table salt has been mixed up with the sugar.</p>

Further extension work

Find out how sugar is obtained from sugar beet. A good place to start is the [British sugar](#) website which describes how sugar is made from growing the sugar beet to packaging and delivering bags of sugar.

[Norbert Rillieux and the sugar industry](#) provides background information and further classroom activities on the extraction of sugar from sugar beet, both in the lab and on an industrial scale. It also includes some background information on Norbert Rillieux, who solved the problem of obtaining white sugar crystals with his invention of the multiple vacuum evaporator in 1846. Although recognised for his work, he was not socially accepted due to the colour of his skin. This activity offers the opportunity to discuss some of the difficulties faced by black scientists in the 19th century.

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