

The salt cellar mystery

A forensic investigation

background

This activity introduces students to the world of forensic science and involves gathering chemical and fingerprint evidence to solve a crime. Police reports and suspect statements are provided to set the scene and at the end of the activity students are asked to present their findings.

pre-planning required

weeks before

- Plan with schools how many students are coming to the session.
- Book rooms, refreshments, staff, inform technicians and ensure chemicals and sufficient safety glasses/lab coats are in stock.

days before

- Train demonstrators to do the practical and the associated safety aspects.
- Ask technicians to prepare apparatus and chemicals.

facilities required

- Laboratory
- Lecture room

general equipment

- FTIR spectrometer and accessories
- OHP for presenting results

Suggested timings for the day

09.00	Welcome and introduction Introduction to forensic science, scenes of crime and fingerprints. Teams view evidence and plan action	12.00	Lunch
09.55	Refreshments	13.00	Laboratory session 2 Flame tests, anion tests and IR analysis
10.15	Laboratory session 1 Fingerprint analysis and dissolving/filtering salt cellar sample to dry in oven over lunch	14.30	Preparation of presentations
		15.00	Refreshments
		15.15	Presentations
		15.45	Summary



materials required

- fingerprint kit
www.csiequipment.com
(CSI Equipment Ltd) small pure squirrel brush small inking pad 5 x 3"
- white porcelain salt cellar
- porcelain evaporating basins (to practice on)
- cotton liners (womens)
- cotton liners (mens)
- graphic powder
- sample X barium sulfate
- sample Y calcium carbonate
- sample Z calcium chloride
- salt cellar contents sodium chloride/barium sulfate
- fingerprint sheets for three suspects and victim
- IR sheets for samples X, Y, Z
- flame test wires
- small beaker and dilute HCl to wash wires
- Bunsen burner and mat
- spatula
- anion test solutions
- dilute nitric acid, fresh limewater, silver nitrate and barium chloride solutions
- five test-tubes/rack/delivery tube and bung
- disposable pipettes
- paper and pens, OHPs for presenting results



SAFETY

A risk assessment must be done for this activity.

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Answers: Police request results – item ABC1 salt cellar

Sample	Number of different fingerprints found	Matched with sample fingerprints
ABC1 salt cellar	2	Mrs A B Smith Mr Z Smith

Chemical analysis

Sample	Sample colour and appearance	Cation present	Anion present	Notes on IR spectrum	Identity of chemical
ABC2: Insoluble salt cellar contents	Granular powder white	Ba ²⁺ Green/orange flame	SO ₄ ²⁻		Barium sulfate
Sample X	Granular powder white	Ba ²⁺ Green/orange flame	SO ₄ ²⁻		Barium sulfate
Sample Y	Granular powder white	Ca ²⁺ Red/orange flame	CO ₃ ²⁻		Calcium carbonate
Sample Z	Granular powder white	Ca ²⁺ Red/orange flame	Cl		Calcium chloride

Example of a paint formulation

(Additional information will be provided near the end of the practical)

Alkyd resin	36.00%
Titanium dioxide	20.00%
Cobalt drier	0.20%
Lead drier	0.50%
White spirit	11.30%
Calcium carbonate	17.00%
Barium sulfate	10.00%
Talc	5.00%

This resource is based on an activity run by Dr Elizabeth Page, University of Reading.



NOTE

For the salt cellar sample even when separated the barium green flame can be difficult to see as the sodium colour is usually still very strong, also you cannot determine SO₄²⁻ for insoluble BaSO₄ as the test uses barium chloride to produce BaSO₄ precipitate.



SAFETY

Lab coat and safety glasses to be worn in the laboratory.

aim

Mrs Smith, a divorcee and mother of one, has been found dead in her home, slumped in front of the TV. The police are called and they suspect foul play. The police call for forensic reports on various items found at the scene of the crime and fingerprints are taken.

It is **your** job to provide the police with the necessary information to allow them to determine the cause of death and to identify the murderer. You will gather both written and chemical evidence to help solve the salt cellar mystery. You will then present your findings to a court of law where it will be used to prosecute the prime suspect.

The experiment**Scenario**

Police and paramedics were called to Flat 23B, Cheddar Way at 15:05 hours on 21st August 2008. On arrival they were met by Miss X Smith. She indicated that her mother appeared to be dead.

Mrs A B Smith was found in the living room fully clothed and seated in front of the TV which was switched on. She was confirmed dead at the scene.

Police suspected foul play due to several domestic incidents reported over the previous months.

Scene of crime officer (SOCO) report

Initial investigation of the scene showed the following:

- no evidence to suggest a break in or immediate foul play;
- no broken items, house in usual state, no forced entry;
- clothing and footwear, hair combs were taken by police at the *Post Mortem*; and
- biological samples were taken from the body by the pathologist at the *Post Mortem*.

Scene of crime analysis

- 1 Who would the police call/use to help them with their investigation?
- 2 How can the police establish whether or not there had been a break in etc?

- 3 What items would you take from Mrs Smith or the scene which may be useful for forensic examination?
- 4 What examination is likely to be performed next?
- 5 Why would such an examination take place?

Pathologist report

A *Post Mortem* of Mrs A B Smith on the 22nd August 08 showed that she had been suffering from diarrhoea and vomiting before her death. She was under weight and dehydrated. Estimated time of death: 13.30 hours on the 21st August 08.

There were no signs of any physical attack or injury to Mrs Smith and there were no signs of any recent medical treatment or operation.

Consultation with her GP revealed she had been prescribed an anti-acid preparation on the 10th August 08, otherwise she was in good health.

Samples of urine, blood and stomach contents were taken for forensic toxicology examination.

Pathologist report analysis

- 6 What is forensic toxicology?
- 7 What do you think the forensic toxicologist is looking for in the samples from the body?

Forensic toxicology report

Forensic toxicology results showed that there were very high levels of barium in the blood, urine and stomach contents samples taken from Mrs Smith.

The presence of barium in the stomach contents, indicates that the material was ingested rather than inhaled or injected. It was not possible to determine the type of barium salt ingested at this stage.

High levels of barium in the body are very unusual. Most barium salts when ingested are highly poisonous resulting in vomiting, diarrhoea and even death if consumed in large enough doses. The dose resulting in a fatality depends on the type of barium salt involved.

Toxicology report analysis

- 8 What has been established so far?
- 9 What do we know about the scene?
- 10 Who do you think we should know more about?
- 11 Who do you think the police should interview?
- 12 Can we rule out suicide?

Pathologist and toxicology report conclusions

Either Mrs A B Smith died from natural causes resulting from a bacterial or viral stomach infection or she had ingested a toxic material that eventually lead to her death.

It is highly unlikely that Mrs A B Smith died from taking the anti-acid preparation.

The presence of very high levels of barium provides strong support for the assertion that Mrs Smith was poisoned by this substance. No other toxic materials were found in the samples.

Background information: Victim**Mrs A B Smith. Flat 23B, Cheddar Way.**

Mrs Smith (deceased) was a divorced 55 year old mother of one.

She worked full time as an Administrator for the Local Council. However, she had been off sick for a week prior to her death.

She had lived in the two bedroom flat since her divorce two years ago.

The separation from her husband was acrimonious with accusations of infidelities on both sides.

The police had been called to her home on several occasions over the past year due to noise and other public disturbances as a result of her arguing with male friends and also with neighbours.

Information (interview/statement): Suspect 1**Mr Z Smith. 191 The Ridge.**

Twice divorced, the latter being from the late Mrs A B Smith. He is 56 years old and has worked for over 10 years as Factory Manager at Potters Paints.

On the morning of the 21st August, Mr Smith got up, had breakfast and left his house at 8.30am and drove straight to work. He finished work at 5:00pm. He went to lunch at the local pub at 13:00 hours and returned to work at 14:00 hours.

During interview he claims that he had not seen the deceased for over seven months. He also claims that he does not have access to Mrs A B Smith's house.

Information (interview/statement): Suspect 2**Miss X Smith. 5 Anvil Close.**

Daughter of Mr and Mrs Smith, a Bank Clerk at the local bank in the High Street.

Miss Smith was on good terms with her mother and visited her twice a week and phoned her daily. She had a key to Mrs A B Smith's flat and often let herself in.

Miss Smith was concerned about her mother's illness and persuaded her to go to the GP on the 10th August. Miss Smith was considering taking her mother to hospital if she had not improved by the end of the day (21st).

Miss Smith had been on a training course for four days prior to the 21st August and was travelling back from Edinburgh on the 21st. She arrived home at 2pm and after unpacking went to see her mother at 3pm.

Information (interview/statement): Suspect 3**Mr A Lawn. 66 Redwood Road.**

Local gardener/groundsman for flats in Cheddar Way.

He knew Mrs Smith well and they often went dancing.

On the 21st August, Mr Lawn got up, had breakfast and left home at 7:00am and travelled over 50 miles to a friend's house to landscape the garden at the property. Mr Lawn did not leave until 9:00pm. The friend confirmed Mr Lawn's whereabouts during the day.

The last time Mr A Lawn saw Mrs Smith alive was on the 18th August 2006 when he went to visit her after hearing she was unwell.

Suspect analysis

- 13 Who is the most likely suspect?
- 14 What should the police do now?
- 15 Who would search the scene?
- 16 Who would search the suspects premises?
- 17 How does barium exist? What does it look like?

Police investigation continued

Further to the pathologist's and forensic toxicologist's report.

SOCO search Mrs Smith's flat for possible sources of barium. The SOCO, via the police, submit a number of items, including a salt cellar, to the Forensic Science Laboratory to be examined for barium. The salt cellar, in addition to analysing the contents, will need to be examined for fingerprints.

Also, due to the ill feeling between Mr and Mrs Smith, police search Mr Smith's house for evidence. Police find three unlabelled substances. Samples were submitted to the Forensic Science Laboratory for identification. These were kept in unmarked bags in Mr Smith's garage. Each weighed about 1 kg.

Police also search Mr Lawn's property. Many chemicals and poisons used for gardening were found in a shed at his home. All appeared to be stored and labelled correctly. None of these were seen to contain any compounds of barium. No samples were seized at this stage.

Practical investigation

Your job is to complete the analysis of the evidence for the police as requested.

Police request 1 from Flat 23B, Cheddar Court.

Item ABC1 Salt cellar

Request: Fingerprint analysis

Item ABC2 Contents of salt cellar

Request: Record appearance, record colour, perform infrared spectroscopy, flame tests and standard anion tests. Collate results.

Police request 2 from 191, The Ridge.

Items X, Y and Z white powder

Request: Record appearances, record colours, perform infrared spectroscopy, flame tests and standard anion tests. Collate results.

Lab session 1**Fingerprint analysis****Perform the analysis requested and complete the table of results.**

Your demonstrator will show you how to collect fingerprints from the evidence. You may be given a porcelain evaporating basin which you can use to practice on.

From Flat 23B, Cheddar Court Item ABC1 – salt cellar

Test the outside of the salt cellar Item ABC1 for fingerprints. How many types are present on the salt cellar? If present, who do these match?

Salt cellar contents analysis

Dissolve the salt sample from the salt cellar in deionised water, filter off any residue and dry this residue in an oven over lunch ready for analysis.

Lab session 2**IR analysis**

You will either be shown how to run an infrared spectrum for the samples or be provided with a copy of the spectrum for analysis.

For Item ABC2 Contents of salt cellar analyse the IR spectra provided for the contents of the salt cellar and note down any interesting peaks.

Flame tests

Metal	Flame colour
Barium	Light green
Calcium	Red-orange
Copper	Blue-green
Magnesium	White
Potassium	Lilac
Sodium	Yellow

For items X, Y, Z compare the spectra obtained for the three powders found at 191, The Ridge, with the spectrum taken from the contents of salt cellar Item ABC2. Do any of them match?

flame tests for cations

Your demonstrator will show you how to perform a flame test safely.

Using a flame test wire cleaned in dilute hydrochloric acid test the samples by dipping the wire in the sample then burning in the Bunsen flame. Note the colour of the flame and use the table provided to identify the cation.

**SAFETY**

Students must be shown how to safely use a Bunsen burner to perform a flame test.

Anion tests

Using the chemicals provided perform small scale test-tube tests on each sample to establish the identity of the anions present.

- Using a spatula put a small amount of the sample to be tested in a test-tube.
- Add about 3 cm³ of dilute nitric acid solution.
- If the sample gives off a gas which turns lime water milky it must contain carbonate.
- If the sample does not give off a gas split the mixture into two test-tubes for further tests.
- To one add a few drops of silver nitrate. If a chloride is present the solution will turn cloudy.
- To the second test-tube add barium chloride solution. If a sulfate is present the solution will turn cloudy.
- Record your results in the table provided.

Summary of results**Fingerprint analysis**

Sample	Number of different fingerprints found	Matched with sample fingerprints

Chemical analysis

Sample	Sample colour and appearance	Cation present	Anion present	Notes on IR spectrum	Identity of chemical
ABC2: Insoluble salt cellar contents					
Sample X					
Sample Y					
Sample Z					

Police request: Results summary

- Analyse all results provided and collected. Use all the evidence and produce a statement about how the crime was committed, and who the murderer was.
- Prepare a brief 3-5 minute presentation to the rest of the group (the findings and final conclusion based on the forensic evidence).

