Yusuf Hamied Chemistry Camp

CSIR-Central Electrochemical Research Institute (CSIR-CECRI)

Karaikudi, Tamil Nadu
22 January - 24 January 2025

The Yusuf Hamied Chemistry Camps are organised by the Royal Society of Chemistry as part of the **Inspirational Science Programme,** sponsored by **Dr. Yusuf Hamied**, leading Indian philanthropist and pioneer in the pharmaceutical industry.

WELCOME

Hello and welcome to the Yusuf Hamied Chemistry Camp at the

CSIR-Central Electrochemical Research Institute (CSIR-CECRI), Karaikudi, Tamil Nadu

This booklet contains all the information you will need for the Camp

so try not to lose it!

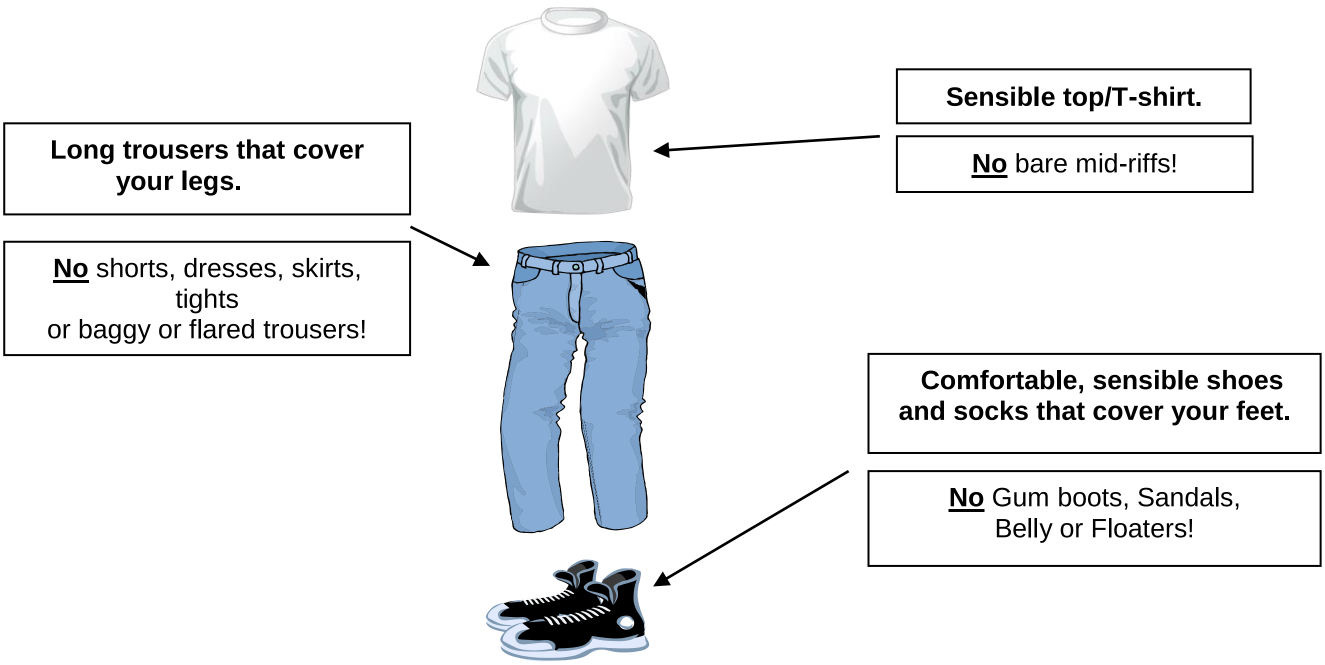
If you've got any problems with anything then be sure to speak to any of the Camp staff, they'll be more than willing to help you.

NAME OF STUDENT…………………………………………………………………

CAMP RULES

- **No alcohol**
- **No smoking**
- **No illegal substances**
- **No boys in girls' rooms and girls in boys' rooms**
- **Lanyards to be worn at all times**
- **Mobile phones or other electronic equipment (i.e. MP3 Players) must be switched off during lab and lecture sessions**
- **Equipment and chemicals must NOT be removed from the labs**
- **Please look after your belongings. The organisers of the Chemistry Camp cannot accept responsibility for such items**
- **All times specified by the Teacher Mentors to be adhered to**
- **Please be prompt**
- **All room keys to be handed to your Teacher Mentor on the morning of departure**
- **There will be a charge for lost room keys**

Please remember that in the labs, you should wear…



Programme Schedule of the Yusuf Hamied Chemistry Camp at CSIR-CECRI (22 January – 24 January 2025)

DATE	7:30 – 8:00 am	9:00 – 11:00 am		11:30am – 12:30pm	12:30 – 1:30pm	1:45 – 3:15 pm		3:30 – 5:00 pm		5.30-6:30 pm	8:00 - 9:00 pm	10:00 pm
Jan 22, 2025 (Wednesday)	**Breakfast**	**9:00 – 9:45 am Registration** **10:30 am Inaugural address** **Ice Breaker Activity & Group Photo**	**Morning snack**	**Lab Safety Briefing and Introduction to Equipment** **(Lab Coats and Safety Specs to be issued)**	**Lunch**	**Colour Creation** (Blue/Green/ Orange) **Crystallisation** (Purple/Red/ Yellow)	**Break**	**Crystallisation** (Blue/Green/ Orange) **Colour Creation** (Purple/Red/ Yellow)	**Snack**	**Quiz Session/ Science Show by University Team**	**Dinner**	**Lights Out**
Jan 23, 2025 (Thursday)	**Breakfast**	**Forensic Challenge** (Blue/Green/ Orange) **Clock Reactions** (Purple/Red/ Yellow)	**Morning snack**	**Popular Science Talk by University Faculty**	**Lunch**	**Slime!** (Blue/Green/ Orange) **Global Coin Battery Experiment** (Purple/Red/ Yellow)	**Break**	**Campus tour**	**Snack**	**Movie Screening/ Science Show/Career Guidance by University Team**	**Dinner**	**Lights Out**
Jan 24, 2025 (Friday)	**Breakfast**	**Clock Reactions** (Blue/Green/ Orange) **Forensic Challenge** (Purple/Red/ Yellow)	**Morning snack**	**Fun Experiments/ Demo by the University Team**	**Lunch**	**Global Coin Battery Experiment** (Blue/Green/ Orange) **Slime!** (Purple/Red/ Yellow)	**Break**	**Finale and Certificate-giving Ceremony**				

CRYSTALLISATION

Background on crystals and their importance in everyday life

Crystals are all around us in everyday life. They range from common and inexpensive items such as salt and sugar through to expensive items such as diamonds and other jewels.

Almost anything can be made into a crystal through the process of crystallisation. Most commonly, crystallisation is the (natural or artificial) process for the formation of solid crystals from a solution. It is possible to grow crystals in other ways too, such as allowing metals to solidify from their melted states. The electronics industry relies on growing single crystals of silicon in this way.

Crystallisation is also a useful chemical technique to separate or purify a solid. This is done by dissolving the sample in a hot liquid, making a saturated solution. Anything that does not dissolve in the hot liquid can be removed by filtration and what remains can then be to grow pure crystals which can be collected and dried.

Definition

A crystalline solid is made up of atoms or molecules which are arranged in a repeating pattern and stacked over and over again, very much like a three-dimensional brick wall (or several layers of stacked marbles on top of one another). In many ways, looking at a crystal is the closest the human eye will ever get to observing the order of atoms and molecules.

History

Just over a hundred years ago, father-and-son team William Henry and William Lawrence Bragg first showed that X-rays can be used to map the positions of atoms within a crystalline solid and determine its three-dimensional structure. This process is called crystallography and, to help celebrate this discovery, 2014 is the International Year of Crystallography. The two Braggs were awarded the Nobel Prize for this discovery in 1915 and, at the age of 25, Lawrence Bragg is still the youngest ever winner. Since this discovery, nearly 30 Nobel Prizes have been awarded which have used crystallography.

Part A: Dissolving and saturating your samples

In this experiment, you will find out that each sample has its own unique properties. You have a choice of five different samples (table salt, sugar, Epsom salts, alum and potassium nitrate) to make into a saturated solution. Once you have chosen your sample, you will need to carry out the experiment three times to obtain an average and record your observations.

A saturated solution is one which will not allow any more of the sample to dissolve at a particular temperature.

Materials

Clear plastic disposable cups (or similar, eg glass beakers)
The five samples: Table salt, sugar, Epsom salts, alum and potassium nitrate (½ a cup of each sample is plenty)
Teaspoon (or spatula)
Cold tap water
Small measure (measuring 40 cm^3 is required, eg. a measuring cylinder, beaker or clean medicine syringe)
Balance or kitchen scales
Thermometer (widely available from online retailers)

Procedure

1. Accurately measure 40 cm^3 of cold tap water into a clear plastic disposable cup and record its mass (record this in the student worksheet provided **[A]**).
2. Carefully add ¼ of a teaspoon of your sample (table salt, sugar, Epsom salts, alum or potassium nitrate) to the cup of water and stir for 30 seconds. Once dissolved, continue adding ¼ teaspoon measures followed by stirring until no more of the sample will dissolve.
3. Measure the temperature of this saturated solution (record in the table **[B]**).
4. Record the mass of the cup and saturated solution which should clearly have approx. ¼ of a teaspoon quantity of solid sample sitting at the bottom (record in the table **[C]**).

5. Calculate the mass of the sample required to saturate 40 cm^3 of your local tap water (record in the table **[D]**).
6. To ensure your data are consistent, repeat steps 1 to 5 twice more or compare with group colleagues.
7. Using the student worksheet, calculate the average temperature of the saturated solution during the experiment **[E]** and record this for posting to the website.
8. Calculate the average mass of your sample needed to saturate 40 cm^3 of your local tap water **[F]** and record this for posting to the website.
9. Gather the data for all five samples and record this in the overall conclusion.

The sample I am testing is ....

	Result 1	Result 2	Result 3
Mass of disposable cup and 40 cm^3 of cold local tap water (g) **[A]**			
Temperature of the saturated solution (^oC) **[B]**			
Mass of saturated solution and cup (g) **[C]**			
Mass of my sample needed to saturate 40 cm^3 of cold local tap water (g) **[C - A = D]**			
Average Data Average temperature of the saturated solution **(^oC)** **[(B1+B2+B3) / 3 = E]**			
Average mass of my sample needed to saturate 40 cm^3 of cold local tap water (g) **[(D1+D2+D3) / 3 = F]**			

Part B: Growing crystals of your samples

You have completed 'Part A: Dissolving and saturating your samples' and will have seen that the five samples have very different properties. In this experiment you will be making a saturated solution at a higher temperature and then cooling it down so that some of the dissolved material comes out of solution in a crystalline form.

All five samples should be tested by the group.

Do you think the amount of sample that dissolves in hot water will be different from cold? Why?

Can you predict which sample will grow the biggest crystal?

Materials

Kettle (hot water required, needs adult supervision)[Potential burns/spill/slip hazards]
Thermometer (widely available from online retailers)
Container/cup (eg glass beakers, styrofoam cup or clear plastic disposable cup)
The five samples: Table salt, sugar, Epsom salts, alum or potassium nitrate (½ a cup of each sample is plenty)
Teaspoon (or spatula)
Small measure (measuring 40 cm^3 is required, eg. a measuring cylinder, beaker or clean medicine syringe)
Filter paper (or paper towel/kitchen roll/coffee filters)
A thin wooden food skewer (contamination: do not re-use)[Potential sharp stick injury]
Clothes pegs (or alternative way to suspend the skewer in the saturated solution)
A magnifying glass to see your crystals more clearly

Procedure

1. Ask an adult to boil tap water.
2. Into a clean container/cup add four full teaspoon measures of your sample (table salt, sugar, Epsom salts, alum or potassium nitrate).
3. Ask an adult to measure 40 cm^3 of the hot water (the temperature needs to be at 70 ^oC or above) and transfer this to your container/cup with your sample inside. [Potential burns/spill/cup melting hazards] – [Safety Tip: you could use secondary containment to prevent burns or spills].
4. Stir for 30 seconds and – if required – add more sample repeatedly until your sample will no longer dissolve (larger amounts than in Part A can be added to get to saturation).
5. Fold a square filter paper into a triangle making two folds and open it making a cone shape.
6. Pour your warm saturated sample through the cone-shaped filter paper into a clean, empty plastic disposable cup (this process removes undissolved material).
7. Using a wooden skewer and clothes pegs, suspend the tip of the skewer just below the surface of the solution.
8. Leave the cup for a week for crystal growth. After a few hours, crystals can often be seen in the bottom of the cup but the slower-growing crystals will grow on the stick. [Tip: if after one day you do not get any crystals add a few grains of solid sample to encourage crystal growth].
9. After a week, record the temperature of the remaining liquid on your results table **[G]**.
10. Remove the stick and identify the best (biggest) single crystal from your cup.
11. Match your crystal to our 'size and shape charts' below and record your data in the results table **[H]** and **[I]**. Collaborate with others to get results for all the samples.

	Table Salt	**Sugar**	**Epsom Salts**	**Alum**	**Potassium Nitrate**
Temperature of the remaining solution (your local room temperature) (^oC) [**G**]					
The size of the biggest single crystal **[H]**					
The shape of the biggest single crystal [**I**]					

COLOUR CREATION

pH colour	1 red	2	3	4 orange	5	6	7 green	8	9	10 blue	11	12	13	14 violet

Background information

Panic! The Art Department at your school has run out of water-based coloured paints just before the GCSE examinations and there is no time to order new stocks.

They need each of red, orange, yellow, green, blue and violet but only have a Universal dyeing solution which changes colour at different pH values.

The Chemistry Department has a little hydrochloric acid and sodium hydroxide solutions left at the end of a very busy year.

Your task is to produce small samples of the six colours to a reliable 'recipe', so that the Art Department can scale up your experiment to make some more paints in time for the examination.

Your task

1. Produce six different coloured solutions
   (i.e. red, orange, yellow, green, blue and violet)

2. When you have produced your six colours produce a reliable 'recipe' which can be used to create any of the six colours on demand.

SLIME!

Turning Glue into Slime, or into a Bouncy Ball

You can do some very interesting chemistry at home, using commonly available materials. For the following experiment, you will need borax (that you can buy at most pharmacies/ medicine stores) and transparent water based synthetic glues (for example, Fevigum).

Making slime:

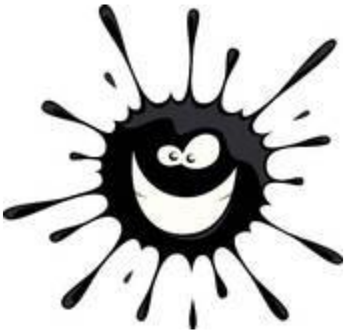
1) Add enough borax to water and stir until no more borax will dissolve. This is called a saturated solution.
2) Mix one part of synthetic glue with two parts of water and stir well. You can add a pinch of food colour to this, to make the slime colourful. To this, add the concentrated borax solution, drop by drop while stirring vigorously. Stop adding borax once this turns into slime.

Making a bouncy ball with the same materials:

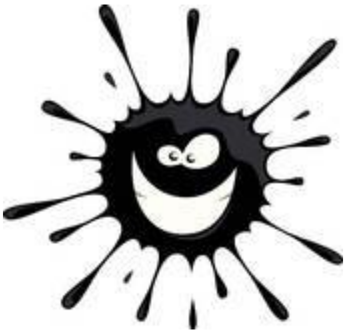
If you add the borax solution to the synthetic glue (don't add water to the glue, like you did for the slime), then you can make a bouncy ball. Make sure that, as you add the borax solution, you stir vigorously to completely mix the borax with the glue. Once the material becomes rubbery, you can roll it in your hands to make a bouncy ball.

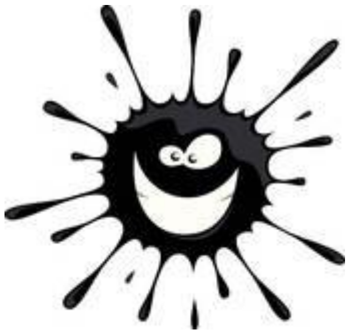
What you have done in these experiments is to *cross-link* the polymer molecules in the glue. Common synthetic glues typically contain polymers such as poly vinyl alcohol and poly vinyl acetate. These are long string-like molecules that dissolve in water. When you add the borax to it, they cross-link, viz. they form chemical bonds so that the strings get knotted. If you make many such knots, you can make a bouncy, rubbery ball. You can try various glues that you can buy locally. Some glues, like, Fevi-Quik, for example won't work since they don't have these polymers and use a different chemistry for adhesion. Try to use different colours, and different glues to see which work, and try and look up the chemical composition of the glues to understand why.

Such cross-linking reactions have an interesting history. During the Second World War, since Malaysian rubber was no longer available, scientists in the West were trying to make synthetic rubber. At the General Electric Company, a chemist called James Wright mixed boric acid with silicone oils (that had been recently invented by Frederick Kipping from the University of Nottingham in the UK) and found that he could cross link the silicone molecules. This material couldn't be used as a substitute for rubber, but it became a very popular toy called "Silly Putty", that you can buy even today. This experiment might have inspired the popular 1961 Disney film, "The Absent Minded Professor" and a more recent version (Flubber, in 1997, with Robin Williams) where a scientist invents a super bouncy material.



The Blot
Strikes Again!





To get started……..

Each pair should have:

- ❖ 1 copy of the Booklet outlining the Challenge
- ❖ 1 copy of the Forensic Report

Read all the information in your Booklet! You will find it helpful to do this all together before you start the Challenge.

There is plenty of time to complete the Challenge so **do not rush**!

The Tests ……..

There are two different tests for you to carry out. When you have finished both tests, discuss your results, then neatly complete your **Forensic Report**. When you have completed the Forensic Report, it will be collected for the Judges' comments.

Health and Safety

Read and note the Hazard warnings on the chemicals. Ask your group leader or a technician to explain what they mean if you are not sure.

You are to wear eye protection at all times during the practical work and gloves **must** be worn when using silver nitrate.

All spillages are to be reported to your group leader or the technicians. Spillages on the bench are to be mopped up immediately. If chemicals are spilt on clothes or skin they are to be rinsed thoroughly with plenty of water. If chemicals are splashed in eyes, help must be sought immediately from the technicians.

Marks will be awarded for the following:-

- ❖ health and safety
- ❖ team work
- ❖ presentation of results

You will also score marks for your Forensic Report and your conclusion.

This is not a race, take your time so that you get the correct results!

For Information

One test involves testing salts. The salt that most people know about is sodium chloride, which is used to flavour foods. However, sodium chloride is just one example of a salt and you will meet several other salts in this activity. Salts contain two parts, a metal part (for example, sodium) and a non-metal part (for example, chloride). In this investigation your team will only have to identify the non-metal parts of salts by carrying out test tube reactions on given samples.

The other test involves paper chromatography. This technique is used to separate different substances dissolved in a liquid, for example, a mixture of dyes. (For example, if you use this technique on brown Smarties, you will find out that the coating is made up of red, blue and yellow food colouring.) Your team will use this technique to compare given samples of ink.

Memo

1 April, 10.00 hrs

To: The Forensic Chemistry "A" Team
From: Chief Inspector Rakesh, Salterstown Police CID

As a team of Forensic Chemists, you are asked to solve the appearance of gnomes in front gardens of houses in Salterstown. A label with a large ink blot was hung round the neck of each gnome. This has led to the thief earning the nickname "Blot". The most recent incident took place earlier today.

The police have identified 5 people who were known to be in the area early this morning. The thief appears to have been careless this time as traces of a white powder were found on the gnome. I have sent you a sample of this, together with samples taken from the clothes of the 5 suspects. The label from the most recent incident is attached together with samples of the ink from the pens of the suspects.

You will need to consider the information from the scene of the crime to find out what happened and how it happened. You will also need to use the clues provided in the attached **Police Report** to support your theory.

So that I can progress with the investigation and brief the Chief Constable, I require a forensic report summarising your analysis of the unidentified substances together with your identification of the chief suspect by noon today.

Police Report

Police Incident Report

I was called to 13, The Crescent at 7am this morning by Rekha, the owner of the house. She had noticed the gnome in her garden at 6.50 am when she opened her front door to take in her milk. She recalled seeing someone hurrying away down the street and it looked as if they were carrying a large bag. The gnome was not there when she let her cat out at 6.05am.

I noticed the label tied round the gnome's neck and there were traces of a white powder on the gnome so I requested assistance from the Forensic Team.

House to house enquiries revealed that 5 people were seen walking down the Crescent around the time of the appearance of the statue. Some of the timings they gave seemed a bit vague so I am not sure they are totally accurate. I also interviewed Uday, the milkman (his statement is below) and have discounted him as a suspect.

WPC Indira

Witness Statement from Uday, the Milkman

I deliver milk to many houses in the Salty Bay area of Salterstown. I am usually finished my round by 6.15 am when I go home and have a cup of tea. My customers rely on me to deliver their milk in time for breakfast. There aren't many people around at that time of the morning, and those that are, are usually in a hurry to get home or get to work, so I was surprised to see someone loitering in the Crescent just as I was delivering to the final customers on my round. It was only just getting light, so I could not see clearly but the person appeared to be carrying a large bag and was wearing dark clothes.

Uday

Exhibits

Sample **A**	from **Ramesh**'s clothing
Sample **B**	from **Piyush**'s clothing
Sample **C**	from **Jyothi**'s clothing
Sample **D**	from **Vidya**'s clothing
Sample **E**	from **Vijay**'s clothing
Sample **F**	from **Tanaya**'s clothing
Sample **X**	from the scene of the crime

Sample **1**	ink from **Ramesh**'s pen
Sample **2**	ink from **Piyush**'s pen
Sample **3**	ink from **Jyothi**'s pen
Sample **4**	ink from **Vidya**'s pen
Sample **5**	ink from **Vijay**'s pen
Sample **6**	ink from **Tanaya**'s pen
Sample **Y**	ink from the blot on the label

Information about the Suspects

Suspect (1): **Ramesh - A Painter and Decorator**
Ramesh lives in Salty Bay and left home around 6am to get to his current job by 7am. He confirmed that he walked down the Crescent on his way. He was wearing denim jeans and a black jacket and carrying a large bag containing his overalls and brushes. He is a keen gardener and loves planning how he would change gardens he walks past.

Suspect (2): **Piyush - A Cleaner**
Piyush works as a cleaner at an office block at the end of the Crescent. He works from 3am until 6am when he walks down the Crescent to catch the bus home. He was wearing blue overalls and was carrying a bag which had contained cleaning materials. He has been known to take up dares from his mates at his local club.

Suspect (3): **Jyothi - A Farm Worker**
Jyothi works at a farm on the outskirts of Salterstown. She is living with her parents at 27, The Crescent, she had overslept and left for work later than usual, just after 6am. She was dressed in her work dungarees but was carrying a large bag with her wellington boots. Although she loves her parents, she finds the Crescent a boring place to live. Everyone is too conventional!

Suspect (4): **Vidya - A Chef**
Vidya works as a chef at the Café Bleu on the High Street in Salterstown. She starts work at 7am and usually walks to work. The Crescent is on her route. She was wearing black jeans and a dark blue jacket and was carrying a large bag containing her chef's whites. She had hoped to buy a house on the Crescent but things hadn't worked out.

Suspect (5): **Vijay - A Builder**
Vijay usually cycles to work but this morning his bike had got a puncture so he had decided to walk to work along the Crescent. The building site he works at is behind the office block at the end of the Crescent. He reckoned he was on site by 6.30am. He is known to have a great sense of humour and loves playing practical jokes.

Suspect (6): **Tanaya – A Gardener**
Tanaya works for the local council in the Memorial Park. She gets of the bus at the top of the Crescent and walks down the Crescent to the Park. The bus usually drops her off at 6.10am. She has worked hard to make the Memorial Park a fun place to spend time by persuading local artists to donate quirky sculptures.

Instructions

Test Tube Reactions to test for the Non-metal Part of Salts

Test the samples A-F and X.

1. Put a small spatula measure of the sample to be tested into a clean test tube
2. Add dilute nitric acid (irritant) to a depth of about 3 - 4 cm
   If your sample fizzes then it must contain carbonate as the non-metal part
3. If your sample does not fizz then split your mixture evenly into 2 clean test tubes
4. To the first test tube add a few drops of silver nitrate (remember to wear gloves).
   If your clear solution goes cloudy, your sample must contain chloride as the non-metal part
5. To the second half of the mixture, add a few drops of barium chloride (harmful).
   If your solution goes cloudy, your sample must contain sulfate as the non-metal part
6. Record your results on the **Results Sheet**, as you test each sample

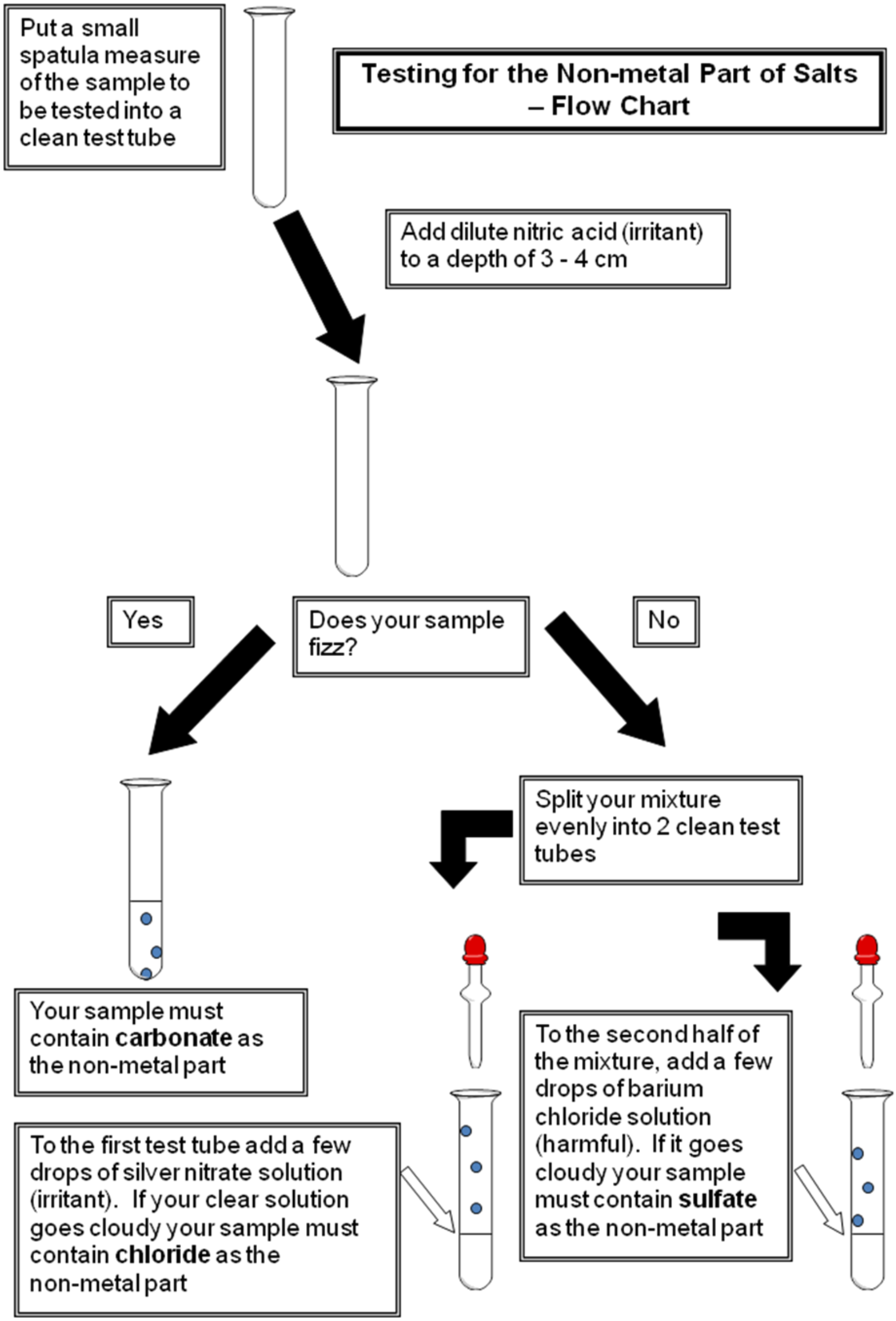
Paper Chromatography to determine the type of ink used

Test the samples 1-6 and Y.

1. To prepare your chromatogram, draw a pencil line horizontally across the chromatography paper 1.5 cm from the bottom. Draw a second line above it which is 3.5 cm from the bottom.
2. Using a thin glass rod dip the end of the rod into sample Y. Carefully dab the end of the rod on to the upper horizontal line you have drawn, making sure the ink spot is not touching the edge of the paper. Allow the spot to dry and then mark underneath it (in pencil) which sample it is, e.g. Y.
3. Repeat this procedure for each of the Samples 1-6 using a clean rod each time, until you have seven spots equally spaced horizontally on the paper. It may be easier to use two pieces of chromatography paper and put fewer dots on each.
4. Allow the ink to dry thoroughly.
5. Carefully add distilled water to the beaker to a depth of 1.5 cm (the same height as the lower pencil line on the paper).
6. Suspend the paper in the beaker provided so that the bottom of the paper just touches the bottom of the beaker.
7. Leave the paper in the beaker for 10 - 15 minutes. Watch carefully as the water rises up the paper. Remove the paper and leave it to dry.

Record your results on the **Results Sheet**, as you test each sample.

Testing for the Non-metal Part of Salts – Flow Chart



Results Sheet

Student Names …………………………………. ………………………………….

Test Tube Reactions to Test for the Non-metal Part of Salts

	Reaction with nitric acid	**Reaction with silver nitrate**	**Reaction with barium chloride**	**Non-metal part present**
	Fizz? yes / no	**Goes cloudy? yes / no**	**Goes cloudy? yes / no**	
Sample A (from Ramesh's clothing)				
Sample B (from Piyush's clothing)				
Sample C (from Jyothi's clothing)				
Sample D (from Vidya's clothing)				
Sample E (from Vijay's clothing)				
Sample F (from Tanaya's clothing)				
Sample X (from the scene of the crime)				

Paper Chromatography

	Colours observed	**Does this match Sample Y? Yes/No**
Sample 1 (ink from Ramesh's pen)		
Sample 2 (ink from Piyush's pen)		
Sample 3 (ink from Jyothi's pen)		
Sample 4 (ink from Vidya's pen)		
Sample 5 (ink from Vijay's pen)		
Sample 6 (ink from Tanaya's pen)		
Sample Y (ink from the blot on the label)		

Forensic Report

Student Names ………………………………………………………………………………

Evidence from Ramesh

Non - metal part present in Sample A is ………………………………[5 marks]

Colours present in Sample 1 are ………………………………[5 marks]

Evidence from Piyush

Non - metal part present in Sample B is ………………………………[5 marks]

Colours present in Sample 2 are ………………………………[5 marks]

Evidence from Jyothi

Non - metal part present in Sample C is ………………………………[5 marks]

Colours present in Sample 3 are ………………………………[5 marks]

Evidence from Vidya

Non - metal part present in Sample D is ………………………………[5 marks]

Colours present in Sample 4 are ………………………………[5 marks]

Evidence from Vijay

Non - metal part present in Sample E is ………………………………[5 marks]

Colours present in Sample 5 are ………………………………[5 marks]

Evidence from Tanaya

Non - metal part present in Sample F is ………………………………[5 marks]

Colours present in Sample 6 are ………………………………[5 marks]

Evidence from the scene of the crime

Non - metal part present in Sample X is ………………………………[5 marks]

Colours present in Sample Y are ………………………………[5 marks]

Conclusion

The chief suspect is ……………………………………………………[max. 10 marks]

Reasons………………………………………………………………………………………………

………………………………………………………………………………………………………

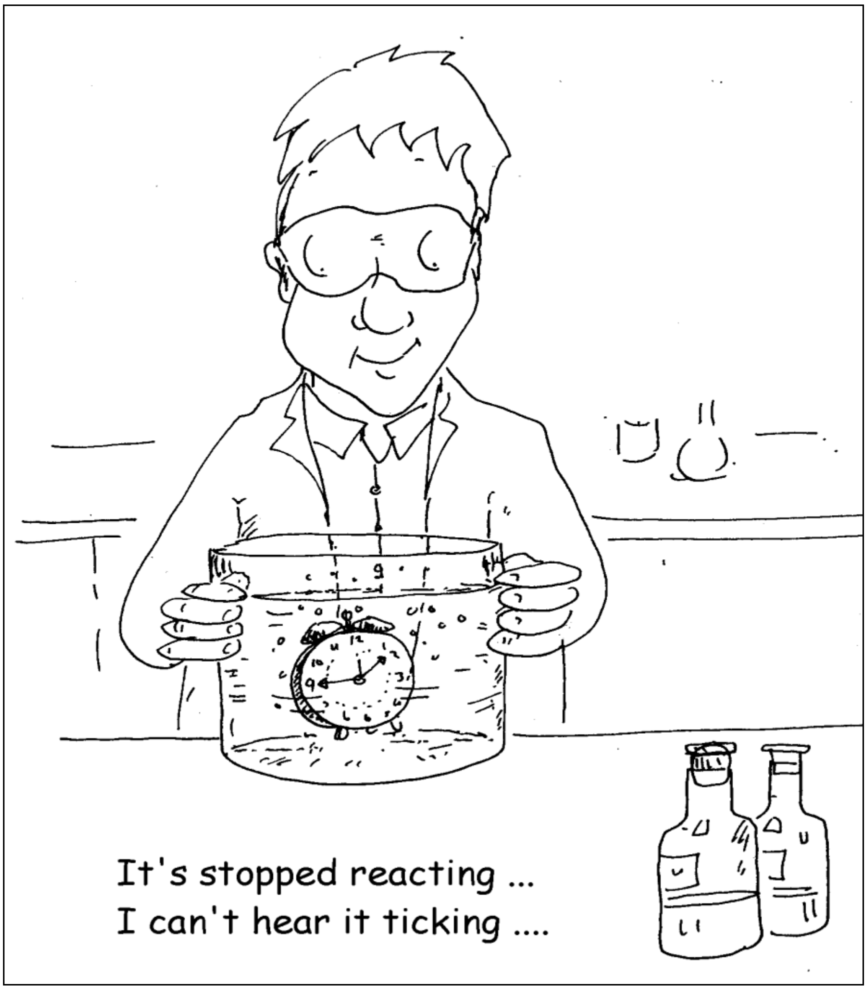
………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………..………… [max. 5 marks]

Grand Total of Marks (max. 85) =

CLOCK REACTIONS



So what are clock reactions reactions? They are among the most fascinating chemical reactions because they seem to contradict common sense. Obviously, a reaction starts when the reactants come together … and proceeds until they are used up … doesn't it?

You will be setting up your own Landolt clock and discovering how surprising these reactions are.

Part A
You will start by investigating the Landolt Clock reaction in which two colourless solutions are mixed and then several seconds later a sudden and dramatic reaction appears to take place.

You will set up a Landolt Clock reaction, time the 'clock period' and investigate the effect of changing the concentration of one or other of the reactants on the clock period.

Part B
You will be assessed by your Group Leader on whether or not your reactions work and how accurately you can set the clock period of your Landolt clock!

NOTE: You must use clean apparatus because the reactions are suppressed by impurities. All the reactions require great care when measuring out masses of solids and volumes of liquids.

Good Luck!

Part A: LANDOLT CLOCK REACTION

Per pair of students:

You will need (for Part A)

- ❑ 2 x measuring cylinders, 100 cm^3
- ❑ 2 x beakers, 500 cm^3
- ❑ conical flask, 250 cm^3
- ❑ stopclock
- ❑ 2 x stirring rods
- ❑ spatula

- ❑ access to a balance
- ❑ access to a permanent marker pen

- ❑ potassium iodate(V), KIO_3, 2.3g
- ❑ sodium metabisulfite, $Na_2S_2O_5$, 2.7g
- ❑ starch solution, 1%, 20 cm^3
- ❑ distilled water

Safety

- **Eye protection must be worn at all times.**
- **Potassium iodate(V), KIO_3, is a strong oxidising agent. Avoid contact with skin.**
- **Sodium metabisulfite, $Na_2S_2O_5$, is harmful if swallowed and can cause *serious* eye damage. Avoid contact with the skin and eyes. When mixed with acid, toxic sulfur dioxide gas is released, which can irritate the respiratory system and exacerbate pre-existing breathing problems (e.g. asthma).**
- **Some people are hypersensitive to sulfites and should avoid doing this experiment.**
- **Do not mix solid potassium iodate(V) with solid sodium metabisulfite.**

Method

1. Dissolve 2.3g of potassium iodate(V), KIO_3, in 450 cm^3 of distilled water and label this beaker '**Solution A**' (use a permanent marker pen). Continuous stirring with a glass rod will help the solid to dissolve.

2. Dissolve 2.7g of sodium metabisulfite, $Na_2S_2O_5$, in 450 cm^3 of distilled water.
   NOW ADD 20 cm^3 of 1% starch solution and label this beaker '**Solution B**'.
   Stir the mixture, using a *different* stirring rod to the one you used to stir solution **A**.

3. Label the 2 x 100 cm^3 measuring cylinders '**A**' and '**B**'. It is very important not to get solutions **A** and **B** muddled up. If either of them gets contaminated then this experiment will not work!

4. Pour 25 cm^3 of solution **B** into measuring cylinder **B**.

5. Using measuring cylinder **A**, pour 25 cm^3 of solution **A** into the 250 cm^3 conical flask.

6. Start the stop clock *as* you pour solution **B** into the conical flask. Give the flask a good swirl.

7. When there is a colour change (mixture should go blue-black), stop the clock and record the time. Dispose of the contents of the flask by pouring it into the waste bucket or beaker provided (this contains sodium thiosulfate to stop the reaction mixture causing problems when it is poured down the sink). Rinse the flask with distilled water.

8. Investigate the effect of changing the concentration of solution **B** on the clock period by pouring 12.5 cm^3 of solution B and 12.5 cm^3 of distilled water into measuring cylinder **B**.

   Add 25 cm^3 of solution **A** to measuring cylinder **A**, just as before. Mix the two solutions and time the clock period.

   Try this again with 5 cm^3 of solution **B** and 20 cm^3 distilled water in measuring cylinder **B**.

Does diluting solution **A** and keeping solution **B** the same concentration have the same effect on the clock period? If, after four minutes, no reaction has taken place – record "NO RESULT".

Results

Mixture	**time taken / s**
25 cm^3 of solution **A** + 25 cm^3 of solution **B**	
25 cm^3 of solution **A** + (12.5 cm^3 solution **B** and 12.5 cm^3 distilled water)	
25 cm^3 solution **A** + (5 cm^3 solution **B** and 20 cm^3 distilled water)	
(12.5 cm^3 solution **A** and 12.5 cm^3 distilled water) + 25 cm^3 solution **B**	

Now, using what you know about rates of reaction and collision theory, and piecing together the evidence you have from these experiments and the chemical substances you have used, try to suggest an explanation for how the Landolt Clock works. Ask your Group Leader if you are unsure about what reactions may be taking place.

Don't clear away your stocks of Solution A and Solution B yet, though
– save them for Part B!

We have a little challenge for you to finish off today's session. This will involve setting up a chemical clock which "ticks" at precise times …..

PART B: CHALLENGE

You will need (*in addition to your solutions from* **Part A**)

- 1 x measuring cylinder, 10 cm^3
- 2 x measuring cylinders, 50 cm^3
- 4 x beakers, 100 cm^3
- 4 x beakers, 50 cm^3

Now let us return to the Landolt clock reaction:

Using the solutions you saved from Part A, your challenge is to make a chemical clock that 'ticks' at 15 seconds, 30 seconds, 45 seconds and 60 seconds. You will need to develop solutions of **A** and **B** which have the right concentrations to do this.

Carry out *small-scale* trial-and-error experiments (maximum volume 50 cm^3)* combined with calculations to work out the correct amounts.

Once you have your reactions 'tuned' and are ready to show your Group Leader, set up a kitchen clock on the bench with a clean 100 cm^3 beaker at each of the 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock positions. Put the correct amount of solution **A** in each of the beakers and have solution **B** ready to add (in four separate containers).

As the second hand gets to '12' add your measured portions of solution **B** to each of the four beakers (all at the same time). You will be judged on how close to each of the beakers the second hand is when the solutions change colour.

**Try to ensure that you keep sufficient solution for the actual challenge run itself*.

THE FINAL CHALLENGE WILL BE TO COMPETE AGAINST THE OTHER COLOUR GROUPS – YOUR GROUP LEADER WILL EXPLAIN HOW THIS WILL WORK.

Take Charge
Global Battery Experiment

Be part of a brighter energy future!
To tackle our growing climate crisis, we need to move away from fossil fuels and embrace electrification. A crucial part of this journey is bigger and better **batteries**; we need them to be a sustainable storage solution to ease our energy transition.
Learning objectives

- Understand that batteries are made up of cells, comprised of layers of different materials.
- Understand that batteries store energy.
- Make observations and record measurements.
- Understand that changing the different layers of a cell can affect its performance.

How to take part
Taking part in our global battery experiment will give you the opportunity to explore the science behind batteries – and why they are such an important part of our bright energy future.

Investigation 1

You will need
• 10 x coins (same shape and size)
• 10 x cardboard discs (same size as coin)
• 10 x aluminium foil discs (same size as coin)
• Vinegar as an electrolyte
• Sticky tape
• Tweezers
• 2 x Petri dishes (or similar)
• LED

Method – to set up
1. Cut out 10 cardboard discs the same size as your coin.
2. Fold a square of aluminium foil four times, draw around a coin, cut out and separate the layers.
3. Soak the cardboard discs in the vinegar (the electrolyte) for about one minute.
4. Place the cardboard discs in a dry dish ready to use.

Method – build your battery
1. Make the first cell
2. Connect an LED to the cell
3. Add more cells
   • Assemble a second cell and place it on top of the first.
   • Test the two-cell device with the LED again.
   • Repeat the process by adding cells until the LED lights up.
   • Record the number of cells required to light up the LED.

Once you have completed your investigation do not forget to share your results on the website (https://edu.rsc.org/global-experiment/share-your-data) and see how they compare with other schools around the world.

Learners can draw a labelled diagram of their battery showing the detail of the individual cells and how the LED completes the circuit.

Discussion questions
- How many cells did it take to light up an LED? Did we all get the same result?
- Did using different solutions as the electrolyte give different results?

- What happened when we added more cells to our battery?
- Is there anything we want to change about this experiment? What else could we test?

Investigation 2

You will need
• 10 x coins (same shape and size)
• 10 x cardboard discs (same size as coin)
• 10 x aluminium foil discs (same size as coin)
• Voltmeter
• Sticky tape
• Tweezers
• LED
• 2 x Petri dishes (or similar)
• Different electrolytic solutions

Preparation

1. Soak the carboard discs in the electrolyte for about one minute.
2. Use tweezers to move discs to the dry dish ready to use.

Electrolyte to test (one from the following):
• Ethanoic acid solution (vinegar)
• Sulfuric acid solution
• Sodium chloride solution (saline)
• Sodium hydroxide solution
• Deionised/distilled water

Method
1. Make the first cell
Stack a coin, a pre-soaked cardboard disc and a disc of aluminium foil.
2. Connect the cell to a voltmeter.
3. Record the potential difference.
4. Add more cells.
5. Repeat the process up to a maximum of 10 cells.
6. Record your result for each addition.

Enter your data on the website.
You can enter your data directly or upload the results table template to share your results and generate graphs to compare the performance of the electrolytes.

Discussion questions
• How do your results compare to the results from different electrolytes?
• Did your results match your predictions throughout?
• What do you predict would happen to the performance of the battery if you added 20 cells?
• Does a higher potential difference relate to a greater performance?
• What sort of graph should we use for these results? Why?
• What could the coin be replaced with?

Evaluation
• How do you feel about our learning objectives today?
• Understand that batteries are made up of cells, comprised of layers of different materials.
• Understand that batteries store energy.
• Understand that changing the different layers of a cell can affect its performance.

Share your data: Upload your results and share them with the world

View the results: Find out what other global experiment scientists have discovered

Make a commitment: Explore our energy saving ideas and be a sustainability champion

Link: https://edu.rsc.org/global-experiment