School of Chemical and Physical Sciences

Chemistry Teachers Day

Lab Demonstration Information

Station 1 (LB116) - Susanna

- Demonstration: Making sparklers and observe the ignition of sparklers (Redox Chemistry and Sustainable Chemistry)
- Demonstration: Chemical Chameleon (Redox Chemistry)

Station 2 (LB116) - Chris

- Demonstration: Golden Rain (Types of Reactions)
- Demonstration: Magic Writing (Types of reactions)
- Demonstration: The Equilibrium between Two Coloured Cobalt Species (Equilibrium)

Station 3 (LB116) - Rachel

- Demonstration: Flame Test using Metal Salts (General interest/Colour and Wavelength and Energy)
- Demonstration: Elephant Toothpaste (Rates of a Reaction/Catalyst)
- Hands on: Agar Jelly (Diffusion)

Station 4 (LB116) - Richie

- Demonstration: Silver Whiskers – Silver Nitrate and Copper (Types of Reactions)
- Demonstration: Rates and Rhubarb (Rates of a Reaction)

Station 5 (LB115) - Tehreema

- Demonstration: The Clock Reaction (Kinetics – Rates of a Reaction)
- Hands on: Alginate Worms with a Thermochromic Dye (Polymer Chemistry)

Station 6 (LB115) - Courtney

- Hands on: Light Sticks (Organic Chemistry/Chemiluminescence – mimics glow sticks)
- Demonstration: Luminol (Chemiluminescence – Forensics Science)

Station One: Procedure for Experiments

Making Sparklers

The experiment procedure is from the article below:

'The production of less harmful and less toxic sparkler in an experiment for school'

Scheid et al. Chemistry Teachers International, 2021; 3(3) 285-294

1. Combine 0.85 g strontium nitrate, 0.1 g aluminium powder, 0.6 g iron powder and 0.2 g water-soluble starch. (Pre-weight those chemicals and put them in a capped plastic vials).
2. Add 0.3 mL of water and use a spatula to mix them to form a single lump.
3. Wear gloves and roll into a cylindrical shape.
4. Stick on to the steel wire and keep rolling to thin cylindrical shape.
5. Place the sparklers vertically in a beaker filled with sand. Air dry for 24 hours.
6. Ignite the sparkler in the fumehood.

Figure 6: Spark pattern of a self-made sparkler (left) and a bought sparkler (right).

Chemical Chameleon

This experiment illustrates redox reactions. The colour change runs from purple to blue to green to orange-yellow and finally to clear.

1. $MnO_4^- + e^- \rightarrow MnO_4^{2-}$

(permanganate ions are reduced to manganate ions, while the sugar is oxidised)

2. $MnO_4^{2-} + 2H_2O + 2e- \rightarrow MnO_2 + 4OH^-$

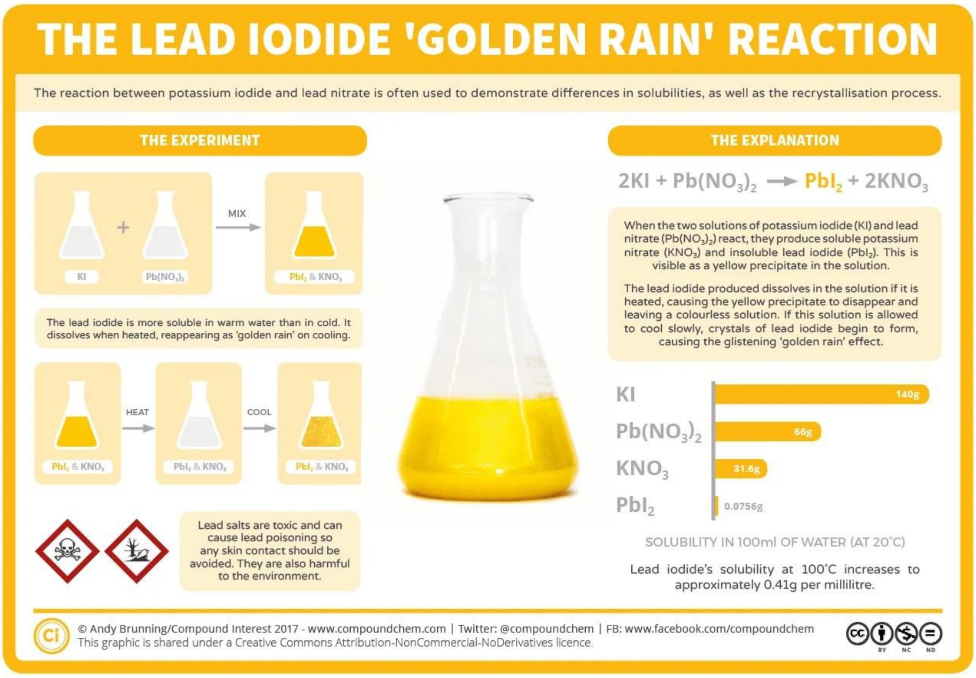
(manganate ions are further reduced and forms manganese dioxide)

1. Put 4 g of sodium hydroxide pellets in a 200-mL beaker. Add sugar just enough to cover sodium hydroxide pellets.
2. Dissolve in 125 mL water.
3. In a separate 500-mL beaker, put ~2 mL (30 drops) of 0.02 M potassium permanganate in 300 mL water.
4. Add sodium hydroxide/sugar mixture to potassium permanganate solution.
5. Observe the changes

Station Two: Procedure for Experiments

Golden Rain

https://edu.rsc.org/exhibition-chemistry/golden-rain/2000048.article



1. Dissolve 0.15 g of lead nitrate in 50 mL of water. Add 5 drops of 2 M hydrochloric acid.
2. Dissolve 0.15 g of potassium iodide in 50 mL of water. Add 5 drops of 2 M hydrochloric acid.
3. Pour lead nitrate solution to potassium iodide solution. Yellow lead iodide precipitate (crystals) form.
4. Heat the solution in 800C water bath. Stir (or swirl) and yellow solids will dissolve. It takes about 5-8 minutes.
5. Cool on ice-water bath. Yellow lead iodide re-crystalises

Magic Writing

https://edu.rsc.org/experiments/magic-writing-with-colour-changing-reactions/829.article

https://www.chemedx.org/article/element-month-iron


Left image: Words written with potassium thiocyanate and potassium ferrocyanide on filter paper

Right image: Writing is sprayed with iron(III) chloride

Iron is a moderately reactive metal, with three important oxidation states 0, +2 and +3 – iron forms many coloured complexes

Iron Thiocyanate, $Fe(SCN)_3$ – reddish brown

Iron Ferrocyanide, $Fe_4[Fe(CN)_6]_3$ – blue 'Prussian Blue'

1. Prepare 10% (w/v) potassium ferrocyanide and saturated potassium thiocyanate.
2. Prepare 0.1 M iron(III) chloride in a spray bottle.
3. Use paintbrushes and dip in 0.1 M potassium ferrocyanide and 0.1 M ammonium thiocyanate to write/draw on a piece of large filter/chromatography paper.
4. Air dry.
5. Spray with 0.1 M iron(III) chloride to show the writing/drawing.

The Equilibrium between Two Coloured Cobalt Species

https://edu.rsc.org/experiments/the-equilibrium-between-two-coloured-cobalt-species/1.article

The two different coloured Co(II) complex ions, $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$, exist together in equilibrium in solution in the presence of chloride ions:

$$[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6H_2O(l)$$

This equilibrium can be disturbed by changing the chloride ion concentration or by changing the temperature. The colour changes accompanying the changes in equilibrium position are as predicted by Le Chatelier's principle. The distinctive colours of the two cobalt(II) species in solution produce an attractive visual demonstration of a reversible reaction and the effect of concentration and temperature on the position of equilibrium

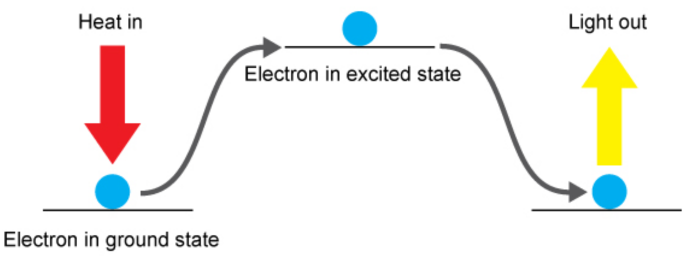
1. Add approximately 1 mL of 0.1 M cobalt nitrate solution in a test tube.
2. Add concentrated hydrochloric acid dropwise to establish the equilibrium (until no further colour change).
3. Now add water dropwise until the original colour restored.
4. Put the test tube in a beaker of boiled water, then put the test tube in an ice bath.
5. Observe the colour change

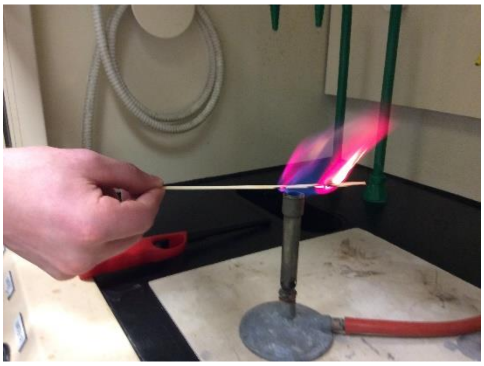
Station Three: Procedure for Experiments

Flame Test using Metal Salts

https://edu.rsc.org/resources/flame-tests-using-metal-salts/1875.article

When a metal salt solution is sprayed onto the flame the electrons in the metal are excited and jump from one electron shell level to the next highest shell level. They are said to be **excited**. They cannot remain there so as they return to the original shell, known as the **grounded state** the energy gained is lost in the form of light known as **emission**.





1. Prepare 1% (w/v) in ethanol.
2. Dissolve the salt in little bit water, then add ethanol. If the salt crushes out, add some water.
3. The salts are used in flame test: sodium chloride, copper(II) chloride, strontium chloride, barium chloride, potassium chloride, caesium chloride, lithium chloride, calcium chloride, rubidium chloride and boric acid.
4. Spay the solution towards the Bunsen burner flam and observe colour (or dip a burning stick into the solution and place in the hottest part of the flame)

Elephant's Toothpaste

https://pubs.acs.org/doi/10.1021/acs.jchemed.5b00037

'Using Elephant's Toothpaste as an Engaging and Flexible Curriculum Alignment Project'

Eldridge, J. Chem. Educ. 2015, 92, 1406−1408

1. Put 10 mL of saturated of potassium iodide in a 1 L measuring cylinder.
2. A few squirts of detergent and a few drops of food colouring.
3. Add 10 mL of 30% hydrogen peroxide.

Alternatively, potassium iodide can be substituted for yeast. The yeast contains an enzyme called Catalase that breaks down hydrogen peroxide (H_2O_2) into oxygen gas and water. The oxygen gas gets trapped by the soap, and you get a large foamy solution that squirts out of the top of the bottle!

The cool thing about this activity is that the enzyme Catalase can also be found in potatoes, dogs and even us! We have the same enzyme in our bodies. That is why you see the 3% hydrogen peroxide bubble when you put it on a cut or scrape. The oxygen released is what kills the germs in the cut. We have this enzyme because we naturally produce low amounts hydrogen peroxide as a by-product of oxidative metabolism (the way that a cell gains useful energy). Our cells need energy, but low amounts of hydrogen peroxide are produced and need to be neutralized through enzymes like Catalase.

Agar Jelly

https://www.exploratorium.edu/snacks/agar-cell-diffusion

Use cubes of agar to visualise how diffusion changes depending on the size of the object taking up the material. The agar cubes represent biological cells. The volume of the cube correlates to the cytoplasm and the surface area of each cube to the cell membrane.

Phenolphthalein decolourizes when placed into an acidic medium

Image attribution: Exploratorium Teacher Institute

1. 1.5 g of agar in 80 mL of water. Boil to dissolve agar.
2. Add 20 mL of 0.2 M sodium hydroxide and 5 drops of 0.4% (w/v) phenolphthalein. (the concentration of sodium hydroxide is 0.04 M).
3. Pour on to petri dishes. Chill and set.
4. Using a spatula to cut into small squares of different sizes (1, 2 and 3 cm)
5. Pour ~10 mL of 2 M HCl in a 50-mL beaker. Put jelly squares in and observe.

Station Four: Procedure for Experiments

Silver Whiskers

https://edu.rsc.org/exhibition-chemistry/displacement-reaction-of-silver-nitrate-and-copper-metal/2020046.article

$Cu(s) + AgNO_3(aq) \rightarrow Ag(s) + Cu(NO_3)_2(aq)$

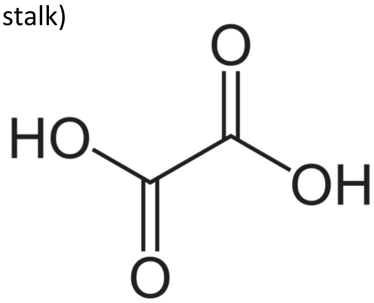
This demonstrate can illustrate metallic bonding in the structure and bonding topic and can be used to illustrate the crystalline structure of metals or an introductory into electrochemistry. By seeing the crystals grow, students can imagine the Ag^+ ions pulling electrons off the silver crystals, which in turn remove electrons from the lump of copper and produce copper ions, thus setting up a simple electrochemical circuit. For each copper ion that forms in solution, two silver ions will add to the silver crystal structure (photo credit: Pedro Amaral)

Rates and Rhubarb

https://edu.rsc.org/experiments/rate-of-reaction-of-potassium-manganatevii-and-oxalic-acid/745.article

In this experiment, students use rhubarb sticks, which contain oxalic acid, to reduce and decolourise potassium permanganate solution.

Rhubarb contains oxalic acid. Oxalic acid reacts with potassium manganate(VII) in acidic solutions and is oxidised to carbon dioxide and water (Note: the leaves contain far more oxalic acid than the stalk)



$2MnO_4^- + 5C_2H_2O_4 + 6H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

1. Add a few drops of 0.02 M potassium permanganate into 1 L of 1 M sulfuric acid.
2. Pour into a 100-mL beaker. Put the cut rhubarb stalks (~3 cm long) into the acidified potassium permanganate.
3. Observe colour change

Station Five: Procedure for Experiments

The Clock Reaction

https://edu.rsc.org/experiments/iodine-clock-reaction-demonstration-method/744.article

This reaction is a self-indicating clock reaction i.e. a reaction in which there is no apparent change for a given amount of time followed by a sudden visible change

The reaction is between persulfate and iodide ions and the reaction is monitored by addling a small known amount of thiosulfate which reacts with the iodine as it is produced.

Once all the thiosulfate has reacted any excess iodine will cause the colour of the solution to turn a dark blue. The colour change can be enhanced by the addition of starch solution

$$S_2O_8^{-2} + 2I^- \longrightarrow 2SO_4^{-2} + I_2$$

$$2S_2O_3^{-2} + I_2 \longrightarrow 2I^- + S_4O_6^{-2}$$

1. In a 100-mL beaker, combine 10 mL of 0.6 M ammonium persulfate and 1 mL of 1% starch. Label as Beaker A.
2. In a separate 100-mL beaker, combine 5 mL of 0.02 M sodium thiosulfate, 10 mL of 0.1 M potassium iodide and 20 mL of 0.1 M ammonium sulfate. Label as Beaker B.
3. Stir the mixture in Beaker B. Add the contents of Beaker A to Beaker B.
4. Observe the change of colour (from colourless to dark blue).

Alter concentration of persulfate and iodide ions and/or you can change the temperature to change the rate of the reaction

Conc. ammonium persulfate (M)	Time	Temperature of solution
0.3	2 min 28 sec	RT, 20 degrees
0.6	1 min 2 sec	RT, 20 degrees
0.6	31 sec	30 degrees
0.6	2 min 5 sec	10 degrees

Polymer Worms with a Thermochromic Dye

Find article: Royal Society of Chemistry – Cross-linking Polymers Alginate Worms

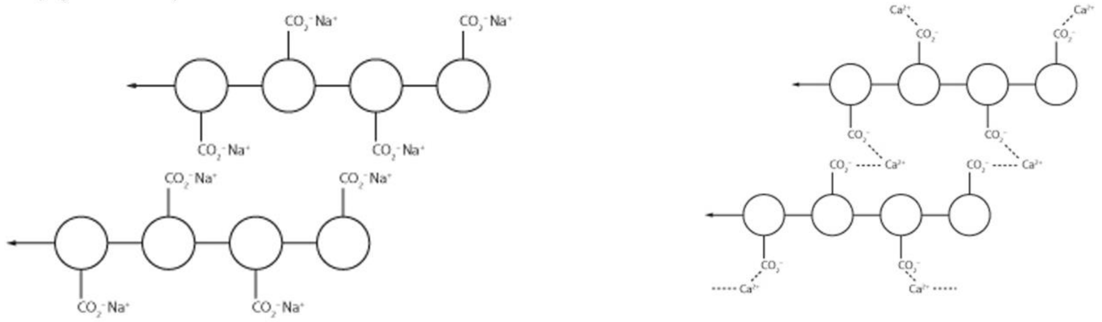
https://www.stevespanglerscience.com/lab/experiments/heat-sensitive-worms/

Sodium alginate is a polymer which can be extracted from brown seaweed and kelps. It is one of the structural polymers that help to build the cell walls of these plants.

When sodium alginate is placed into a solution of calcium ions (calcium chloride) the calcium ions replace the sodium ions in the polymer. Each calcium ion can attach to two polymer stands – this called cross linking – much like the rungs of a ladder that link the two sides.

Heat Sensitive worms – the addition of a thermochromic dye allows the colour of the cross-linked polymer ‘worms’ to change colour when in hot or cold water. The pigment in the dye reacts by twisting to a new shape, changing the wavelength that it reflects. Thermochromic dyes and inks find use in a lot of objects, from colour changing bath toys and coffee mugs, to child thermometers and battery indicators.

The polymer can be represented like this:



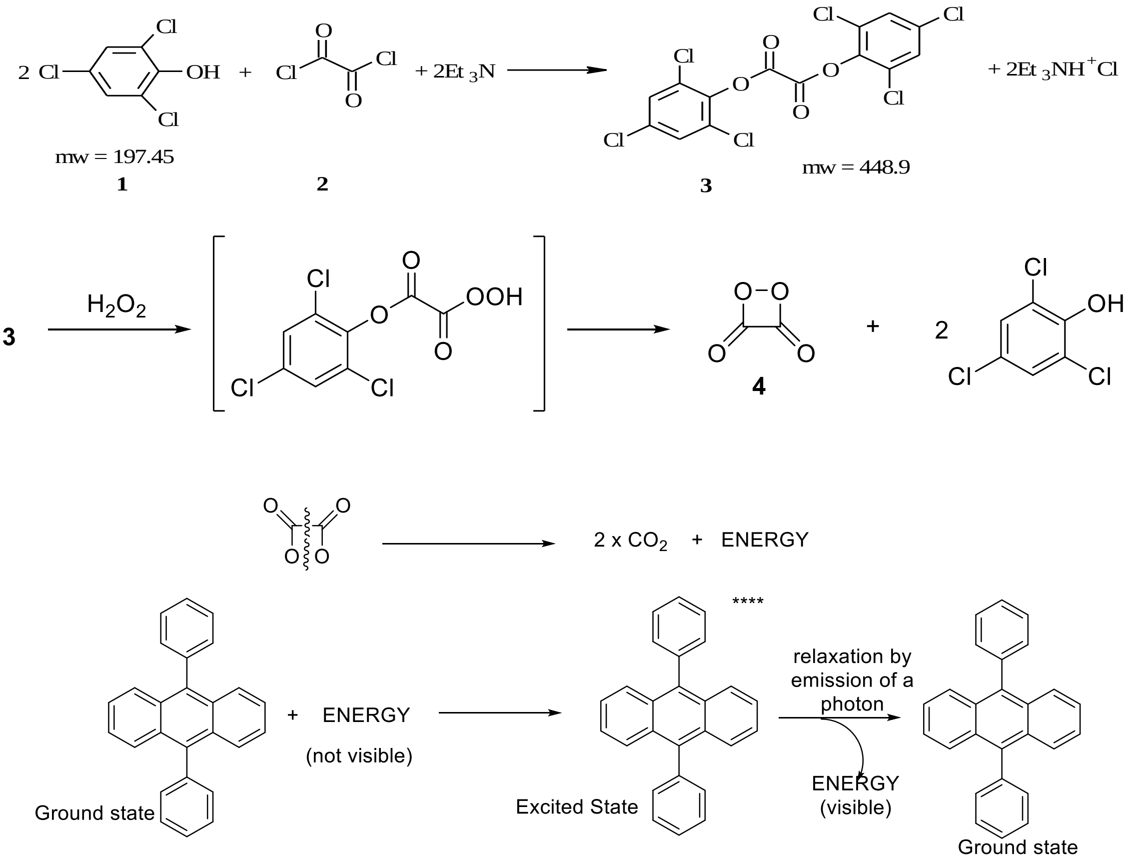
1. Weigh 15 g of sodium alginate in a beaker. Add 1L of water. Warm it gently (less than 500C).
2. Stir to dissolve. It may take at least 3 hours (or do it overnight). Add ~0.2 g of thermochromic dye into alginate solution. Can be kept in the fridge.
3. Pour in a 500-mL dropper bottle.
4. Squeeze alginate solution into 5% (w/v) calcium chloride solution. Alginate will polymerise to form “solid” alginate
5. Transfer alginate into a warm water (> 300C) and colour will change.

Station Six: Procedure for Experiments

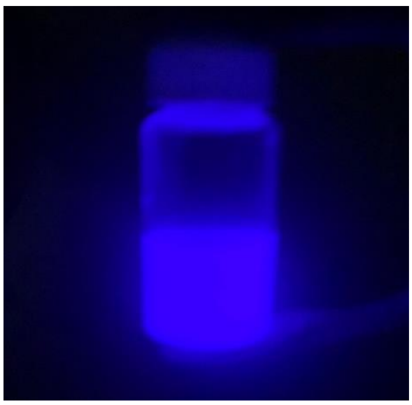
Light Sticks

https://edu.rsc.org/exhibition-chemistry/the-glow-stick-reaction/3010386.article

The chemiluminescent reaction is initiated by the oxidation of the oxalate ester in the presence of hydrogen peroxide and catalysed by a base such as sodium acetate or triethylamine. The initial oxidation product is 1,2-dioxetanedione, which rapidly decomposes to electronically excited carbon dioxide. Alone this will not efficiently chemiluminesce but a fluorescent dye (such as 9,10-diphenylanthracene) can capture energy from the CO_2 efficiently and release this in the form of visible light

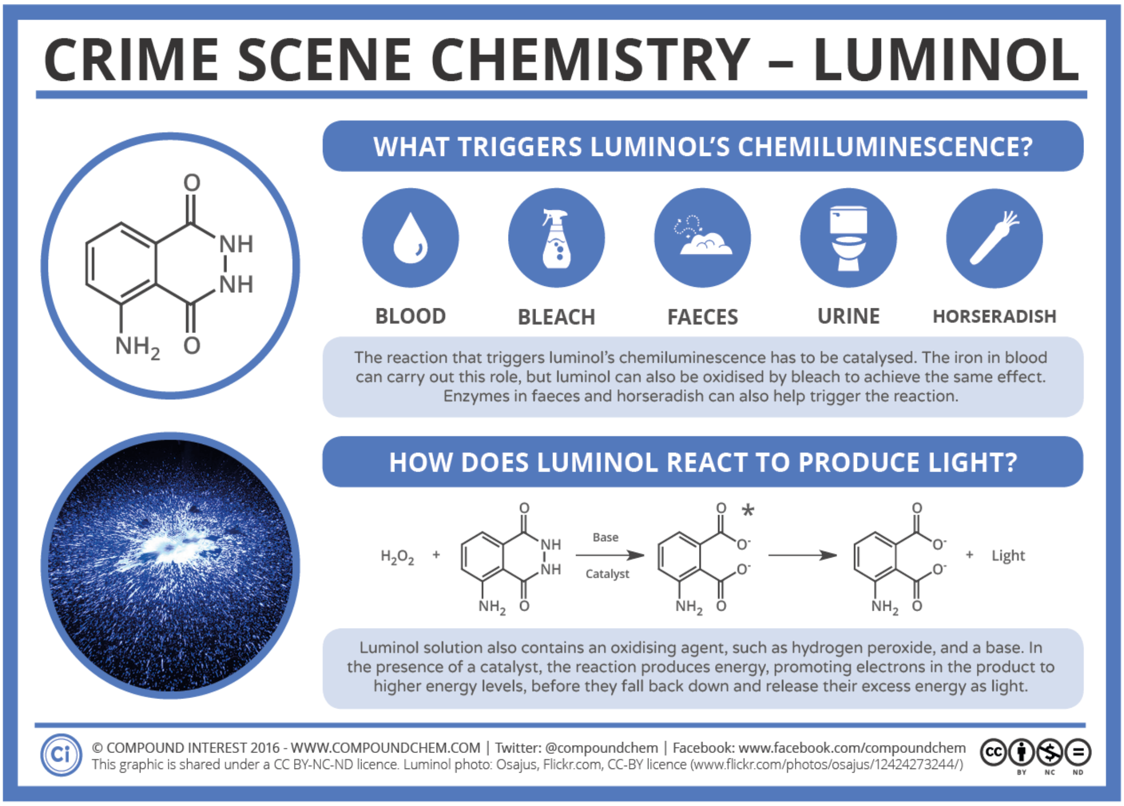


1. Pre-weight 50 mg of cyalume [Bis(2,4,6-trichlorophenyl)oxalate] and 3.5 mg of 9,10-diphenylanthracene. Put them in a sample bottle. Add 5 mL of diethyl phthalate. Labelled as A.
2. In the second sample bottle, put 0.2 mL of 30% hydrogen peroxide and 5 mL diethyl phthalate. Labelled as B.
3. Put two sample bottles on hot sand bath. Warm two solutions until solids dissolve.
4. Pour the contents of bottle B into the bottle A. Shake and observe.



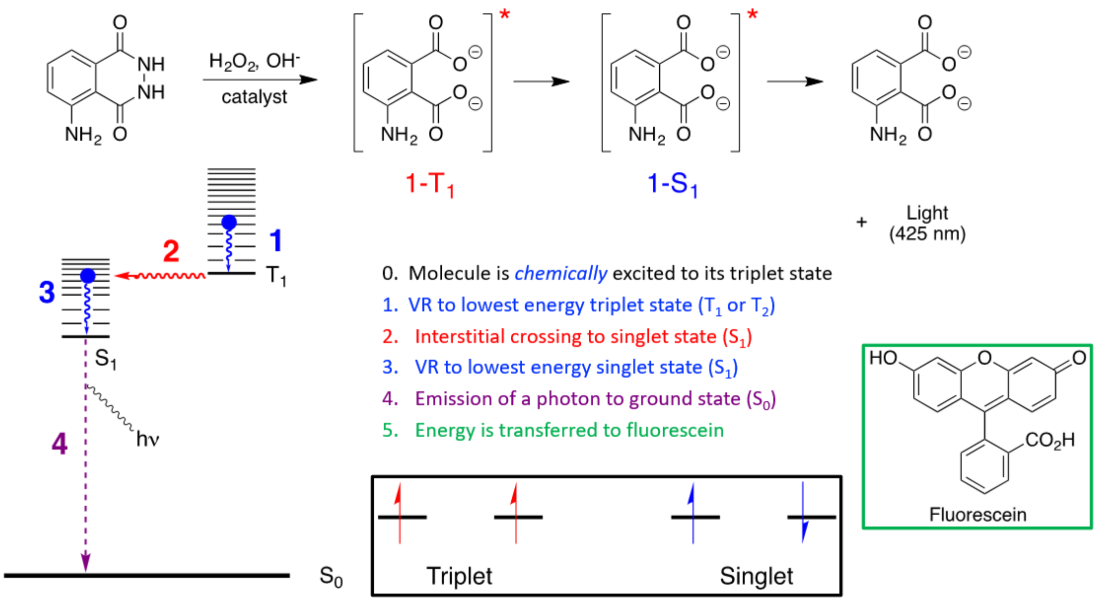
Luminol

https://edu.rsc.org/resources/chemiluminescence-of-luminol-a-cold-light-experiment/823.article



Luminol Reaction

Chemiluminescence: is the process whereby light is produced by a chemical reaction



Luminol, known chemically as 5-Amino-2,3-dihydro-1,4-phthalazinedione, isn't used in the CSI's mysterious spray bottle on its own. It's joined by a number of other chemicals which are just as vital for the reaction to take place. The first of these additions is a strong oxidising agent such as hydrogen peroxide; this chemical is directly involved in the reaction with luminol. What's also needed is a basic solution, which can be achieved via addition of an alkali such as sodium hydroxide. This is necessary because, in neutral solution, luminol forms what's known as a zwitterionic structure; that is, a molecule with both a positive and a negative charge. In a basic solution, it forms an anion, a negatively charged molecule which can be oxidised by the oxidising agent.

The reaction also needs a catalyst in order for it to proceed. Blood contains haemoglobin, which contains iron atoms. These iron atoms can act as a catalyst for the reaction between luminol and hydrogen peroxide, allowing it to proceed (or other metal ions can catalyse the reaction). A cyclic peroxide is produced by the reaction, which quickly decomposes to give a chemical called 3-aminophthalate. The reaction releases energy, which is transferred to electrons in the 3-aminophthalate molecules, promoting them to a higher energy level. As the electrons drop down to a more stable energy level, they release their excess energy as photons of light, resulting in blue chemiluminescence. Luminol can detect the presence of blood at dilutions of up to 1:1,000,000, or 1 part per million

1. Solution A: Combine 4 g of sodium carbonate anhydrous, 0.2 g luminol, 24 g sodium bicarbonate, 0.5 g ammonium carbonate monohydrate, 0.4 g copper sulfate pentahydrate. Dissolve in 1 L of water.
2. Solution B (1 L): 0.15% hydrogen peroxide.
3. Pour two solutions simultaneous into a 5 L flask.
4. Additionally, add a few drops of fluorescein into the flask