D1: Chemiluminescent Ammonia Fountain

- **Preparation time 30-60 minutes**
- **Demonstration time less than 5 minutes**

Requirements

weighing balance
2 x 1 dm^3 conical flasks
round bottomed flask (strong), volume between 500 cm^3 and 2 dm^3
stirring rod
plastic syringe
assorted bungs and delivery tubes to set up the apparatus in the diagram
safety screen
access to a fume cupboard

ammonia solution, NH_3 (aq), concentrated '880'
0.2 g luminol*
4 g sodium carbonate, Na_2CO_3
24 g sodium hydrogencarbonate, $NaHCO_3$
0.5 g ammonium carbonate, $(NH_4)_2CO_3$
0.4 g copper sulphate, $CuSO_4$
50 cm^3 hydrogen peroxide, H_2O_2, 3%

eye protection

*Advance warning: luminol is available from Aldrich Chemicals, see Section 3 for address.

conduct this demonstration behind safety screens or in a fume cupboard, wearing eye protection

CORROSIVE

'880' ammonia solution

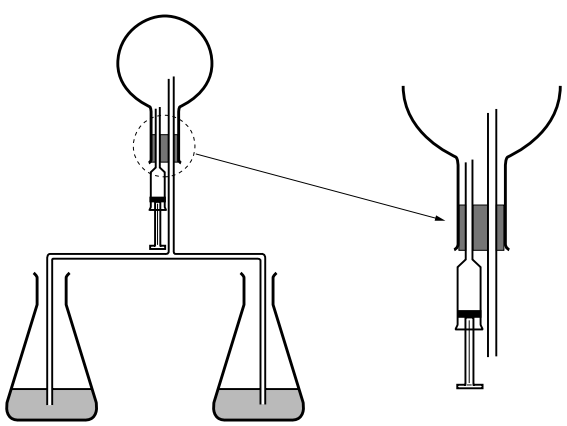
HARMFUL

copper sulphate solid

TOXIC

ammonia gas

Method



1. 
   Set up the apparatus as shown in the diagram, behind a safety screen or in a fume cupboard.

2. 
   Prepare solution A: Dissolve 4 g Na_2CO_3 in 500 cm^3 of water and add 0.2 g luminol. Stir to dissolve. Add 24 g $NaHCO_3$, 0.5 g $(NH_4)_2CO_3$ and 0.4 g $CuSO_4$. Stir well until all the solids dissolve. Dilute to 1 dm^3 with water. Fill one of the conical flasks with this solution.

3. Prepare solution B: Dilute 50 cm^3 of 3% H_2O_2 to 1 dm^3 with distilled water. Fill the other conical flask with this solution.

D1: Chemiluminescent Ammonia Fountain

conduct this demonstration behind safety screens or in a fume cupboard, wearing eye protection

CORROSIVE

'880' ammonia solution

HARMFUL

copper sulphate solid

TOXIC

ammonia gas

4. 

   Fill the round bottomed flask with NH_3 gas in one of two ways.
   Either swill a small amount of concentrated '880' ammonia (approx. 1 cm^3) around the flask. Take great care with this.
   Or heat the concentrated '880' ammonia in another flask to which you have attached a delivery tube. Fill the round bottomed flask from this flask for about 5 minutes to ensure that it contains a good supply of gas.

5. Fill the syringe with water.

6. Turn off the lights and darken the room if possible.

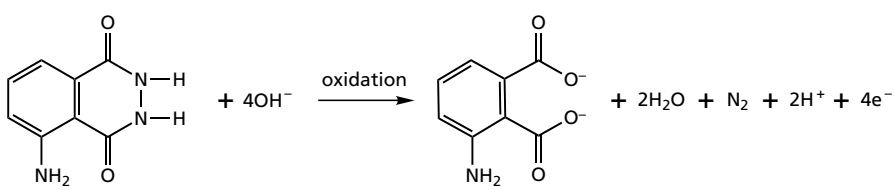
7. Inject several cm^3 of water from the syringe into the ammonia-filled flask. This starts the reactions.

8. By increasing the concentration of H_2O_2 or the amount of luminol, the chemiluminescence increases.

Chemical background

When a small amount of water is injected into the flask containing ammonia, the ammonia dissolves. The reduction in pressure causes solution A and B to be simultaneously drawn into and mixed in the inverted flask. This should produce a bright blue luminescent fountain.

Luminol is oxidised by hydrogen peroxide to the aminophthalate ion which is produced in an excited state and emits light when it drops down to the ground state.



D2: Howling Jelly Baby

● Preparation and demonstration time 30 minutes

Important note
This is NOT covered by the model (general) risk assessments adopted by most education employers. Before conducting this experiment you should go through whatever procedure your employer has laid down for obtaining a special risk assessment.

Requirements

weighing balance
spatula
access to a fume cupboard
2 safety screens
clamp and stand
fire resistant surface
fire extinguisher

Pyrex boiling tube
15 g potassium chlorate(V), $KClO_3$, (reagent grade)
one jelly baby

full face shield for teacher
eye protection for pupils

Method

1. Put 15 g potassium chlorate(V) into a test tube. Clamp the test tube loosely at a slight angle from vertical (approx. 60°) and set it up in a fume cupboard or an outdoor area.
2. Surround the tube assembly with safety screens and heat the potassium chlorate(V) until it melts.
3. Wearing heat resistant gloves and using tongs drop a jelly baby into the molten potassium chlorate(V) and stand back with a fire extinguisher for dramatic effect.
4. The jelly baby will ignite and burn furiously with a high pitched roar.

Teachers may like to video this activity to be shown in areas not equipped for demonstrations.

Safety advice

Take extreme care. Potassium chlorate(V) can explode unpredictably.
Ensure that the boiling tube is scrupulously clean - any trace of oxidisable material can cause a violent reaction.
The apparatus should be completely surrounded by safety screens.
Pupils must wear eye protection and observe from several metres away.
Wash away any spattered product with plenty of water.
Do not let the pupils handle the potassium chlorate(V) bottle.

Chemical background

The carbohydrate in the jelly baby is oxidised by the molten potassium chlorate(V). This demonstration is a very effective and memorable way of showing that food stuffs provide energy.
Motivation for the class could be the promise of making a jelly baby howl if all work is completed (or some other task).


see important note at start


eye protection must be worn


HARMFUL
potassium chlorate(V)


OXIDISING
potassium chlorate(V)


the demonstration must be carried out over a fire resistant surface because $KClO_3$ sometimes flies over the edge


do not use sugar as this may cause an explosion

D3: Pocket Rocket

- **Preparation time 30-60 minutes**
- **Demonstration time less than 5 minutes**

see important note at start

eye protection must be worn

Important note
This is NOT covered by the model (general) risk assessments adopted by most education employers. Before conducting this experiment you should go through whatever procedure your employer has laid down for obtaining a special risk assessment.

Requirements

1 ball pen (Bic or similar make with hexagonal cross section)
a pair of scissors
safety match
nichrome wire
12 V d.c. power supply, adequate extension cable and props to hold windows or doors open
1.5 cm x 2 cm piece of paper
~1m steel rod for launching
pestle and mortar
plastic lid (margarine or ice cream tub)
glue gun (checked for electrical safety and safe to use in schools)
large diameter plastic drinking straw ~8 cm long
heat proof mat with hole drilled in the centre (must not be asbestos)
access to a fume cupboard
outdoor launch site
3 g zinc powder (preferable to dust, which is finer)
1 g sulphur powder
eye protection

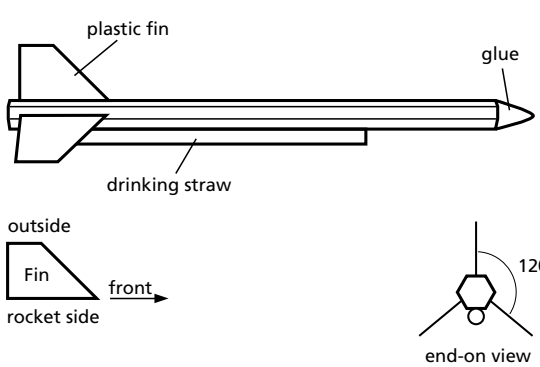
Method

Construction of the rocket

1. Remove the plug from the end and the ink tube from the inside of the ball pen, so that all you are left with is a hollow plastic tube.

2. Using a pair of scissors, cut out three fins from the plastic lid. See diagram below. Ensure that the fins are all the same size.

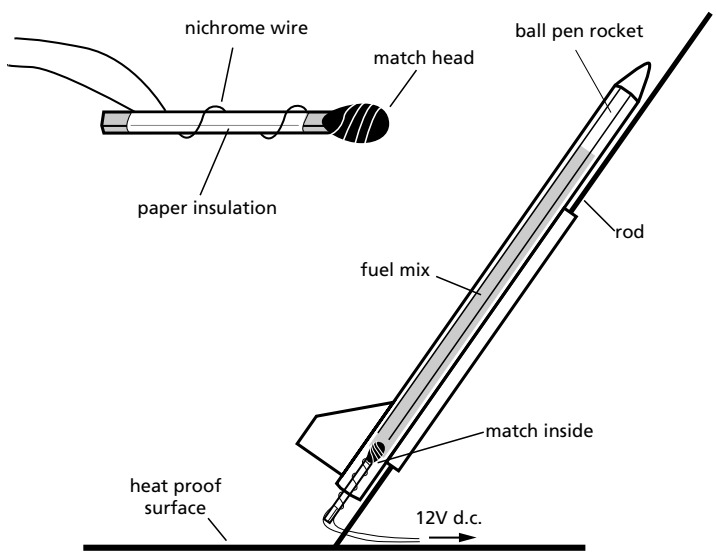
3. Using the glue gun, fill the nib end of the pen with glue. The glue should extend about 1cm up the tube. Try to ensure that the glue at the end of the ball pen casing is slightly rounded to increase the aerodynamic efficiency.



Glue a plastic fin on alternate sides of the end of the ball pen. When looking straight down the length of the ball pen, the fins should be straight and at an angle of 120° to each other. On one side, in between two of the fins and about 1 cm from the end, glue the plastic drinking straw. See diagram.

D3: Pocket Rocket (contd)

4. Construction of the ignition system
   Wrap the nichrome wire carefully, in a spiral, around the wooden shaft of the match. Leave about 2 cm of wire free. The wire should go through 1 or 2 complete turns before reaching the match head (see diagram below). Wrap the wire tightly a few times around the match head.
   Twist the small piece of paper around the shaft of the match. Wrap the rest of the nichrome wire back down the shaft from the head. The paper should insulate the two wires from one another and prevent a short circuit when the ignition is switched on. The twisted wire should also stop the paper unwinding. The two ends of the nichrome wire should be free. Make sure that the match head and shaft fit freely into the back end of the ball pen tube, with the ends of the wire free; this will allow a smooth take-off.



5. Mixing the rocket fuel
   Grind 1 g of sulphur to a fine powder in a fume cupboard. Place 3 g of zinc powder on to a piece of paper. Pour the sulphur on to this zinc powder.
   Pour the mixture on to another piece of paper and repeat the procedure carefully until the powders are well mixed. Do not grind the two powders together.
   Pour the fuel into the ball pen case from the bottom end. Tap the pen case to pack the fuel. Insert the ignition system (see diagram).

6. Guidance system
   Place the heat proof mat in the centre of the launch site. Insert the steel rod through the hole drilled in the centre and stick it into the ground. You can angle the rod to give some directional control.

D3: Pocket Rocket (contd)

see important note at start

eye protection must be worn

7. Launching the flight

Find a launch site that is free of people and objects that could be damaged.

Place the straw of the ball pen rocket on to the steel guidance rod.

Lower the rocket gently on to the heat proof mat. Do not worry if some fuel leaks out. Carefully attach the insulated copper wires to the ends of the nichrome wire. This can be done by a simple twist.

Run the wires back to the power supply and connect to the 12 V output. It is advisable to have a screen between the rocket and the power supply. Ensure that electrical cable does not get 'nicked' in slammed doors or windows by using props to hold them open.

When there is no wind, the launch and flight area are free of objects that could be damaged, and all observers are standing at least 10 m away from the launch site and outside the flight area, then stand back and switch on the power pack. This is best done at the mains switch rather than the 12 V d.c. power pack.

It takes about 2 seconds for the nichrome wire to heat up enough to ignite the match, which in turn ignites the fuel and your rocket should fly!

If the rocket does not lift off, turn off the power supply and wait several minutes before approaching the rocket. Assess whether the match has ignited.

If the match has not ignited, then there is a problem either with the wires or the ignition system. Carefully check all contacts along the wires.

For the ignition system check that parts of the nichrome wire aren't touching each other. Also ensure that there is nichrome wire wrapped around the match head.

If the match has ignited, but has failed to ignite the fuel, then carefully replace the ignition system. Gently tap the rocket to ensure that the fuel falls down the biro and is in contact with the match head.

If the flight is successful, collect the rocket and check for any stress fractures, or distortion. If there is no damage it is safe to reuse with caution (to date the maximum number of flights undertaken by any one ball pen is three). Otherwise, it is best not to use the rocket again.

Chemical background

Zinc and sulphur react when heated by the burning match head. The reaction is:

$$8Zn(s) + S_8(s) \longrightarrow 8ZnS(s)$$

The reaction is exothermic and explosive. When the reaction is confined inside the ball pen case the pressure is released out of the open end forcing the rocket skywards.

D4: Egg-splosion

- **Preparation time 30-60 minutes**
- **Demonstration time less than 5 minutes**

Requirements

one raw egg
sharp nail
10-15 cm wire
masking tape
capillary tube
top portion of a 2 dm^3 plastic disposable lemonade bottle
source of hydrogen (e.g. granulated Zn and 4.0 mol dm^{-3} HCl, in a conical flask fitted with a delivery tube)
ethanol
safety screens
eye protection

eye protection must be worn

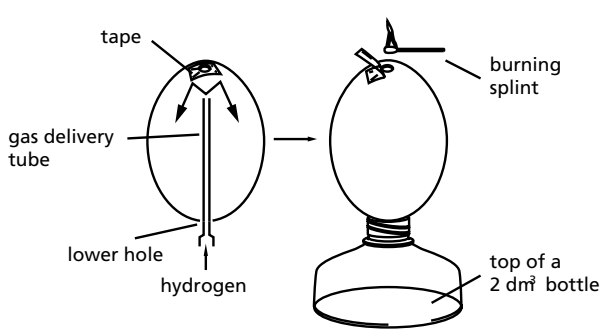
HIGHLY FLAMMABLE
hydrogen
ethanol

there may a risk of *Salmonella* infection from raw eggs

IRRITANT
hydrochloric acid

Method

1.
   Wash the egg thoroughly, rinsing with ethanol as a disinfectant.
2. Using the nail gently tap a small hole 2-3 mm in diameter in the top (narrower) end of the egg and a slightly larger hole 3-4mm diameter in the bottom.
3. Insert the wire and stir up the yolk.
4. Over a large bowl, blow into the small hole to force the egg's contents out through the larger hole. You could use a straw to do this.
5. Rinse the inside of the eggshell several times with ethanol and leave the egg to dry for at least 2 minutes.
6. Cover the top hole of the eggshell with a piece of tape and introduce hydrogen gas through the bottom hole via a long capillary tube extending upward almost to the top of the egg. The eggshell must be completely filled with hydrogen gas. Use a generous volume of hydrogen.
7. Place the egg on the top of the plastic lemonade bottle (see diagram) and put it between two safety screens arranged to protect you and the pupils.
8. Remove the tape and hold a burning splint, briefly, to the hole. Stand back!



D4: Egg-splosion (contd)

Chemical background

The initial pop is probably caused by a small portion of the hydrogen leaking out, mixing with the air immediately above the hole and forming a minute combustible mixture.

As more hydrogen escapes through the top hole, it continues to react with oxygen in the air and burns with an invisible and silent flame.

At the same time, oxygen-containing air is drawn into the egg through the bottom hole and mixes with the remaining hydrogen. When enough air has entered to form a combustible mixture inside the egg, the flame backfires down through the hole and ignites the mixture. Since the reaction is very exothermic, and since the holes in the egg are not large enough to accommodate the rapid expansion of the gases, the pressure inside the egg increases rapidly and it explodes into several small pieces.

D5: Cannon Fire

- **Preparation time within 30 minutes**
- **Demonstration time less than 5 minutes**

Important note
This is NOT covered by the model (general) risk assessments adopted by most education employers. Before conducting this experiment you should go through whatever procedure your employer has laid down for obtaining a special risk assessment.

Requirements

heat-proof surface
large evaporating basin
safety screens
taper or splint (for lighting mixture)
pipette (or similar) for dispensing 20-30 cm^3

hydrogen peroxide, H_2O_2, 20 vol
0.5 g potassium manganate(Vll), $KMnO_4$
Remove concentrated sulphuric acid from the lab when $KMnO_4$ is used.
20 cm^3 ethanol

eye protection

Method

1. Place the evaporating basin on the heat-proof surface.

2. 
Add 30 cm^3 hydrogen peroxide (20 vol) and 20 cm^3 ethanol.

3. 
Arrange the dish between safety screens arranged to protect both pupils and teacher. Light the mixture with a taper. The ethanol will burn invisibly.

4. 
Sprinkle about 0.5 g of potassium manganate(VII) into the dish. Avoid inhaling any of the vapour produced.

Chemical background

The potassium manganate(VII) reacts with the hydrogen peroxide and releases oxygen gas making a series of loud bangs in the process.

$$2MnO_4^-(aq) + 3H_2O_2(aq) \longrightarrow 2MnO_2(s) + 2H_2O(l) + 3O_2(g) + 2OH^-(aq)$$


see important note at start


eye protection must be worn


IRRITANT
hydrogen peroxide


HIGHLY FLAMMABLE
ethanol


OXIDISING
potassium manganate(VII)


HARMFUL
potassium manganate(VII)


remove concentrated sulphuric acid from the lab when potassium manganate(VII) is used