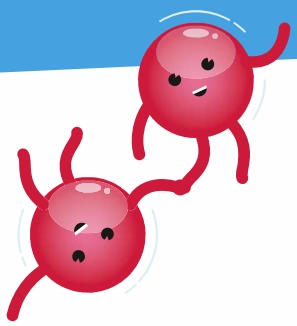
7. Blazing wotsits

A powerful demonstration of rapid oxidation in action



Overview

Potassium chlorate can be used as a brilliant oxidiser, spontaneously combusting any organic materials added to it with a dramatic sheet of fire, smoke and sometimes a high pitched 'screaming' sound.

What's happening?

When potassium chlorate ($KClO_3$) is heated to a 'rolling boil' (all material is molten and small bubbles can be observed in the melt), it starts to decompose and give off oxygen. The potassium chlorate is decomposing to potassium chloride (KCl) and oxygen (O_2).

$2KClO_3 \rightarrow 2KCl + 3O_2$

When the cheese puff snacks are added, the carbohydrates found in the crisps react with the oxygen present to produce carbon dioxide (CO_2) and water vapour (H_2O). The chemical energy in the crisps is rapidly converted into heat, light and sound in a dramatic oxidation reaction.

$C_m(H_2O)_n + mO_2 \rightarrow mCO_2 + nH_2O$

This heat can then decompose any residual carbohydrate into carbon and water.

$C_m(H_2O)_n$ + heat → mC + nH2O (3)

Why is this important?

This reaction is very similar to the process of respiration that takes place inside your body that allows us to extract energy from the carbohydrates and fats in the food we eat, although the reaction is not quite as dramatic inside your cells! This reaction is a fundamental equation that sustains life on Earth.

As well as being essential for life, oxygen reacts with virtually all other elements and its chemistry dominates many processes found on Earth. Burning fuels or corrosion of metals are also reactions where oxygen is acting as an oxidising agent. Most industrial processes take advantage of this, from combustion engines in cars to the production of steel.

More stories to tell

Is this an oxidation reaction?

Yes, but it is actually an oxidation-reduction reaction, often called a redox reaction. Oxidation can be thought of

as the addition of oxygen to an element or compound. More specifically, it refers to a reaction where electrons move between two substances. Redox reactions are always made up of two parts, one part loses electrons (the oxidised half) and one part gains electrons (the reduced half). A simple acronym to remember this is OILRIG (Oxidation Is Loss, Reduction Is Gain).

In our blazing wotsits experiment, the oxygen is the oxidising agent but it is actually the part of the reaction that is reduced (gains electrons). It is the carbohydrate that is oxidised (loses electrons).

Why is oxygen so reactive?

Oxygen is so incredibly reactive because of something called electronegativity. An atom is described as being electronegative when it needs electrons in order to be stable. Put an oxygen atom next to something that has available electrons and oxygen will react with it (often violently) forming a compound. We call this combustion. When we think of combustion we usually think of burning paper, coal, oil, etc, but given the right concentration of oxygen, almost anything can combust. Under the right conditions, even metals like iron can burn! This is a serious concern on submarines where they have to manually control the concentration of gases in the air they breathe. If they get things wrong the inside of the submarine can ignite.

The Activity

We strongly recommend that you never vary any part of this reaction unless you are suitably qualified and have access to an adequate testing environment.

Before the show:

1. Add 15 g of potassium chlorate to a large (500 mL) wide neck borosilicate round bottom flask (RBF).

2. Prepare five cheese puff crisps by crushing them into ~ 5 mm sized chunks and set aside.

3. Clamp the borosilicate RBF in place using a clamp, boss and retort stand and place on a minimum 50 x 50 cm area of heat-proof mats.

4. Place a portable Bunsen burner on the heat-proof mats and adjust the borosilicate RBF so it is approximately 15 cm above the nozzle of the burner.

5. Set up a safety screen on both audience and demonstrator sides of the experimental area.

6. The neck of the RBF should be pointing up and away from both audience and demonstrator (parallel to the front row of the audience). It should be angled at 45 degrees.

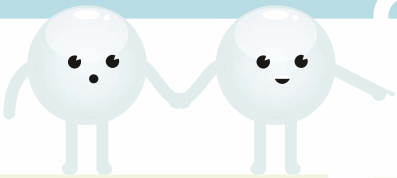
7. There should be no flammable materials within three metres of the direction the RBF is pointing in.

Immediately before the show:

1. Ignite the Bunsen burner to a semi roaring flame with the inlet valve half open.

2. Readjust the height of the RBF so the potassium chlorate slowly starts to melt but is not being rapidly heated.

If you have someone supporting you then they can do this for you during the show.



During the show, before the demonstration:

1. Monitor the status of the potassium chlorate, if it is bubbling too fiercely, reduce the heat by raising the RBF and/or closing the inlet valve of the Bunsen burner. Be careful, the RBF will be hot!

During the show, immediately before the demonstration:

1. Lower the RBF so the molten potassium chlorate is slightly bubbling. However, the demonstration should still work if there are no bubbles.

The demonstration:

1. Turn down the lights for extra effect.

2. Turn off and remove the Bunsen burner from the area.

3. Using the extended funnel, while wearing heat resistant gloves, pour the cheese puff crisps into the RBF from the side.

4. There should be a couple of bursts of flame initially followed by a dramatic jet of white/pink flame, 'whoosh' sound and a large quantity of smoke. The light emitted may have a purplish tinge due to the presence of potassium.

Disposal:

1. Wait at least ten minutes before handling the RBF to allow it to cool down.

2. Rinse out the unreacted potassium chlorate with warm water, this solution can go down the sink via mass dilution.

3. Scrub all carbon residue from the RBF before re-using it.

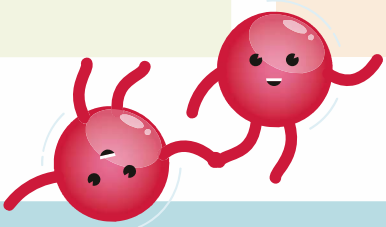
In front of the audience ignite a single cheese puff in air to demonstrate both the fire triangle (for fire you need fuel, oxygen and energy) and the energy stored within the crisp. This shows the difference between combustion reactions in air verses combustion in an oxygen enriched environment.

For a more controlled version, you can replace the crushed cheese puffs with a single 'screaming' jelly baby. **Do not use more than one jelly baby or jelly babies coated in granulated sugar.** Add the jelly baby from the side using a pair of tongs.

Troubleshooting

1. It takes approximately five minutes to melt the potassium chlorate and get it to a rolling boil, so the Bunsen can be ignited at the beginning of the oxygen section, as long as it is carefully controlled.

2. Check the status of the round bottom flask (RBF) prior to every use, ensure it is clean, dry and free of any cracks. Any impurities may cause an explosion so care must be taken to properly clean the RBF after every use.



Health and Safety

Every delivery centre must undertake their own risk assessments for the specific audiences, locations and conditions they are presenting in. Sample assessments are available on The Secret World of Gases website. Below is a guide to the key risks and hazards:

1. Ensure all demonstrators have been trained and always practice this demonstration before the show to ensure you are comfortable with the timings. You may want to have a second person supporting you.

2. Plastic will melt and glass will smash. A borosilicate RBF is essential.

3. Make sure the demonstration is carried out only in a large, very well ventilated area with no smoke sensors or with the fire alarms isolated.

4. This experiment should always be carried out in the open. Ejected molten liquids have been known to melt plastic, crack glass and ignite pre-filters in fume cupboards.

5. Since the reaction is very vigorous there is a chance that molten potassium chlorate and products of the reaction may shoot out of the RBF. Safety screens should be arranged to surround the experiment and stop ejected materials from being scattered around the room.

6. All equipment should be on heat-resistant mats that cover the demonstration area.

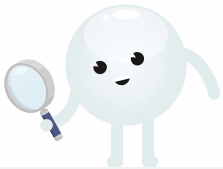
7. Any materials spattered with potassium chlorate should be washed with plenty of warm water to prevent the risk of accidental combustion.

8. The audience should be a minimum of three meters away from the demonstration and protected by safety screens.

9. The demonstrator should wear appropriate PPE including safety glasses and a fire resistant lab coat. For this experiment it is recommended that a face shield is also worn.

10. The demonstrator's hand is at risk when adding the cheese puffs to the molten potassium chlorate, even if tongs or an extended funnel are used. Heat resistant gloves should be worn.

11. Impurities can cause an explosion, so care should be taken to ensure that the potassium chlorate is pure and that the glassware is clean and free from impurities and traces of carbon.



SECRET GAS FACT

Oxygen is common in the universe. You can see the evidence of oxygen on the surface of other planets even without a telescope. Take a look at Mars in sky. The distinctive red colour of rocks on the surface of Mars is caused by iron minerals oxidising (rusting) in the presence of oxygen.