13. Making hydrogen

A rapid and dramatic demonstration producing hydrogen for further use and demonstrations

Overview

Hydrogen is the most abundant element in the Universe and is a potential solution to move away from fossil fuels. This demonstration shows a simple chemical way of generating hydrogen gas.

What's happening?

The chemical reaction

Acids can react with reactive metals such as magnesium to form the metal salt and hydrogen. In this example, dilute hydrochloric acid (HCl) reacts with magnesium to form hydrogen gas and magnesium chloride (equation 1). The hydrogen can be captured using a balloon for use with the hydrogen kit.

$2HCl + Mg \rightarrow MgCl_2 + H_2$ (1)

Why is this important?

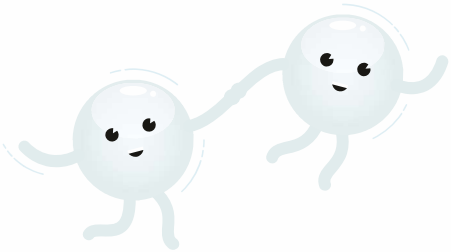
Humanity has been reliant on fossil fuels for thousands of years and since the industrial revolution the negative consequences of using oil, coal and natural gas have become apparent. One of the largest challenges facing scientists at the moment is finding a clean, renewable, energy dense material that can replace fossil fuels. Hydrogen has the potential to be that material. Its energy density is almost three times that of petrol, its combustion in air releases only water and it is the tenth most abundant element on earth (most of it is bonded to oxygen in water).

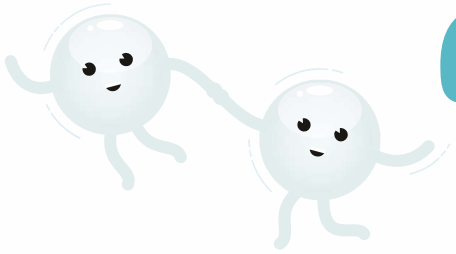
The Activity

1. Hydrogen generation:

a. Before the show:

i. Add 50 mL of 2 M hydrochloric acid to a 250 mL narrow neck (B19 quick-fit recommended) conical flask.
ii. Cut up 10 x 2 cm strips of magnesium ribbon and leave on a heat-proof mat.
iii. Have three balloons ready.





> Hydrogen is the most abundant element in the Universe

b. During the show:

i. Add the magnesium strips, you should see immediate bubbling.
ii. Quickly put a deflated balloon over the neck of the flask, taking care to maintain the seal so not to lose any produced hydrogen.
iii. Remove the balloon once the reaction is complete, being careful not to lose hydrogen.

c. After the show:

i. Dispose of the $MgCl_2$ and HCl mixture down the sink with plenty of water – ensure you always add the acid to the water to avoid a run-away exothermic reaction.

More stories to tell

Most hydrogen is produced from fossil fuels via steam reforming, a process which reacts methane with water over a nickel oxide catalyst to produce carbon monoxide and hydrogen gas. The carbon monoxide is then further reacted with water to form carbon dioxide and hydrogen. This still has the disadvantage of using a non-renewable resource (methane) and produces carbon dioxide as a by-product.

For hydrogen to be a successful replacement for fossil fuels, hydrogen would need to be made via electrolysis (splitting of water using electricity), using a pollution free source of electricity such as wind power. Producing hydrogen on a large scale using reactive metals would be prohibitively expensive so this experiment is not a viable option for large scale production of hydrogen. It does show that we can make a gas using a simple chemical reaction which we can then use with fuel cells to provide a source of energy.

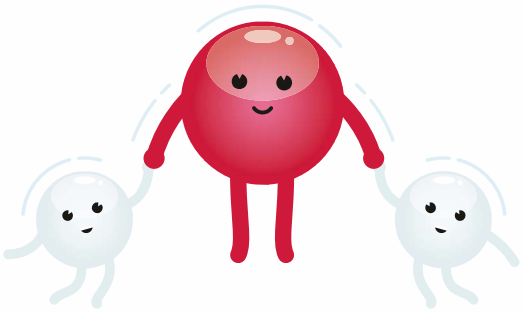
Troubleshooting

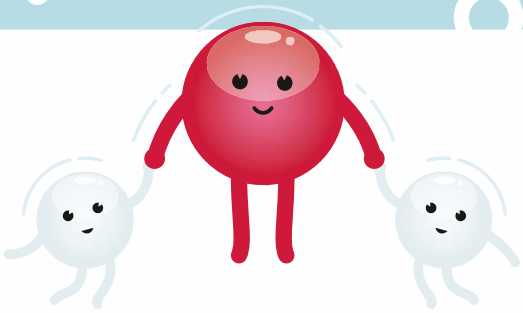
1. It may help to pre-inflate and then deflate the balloons prior to the show so they fill with hydrogen easily.

2. If you are experiencing problems with purity in follow-on demonstrations you can purge the conical flask of air by waiting a second or two before attaching the balloon.

3. If possible, have a balloon of hydrogen (potentially from a cylinder) prepared as a back-up.

4. An addition of a HD webcam will allow the audience to see the hydrogen bubbles clearly.





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. Hydrogen risks. Please see the hydrogen handling page in the 'Additional Resources' section of the handbook.

2. This reaction is exothermic and will get hot, keep it on a heat-proof mat and take care not to touch the conical flask straight after the reaction.

3. The vapour from this reaction can contain hydrochloric acid, avoid inhaling it.

4. Hydrochloric acid risks:

a. At concentrations less than 2.7 M hydrochloric acid is not assigned a hazard classification, however it is recommended that eye protection is worn when handling. If the acid gets on your skin, wash with copious amounts of water.
b. If you are preparing your own standard solution of hydrochloric acid, ensure you have carried out your own risk assessment and are trained.

5. Magnesium risks (from GHS Hazard Statements):

a. H228: Flammable solid
b. H260: In contact with water or acids may release flammable gases that may ignite spontaneously

SECRET GAS FACT

Hydrogen was discovered by Henry Cavendish in 1766. He called it 'inflammable air' and noted that when hydrogen was burned, water vapour was produced, combining the hydrogen with oxygen from the air to make H_2O. It's name comes from the greek words for 'water' (hydro) and 'former' (gen).