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| **Hydrogen power** |
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| Making hydrogen from water  |
| **Subject(s):** Design and Technology, Engineering, Science**Approx time:** 50-70 minutes |  | **Key words / Topics:** * chemistry
* current
* electrode
* electrolyte
* future of flight
* hydrogen
* power supplies
* renewable energy
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for:• ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To understand the environmental issues with using petrol and diesel fuels to power vehicles.
* To understand the benefits of hydrogen based fuels.
* To be able to make a hydrogen from water.
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| **Introduction** |  |  |
| This is one of a series of resources designed to allow learners to use the theme of the future of flight to develop their knowledge and skills in Design & Technology, Engineering and Science. This resource focusses on making hydrogen from water, which is the basis of hydrogen fuel cell technology.Hydrogen is an alternative to petrol and diesel fuels for combustion engines. The only byproduct of using it is water, so it does not harm the environment or cause pollution. Hydrogen fuel cells could potentially be used to power cars, buses and even aircraft. |
| **Purpose of this activity**In this activity learners will make use of the theme of the future of flight to investigate one of the potential energy sources of the future. They will discuss the problems associated with the use of oil-based fuels and how the use of hydrogen fuels could solve them. They will then produce hydrogen from water and investigate ways to make it work better.This activity could be used as a main lesson activity to teach about power supplies and renewable energy within a transport context. It could also be used as part of a wider scheme of learning to teach about sustainability and environmental issues within Design and Technology and Engineering or to teach about electrolysis and simple chemical reactions in Science. |
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| **Activity** |  | **Teacher notes** |
| **Introduction (10 minutes)**Class to discuss the issues with using petrol and diesel fuels to power vehicles. Teacher to explain how hydrogen-based fuel cells could solve these issues.**Making hydrogen (20-30 minutes)**Learners to follow the steps listed below and given in the presentation to make hydrogen from water:* Step 1 - Straighten the paperclips. Strip the plastic off both ends, one end longer than the other. Wind the longer stripped ends round the connectors on the battery. ⚠
* Step 2 - Add water to the vessel. Put the rubber band around the top of the vessel.
* Step 3 - Push the battery through the rubber band so that the two ends of the paperclips hang in the water. Small hydrogen bubbles should slowly start to appear. ⚠
* Step 4 - To increase the rate of hydrogen production, add an electrolyte. Add a spoonful of salt (NaCl) and see what happens.

**Improving the experiment and testing for hydrogen (20-30 minutes)**Learners to qualitatively evaluate how much hydrogen is produced and discuss ways in which this could be increased. They could then follow the steps shown on slides 10-15 of the presentation as an extension to the main activity. Learners to follow the instructions on slide 16 to test for hydrogen. |  | **Petrol and diesel fuels**Discuss the issues with using petrol and diesel fuels. E.g. drilling for crude oil, the fact that oil is a fossil fuel/not renewable, production of carbon emissions/greenhouse gases, pollution, health concerns from breathing in fumes etc. Learners could also research these as a starter activity.**Making hydrogen**Discuss the benefits of hydrogen-based fuels in comparison to petrol and diesel fuels.Paperclips with a plastic covering could be used.A large square vase or similar could be used for the glass vessel. Ideally this should be glass, to allow the bubbles to be observed. Ensure that the 9 V battery has some charge – this can be tested using a battery tester.Step 3 - Make sure the paperclip ends are as close together as you can get them without them touching. This will make the experiment more effective as the shorter the distance between the paper clips, the lower the amount of energy the battery needed to push the current through the gap.If you look really carefully at the negative electrode you should see some bubbles forming on the wire. This is a slow process.After some time you might see bubbles on the positive wire as well. The negative electrode (wire) the has the hydrogen. The other electrode has the oxygen.**Adding an electrolyte (step 4)**Electrolytes make the water more conductive to electricity, thus increasing current flow form the battery – salt is an effective electrolyte. Instead of making hydrogen and oxygen the positive electrode reacts with the chlorine from the salt and makes copper chloride. If you use steel paper clips you should get ferric chloride. This sticks to the electrode, which is why the electrode starts to look ‘dirty’.If you leave the experiment running the water slowly turns a yellowy brown. This is the copper chloride and another chemical that is made, sodium hydroxide, making the water this colour. The water needs to be disposed of carefully as it will now be alkaline.**Improving and testing**Test tubes and splints are commonly available in most science departments. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Pre-strip the ends of the paperclips.
* Pre-connect the paperclips to the batteries.
* Set up an exemplar of the experiment.
 |  | * Investigate and implement ways to improve the effectiveness of the hydrogen production. E.g., using pencils as leads instead of paperclips to reduce reaction with the salt.
* Investigate how hydrogen fuel cells could be used to power aircraft or other transport vehicles.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Paperclips
* Glass vessels
* Water from a tap
* 9V batteries
* Rubber bands
* Pencils
* Playdough or modelling clay
* Crocodile clips
* Bendy straws
* Test tubes
 |  |  Presentation – Hydrogen power |
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| **Additional websites** |
| * **BBC Bitesize - fuel cells:** Revision notes on how fuel cells work and the underlying chemistry. <https://www.bbc.co.uk/bitesize/guides/z2396yc/revision/2>
* **Fueling a green future with hydrogen electric:** <https://www.amrc.co.uk/news/fuelling-a-green-future-with-hydrogen-electric>
* **Jaguar Land Rover:** <https://media.jaguarlandrover.com/news/2021/06/jaguar-land-rover-develop-hydrogen-powered-defender-fuel-cell-prototype>
* **BMW IX5:** <https://discover.bmw.co.uk/article/step-inside-the-new-bmw-ix5-hydrogen>
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Research and discuss the problems with using petrol and diesel fuels to power transport vehicles.
 | **Plenary*** Present findings of the experiment to the class.
* Discuss other options for sustainably powering transport vehicles, such as solar, wind, biofuels etc. What are the relative advantages and limitations? Which would be the most effective for aircraft?
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| **The Engineering Context** film |
| * The future of flight is a great context to explore the opportunities that working in the aeronautical engineering industry presents! For example, designing, making, and maintaining aircraft and spacecraft, and all their different parts.
* Designers and engineers have a responsibility to ensure that the work they do does not negatively impact on the environment and is sustainable. For example, making greater use of renewable energy sources.
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| **Curriculum links** |
| **England: National Curriculum**Design & Technology * KS3 1b, 2b

Science * KS3 Electrolysis and chemical reactions.

**Scotland: Curriculum for Excellence**Technologies* TCH 3-06a
* TCH 3-07a
* TCH 3-10a

Science* SCN 3-10a
 | **Northern Ireland Curriculum**Science* Forces and energy - Using electricity

Technology & Design* Manufacturing – selecting and using materials fit for purpose.

**Wales: National Curriculum** Design and Technology* KS3 skills: Designing 3
* KS3 skills: Making 1, 3
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| **Assessment opportunities** |
| * Informal and formal teacher assessment of practical skills used.
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