

Key Stage 4 Lesson Plan; Hydrogen Fuel Cells

Learning objective

Find out about the particle nature of the element Hydrogen and its compounds, to find out how hydrogen fuel cells can create electricity and to understand the chemical reactions involved in hydrogen fuel cells and hydrogen fuelled internal combustion engines.

Introduction - Hydrogen as a source of energy

Syllabus topics covered: atoms, elements and compounds

Hydrogen is a clean renewable energy carrier which can be used as a fuel in vehicles or to create electricity. When hydrogen is used it only produces water and heat.

More about the element Hydrogen

Syllabus topics; atoms, elements and compounds, the periodic table, the particulate nature of matter

- Hydrogen is a chemical element with the symbol H
- Hydrogen consists of one negatively charged electron that orbits around the nucleus, which in a hydrogen atom consists of a single positively charged proton.
- Hydrogen makes up 75% of all matter in the universe by mass and is hence the most abundant element.
- Hydrogen is mainly found in combination with other elements to form compounds most commonly with oxygen. Together hydrogen and oxygen form water which is represented by the chemical symbol H₂O.

Obtaining hydrogen

Syllabus topics covered; fuels and energy resources, atoms elements and compounds, chemical reactions, redox reactions, electrochemistry

- In order to get pure hydrogen we need to remove it from a compound.
- Hydrogen can be produced by a process called steam reforming on an industrial level from a natural gas (methane), however natural gas is a non-renewable fossil fuel. This is a dirty process as carbon dioxide and carbon monoxide are the bi-products.
- A more sustainable way to produce hydrogen is either from biomass or from water via the process of electrolysis.
- Electrolysis provides a way of splitting a water molecule into its constituent atoms oxygen and hydrogen.
- Reactions in Electrolysis and Fuel Cells are examples of redox reactions (oxidation-reduction reactions).

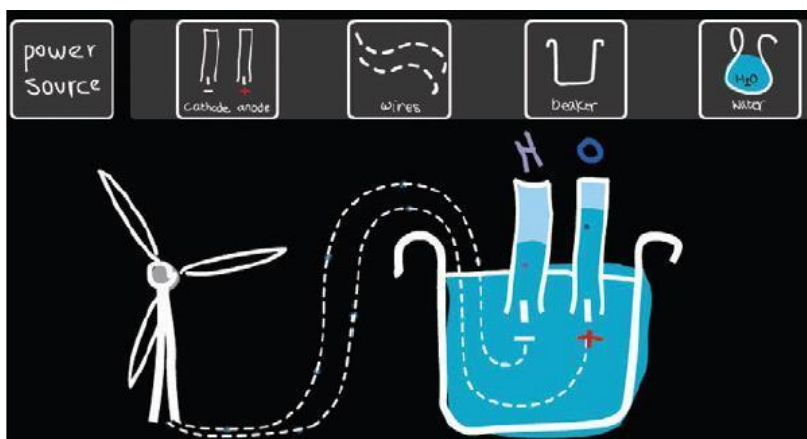
Electrolysis

Syllabus topics covered; electrochemistry, products of electrolysis of various substances, reactions at the electrodes, energy changes and transfers, matter- physical changes, particle model, current electricity

Video; <https://www.youtube.com/watch?v=KriSBR4rhZA>

- Electrolysis is the process of separating bonded chemical elements that form a compound bypassing an electric current through them.
- Electrical current is needed for the process of electrolysis.
- Power can come from renewable and non-renewable sources.
- Renewables: wind and solar are renewable source of energies that can be used to generate electricity without giving off the greenhouse gas carbon dioxide.
- Non-renewables: Fossil fuels, such as coal, gas and oil. Fossil fuels give off the greenhouse gas carbon dioxide when they are burnt and they might also one day run out.

Diagram to show process of electrolysis



Hydrogen fuel cells

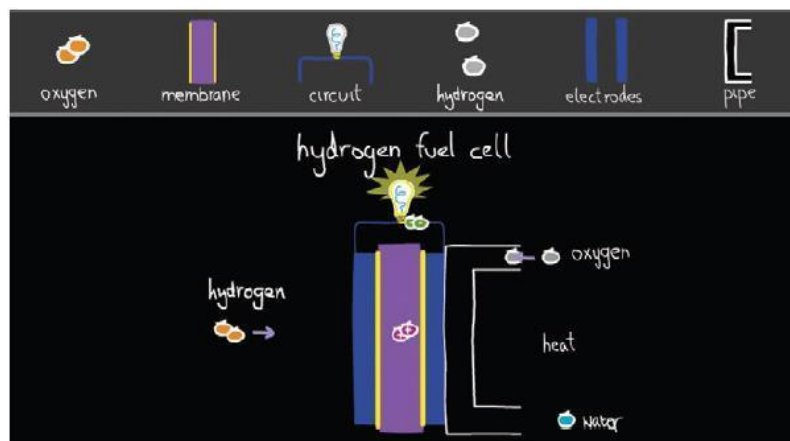
Syllabus topics covered; fuel cells, electrochemistry, electric circuits, and changes as energy transfer, particle model, atoms elements and compounds.

Video; http://www.youtube.com/watch?v=oc6c3p_70LY

- Hydrogen fuel cells are devices that generate electricity using a process that transforms chemical energy from hydrogen into electrical energy.
- In a fuel cell, hydrogen atoms are split into negatively charged electrons and positively charged protons. The electrons are forced to travel through a circuit, which creates an electric current.
- Once the electrons have travelled through the circuit they combine with the hydrogen protons and oxygen molecules to produce water (H₂O) and heat.
- As hydrogen fuel cells do not give off carbon dioxide or any other pollutants they can be used to help create a zero-emission energy system.

- Fuel cells can be used to provide power to buildings, aeroplanes, vehicles and many different types of electronic equipment. In order to provide the large amounts of electricity needed to power vehicles and other electronic equipment, many fuel cells can be combined together to form a fuel cell stack.

Diagram to show how a hydrogen fuel cell works;



- Hydrogen enters the fuel cell at the electrode known as the anode. The hydrogen atoms are split into electrons (negative charge) and protons (positive charge).
- The positively charged protons are able to pass through the membrane inside the fuel cell. The negatively charged electrons cannot pass through the membrane so they are forced to travel through a circuit.
- The movement of electrons through the circuit creates an electrical current, which can be used to provide power for buildings, vehicles and electronic equipment.
- Oxygen atoms (O) from the air enter the fuel cell at the electrode, known as the cathode. The oxygen joins with the hydrogen protons and electrons to form water molecules. Each water molecule consists of two hydrogen atoms and one oxygen atom.
- Heat energy is also produced by the chemical reactions that take place within the fuel cell.
- Fuel cells only give off heat and water so no greenhouse gases are produced.

Hydrogen Combustion

Syllabus topics covered; chemical reactions, energy changes and transfers, electric circuits.

- Hydrogen can provide power in two ways: hydrogen fuel cells can be used to create electricity or hydrogen combustion engines can be used to power vehicles.
- Combustion means 'burning'. Combustion is a type of chemical reaction between a fuel and oxygen from the air which produces heat and light energy.
- When petrol and diesel are burnt they produce the greenhouse gas carbon dioxide and carbon monoxide which contributes to climate change. Whereas, when hydrogen is burnt it only produces pure water vapour or steam. But it also releases traces of oxides of nitrogen, known as NOx emissions.
- Hydrogen powered vehicles have a type of combustion engine specifically designed to burn hydrogen. When hydrogen is burnt in the presence of air, energy is released that powers the car, in a similar way to petrol or diesel engines.