Hydrogen

The lightest element in the periodic table and the most abundant substance in the universe…

Hydrogen

Accounting for more than 90% of the observable universe.

It's also the simplest element – composed of only one proton and one electron.

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Hydrogen

History

- Scientists had been producing hydrogen for years before it was recognised as an element.
- It is documented that Robert Boyle produced hydrogen gas as early as 1671 while experimenting with iron and acids.
- Hydrogen was first recognised as a distinct element by Henry Cavendish in 1766.

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Properties

- At standard temperature and pressure, hydrogen is a colourless, odourless, tasteless and non-toxic gas. Hydrogen gas is highly flammable. Under ordinary conditions on Earth, hydrogen exists as gas.
- Usually, when we refer to hydrogen, we actually refer to H2 or dihydrogen, the molecule made of two atoms of hydrogen in a gaseous form.
- Hydrogen has the highest energy content of any common fuel by weight.
- Hydrogen doesn’t exist naturally on Earth but is found in all growing things.

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Uses

- The need for clean, renewable and non-toxic sources of energy has become increasingly important due to rising temperatures around the world.
- Great amounts of hydrogen are combined with nitrogen from the air to produce ammonia (NH_3).
- Liquid hydrogen is used in the study of superconductors and, when combined with liquid oxygen, makes an excellent rocket fuel.

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Hydrogen applications include (but not limited to):

- chemical industry,
- fertiliser production,
- coolant in power plant generators,
- semiconductors,
- hydrogenation,
- welding,
- automotive and transportation.

Hydrogen

- Fuel cells are being integrated more and more into various types of vehicles.
- A hydrogen fuel cell is a device that combines hydrogen with oxygen from the air in an electrochemical reaction to create electricity.
- Fuel cells emit only heat and water, without producing any air pollutants or greenhouse gases.
- Hydrogen trains, trucks, buses and cars are becoming a part of our daily lives.
- Even hydrogen powered planes might not be so distant anymore.

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Hydrogen

- 2020 Tokyo Olympic Games (postponed to 2021, but still happening) will be fuelled by hydrogen.
- There will be hydrogen buses, cars, and the Olympic village's electricity will be provided by hydrogen.
- Even the Olympic Flame will be fuelled by hydrogen.
- "The 1964 Tokyo Olympics left the Shinkansen high-speed train system as its legacy. The upcoming Olympics will leave a hydrogen society as its legacy."

  Yoichi Masuzoe, Governor, Tokyo Metropolitan Government

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Production

- Although clean at the point of use, hydrogen can be dirty. Looking at the whole chain, production of hydrogen is the villain.
- About 95% of all hydrogen is being produced by a process called steam reforming, where natural gas is being used, making it unclean.
- Hydrogen is considered to be gray, blue or green.
- Gray hydrogen is being produced by carbon intensive processes.
- So is blue hydrogen, but carbon capture and storage (CCS) methods are being implied to reduce carbon emissions.
- Green hydrogen is produced using clean energy sources such as wind or the sun.

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To harness green hydrogen, a process called electrolysis comes to play – the process of using (renewable) electricity to split water into hydrogen and oxygen.

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Conclusion

As improvements in hydrogen fuel cell technology occur globally, the cost of hydrogen is going down, allowing hydrogen technologies to be implemented on a wide scale.

In 1970, General Motors first used the phrase “hydrogen economy.”

50 year later, seems like we’re getting there.

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Hydrogen

- Electrolysis of water is the process of using electricity to decompose water into oxygen and hydrogen gas.
- Hydrogen gas released in this way can be used as hydrogen fuel, or remixed with the oxygen to create oxyhydrogen gas, which is used in welding and other applications.
- Sometimes called water splitting, electrolysis requires a minimum potential difference of 1.23 volts.

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- **Principle**

- A DC electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum or iridium) which are placed in the water. Hydrogen will appear at the cathode (where electrons enter the water), and oxygen will appear at the anode. Assuming ideal efficiency, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution.
- Electrolysis of pure water requires energy to overcome various activation barriers. Without the energy, the electrolysis of pure water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Pure water has an electrical conductivity about one-millionth that of seawater. Many electrolytic cells may also lack the requisite electrocatalysts. The efficiency of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electrocatalysts.
- Currently the electrolytic process used in industrial applications since hydrogen can currently be produced more affordably from fossil fuels.[6]

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Hydrogen

Efficiency - Industrial output

- Efficiency of modern hydrogen generators is measured by energy consumed per standard volume of hydrogen (MJ/m3), assuming standard temperature and pressure of the H2.
- The lower the energy used by a generator, the higher its efficiency would be a 100%-efficient electrolyser would consume 39.4 kilowatt-hours per kilogram (142 MJ/kg) of hydrogen,[24] 12,749 joules per litre (12.75 MJ/m3).
- Practical electrolysis (using a rotating electrolyser at 15 bar pressure) may consume 50 kW·h/kg (180 MJ/kg), and a further 15 kW·h (54 MJ) if the hydrogen is compressed for use in hydrogen cars.

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- There are two main technologies available on the market, alkaline and proton exchange membrane (PEM) electrolyzers.
- Alkaline electrolyzers are cheaper in terms of investment (they generally use nickel catalysts), but less efficient
- PEM electrolyzers, conversely, are more expensive (they generally use expensive platinum-group metal catalysts) but are more efficient and can operate at higher current densities, and can, therefore, be possibly cheaper if the hydrogen production is large enough.

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Hydrogen

Abstract

- Hydrogen is the most efficient energy carrier. Hydrogen can be obtained from different sources of raw materials including water.
- Among many hydrogen production methods, eco-friendly and high purity of hydrogen can be obtained by water electrolysis. However, In terms of sustainability and environmental impact, PEM water electrolysis was considered as most promising techniques for high pure efficient hydrogen production from renewable energy sources and emits only oxygen as byproduct without any carbon emissions.
- Moreover, the produced hydrogen (H2) and oxygen (O2) directly used for fuel cell and industrial applications. However, overall water splitting resulting in only 4% of global industrial hydrogen being produced by electrolysis of water, mainly due to the economic issues. Nowadays, increased the desire production of green hydrogen has increased the interest on PEM water electrolysis.
- Thus the considerable research has been completed recently in the development of cost effective electrocatalysts for PEM water electrolysis.

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