

The History and Uses of Hydrogen

Hydrogen's tendency towards combustion is what makes it both a dangerous chemical element and a useful energy source.

Name: Hydrogen

Symbol: H

Atomic Number: 1

Relative Atomic Mass: 1.008

Category: Reactive nonmetal

Appearance: colourless, odorless gas

Hydrogen is the simplest and most common of the chemical elements, which are the building blocks of all matter. Other atoms are made up of protons, neutrons, and electrons. But hydrogen has only one electron and one proton. It's also the most abundant element. In fact, hydrogen makes up about three quarters of all matter in the universe.

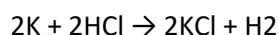
Did you know?

The United States produces around 85 million cubic metres of hydrogen every year. That's equivalent to more than 50 times the volume of the Rogers Centre in Toronto!

Hydrogen is a colourless, odourless non-metal. In its most common form, it's extremely combustible. In other words, it has a tendency to burst into flame. This tendency makes hydrogen both a very dangerous and a very useful resource.

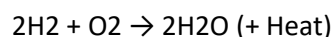
When was hydrogen discovered?

Hydrogen was first discovered in 1671 by British scientist Robert Boyle. He had been experimenting with different metals by dipping them in acid. When a pure metal is placed in acid, a type of reaction called a single-displacement reaction takes place. For example, adding a piece of potassium (K) to a solution of hydrochloric acid (HCl) causes the following reaction to occur:



The solid potassium metal reacts with the acid to form a salt called potassium chloride. Meanwhile, the leftover hydrogen atoms combine to form hydrogen gas.

In a 1776 paper, a British scientist named Henry Cavendish confirmed that hydrogen is a distinct element. Both Boyle and Cavendish noticed that hydrogen gas is very flammable. Specifically, it quickly and violently undergoes a combustion reaction with oxygen.



The reaction takes molecules of hydrogen and oxygen and combines them together to form H₂O (water). This reaction is exothermic. That means it generates heat energy - in other words, fire. Other scientists would later discover that hydrogen provides the fuel for the nuclear fusion reactions that happen inside stars. Those fusion reactions generate all of the light and heat that the Sun and other stars produce.

Did you know? - Hydrogen melts at 14° above absolute zero (14° Kelvin or -259 C

What has hydrogen been used for in the past?

Along with its flammability, Boyle and Cavendish also observed that hydrogen is less dense (lighter) than air. Hydrogen is great at lifting things like balloons. In this way, it's similar to the second simplest element, helium. In fact, hydrogen is even better at lifting things than helium. So it was only a matter of time before people started designing hydrogen-filled balloons for transportation. By the early 1900s, large airships that used hydrogen as their lifting gas had become a popular form of air travel.

However, the hydrogen-filled airship craze didn't last long. In 1937, tragedy struck in the United States. The German airship Hindenburg caught fire and exploded at Lakehurst, New Jersey, killing 36 people.

Airship designers knew that hydrogen is flammable and that helium was a safer choice. However, helium was rare and expensive. So they went with the cheaper but less safe option. After the Hindenburg disaster, hydrogen was quickly abandoned as a lifting gas. At the same time, airplanes were becoming more common.

What has hydrogen been used for more recently?

You've probably seen videos of a Space Shuttle launch from the Kennedy Space Center or docking at the International Space Station. That program was cancelled in 2011. But until then, the Shuttle was the main way for NASA astronauts to get into space. Ever wonder what powered those impossibly huge engines? It was hydrogen!

The Space Shuttle's main engine was powered by burning liquid hydrogen and liquid oxygen. How much power does burning hydrogen provide? So much that it's hard to imagine! Three Space Shuttle engines working together put out roughly the same amount of energy as 120 railroad locomotives.

NASA engineers also understood just how dangerous hydrogen could be. However, they decided they could take advantage of all that raw power as long as they were very careful.

Lately, people have been increasingly interested in reducing their impact on the environment. One way to do this is to stop burning fuel to power cars. There is a lot of interest in developing hydrogen fuel cell-powered cars. The nice thing about using hydrogen to fuel cars is that, unlike with gasoline, the waste product isn't a greenhouse gas - it's water!

Did you know? - As of 2018, there are three hydrogen-powered cars in production. Honda, Hyundai, and Toyota are each producing a hydrogen-powered car.

How does a fuel cell work? (2011) by Naked Science Scrapbook (4:01 min.).

Unlike the Hindenburg, hydrogen-powered cars don't need to be super light like balloons so the fuel is compressed and stored in very tough tanks to prevent leaks. The best solution would be to store the fuel as a solid rather than as a gas. The material can still burn as a result of an accident. However, it would be unlikely to explode. The risk of fire in accidents is about the same as with a gasoline-powered car.

But one of the main problems with using hydrogen as a fuel source for cars is storage. Hydrogen has more energy than gasoline by weight, but it has less energy by volume. That means that you need a pretty big tank of hydrogen gas to drive your car a reasonable distance before refuelling. The gas tanks of most cars are too small to store enough hydrogen gas to get around town!

Scientists have been looking into converting the hydrogen from a gas to a solid. The reason for this is low energy density. When hydrogen is absorbed into a solid chemical, it can gain a higher energy density. Academic, industry, and government researchers are all looking into this innovative way of bringing hydrogen to the forefront of the energy economy.

Human understanding of hydrogen has come a long way since its discovery in 1671. It's been used to lift zeppelins and get people into space. And it just might be the power source that fuels the cars of tomorrow.

Source : <https://letstalkscience.ca/educational-resources/stem-in-context/history-and-uses-hydrogen>