

Hydrogen

One for every household

Top of the periodic table!

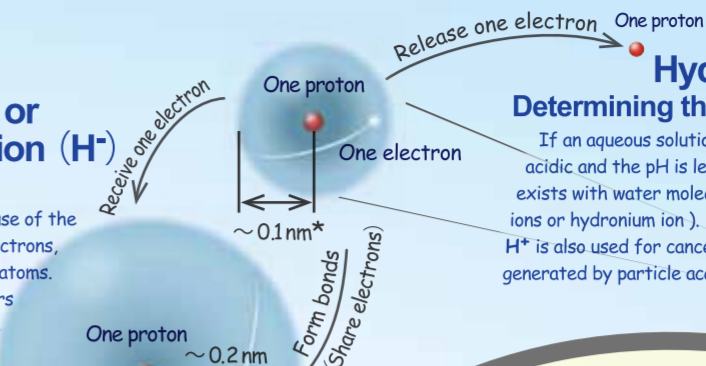
H	He						
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

The atomic symbol H stands for the Latin word Hydrogenium, which means "water generator."

The basics of hydrogen

Hydrogen atom (H)
Light, ever-changing, and sociable

H is composed of one proton and one electron. The element with single electron is unstable and rarely exists on its own in nature. Hydrogen is easily ionized to become a cation or an anion releasing or receiving an electron.

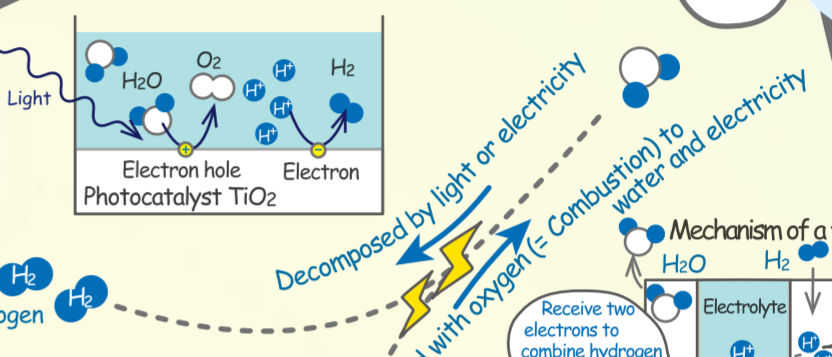


Convert water into energy

The Earth is also called the "water planet." Almost all hydrogen on the Earth exists in the form of H₂O. Hydrogen cycle involving water should be achieved to realize an ideal hydrogen society.

Make hydrogen from water

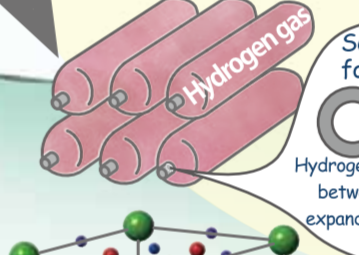
Practical application of CO₂-free hydrogen mass production technology, such as photocatalysis, in which hydrogen is generated from water using solar energy, is expected.



Store hydrogen

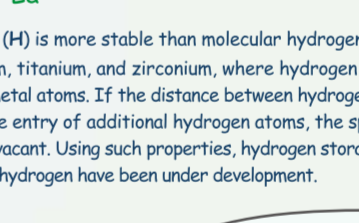
Hydrogen is a very bulky fuel, because it exists as a gas at ambient temperature and pressure. To load hydrogen into a car as a fuel, it has to be compressed to about 1/1000.

High-pressure gas



Hydrogen getting everywhere

The smallest atom, hydrogen, can get into spaces between molecules and atoms in various materials.



Medical diagnosis with hydrogen

An MRI produces cross-sectional images of tissues of the body using the nuclear magnetic resonance of hydrogen. Water and fat, which contain high ratios of hydrogen, are bright, and bones and teeth, which contain almost no hydrogen, are dark in MRI image.

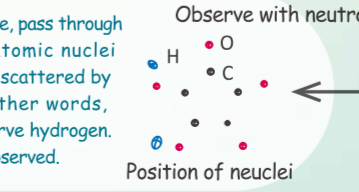


Breaks steel materials

Hydrogen in materials tends to gather at boundaries. The materials become brittle from such boundaries and will break or crack. It is called hydrogen embrittlement.

It is difficult to observe hydrogen in materials.

Observation of hydrogen requires accelerator-based cutting-edge technology such as neutrons and X-rays.



In a hydrogen society, contact between hydrogen and other materials will increase. Hydrogen easily penetrates into materials, and brings about significant influence on the materials properties, even for a very low concentration of 1/1,000,000 (1 ppm). How can we detect such a minute amount of hydrogen? How does hydrogen affect materials? We must face the challenge of the forthcoming hydrogen society.

Molecular hydrogen (H₂)

The lightest gas, will play a leading part in future energy
Two hydrogen atoms combine with each other to make the molecular hydrogen H₂. The word "hydrogen" often refers to molecular hydrogen. H₂ is an odorless, colorless, stable gas at ambient temperature and pressure. Hydrogen gas is a clean energy carrier because it does not emit carbon dioxide after combustion.

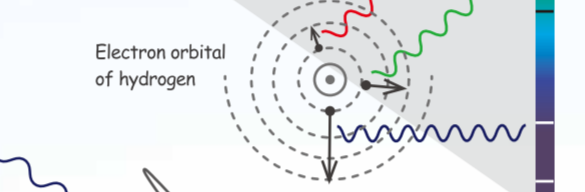
Is H₂ flammable?

H₂ will readily burn if it is mixed in air at a concentration of only 4%. Because H₂ is very diffusible, its flame will not expand over a wide area; rather, it will form a narrow column that burns out in a short time. H₂ will not burn if the hydrogen concentration is too high (more than 75%).

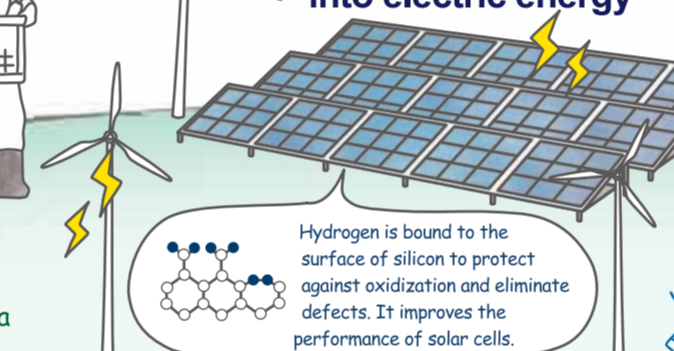
* The Bohr radius of hydrogen atom is 0.053 nm. Since the orbit of electron around the nucleus is not sharply defined, the size of hydrogen can not be defined uniquely.

Hydrogen and quantum mechanics

Dark lines may be found in its spectrum of the sunlight dispersed by a prism. This is because hydrogen in the sun absorbs the particular wavelengths of the light. Detailed studies on the intervals between the dark lines clarified the atomic structure of hydrogen and led to the establishment of quantum mechanics. Because hydrogen is the simplest element, precise comparisons between theory and experiments can be made.



Convert light energy into electric energy



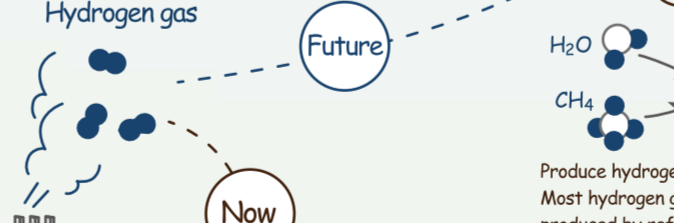
Convert electric energy into chemical energy of H₂



Produce and use hydrogen

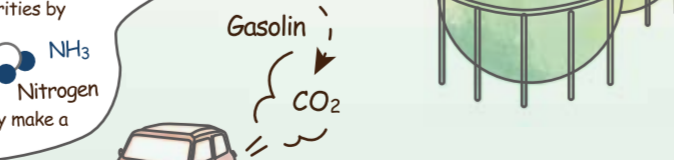
From coke ovens, in which coal is pyrolyzed at a high temperature to produce the coke used in the iron-making process, 8 billion m³ of hydrogen gas (at 1 atm 0 °C) is produced per year as a by-product. Therefore, coke ovens are attracting attention as a source of hydrogen.

Observe hydrogen



Household fuel cell (ENE FARM)

Use natural gas and fuel cells



Japan's most hydrogen consumption for industry

Remove impurities by hydrogen
H₂S Sulfur
NH₃ Nitrogen
Hydrogen easily make a chemical bond.

Visit our website to learn more about hydrogen!
<http://www2.kek.jp/imss/education/hydrogen/eng>
Institute of Materials Structure Science, High Energy Accelerator Research Organization

Hydrogen, the simplest element as its atomic number is 1, was produced very early in the life of the universe. As compared to the long history of hydrogen itself, humans discovered it only 250 years ago. Since then, we have found that hydrogen plays an important role in many occasions, leading to the development of new uses. Let's explore the potential of hydrogen's future together!

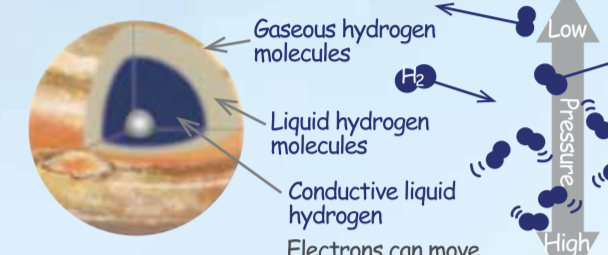
The universe and hydrogen

The first atom in the universe

In the first three minutes just after the birth of the universe, the ultra-hot universe rapidly expanded and cooled, and then protons and neutrons were created. This is the birth of protons, that is, hydrogen nuclei. 3 - 4 millions years after, protons caught electrons to form hydrogen atoms. Hydrogen produced in this way makes up approximately 90% of all the elements in the universe.

Superconductivity with hydrogen

Inside the planet Jupiter, hydrogen itself is predicted to be superconductive. The ultra-high pressure inside Jupiter reduces the distance between the electrons, and makes the electrons to gain superconductivity with increases pairing interactions.



A room-temperature superconductor is no longer a dream?

In 2014, hydrogen sulfide was found to become a superconductor at approximately -70 °C under an ultra-high pressure of 1.5 million atm. As of 2015, this is the unbroken record for high-temperature superconductivity.

under ambient pressure
Hydrogen sulfide
Cause of the smell of hot springs

under ultra-high pressure
Superconducting mechanism involved in hydrogen sulfide is under investigation by researchers worldwide.

Hydrogen and life

Bonds in the backbone of DNA are "covalent bonds". To keep the genetic information, the backbone is made by strong bonding.

Consume energy from leaves and fruits of plants

Organisms are full of hydrogen

Hydrogen is the most numerous of biological constituent elements; more than 60% of the atomic species by number is hydrogen. Based on the weight, hydrogen is the third, after oxygen and carbon. Hydrogen exists as water, which accounts for about two-thirds of a cell, and is contained in various biological molecules such as proteins, lipids, and DNA.

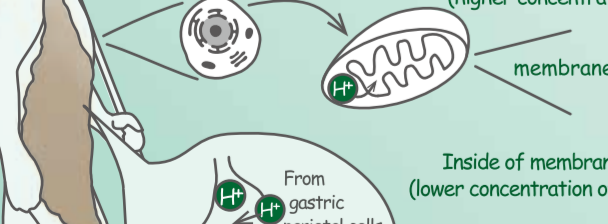


Broken and rejoined

DNA is the blueprint of life. "hydrogen bonds" are making the pairs of the adenine-thymine and the guanine-cytosine in DNA. In daily vital activity, bonds of the DNA double helix are repeatedly broken and rejoined for replication and transcription. Moderate bonding of hydrogen bonds supports life.

Hydrogen bonds

Because hydrogen bound to oxygen or nitrogen assumes a slight positive charge, it tends to form bonds with slightly negatively charged atoms such as oxygen and nitrogen.



Proton pumps that produce concentration gradients of H⁺

In cells, many reactions driven by concentration gradients of H⁺ across membranes occur. A reaction producing the cellular energy unit, adenosine triphosphate (ATP), is an example. A proton pump is a mechanism producing the concentration gradient of H⁺.

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