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Heavy hydrogen and the nuclear reactor

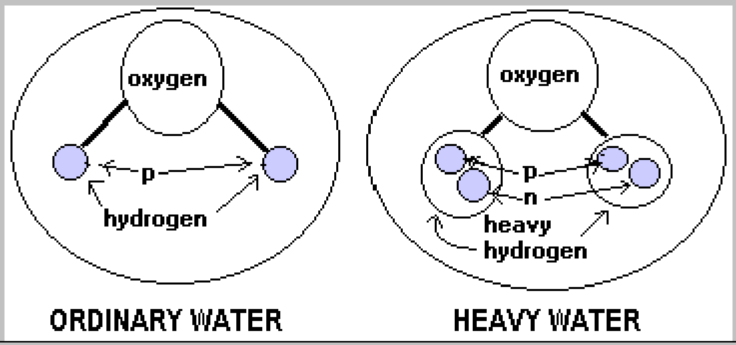
Hydrogen occurs in a rare alternate form called ‘heavy hydrogen’, which has its own important uses, says S.Ananthanarayanan.

The normal hydrogen atom has one heavy, positive proton at the nucleus and a tiny, negative electron in orbit. The nucleus makes for the mass of the atom, while the chemical properties arise from the orbital electron.

But in a few cases in a million, the nucleus has not just a proton, but also a neutron. The neutron has no charge and does not affect chemical behaviour, but it makes the nucleus almost twice as heavy. This kind of hydrogen is called ‘heavy hydrogen’ or ‘deuterium’.

Heavy Water

As the water molecule consists of an atom of oxygen and two of hydrogen, one or both hydrogen atoms could be ‘heavy hydrogen’. Water where both hydrogen atoms are ‘heavy’ is called heavy water. Heavy water is just like ordinary water, except that it is ten percent heavier.

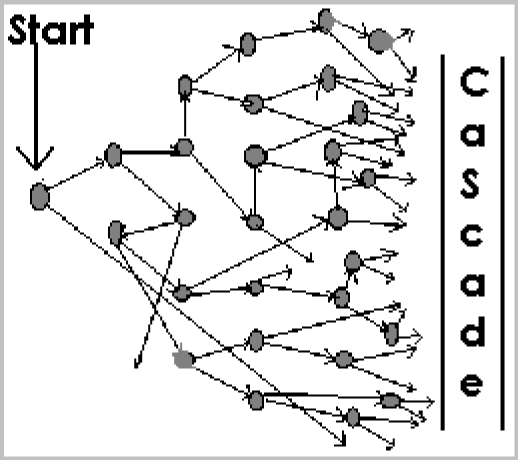


As heavy hydrogen atoms are more massive, they are more difficult to knock around. This makes them more effective in slowing things down if they got in the way, a quality found useful in the working of nuclear reactors.

The nuclear reactor

Just like the hydrogen nucleus can contain either one or two particles, uranium occurs with 233, 235, 238, etc particles in the nucleus. A property of U235 is that a chance neutron breaks it up into a pair of simpler nuclei. And in addition to energy, in the speed of the ‘daughter’ nuclei, fission of U235 gives off two more neutrons. Each fission of Uranium could thus lead to more than just one more fission of other uranium nuclei

This property is used in the atomic reactor and the atom bomb. If about 90 kg of uranium are packed close together, each of the neutrons produced in fissions has a good chance of starting off another fission. In a fraction of a second after the first fission takes place, a huge number of fission events snowball, leading to an explosion.



In power generation, 90 kg are not brought together, but small quantities react so that they just generate tremendous heat. And this heat is drawn off by water circulating around the fuel rods. Rods of carbon, which absorbs neutrons and knocks them out of the 'chain reaction', help control the rate of the reaction, and power is drawn from the reactor at a steady pace.

Enter heavy water

In practice, there are a number of details to take care of. One is that the chain reaction is more efficient if the neutrons given off were not quite so energetic! Hence, a concern of nuclear engineers is to slow the neutrons down and make them more effective in starting fission reactions

It is found that heavy water, with its heavier hydrogen nuclei, can do just this. Hence, the coolant, which circulates and draws off the heat, is made of heavy water. Neutrons emerging from a fuel rod slow down to the optimum speed when they bounce off heavy hydrogen nuclei!