A NEW PROPOSAL

Making hydrogen a metal

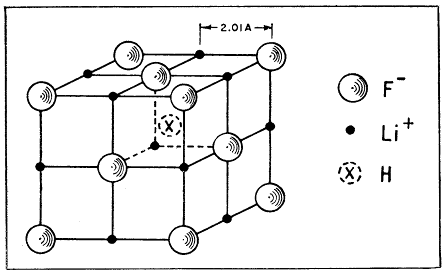
In the periodic table of the elements hydrogen stands at the head of a column of metals including lithium, sodium, potassium, copper, rubidium, silver, cesium and gold. Elements in the same column are expected to have similar chemical properties, but unlike the others in its column, hydrogen does not appear naturally in metallic form.

Natural hydrogen appears most commonly as hydrogen molecules, two atoms linked by a bond based on the sharing of their two electrons. So strong is this molecular hydrogen bond, that extreme, unnatural, pressures would be required to convert it into a metallic bond that would allow a larger number of hydrogen atoms to be linked into some form of crystal. Estimates of the necessary pressure range from 0.8 million bar to 20 million bar. (Normal atmosphere pressure is slightly more than one bar.)

If metallic hydrogen could be made, it would be a useful substance to have around. It would be the simplest of all possible metals, and thus a very useful model and example for students of the solid state. It is expected to have a very high transition temperature for superconductivity, possibly room temperature or higher. It would be about five times as dense as liquid hydrogen. This makes metallic hydrogen an attractive form in which to store hydrogen and perform nuclear fusion experiments.

Experimenters have sought to produce metallic hydrogen by applying enormous pressures to ordinary hydrogen. Now Dr. J. J. Gilman of the Allied Chemical Corp. in Morristown, N.J., suggests a method by which the pressure requirement might be drastically lessened.

Dr. Gilman proposes first making the compound lithium dihydrogen fluoride and then compressing it to a stable form. Forming the compound has the effect of embedding the hydrogen atoms in a matrix of lithium fluoride crystals. In the hypothetical structure exhibited by Dr. Gilman, lithium fluoride forms a cube with lithium atoms at four corners and fluorine atoms at the other four. One hydrogen atom would lie in the center of each cube.



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Cube of lithium dihydrogen fluoride.

Making lithium dihydrogen fluoride, says Dr. Gilman, has the effect of changing the dielectric constant of the space around the hydrogen. (The dielectric constant measures the relative displacement of positive and negative charges in a material when an electric field is applied.) The dielectric constant of free space is one, that of lithium fluoride is two. Since the equilibrium separation of atoms in a material and the compressibility vary with the dielectric constant, substantially less pressure should be needed to insure the stability of metallic hydrogen when it is embedded in lithium fluoride than when it is embedded in free space.

Lithium dihydrogen fluoride molecules are not known to exist in gaseous or solution form. Nevertheless, says Dr. Gilman, there is some evidence that the substance is nearly stable and that it may be amenable to being made stable by pressure. It is a mixed compound of lithium hydride and hydrogen fluoride, both of which are stable. Also, all of the ionic combinations that might be formed by atoms within lithium dihydrogen fluoride are stable with respect to one another. The compound could be prepared by dissolving lithium hydride in hydrogen fluoride or dissolving molecular hydrogen into lithium fluoride at high pressure.

Making a stable sublattice of metallic hydrogen inside the lithium fluoride depends on compressing the material so that the distance between hydrogen atoms is that of a stable metallic hydrogen sublattice. Depending on how the hydrogens associate with each other in the material, various pressures in the hundreds of thousands of bar could accomplish this. There is also some indication that at very low temperatures substantially less pressure, maybe as low as atmospheric pressure, would be required. But the calculations are rough, says Dr. Gilman, and exact knowledge of the relevant numbers awaits experimental formation and study of lithium dihydrogen fluoride. □

Soviets report successful thermionic unit

In a nuclear fission reactor, heat is generated by continuous chain reactions of fissioning atomic nuclei. Converting this heat to electric power is a process that in the usual technology involves several steps.

First the heat must be removed from the reactor by a coolant. Water and liquid sodium are the most popular because they are efficient heat collectors and do not absorb many of the neutrons that are necessary to keep the chain reaction going in the reactor. The coolant is then cycled through a heat exchanger, where it transfers its heat, often to the same liquid in another circuit. The liquid in the second circuit goes to a boiler where it makes steam. The steam drives a turbine, which drives an electrical generator.

In effect this kind of system replaces the fire of a conventional power plant with a reactor.

Ways are under development to use the reactor's heat to generate electric power more directly. This would avoid the capital costs and maintenance problems of the conventional system. In Western countries development has not gotten beyond small units of a few watts power. But last week the Soviet news agency Tass reported that Soviet scientists had developed a direct converter, a thermionic system, of several kilowatts power. A working unit of this size could point the way toward using thermionic conversion in large power stations.

Thermionic conversion is possible because some metals emit electrons when heated. If an anode of such a metal is continually heated, the electrons it gives off can be collected by a cathode some distance away, and if anode and cathode are connected by an external circuit, a current will flow, driven by the heat supplied to the anode. The principle has been used in radio tubes for decades.

If the anode is heated by the coolant from a reactor, a direct conversion of reactor energy to electricity would be achieved. There are many technical difficulties in making thermionics work for large amounts of power, but the Russians now say they can do it in the kilowatt range. They did not say where the system is located nor whether it is a laboratory experiment or a more commercial sort of installation. American commentators say it seems to be a significant advance, but they are wary of making judgments until they have more information.