ORESOME RESOURCES
Minerals and Energy Education

Water Electrolysis and Hydrogen Electrolysers

Water Electrolysis

Electrolysis is the process that uses electric current to induce non-spontaneous chemical reactions in electrolytic cells. An electrolytic cell consists of a power supply connected to two electrodes, a cathode and an anode that are separated by an ionically conducting electrolyte.

The electric current sent through the electrolytic cell flows in the form of electrons in the electrodes and as ions in the electrolyte causing two sets of reactions take place at the separate electrodes.

The electrolysis of water splits the water molecules (H2O) into hydrogen (H2) and oxygen (O2) molecules.

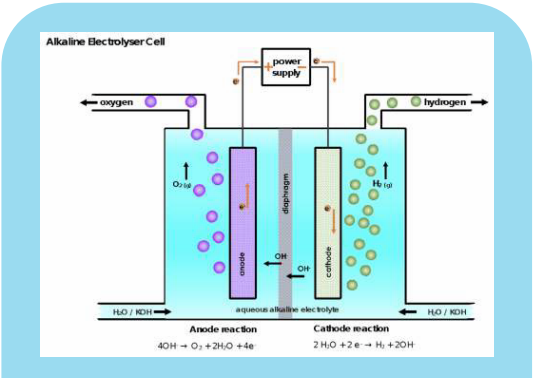
$$2\,H_2O_{(l)} \rightarrow 2\,H_{2\,(g)} + O_{2\,(g)}$$

Electrolysers are used for the commercial production of hydrogen gas and can range in size from small, appliance-size equipment to large-scale production facilities.

There are three main types of electrolysers cells used to produce hydrogen by electrolysis of water, alkaline electrolysers, proton exchange membrane (PEM) electrolysers and solid oxide electrolysers. The different electrolysers function in slightly different ways because of different electrolytes involved.

Alkaline Electrolysers

Currently, most of the larger scale commercial electrolysers use alkaline electrolysis and operate with aqueous electrolytes containing approximately 30% potassium hydroxide (KOH). At the alkaline electrolyser cathode with a negative voltage applied, water splits to form hydrogen gas and negatively charged hydroxide ions. The hydroxide ions transport the current through the electrolyte to the anode. At the anode, hydroxide ions combine to form oxygen gas and water.



These electrolysers operate at temperatures between 100°–150°C and are often at elevated pressures of approximately 30 bar, the most energy efficient means of producing as well as for compressing the hydrogen gas. The electricity requirement to produce 1 kg of hydrogen range between 48 and 52kWh. Use of an alkaline electrolyte allows for the use of low-cost non-precious metal catalysts, such as nickel, for the electrodes, instead of more expensive platinum electrodes.

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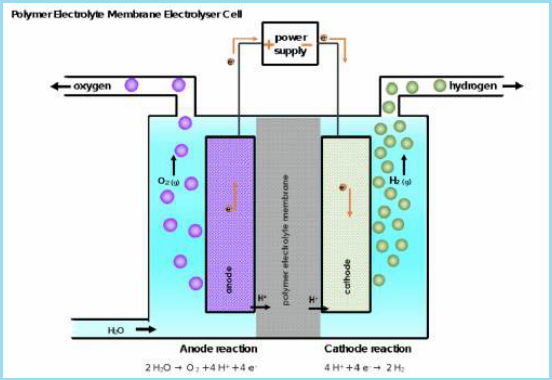
Polymer Electrolyte Membrane Electrolysers

The polymer electrolyte membrane (PEM) electrolysers contain an electrolyte made from a specialty solid plastic material and platinum electrodes. The PEM electrolysers operate at temperatures between 70°–90°C. To produce 1 kg of hydrogen a PEM electrolyse has an electricity requirement of 56-60kWh.



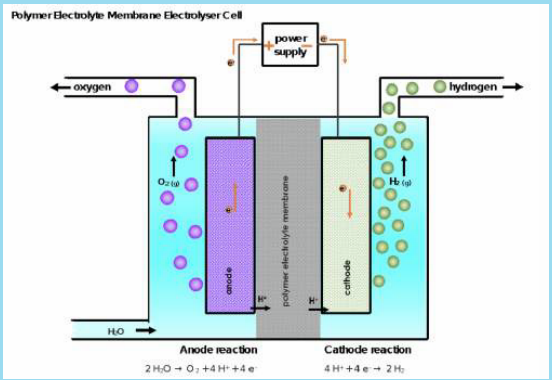
At the PEM electrolyser anode, water splits to form oxygen and positively charged hydrogen ions and releases electrons.

The electrons flow through the external circuit and the hydrogen ions selectively move across the PEM to the cathode.

At the cathode, hydrogen ions combine with electrons from the external circuit to form hydrogen gas.

Solid Oxide Electrolysers

Solid oxide electrolysers (SOE) operate at elevated temperatures use a solid ceramic material as the electrolyte and platinum for the electrodes.



At the SOE cathode steam combines with electrons from the external circuit to form hydrogen gas and negatively charged oxygen ions. The ceramic membrane selectively conducts the negatively charged oxygen ions allowing them to pass through the to the anode. At the anode, the oxygen ions combine to form oxygen gas and release electrons to the external circuit.

Solid oxide electrolysers must operate at temperatures high enough, about 700°–800°C. The high operating temperature enables greater electrical efficiency, 41-45kWh to produce 1kg of hydrogen but require an additional heat source to supply the steam. The solid oxide electrolysers can effectively use heat available, from various sources, including nuclear energy, to operate at elevated temperatures.