

17.4: Aluminum Production

Aluminum is easily oxidized, and so its ore, Al_2O_3 , is difficult to reduce. In fact water is reduced rather than $\text{Al}^{3+}(\text{aq})$, and so electrolysis must be carried out in a molten salt. Even this is difficult because the melting point of Al_2O_3 is above 2000°C —a temperature which is very difficult to maintain.

The first successful method for reducing Al_2O_3 is the one still used today. It was developed in the United States in 1886 by Charles Hall (1863 to 1914), who was then 23 years old and fresh out of Oberlin College. Hall realized that if Al_2O_3 were dissolved in another molten salt, the melting point of the mixture would be lower than for either pure substance. The substance Hall used was cryolite, Na_3AlF_6 , in which the Al_2O_3 can be dissolved at just over 1000°C .

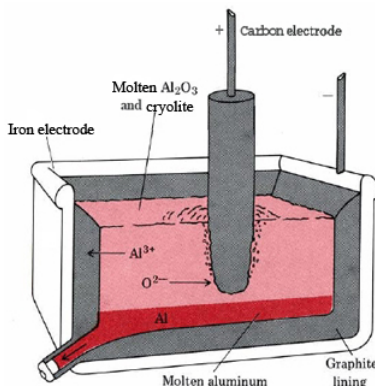


Figure 17.4.1: The Hall process.

The electrolytic cell used for the Hall process. (Figure 17.4.1) consists of a steel box lined with graphite. This contains the molten Na_3AlF_6 and Al_2O_3 and also serves as the cathode. The anode is a large cylinder of carbon. Passage of electrical current maintains the high temperature of the cell and causes the following half-equations to occur:



Since the carbon anode is consumed by the oxidation half-equation, it must be replaced periodically.

Aluminum production requires vast quantities of electrical energy, both to maintain the high temperature and to cause half-equations 17.4.1 and 17.4.2 to occur. Currently about 5 percent of the total electrical energy produced in the United States goes into the Hall process. Much of this energy comes from combustion of fossil fuels and hence consumes a valuable, nonrenewable resource. Since Al is protected from oxidation back to Al_2O_3 by a surface coating of oxide, it is a prime candidate for recycling, as well as for applications such as house siding, where it is expected to remain for a long time. Throwing away aluminum beverage cans, on the other hand, is a tremendous waste of energy.

Several other easily oxidized metals are currently produced by electrolysis, but not in such large quantities as Al. Mg is obtained by electrolyzing molten MgCl_2 which is derived from seawater, and Na and Ca are produced together from a molten mixture of NaCl and CaCl_2 .

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