Chapter 7

Sodium Production

The University of Jordan
Chemical Engineering Department
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Prof. Yousef Mubarak

Introduction

- Sodium is the most common alkali metal and the sixth most abundant element on earth, comprising 2.8 percent of Earth's crust.
- Sodium is the most abundant of the alkali metals.
- Sodium chloride (table salt) is the most common compound of sodium, but many others also are known.
- Sodium is an important constituent of a number of silicate materials, such as feldspars and micas.
- Because sodium is extremely reactive, it never occurs in the free state in the Earth's crust.

- *Sodium is a soft, silvery white, highly reactive element and is a member of the alkali metals within "group 1".*
- *Pure sodium metal has virtually no practical application since it reacts vigorously under normal environmental conditions.*
- *Sodium is an abundant metallic element which is widely distributed. However, because of its high reactivity is not found naturally in its elemental state.*
- *The sodium content of the sea is approximately 1.05 percent, corresponding to a concentration of approximately 3 percent of sodium halides.*

- *There are huge deposits of rock salt in various parts of the world, and sodium nitrate deposits exist in Chile and Peru.*
- *Sodium Chloride is present at a concentration of 3.5% in seawater.*
- *Lighter than water, it can be cut with a knife at room temperature but is brittle at low temperatures.*
- *In 1807 Sir Humphry Davy became the first to prepare sodium in its elemental form, applying electrolysis to fused sodium hydroxide (NaOH).*

Uses

Sodium compounds are important to the chemical, glass, metal, paper, petroleum, soap, and textile industries:

1- Nuclear power plants:

- *Sodium is used number of times as a heat exchange medium in nuclear power plants.*
- *Heat exchange medium is a material that picks up and carries heat from one place to another.*

2- Soap manufacture:

- *Sodium hydroxide compound is used in soap manufacture. Most soaps that we find today are salts of fatty acids.*

3- Light bulbs:

Sodium is often used in the making of light bulbs. The sodium, in light bulb making, is converted into vapor and injected to a glass bulb. An electric current is passed through a wire in the sodium vapor-filled bulb. The combination of the electric current and the sodium vapor produces a yellowish glow in street lamps.

4- Paper making:

Sodium hydroxide is also used in paper making. It is helping in the regeneration of the chemicals that is used to pulp wood chips in the pulping process. Thus, allows the pulp mill to reuse the chemicals and cut the production cost.

5- Paper bleaching:

Sodium hydroxide is used in paper bleaching as an alternative for chlorine.

6- Glass manufacturing:

Sodium can also be used in the manufacturing process of glass. Sodium carbonate, in glass making, is combined with calcium oxide and heated for quite a period of time

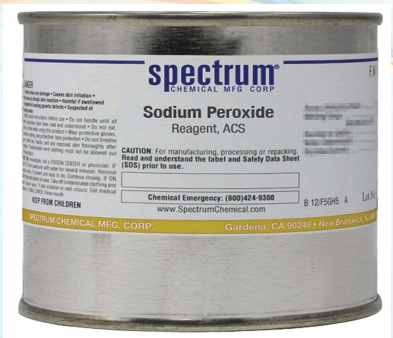
7- Medical uses:

Sodium compounds, such as diclofenac sodium, is used for medication. It is a prescription non-steroidal anti-inflammatory drug (NSAID).

8- Metal manufacturing:

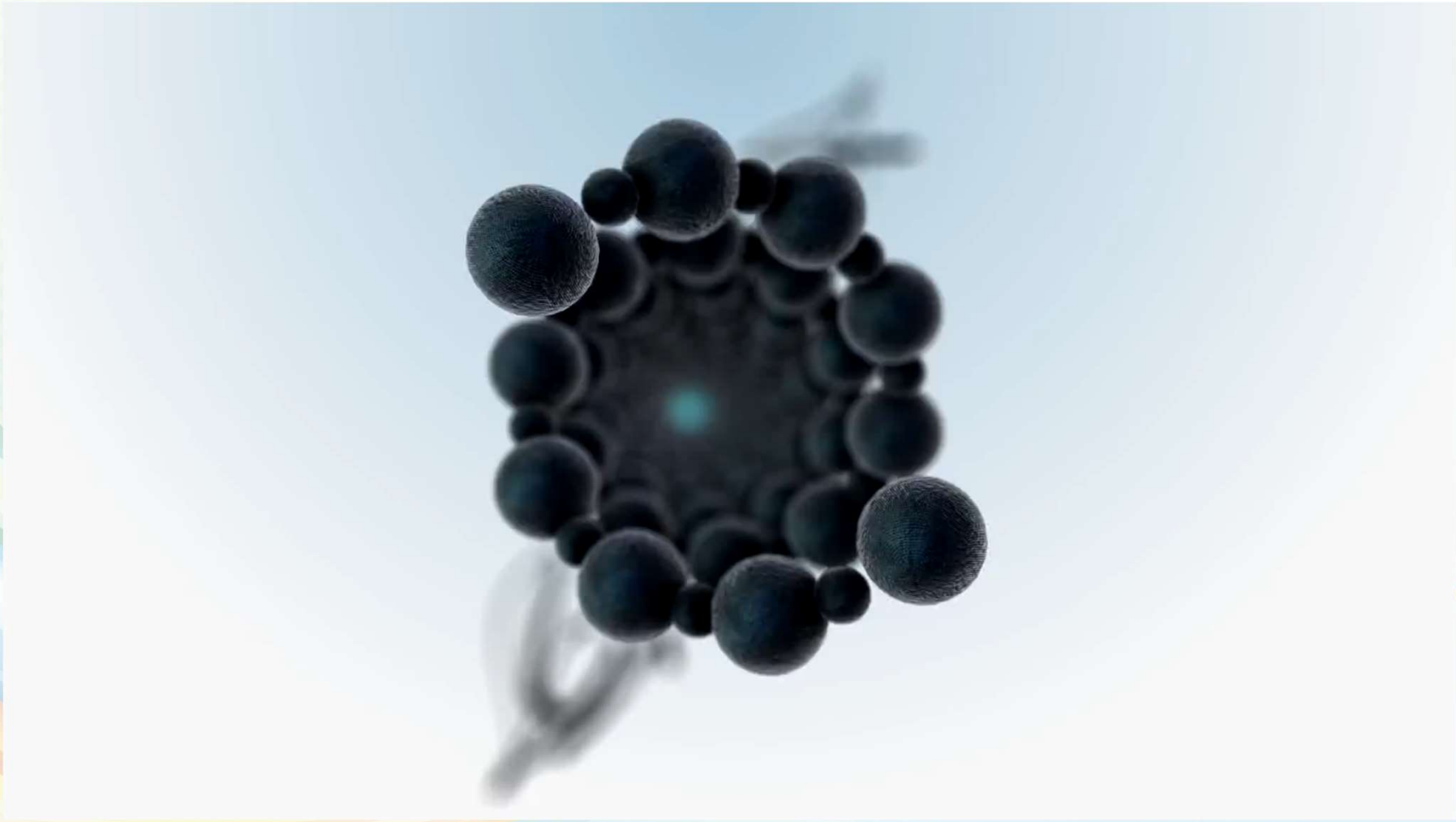
Sodium can also be used in the process of making metals.

9- Sodium metal is used in the manufacture of sodium peroxide, sodium cyanide and sodium amide.



Reactions

- Sodium is highly reactive around water, producing sodium hydroxide and hydrogen gas.
- The heat generated when sodium meets water can ignite the hydrogen gas, causing explosions.
- Sodium does not react with nitrogen and hardly reacts with carbon.
- Sodium does not react with halogens.
- When sodium meets alcohols, it produces similar results as the sodium-water combination, only slower.
- When sodium reacts with oxygen, a yellow light is given off.



Salts

- Sodium presence in the diet helps the body maintain a healthy water balance between the body's cells and fluids.
- Too much dietary sodium can lead to high blood pressure as well as kidney damage.
- Sodium ions also help the transmission of electrical signals in your nervous system.
- Other salts found in nature are sodium carbonate, sodium borate, sodium nitrate and sodium sulfate.
- These salts are all found in seawater, salty lakes and mineral spring water.

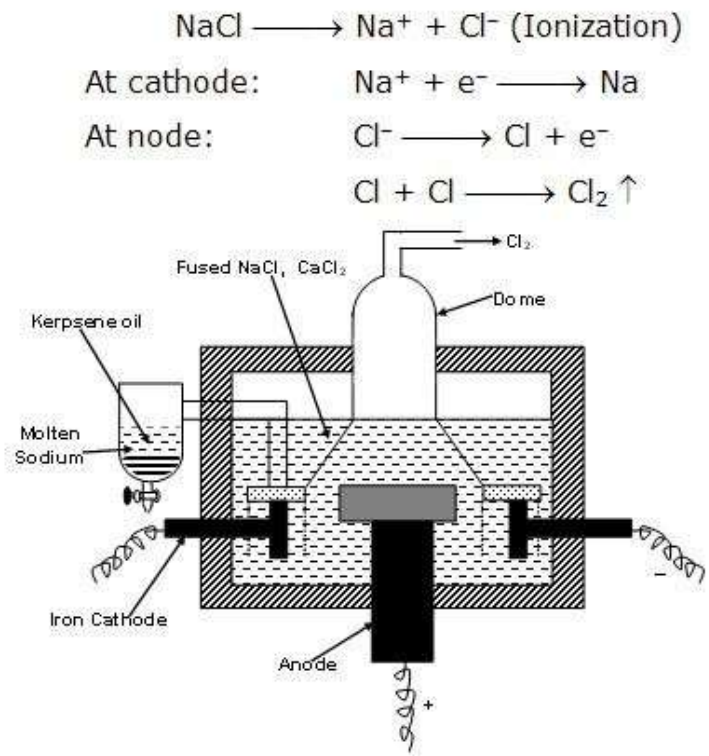
Sodium Nitrate

Sodium Borate

History

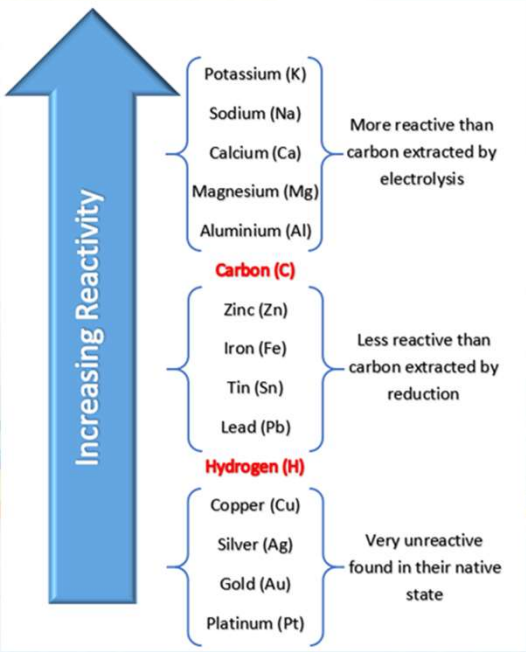
- Sir Humphry Davy first isolated metallic sodium in 1807 by the electrolytic decomposition of sodium hydroxide.
- Later, the metal was produced experimentally by thermal reduction of the hydroxide with iron.
- In 1855, commercial production was started using the Deville process, in which sodium carbonate was reduced with carbon at 1100 °C.
- In 1886 a process for the thermal reduction of sodium hydroxide with carbon was developed.
- Later sodium was made on a commercial scale by the electrolysis of sodium hydroxide.

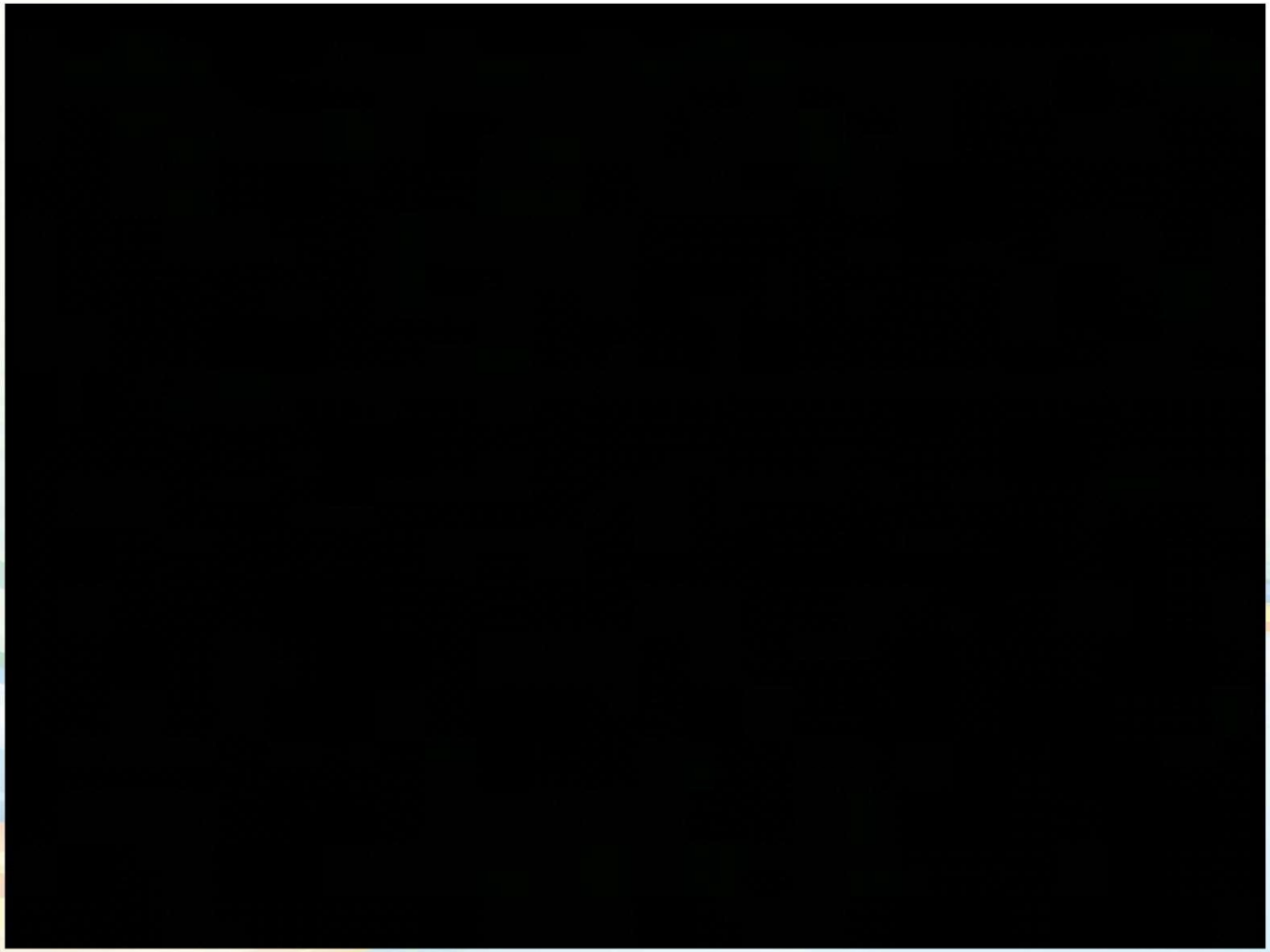
- *The process for the electrolytic decomposition of fused sodium chloride, patented in 1924, has been the preferred process since installation of the first electrolysis cells at Niagara Falls in 1925.*
- *Sodium chloride decomposition is widely used throughout the world.*

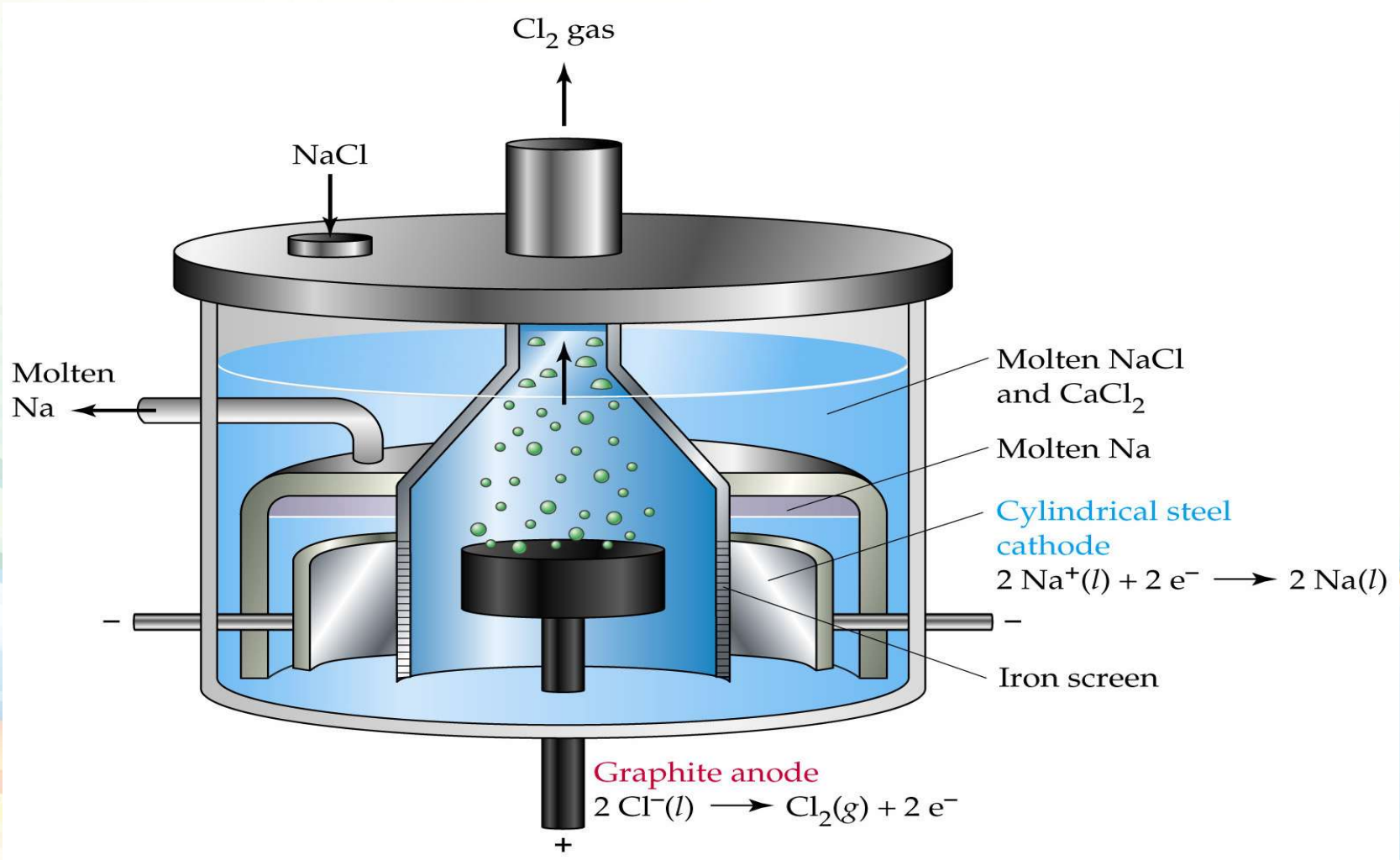


Production

- Because its position in the reactivity series of metals, sodium cannot be extracted using carbon.
- Sodium is above carbon and cannot be displaced by it.
- So, sodium is too reactive to be obtained by carbon reduction of its oxide and another method must be employed which is called electrolysis.
- Sodium, like many of the most reactive metals, can be extracted by electrolysis of its molten chloride.
- This can be done in the 'Down's Cell' shown in the diagram.





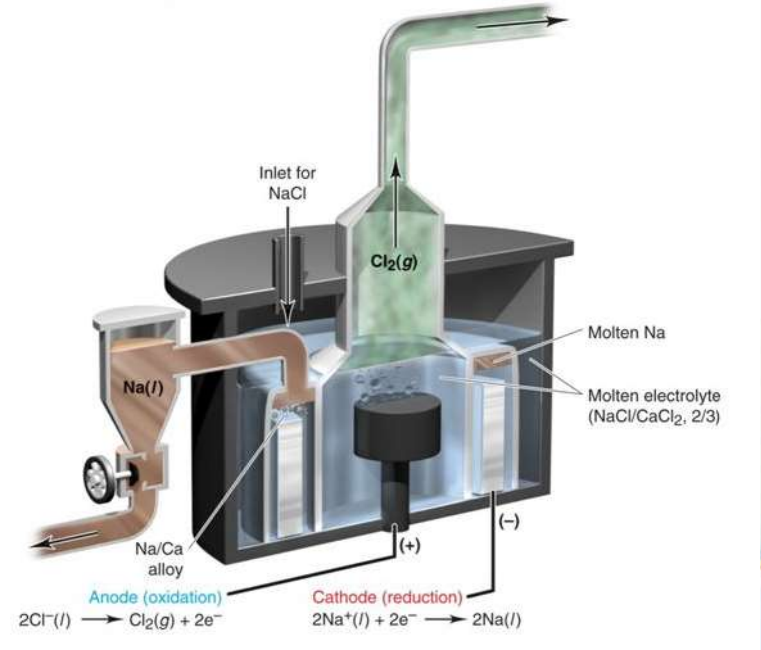

Cl_2 gas
NaCl
Molten Na
Molten NaCl and $CaCl_2$
Molten Na
Cylindrical steel cathode
$2\ Na^+(l) + 2\ e^- \longrightarrow 2\ Na(l)$
−
−
Iron screen
Graphite anode
$2\ Cl^-(l) \longrightarrow Cl_2(g) + 2\ e^-$
+

Down's cell

- The electrolyte medium through which current flows is molten NaCl.
- Calcium chloride, $CaCl_2$, is added to lower the melting point of the cell medium from the normal melting point of NaCl, 804 ^oC, to around 600 ^oC.
- The $Na_{(l)}$ and $Cl_{2(g)}$ produced in the electrolysis are kept from coming in contact and reforming NaCl.
- In addition, the Na must be prevented from contact with oxygen because the metal would quickly oxidize under the high-temperature conditions of the cell reaction.

$$2NaCl \longrightarrow 2Na_{(l)} + Cl_{2\,(g)}$$

- *The cell is designed to collect sodium at the cathode and chlorine at the anode without allowing these two products to react with each other.*
- *The cell does not produce calcium metal because the electrowinning of sodium occurs at a less negative cathode potential than does the electrowinning of calcium.*
- *Modern Downs cells operate at 25 to 40 kA and at potentials of 7 to 8 volts.*



- The actual difference in reversible potential between sodium and chlorine under industrial conditions is only 3 to 4 volts, almost the same as the difference in their aqueous standard potentials (4.0745 V).
- The rest of the applied potential (nearly half) is used to overcome the IR drop due to the cell resistance and the overpotential for chlorine evolution.
- The Downs cell is the major production process for sodium metal and is a minor source of industrial chlorine.