The University of Jordan

Department of Chemical Engineering

095509 Special Topics in Chemical Engineering

(Electrochemical Technology: ECT)

First Semester 2019-2020

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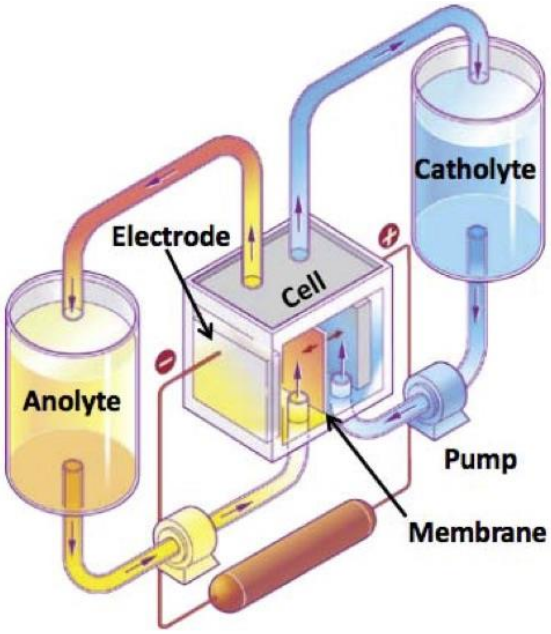
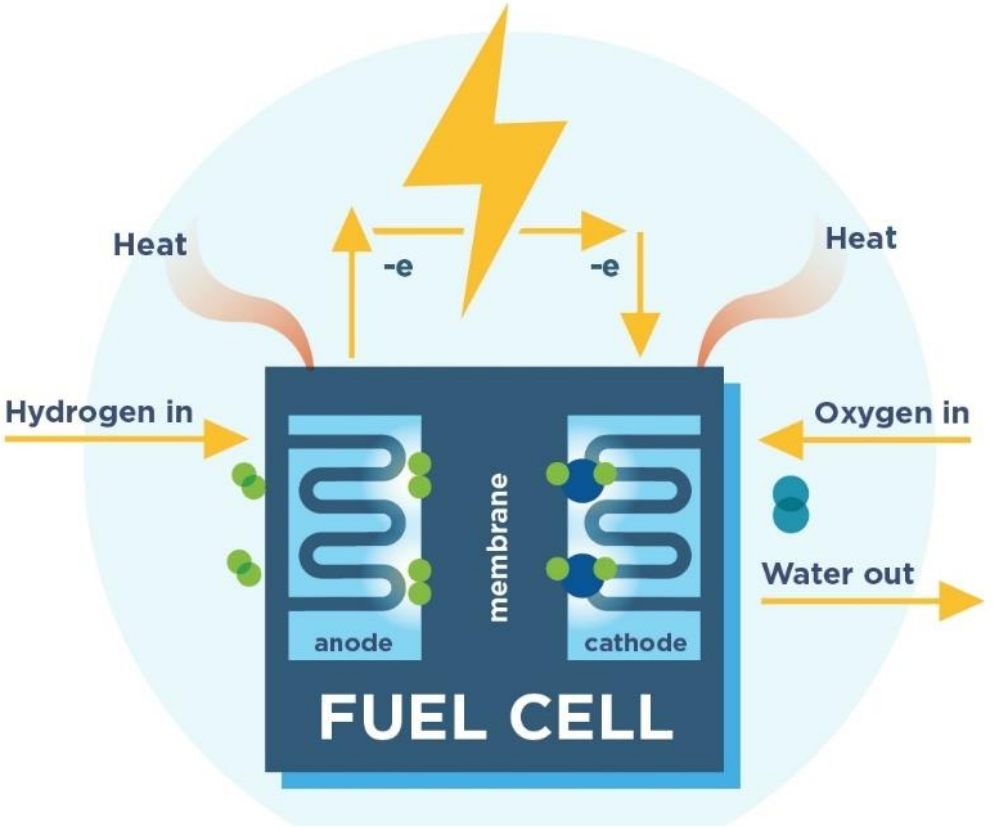


Galvanic Cells Applications

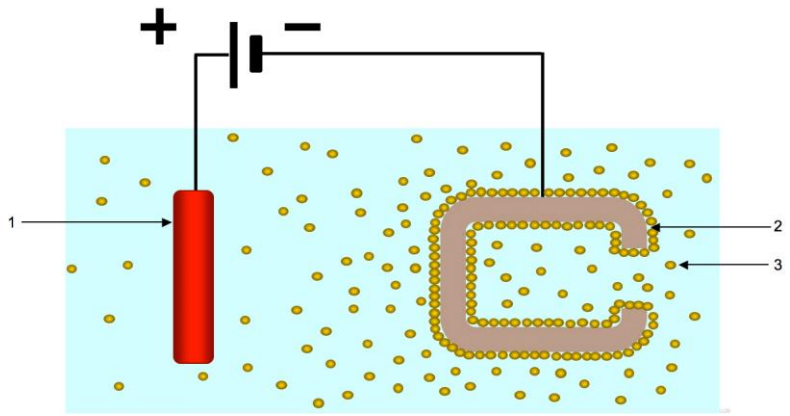
Lab analysis



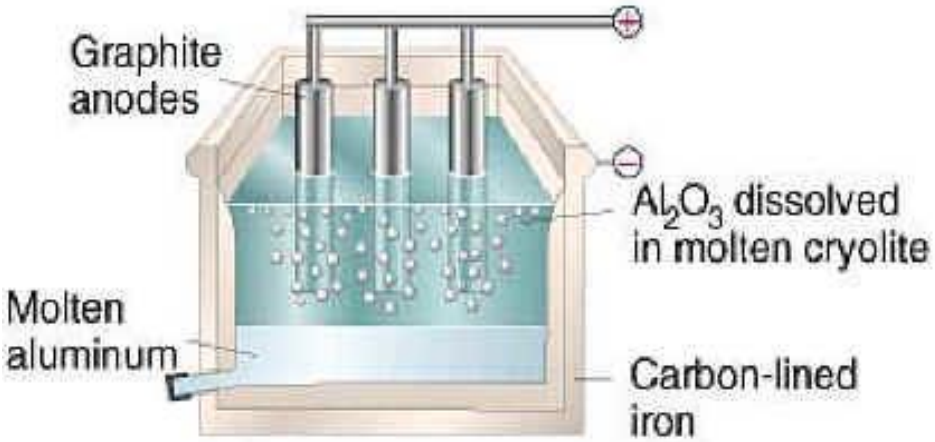
Fuel Cells

Corrosion Control

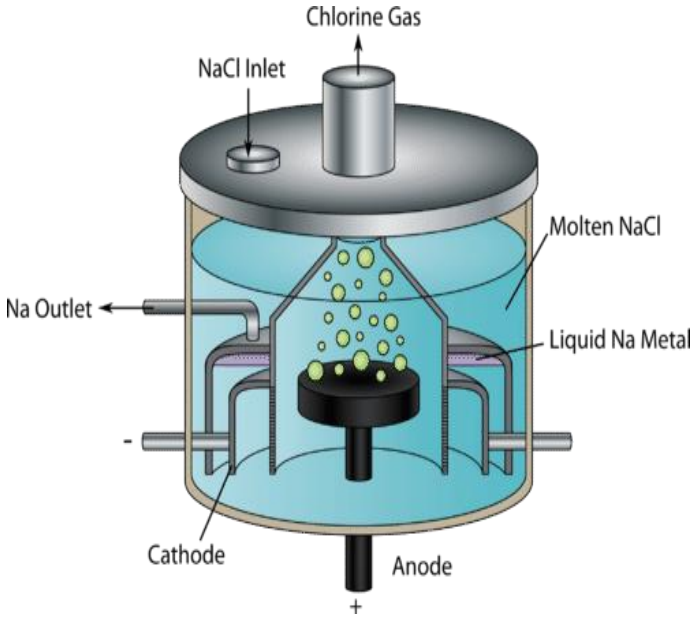
Electrolytic Cells Applications



Metal Electroplating

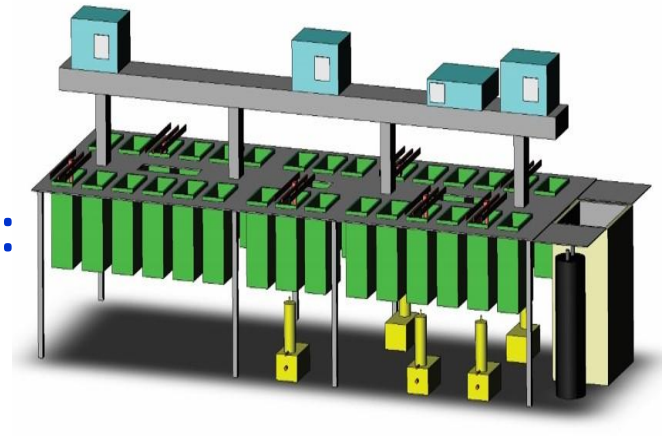


Electrowinning of Aluminum



Chlor-Alkali Process

Course Outline



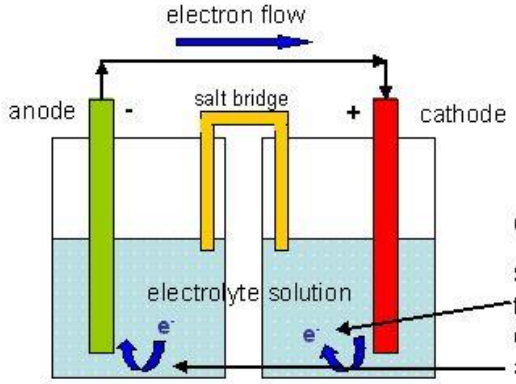
This course covers the following topics:

1. Course overview and introduction.
2. Electrolysis principles and practice
3. Theory of mass transfer, heat transfer, reaction kinetics and design of electrochemical reactors.
4. Theory of metal deposition and the industrial applications of electrowinning, electrorefining, electroplating, electroforming.
5. The chlor-alkali process and other industrial electrochemical production processes.
6. Environmental applications in water and industrial effluent treatment.
7. Applications of electrochemical technology in energy storage and energy conversion.
8. Other applications: Instrumentation, corrosion control.

CHAPTER ONE

OVERVIEW & INTRODUCTION

ELECTROCHEMICAL CELLS

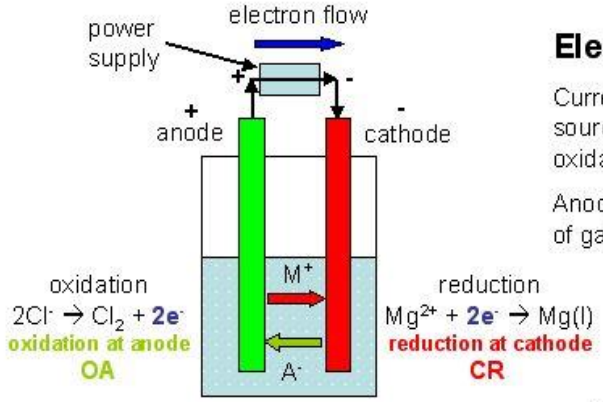


Galvanic Cell

Spontaneous rx. draw e⁻ into cell from cathode where reduction occurs and release them at anode where oxidation occurs

Example:

$Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$



Electrolytic Cell

Current supplied by external source drive nonspontaneous oxidation/reduction reaction.

Anode + and cathode -, opposite of galvanic cell

Example:

$2Cl^- + Mg^{2+} \rightarrow Cl_2 + Mg(l)$

Cations (M^+) move to cathode,
Anion (A^-) move to anodoe

After Atkins, General Chemistry, 2nd edition

Electrochemical Engineering & Technology

- **Engineering** is the application of scientific knowledge and methods to solve particular problems (a discipline of study that imparts scientific knowledge of designing and building structures, machines, materials, systems and processes as well as application of this knowledge for production of all such categories).
- **Technology** is "the capability given by the practical application of knowledge". It is commonly used in processes where knowledge of science and engineering is used to control and adapt to our environments. The term **technology** was first used to describe the ability of human beings to convert natural resources into tools for use.
- that is, *technology describes the product of Engineering, rather than the engineering process itself.*

Electrochemical Engineering

- Electrochemical Engineering deals with the design and operation of electrochemical processes and applications. It is basically a discipline joining Electrochemistry and Chemical Engineering.

- Electrochemical Engineering may be defined as “Study and development of practical materials and processes which involve electrochemical reactions“.
  - The discipline includes electrochemical methods of synthesis, process recycling, energy conversion and materials protection or coating).
  - Moreover, its importance must grow as society becomes more sensitive to the protection of the environment and the need for clean energy conversion.

Electrochemical Engineering

- **Electrochemistry** is an interdisciplinary field concerned with the study of the interaction between electricity and matter which results in a chemical change. It deals with the relationships between electrical energy and chemical energy at the microscopic level.
  - Electrical energy can be converted into chemical energy through a chemical reaction in an "Electrolytic Cell". Chemical energy can be converted into electric energy through a chemical reaction in a "Galvanic Cell".
  - An electrochemical process is simply a chemical reaction occurring in solution accompanied by the transfer of electrons through an external circuit.
- **Chemical Engineering** scales up the electrochemical process into macroscopic level using reactor design, fluid flow, mass & heat transfer, control, safety and other applied sciences, which will be illustrated and discussed in this course.
  - Scaling up involves many problems that engineers must be able to solve, e.g. current inefficiency, overpotential, mixing and cost-effective design, operation and maintenance.

Electrochemical Processes (ECPs)

(ECPs) and their applications may be divided into two broad categories:

A) ECPs based on electrolytic cells which include:

1. Production of inorganic and organic chemicals such as chlorine, caustic soda, hydrogen, sorbitol and glutonic acid.
2. Electrochemical processing of metals such as electrowinning of zinc from ZnS ores, electrorefining of crude copper, electroplating of steel (with Ni, Cr or other metals), and electroforming of aluminum to produce Al foils.
3. Water and wastewater treatment using ion separation techniques such as electrodialysis.

B) ECPs based on galvanic cells which include:

1. Analytical applications which include the determination of pH, activity coefficients of ionic species, solubility products of salts and equilibrium constants of reversible chemical reactions in solution.
2. Producing and storing energy in the form of batteries and fuel cells.
3. Understanding the causes of metal corrosion and how to prevent or minimize corrosion damage.

Electrochemical Processes (ECPs)

Electrochemical processes provide significant benefits including:

1. Easy integration with renewable energy (electricity) sources: The scalability of the technologies, as well as their ability to easily operate in an on-demand mode, facilitates the technologies' ability to interface with renewable, time varying energy sources.
2. Minimization of purification and separation costs: Electrochemical synthesis and/or electrolysis potentially allow the direct production of pure fuels and/or chemicals.
3. Ease of operation at low temperature and pressure: Electrochemical synthesis and/or electrolysis typically takes place at low temperatures and pressures as compared to traditional heterogeneous catalytic synthesis. This could represent significant cost savings.
4. Mid-term impact: The timeframe for implementation of these technologies could be mid-term to long-term (five to twenty years from now).
5. Ease of storage and transportation of feedstock and fuels: Liquid fuels catalyzed through these processes can be transported, stored, and used using existing technology and infrastructure.

References

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