Designing an Efficient Battery System	Grade 12 Chemistry (SCH4C)

Lesson Plan

Learning Outcomes	Specific Expectations
Students will develop a solid understanding of galvanic cells, including their components, electron transfer, and the role of oxidation-reduction reactions in generating electrical energy. Students will apply the principles of redox reactions to design and construct efficient battery prototypes, demonstrating an understanding of how electron transfer drives electrical energy production. Students will design and conduct experiments to test the efficiency of their battery prototypes. This includes selecting appropriate materials, constructing the batteries, and measuring and recording voltage, fostering skills in scientific inquiry and experimental design.	**Electrochemistry** **D1.1** analyse, on the basis of research, a technological application that is based on the oxidation-reduction (redox) reaction that occurs in galvanic cells (e.g., in cardiac pacemakers, batteries, electroplating) [IP, PR, AI, C] **D2.1** use appropriate terminology related to electro-chemistry, including, but not limited to: oxidation, anode, and electrolyte [C] **D2.3** analyse the processes in galvanic cells, and draw labelled diagrams of these cells to show the oxidation or reduction reaction that occurs in each of the half-cells, the direction of electron flow, the location of the electrodes, and the direction of ion movement [AI, C] **D2.4** design and conduct an inquiry to determine the factors that affect rate of corrosion of a metal (e.g., stress on the metal, contact between two metals, surface oxide, the nature of the electrolyte, the nature of the metal) [IP, PR, AI] **D3.1** explain the concepts of oxidation and reduction in terms of the chemical changes that occur during redox reactions **D3.2** describe the components of a galvanic cell, and explain how each component functions in a redox reaction

Description

Students will use Problem-Based Learning to design a more efficient battery system. Students will create a galvanic cell and see how it works. They will then use different materials to see how it affects the efficiency of the battery and design a more efficient battery system thinking about the context of where we use batteries most often.

Materials

- Informational materials on galvanic cells and oxidation-reduction reactions. See introduction or online. Informational materials on different types of devices that use rechargeable batteries.
- Safety goggles
- Lab coats

- Gloves
- 2-500 mL beakers
- 250 mL graduated cylinder
- Copper metal and zinc metal electrodes
- 1.0M Copper sulfate solution ($CuSO_4$)
- 1.0M Zinc sulfate solution ($ZnSO_4$)
- Salt bridge
    - 50 mL NaCl solution
    - Pipette
    - 20 cm filter paper strip
- Voltmeter
- Alligator clips for connecting wires and loads
- Various materials for constructing battery prototypes (e.g., different metals, electrolytes, separator materials)
- Multimeter
- Materials for prototyping (e.g., wires, connectors, insulating materials, different loads (LEDs, buzzers etc.)
- Paper and pencils

Introduction

Galvanic or voltaic cells generate electrical energy through redox reactions. Two different half-cells are connected. The galvanic cell contains an oxidation half-cell and a reduction half-cell. Each half-cell contains a metal electrode in an electrolyte solution.

In the oxidation half-cell, oxidation happens at the metal electrode. The metal atoms lose electrons and become ions: $M \rightarrow M^{n+} + e^-$. Electrons are released into the electrode.

In the reduction half-cell, reduction happens at the metal electrode. Positive ions in the electrolyte gain electrons and are reduced: $X^{n+} + e^- \rightarrow X$. Electron from the oxidation half-cell are consumed in the reduction half-cell.

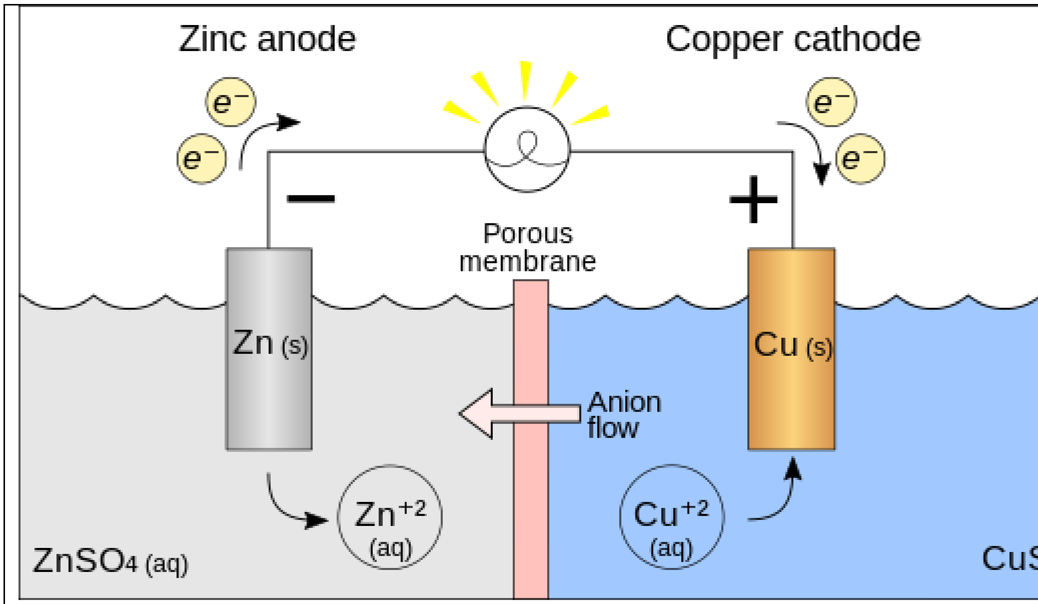
A salt bridge is used to connect the two half-cells and allows the flow of ions between the two half-cells and maintain charge neutrality.

Electrons released in the oxidation reaction flow through an external circuit to the reduction half-cell and this creates an electric current. This electric current is used to do work.

The cell reaction students will initially try is:

$$Zn\ (s) + Cu^{2+}(aq) \text{ --> } Zn^{2+}(aq) + Cu\ (s)$$

The direction of electron flow is determined by the electrode potentials of the half-cells. The more reactive metal tend to undergo oxidation and the less reactive metal tends to undergo reduction.



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Action

Introduce the problem: "How can we design a more efficient battery system to meet the growing demand for portable electronic devices?" Discuss the importance of battery efficiency in everyday life.

Activity 1: Exploring how galvanic batteries work. (45 minutes)

See Handouts:

- How to Make a Galvanic Cell.
- Students Worksheet – Galvanic Cell.

Activity 2: Constructing Battery Prototypes (90 minutes)

1. Guide students to explore various materials for constructing battery prototypes (different metals, electrolytes, separator materials).
2. Encourage students to brainstorm and plan their battery design.
3. Allow students time to construct their battery prototypes based on their plans.
4. Provide guidance and support as needed.
5. Emphasize the importance of testing different combinations of materials.
6. Students can test their batteries using the voltmeter, but also by using different loads provided.
7. Have each group measure and record the voltage produced by their battery prototypes using a voltmeter.

Analysis (30 minutes):

1. Discuss the factors influencing the efficiency of the batteries.
2. Explore the concept of trade-offs in battery design (e.g., energy density, cost, environmental impact).

Consolidation/Extension

Students can create an infographic or some other presentation format to explain their battery design and results. They should be able to explain the principles behind the efficiency of their batteries, taking into consideration factors such as voltage produced, materials used and overall design.