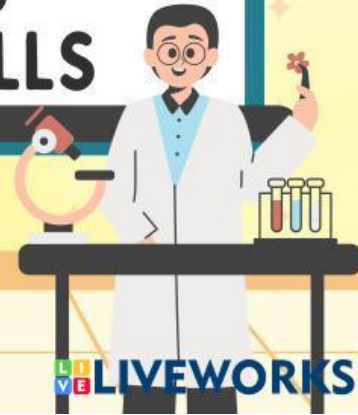


E-LKPD CHEMISTRY IN HIGH SCHOOL

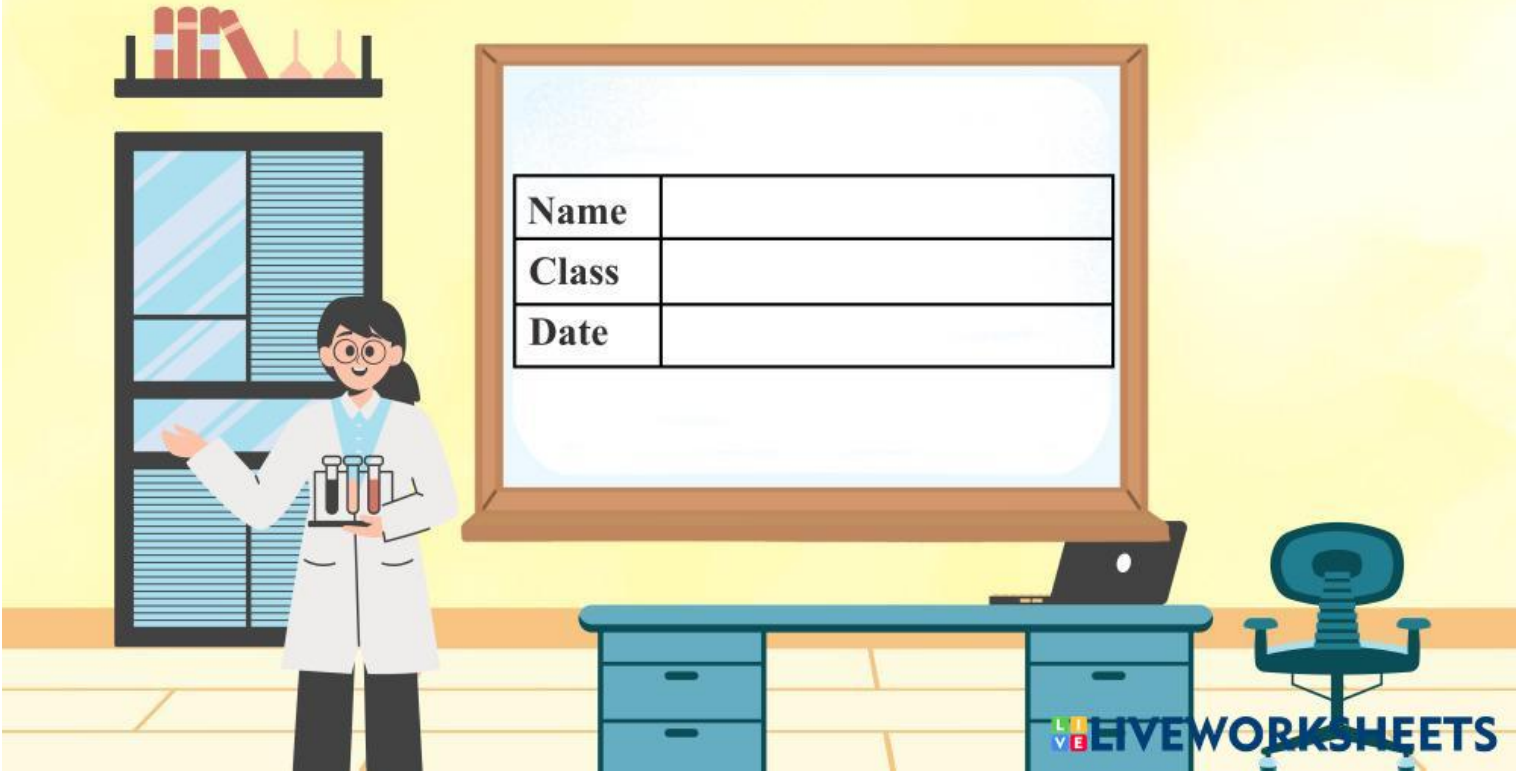
Electrochemical Engineering:

ENERGY TRANSFORMATIONS IN VOLTAIC AND ELECTROLYTIC CELLS



 **LIVEWORKSHEETS**

CURRICULAR ALIGNMENT: SELF-PACED INQUIRY BASED ON THE 7-SLIDE INTERACTIVE DECK



SECTION 1: REACTION SYSTEM INITIATION

INSTRUCTIONS: DRAW CONNECTING LINES (JOIN WITH ARROWS) FROM EACH COMPARATIVE ASPECT ON THE LEFT TO ITS CORRESPONDING ELECTROCHEMICAL FUNDAMENTAL ON THE RIGHT!

Comparative Aspect

Energy Conversion in Voltaic Cells

☐

Energy Conversion in Electrolytic Cells

☐

Electrode Polarity in Voltaic Cells

☐

Electrode Polarity in Electrolytic Cells

☐

Electrochemical Fundamental

☐ Anode connects to the positive terminal (+) of the power source; Cathode connects to the negative terminal (-).

☐ Converts chemical energy from spontaneous redox reactions into electrical current ($E^{\circ}_{\text{cell}} > 0$).

☐ Anode is negatively charged (-) as the electron source; Cathode is positively charged (+) where electrons are consumed.

☐ Utilizes external direct current (DC) electrical energy to drive non-spontaneous redox reactions ($E^{\circ}_{\text{cell}} \leq 0$).

SECTION 2: ELECTRON TRANSFER PHENOMENON

Instructions: Analyze the submicroscopic mechanism of the standard Daniell Cell (Zn - Cu) and select the correct parameter from each Drop-down Menu!

- 1. Zinc metal (Zn) exhibits a greater tendency to lose electrons compared to Copper (Cu). Consequently, the Zn electrode functions as the**
: Choose: and undergoes Choose:
- 2. The half-reaction occurring at the surface of the zinc electrode is**
: Choose: As a direct consequence of this reaction, the physical mass of the Zn strip will Choose:
- 3. Aqueous copper ions (Cu^{2+}) migrate toward the copper electrode to accept electrons. The Cu electrode acts as the strip will increase.**
: Choose: The physical mass of the Cu Choose:

SECTION 2: ELECTRON TRANSFER PHENOMENON

Instructions: Analyze the submicroscopic mechanism of the standard Daniell Cell (Zn - Cu) and select the correct parameter from each Drop-down Menu!

4. **Electrons travel spontaneously through the external circuit (conducting wire) from the**
: Choose: electrode.

5. **Without a salt bridge, a positive charge accumulation of Zn^{2+} occurs in the anode compartment, alongside a deficit of positive ions in the cathode compartment. The salt bridge (KNO_3) maintains electrical neutrality by migrating nitrate anions (NO_3^-) toward the:** Choose: compartment and potassium cations (K^+) toward the
Choose: compartment.

SECTION 3: INTERACTIVE REDOX SIMULATION

Instructions: Analyze the submicroscopic mechanism of the standard Daniell Cell (Zn - Cu) and select the correct parameter from each Drop-down Menu!



Standard Reduction Potential Reference Data (25°C, 1 M):

- $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Mg}(\text{s})$ $E^{\circ} = -2.37 \text{ V}$
- $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Fe}(\text{s})$ $E^{\circ} = -0.44 \text{ V}$
- $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$ $E^{\circ} = +0.34 \text{ V}$
- $\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$ $E^{\circ} = +0.80 \text{ V}$

Spontaneity Equation: $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{Reduction (cathode)}} - E^{\circ}_{\text{Oxidation (anode)}}$

THE QUESTION IN NEXT SLIDE



Instructions: Analyze the submicroscopic mechanism of the standard Daniell Cell (Zn - Cu) and select the correct parameter from each Drop-down Menu!

Standard Reduction Potential Reference Data (25°C, 1 M):

- $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Mg}(\text{s})$ $E^{\circ} = -2.37 \text{ V}$
- $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Fe}(\text{s})$ $E^{\circ} = -0.44 \text{ V}$
- $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$ $E^{\circ} = +0.34 \text{ V}$
- $\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$ $E^{\circ} = +0.80 \text{ V}$



Spontaneity Equation: $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{Reduction (cathode)}} - E^{\circ}_{\text{Oxidation (anode)}}$

Cell Notation System	Cathode (+)	Anode (-)	Calculated E°_{cell} (Type Value)	Spontaneity (Drag & Drop)	Electron Flow (Drag & Drop)
System A: $\text{Mg} \text{Mg}^{2+} // \text{Cu}^{2+} \text{Cu}$	Cu	Mg	$+0.34 - (-2.37) = [\quad] \text{ V}$	[]	[]
System B: $\text{Fe} \text{Fe}^{2+} // \text{Ag}^{+} \text{Ag}$	Ag	Fe	$+0.80 - (-0.44) = [\quad] \text{ V}$	[]	[]
System C: $\text{Cu} \text{Cu}^{2+} // \text{Fe}^{2+} \text{Fe}$	Fe	Cu	$-0.44 - (+0.34) = [\quad] \text{ V}$	[]	[]

You can Drag From Here

+2.71 +1.24 -0.78

SPONTANEOUS

SPONTANEOUS

NON-SPONTANEOUS

From Mg to Cu

From Fe to Ag

Requires External Power

LIVEWORKSHEETS



SECTION 4: FARADAIC KINETIC ANALYSIS

Instructions: Complete the quantitative and mechanistic analysis for the electroplating of an iron spoon (F) with silver (Ag) using an aqueous AgNO₃ electrolyte and a pure silver anode!

1. Electrode Reaction Identification:

- The substrate to be coated (Iron spoon, Fe) must be connected to the negative terminal ([]).

Reduction half-reaction forming silver deposit:

[]

- The plating metal (Silver bar, Ag) must be connected to the positive terminal ([]).

Oxidation half-reaction dissolving silver ions:

[]

2. Faraday's First Law Calculation:

An electroplating circuit operates with a constant current of $I = 5.0 \text{ A}$ for a duration of $t = 1,930$ seconds. Given the molar mass of silver $A_r(\text{Ag}) = 108 \text{ g/mol}$ and valence charge $n = 1$:

Formula:
$$w = \frac{A_r \cdot I \cdot t}{n \cdot 96,500}$$

Numerical Substitution:
$$w = \frac{108 \cdot 5.0 \cdot 1,930}{1 \cdot 96,500}$$

Theoretical mass of silver deposited: [] grams.

SECTION 5: POTENTIAL EQUILIBRIUM SYNTHESIS

Instructions: Evaluate each conceptual statement below by selecting [T] (True) or [F] (False) based on electrochemical principles!

No	Conceptual Synthesis Statement	Cognitive Evaluation
1	Across all electrochemical cells (both Voltaic and Electrolytic), Oxidation invariably occurs at the Anode, while Reduction invariably occurs at the Cathode.	[]
2	A positive standard cell potential ($E_{\text{cell}} > 0$) signifies that the net redox reaction is thermodynamically favorable and generates electrical work spontaneously.	[]
3	During the electrolysis of aqueous solutions using inert electrodes (Pt/C), active metal cations from Group IA, IIA, Al, Mn are reduced at the cathode to form solid metal deposits.	[] (Water is reduced instead)
4	The further left a metal is positioned in the Activity Series (e.g., Li, K, Ba, Ca, Na, Mg), the more readily it loses electrons, functioning as a stronger reducing agent.	[]
5	Cathodic protection of underground steel pipelines using a sacrificial magnesium (Mg) anode works because the reduction potential of magnesium is more positive than that of iron (Fe).	[] (Mg is more negative/easily oxidized)