Name…… **Period……**

Unit 8: REDOX and Electrochemistry

Skills:

1. Assigning Oxidation Numbers
2. Identifying Oxidation and Reduction
3. Writing Half Reactions
4. Balance Redox Reaction
5. Table J and Spontaneous Reactions
6. Distinguish Between electrochemical batteries: Voltaic and Electrolytic
7. Solve Voltaic Cell Problem
8. Identify Electrolytic Cells and Compare

Unit 8: Vocabulary: **Complete throughout unit. Due on test day!**

Word	Definition
Reduction	
Oxidation	
Anode	
Cathode	
Voltaic Cell	
Electrolytic Cell	
Electrolysis	
Electroplating	
Salt Bridge	
Spontaneous	

Unit 8 Resources:

What is REDOX?..... REDuction-OXidation Reactions!

- Reactions that involve the TRANSFER OF ELECTRONS; both reduction and oxidation must happen _____!
- **Reduction** = _____ by an atom or ion; _____ _____ goes _____/_____
- **Oxidation** = LOSS OF ELECTRONS by an atom or ion; OXIDATION NUMBER goes _____/_____.

Skill 1: Assigning Oxidation Numbers

Oxidation Numbers = Charge numbers

- ☐ UNCOMBINED ELEMENTS (elements not bonded to another element) have an oxidation number of _____.
- ☐ First elements in compounds are positive and second elements are negative.
- ☐ In _____, the sum of the CHARGES for all elements must ADD UP TO ZERO

Ex: Mg:_____ O_2:_____ Cu:_____ Fe:_____

(a) **$CoCl_2$** Co _____ Cl _____

(c) **$FeCO_3$** Fe _____ C _____O _____

(b) **H_2O** H _____ O _____

(d) **H_2** H _____

SKILL #2: Identifying Oxidation & Reduction -

A reaction is REDOX if...OXIDATION NUMBERS _____.

- ☐ **Reduction (GER)** = _____ OF ELECTRONS by an atom or ion; oxidation number goes down/reduces
- ☐ **Oxidation (LEO)=** _____ OF ELECTRONS by a atom or ion; oxidation number goes up/oxidizes

Trick 1: SINGLE REPLACEMENT REACTIONS are always REDOX!

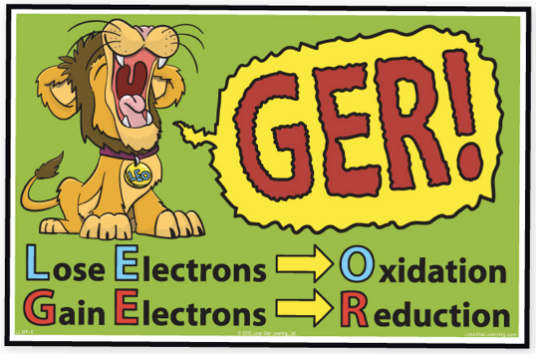
Example: Zn + HCl → ___ _____ + ___ _____

*___/___ are bonded on one side and alone on the other

Trick 2: DOUBLE REPLACEMENT REACTIONS are NOT REDOX!

Example: Na(OH) + HCl → ___ _____ + ___ _____

***Charges stay the same for all elements in the rxn**



$C + H_2O \rightarrow CO + H_2$

	Charge: Increase/ Decrease	Oxidized or Reduced?	Electrons: Lost/ Gained
C^0			
H^{+1}			

$Mn(OH)_4 + 2NaCl \rightarrow MnCl_4 + 2NaOH$

	Charge: Increase/ Decrease	Oxidized or Reduced?	Electrons: Lost/ Gained
Cl^{-1}			
Mn^{+4}			

$FeBr_2 + Br_2 \rightarrow FeBr_3$

	Charge: Increase/ Decrease	Oxidized or Reduced?	Electrons: Lost/ Gained
Fe			
Br			

Check for Understanding:

1. When a neutral atom undergoes oxidation, the atom's oxidation state

(1) decreases as it gains electrons (2) decreases as it loses electrons
(3) increases as it gains electrons (4) increases as it loses electrons

SKILL #3A: Identifying Oxidation and Reduction Half-Reactions

Half reactions allow us to show the _____ of _____ in a redox rxn. For each redox reaction, we can illustrate two _____ REACTIONS. One half-reaction shows _____ and other shows REDUCTION.

Example of a Reduction Half Reaction: Fe^{3+} + **3e-** → Fe

Electrons on left hand side, GAINED in the rxn (GER). Notice also how the charge for Fe goes down from left to right, REDUCTION (GER). Charge goes down because Fe GAINED e^-.

Example of an Oxidation Half Reaction: Fe → Fe^{3+} + **3e-**

Circle the electrons in the half-reactions below and identify as oxidation or reduction.

(a) $S + 2\ e^- \rightarrow S^{-2}$ (b) $Na \rightarrow Na^+ + e^-$ (c) $Ca^{2+} + 2e^- \rightarrow Ca$

Trick: Always ADD ELECTRONS to the side of rxn that has a HIGHER TOTAL CHARGE !
(Remember: electrons are _____)

Complete the half-reactions below by ADDING in electrons to the correct side in order to equalize charge (show conservation of charge).

(a) $Fe^{2+} \rightarrow Fe^{3+}$

Type:_____

(c) $Sn^{4+} \rightarrow Sn^{2+}$

Type:_____

(b) $K \rightarrow K^+$

Type:_____

(d) $Cr^{6+} \rightarrow Cr^{3+}$

Type:_____

Skill 3B: Creating Redox Half Reactions

FOLLOWING THE LAW OF CONSERVATION:

- ☐ Half reactions follow the LAW OF _____ of _____. This means that there must be the SAME NUMBER OF ATOMS and on both sides of the reaction arrow
- ☐ There must also be a CONSERVATION OF _____. In half reactions, the NET CHARGE MUST BE THE _____ ON BOTH SIDES of the equation.

Example 1:

___Mg + ___$ZnCl_2$ → ___$MgCl_2$ + ___Zn

- **OXIDATION Half Reaction:**

  _____

- **REDUCTION Half Reaction**:

  _____

Steps to Write Half Reactions:

Step 1: Determine ALL oxidation numbers

Step 2: Identify which element is reduced

Step 3: Write reduced element in present form on reactants side and product side

Step 4: Balance charge with electrons

Example 2: **____Hg + ____S → ____HgS**

- **OXIDATION Half Reaction:**

  _____

- **REDUCTION Half Reaction**:

  _____

Example 3:

$Cu + 2\,Ag^+ \rightarrow 2\,Ag + Cu^{2+}$	Reduction:	
	Oxidation:	

Skill 4: Balancin g Redox Equations

Example: Balance the REDOX reaction below:

$$\_\_\_Cr + \_\_\_CuBr_2 \rightarrow \_\_\_CrBr_3 + \_\_\_Cu$$

Step 1: Write the oxidation numbers for each atom in the reaction

Step 2: Identify the substance being oxidized and reduced.

Oxidized: _____

Reduced: _____

Step 3: Write the half reactions (see skill 3)

Step 4: Multiply each half reaction so the electron number is equal in both reactions.

Step 5: Add the two balanced half-cell reactions together for NET Reaction.

$$\_\_CsF + \_\_\_Na \rightarrow \_\_\_NaF + \_\_\_Cs$$

Reduction: _____

Oxidation: _____

Net Reaction: _____

___$MgCl_2$ + ___Cr → ___Mg + ___$CrCl_3$

Reduction: _____

Oxidation: _____

Net Reaction: _____

Ion notation Redox! (Minus the spectators!)

1) _____ Mg + _____ Fe^{3+} → _____ Mg^{2+} + _____ Fe^{2+}

Reduction: _____

Oxidation: _____

2) _____ Al + _____ Ti^{4+} → Al^{3+} + _____ Ti

Reduction: _____

Oxidation: _____

3) _____Cu + _____Ag^{+1} → _____ Cu^{+2}+ _____Ag

Reduction: _____

Oxidation: _____

4) _____Fe + _____Pb^{+2} → _____Fe^{+3} + _____Pb

Reduction: _____

Oxidation: _____

5) _____Ag^{+1} _____Cr → _____ Ag + _____Cr^{+3}

Reduction: _____

Oxidation: _____

6) ____Ni^{+2} + _____Li → ____ Li^{+1} +_____ Ni

Reduction: _____

Oxidation: _____

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7. The outer structure of the Statue of Liberty is made of copper metal. The framework is made of iron. Over time, a thin green layer (patina) forms on the copper surface.

   (a) When copper oxidized to form this patina layer, the copper atoms became copper (II) ions (Cu^{2+}). Write a balanced half-reaction for this oxidation of copper.

   (b) Where the iron framework came in contact with the copper surface, a reaction occurred in which iron was oxidized. Using information from Reference Table *J*, explain why the iron was oxidized.

Skill 5: Table J and Spontaneous Reactions

- **General Rule:** elements _____ on Table J are _____ reactive than the elements below them.

- **Spontaneous rxn** = rxn occurs w/out adding energy to system.

  If the "single" element is more active than the "combined" element, the reaction will be spontaneous.

- **Non-spontaneous rxn** = rxn will not occur unless energy is added to system.

  If the "single" element is _____ _____ than the "combined" element, the reaction will NOT be spontaneous.

  Ex1: Zn + $PbCl_2$ →_____

  Ex2: Zn + BaO →_____

For the following: State whether or not the reaction is spontaneous or non-spontaneous using Table J of the reference tables.

1) CsF + Na→NaF + Cs _____

2) $MgCl_2$ + Cr→Mg + $CrCl_3$ _____

3) Pb + Ag_3PO_4→$Pb_3(PO_4)_2$ + Ag _____

Table J
Activity Series**

Most	Metals	Nonmetals	Most
	Li	F_2	
	Rb	Cl_2	
	K	Br_2	
	Cs	I_2	
	Ba		
	Sr		
	Ca		
	Na		
	Mg		
	Al		
	Ti		
	Mn		
	Zn		
	Cr		
	Fe		
	Co		
	Ni		
	Sn		
	Pb		
	$**H_2$		
	Cu		
	Ag		
	Au		
Least			Leas

**Activity Series based on hydrogen standard
Note: H_2 is *not* a metal

4. Which metal reacts spontaneously with a solution containing zinc ions?
   (1) magnesium (3) copper
   (2) nickel (4) silver

5. Which metal with react with Zn^{2+} spontaneously, but will not react with Mg^{2+}?
   (1) Al (3) Ni
   (2) Cu (4) Ba

6. Because tap water is slightly acidic, water pipes made of iron corrode over time, as shown by the balanced ionic equation below:

$$2Fe(s) + 6H^+(aq) \rightarrow 2Fe^{3+}(aq) + 3H_2(g)$$

Explain, in terms of chemical reactivity, why copper pipes are less likely to corrode than iron pipes.

Skill 6: Identify Voltaic Batteries

Voltaic Vocabulary:
Anode: The _____ACTIVE of the 2 metals (Table J)

Cathode: The _____ ACTIVE of the 2 metals (Table J)

Anode:

- Spontaneously _____electrons to cathode
- The negative electrode in a **VOLTAIC CELL**
- Electrode where _____occurs (AN OX)

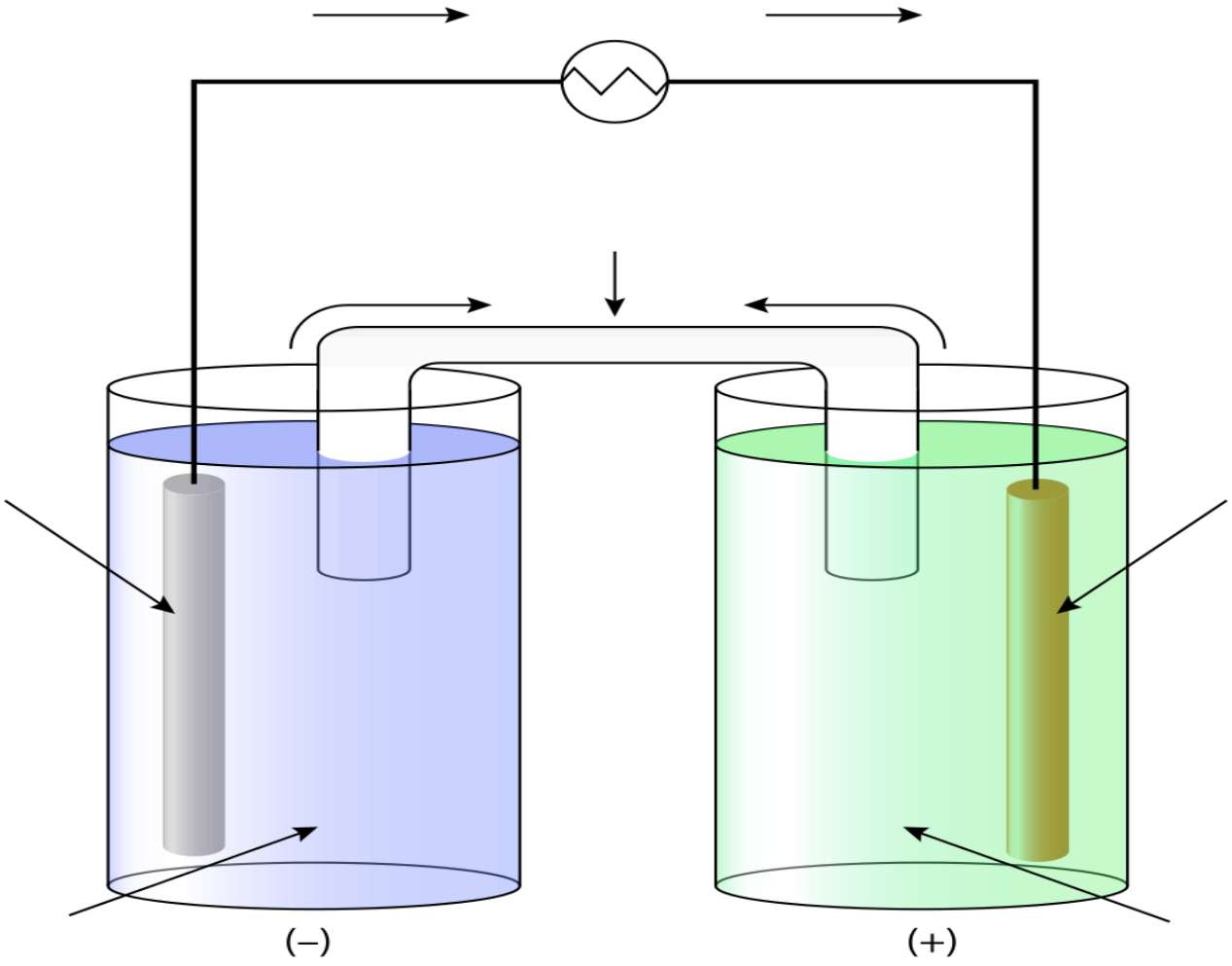
Cathode:

- Spontaneously _____ electrons to it
- The positive electrode in a **VOLTAIC CELL**
- Electrode where _____occurs (RED CAT)

An Active Ox → Anode is where oxidation occurs

Red Cat→ Reduction happens at cathode

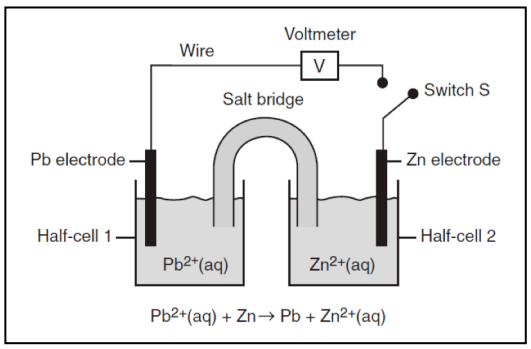
Voltaic Cells: Cells that convert CHEMICAL energy into _____ energy.



Skill 7: Solving Voltaic Cell Problems

Example:

1. Base your answers to the following questions on the diagram below, which represents a voltaic cell at 298 K and 1 atm.



(a) In which half-cell will oxidation occur when switch *S* is closed?

(b) Write the balanced half-reaction equation that will occur in half-cell 1 when switch *S* is closed.

(c) Describe the direction of electron flow between the electrodes when switch *S* is closed.

Practice!

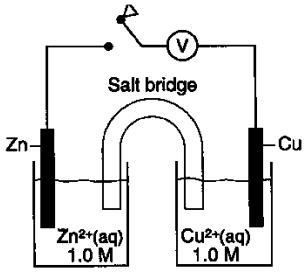
2. A voltaic cell spontaneously converts

(1) electrical energy to chemical energy
(2) chemical energy to electrical energy
(3) electrical energy to nuclear energy
(4) nuclear energy to electrical energy

3. Which half-reaction can occur at the anode in a voltaic cell?

(1) $Ni^{2+} + 2e^- \rightarrow Ni$
(2) $Sn + 2e^- \rightarrow Sn^{2+}$
(3) $Zn \rightarrow Zn^{2+} + 2e^-$
(4) $Fe^{3+} \rightarrow Fe^{2+} + e^-$

Answer questions 4 and 5 using the diagram below, which represents an electrochemical cell.



4. When the switch is closed, in which half-cell does oxidation occur?

5. What occurs when the switch is closed?
(1) Zn is reduced.
(2) Cu is oxidized.
(3) Electrons flow from Cu to Zn.
(4) Electrons flow from Zn to Cu.

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6. What is the purpose of the salt bridge in a voltaic cell?
(1) It blocks the flow of electrons.
(2) It blocks the flow of positive and negative ions.
(3) It is a path for the flow of electrons.
(4) It is a path for the flow of positive and negative ions.

7. Which statement is true for any electrochemical cell?
   (1) Oxidation occurs at the anode, only.
   (2) Reduction occurs at the anode, only.
   (3) Oxidation occurs at both the anode and the cathode.
   (4) Reduction occurs at both the anode and the cathode.

8. Given the balanced equation representing a reaction occurring in an electrolytic cell:
   $2NaCl_{(l)} \rightarrow 2Na_{(l)} + Cl_{2(g)}$
   Where is Na(l) produced in the cell?
   (1) at the anode, where oxidation occurs
   (2) at the anode, where reduction occurs
   (3) at the cathode, where oxidation occurs
   (4) at the cathode, where reduction occur

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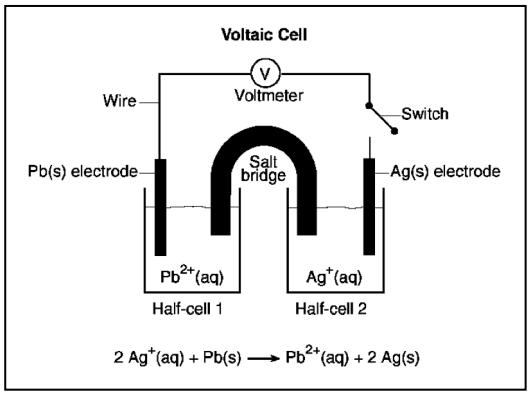
9. Base your answers to the following questions on the diagram of the voltaic cell below.



(a) Identify the anode and the cathode.

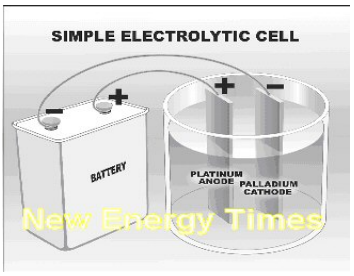
(b) Write the oxidation and reduction half-reactions for this voltaic cell.

(f) State the electrode to which positive ions migrate when the switch is closed.

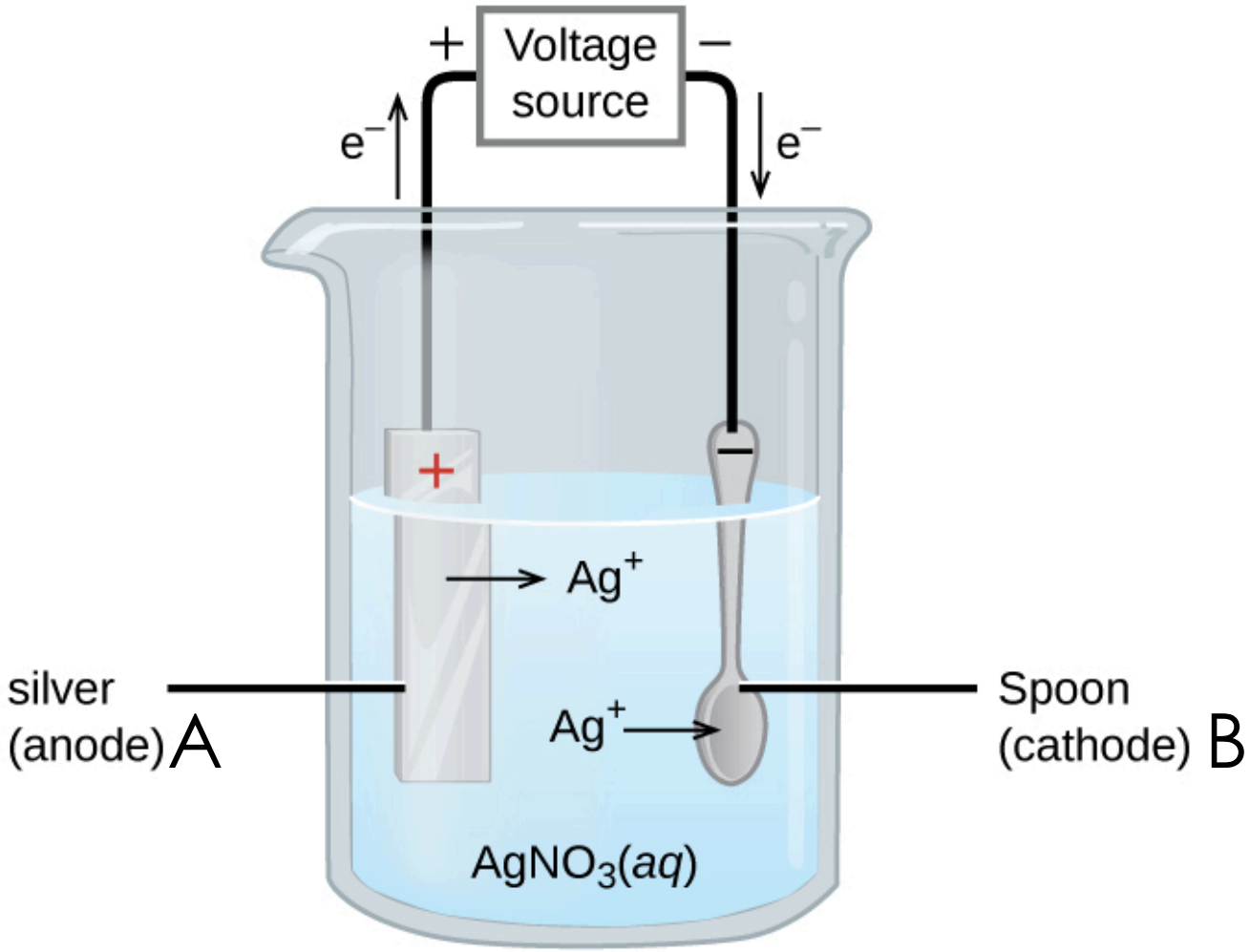
(g) As this voltaic cell operates, the mass of the Ag(s) electrode increases. Explain, in terms of silver ions *and* silver atoms, why this increase in mass occurs.

Skill 8: Identify Electrolytic Cells

Electrolytic Cells: Cells that use ELECTRICAL ENERGY to force a _____ chemical reaction to occur.



- ☐ The Process of Electroplating occurs through a forced reaction.
- ☐ How do I know it's electrolytic? **IF YOU SEE A POWER SOURCE CONNECTED.**



1. Given the reduction reaction for this cell: $Ag^+(aq) + 1e^- \rightarrow Ag(s)$
This reduction occurs at

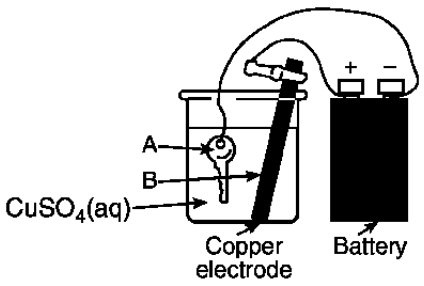
(1) A, which is the anode
(2) A, which is the cathode
(3) B, which is the anode
(4) B, which is the cathode

2. Which energy transformation occurs when an electrolytic cell is in operation?

(1) chemical energy → electrical energy
(2) electrical energy → chemical energy
(3) light energy → heat energy
(4) light energy → chemical energy

Practice: Use the diagram of a key being plated with copper to answer the following:

1. What is the name of the process shown in the diagram?



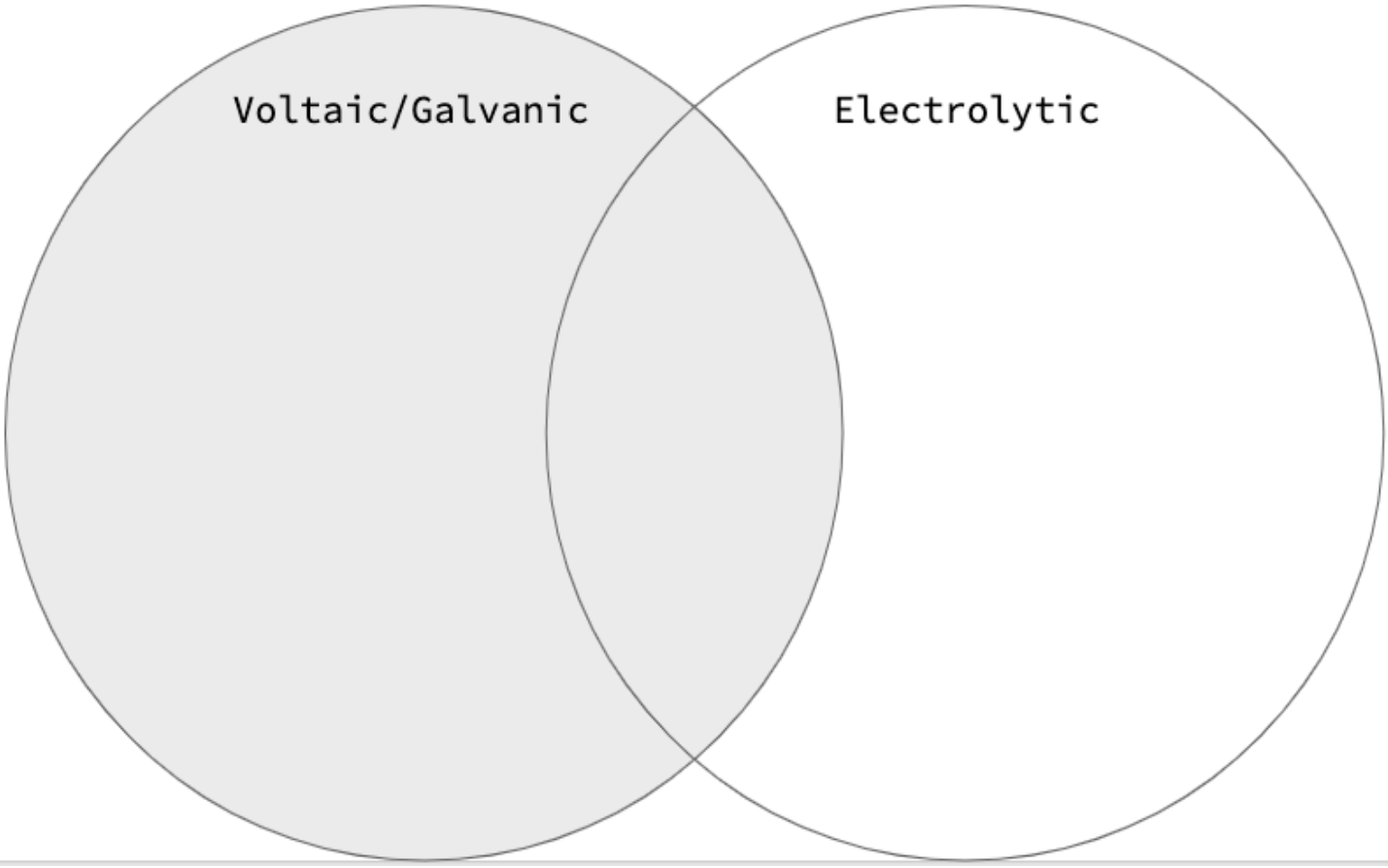
2. What is the purpose of the battery in this electrolytic cell?

3. Which electrode, A or B, attracts positive copper ions?

4. What half reaction is taking place at the key?

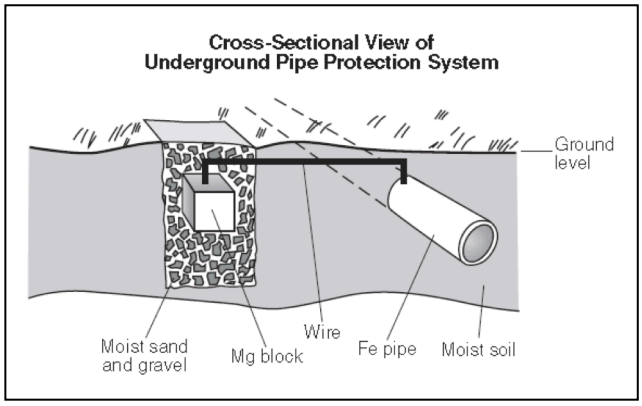
Voltaic and Electrolytic Comparison!

Brainstorm Similarities and differences



1.Base your answers to the following questions on the information below.

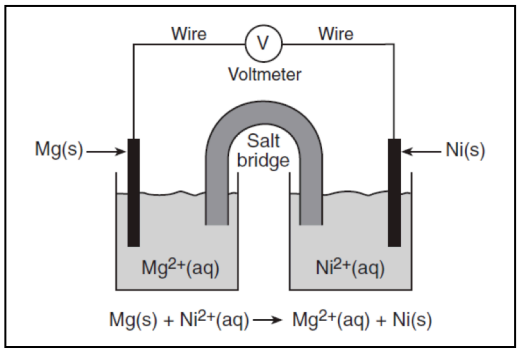
Underground iron pipes in contact with moist soil are likely to corrode. This corrosion can be prevented by applying the principles of electrochemistry. Connecting an iron pipe to a magnesium block with a wire creates an electrochemical cell. The magnesium block acts as the anode and the iron pipe acts as the cathode. A diagram of this system is shown below.



(a) State the direction of the flow of electrons between the electrodes in this cell.

(b) Explain, in terms of reactivity, why magnesium is preferred over zinc to protect underground iron pipes. Your response must include *both* magnesium and zinc.

2. Base your answers to the following questions on the diagram of a voltaic cell and the balanced ionic equation below.



(a) What is the total number of moles of electrons needed to completely reduce 6.0 moles of $Ni^{2+}(aq)$ ions?

(b) Identify *one* metal from Reference Table *J* that is more easily oxidized than Mg(s).

(c) Explain the function of the salt bridge in the voltaic cell.