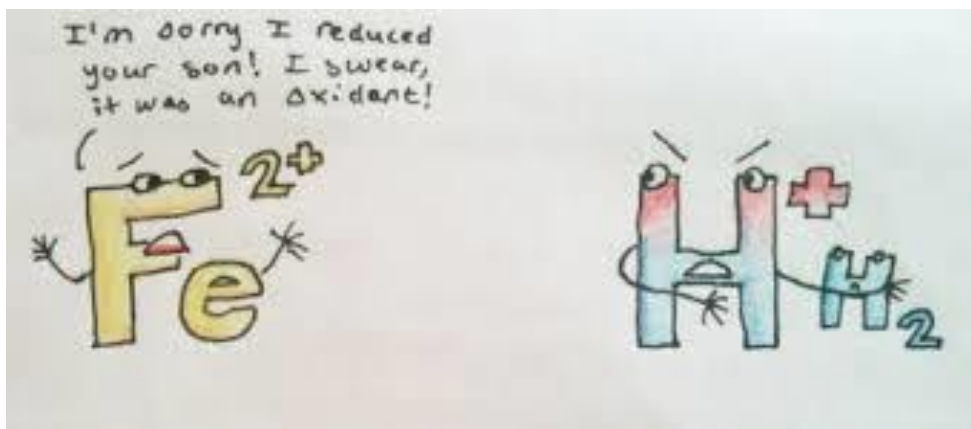


Regents Chemistry:

Practice Packet Unit 12: Electrochemistry



**Redox and
Batteries?
Ain't nobody
got time for
that!!!**

PRACTICE PACKET: ELECTROCHEMISTRY

Vocabulary

For each word, provide a short but specific definition from YOUR OWN BRAIN! No boring textbook definitions. Write something to help you remember the word. Explain the word as if you were explaining it to an elementary school student. Give an example if you can. Don't use the words given in your definition!

Reduction: _____

Oxidation: _____

Spectator Ion: _____

Half Reaction: _____

Redox Reaction: _____

Electrochemical Cell (Voltaic): _____

Anode: _____

Cathode: _____

Salt Bridge: _____

Electrolytic Cell: _____

PRACTICE PACKET: ELECTROCHEMISTRY

Lesson 1: Oxidation States

Objective:

- Determine the oxidation numbers of atoms and ion in a chemical reaction

Oxidation numbers are very important in this chapter "Redox Reactions." Without the complete understanding of how to assign these numbers, we cannot move ahead with this chapter. They are much like ionic charges, except the every element will be assigned a number. The most important rules that cannot be broken are:

Oxidation Number Rules:

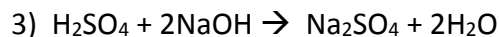
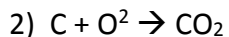
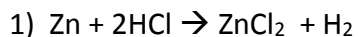
1. All pure elements have an oxidation number of _____. Elements are not charged.
2. All ions have the oxidation number equal to the _____.
3. All compounds must have a sum of oxidation numbers equal to _____. Compounds are not charged.
4. All group 1 elements (except H) have a _____ oxidation number as seen on the periodic table. Similarly, group two must have _____. Aluminum is _____. (in a compound!!)
5. The anion in an ionic bond always has the _____ oxidation state. If bonded with nonmetal, the element with the greater _____ (Hint: See Table S) gets the negative charge and is typically written last.
6. If Oxygen in a compound will have a charge of _____ UNLESS it is with F (OF_2) or in peroxides (e.g., Na_2O_2).
7. H is _____ when bonded with another nonmetal and _____ when bonded with a metal.
8. The sum of oxidation numbers for a polyatomic ion must equal the ion's _____.

Questions: Find the oxidation number of all elements below:

Mg	MgO	OF_2	KClO_3
H_2O	H_2S	NaClO	KClO_4
Br_2	NaH	Ca^{+2}	SO_3
MnCl_2	Cr_2O_3	KClO_2	SO_3^{-2}
Li_2O_2	N_2O_5	AgNO_3	MgSO_3

PRACTICE PACKET: ELECTROCHEMISTRY

What is the oxidation number of each element in each of the following reactions:



Regents Questions:

1. In which substance does hydrogen have an oxidation number of zero?

a) LiH

b) H₂O

c) H₂S

d) H₂

2. Which polyatomic ion has a charge of -3?

a) acetate

b) carbonate

c) phosphate

d) thiosulfate

3. What is the oxidation state of chlorine in the compound KClO₄?

a) +7

b) -1

c) +5

d) +1

4. In which compound does chlorine have the highest oxidation number?

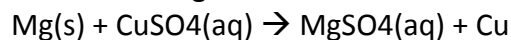
a) NaClO

b) NaClO₂

c) NaClO₃

d) NaClO₄

5. Given the following reaction:



During this reaction, the oxidation number of Mg changes from

a) 0 to +2

b) 0 to -2

c) +2 to 0

d) -2 to 0

6. What is the oxidation number of chromium in K₂Cr₂O₇?

a) +12

b) +2

c) +3

d) +6

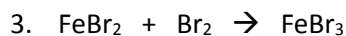
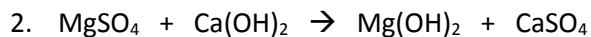
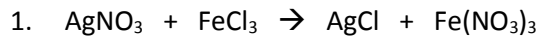
ASSESS YOURSELF ON THIS LESSON: _____/37

If you missed more than 5, do the Additional Practice. If not, go on to the next hw video!!!

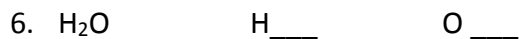
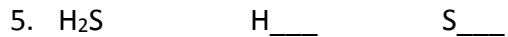
PRACTICE PACKET: ELECTROCHEMISTRY

ADDITIONAL PRACTICE LESSON 1

What is the oxidation number of each element in the following reactions:



Assign oxidation numbers to each element in the following (use the Periodic Table to help you)



ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/9

If you missed more than 2 you should see me for extra help and/or re-watch the lesson video assignment

PRACTICE PACKET: ELECTROCHEMISTRY

LESSON 2: Identifying a Redox Reaction

Objective:

- Determine if a reaction is a Redox reaction
- Determine which species is oxidized and which is reduced

A redox reaction is a reaction in which **electrons are transferred** from one element to another.

The term redox comes from two words, "oxidation" and "reduction." If something is oxidized, it "burns" in oxygen, as shown below:



1.) Write out the Lewis dot diagrams for each species above.



As you can see, Mg is being oxidized as it loses its two valence electrons, while oxygen gains two.

LEO =

GER =

- In all reactions, both mass and charge must be "conserved" (maintained).
- All SINGLE REPLACEMENT Reactions are redox. (Reactions involving a free element by itself)
- DOUBLE REPLACEMENT reactions are NEVER redox.

2.) Which equation is an example of an oxidation-reduction reaction?

1. $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
2. $\text{HCl} + \text{NaOH} \rightarrow \text{HOH} + \text{NaCl}$
3. $\text{Pb}(\text{NO}_3)_2 + 2\text{NaI} \rightarrow 2\text{NaNO}_3 + \text{PbI}_2$

3.) In a redox reaction, there is conservation of

- a. mass, only 2. charge, only 3. both mass and charge 4. neither mass nor charge

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15.) Given the reaction: $\text{Zn}(s) + 2 \text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2(g)$

Which statement correctly describes what occurs when this reaction takes place in a closed system?

- a) Atoms of Zn(s) lose electrons and are oxidized. b) There is a loss of mass.
b) Atoms of Zn(s) gain electrons and are reduced. c) There is a gain of mass.

16.) Given the equation: $\text{C}(s) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + \text{H}_2(g)$

Which species undergoes reduction?

- a) C(s) b) H⁺ c) C²⁺ d) H₂(g)

Questions:

1. For the following reactions, identify the redox reactions. For the redox reactions ONLY: identify the elements as reducing, oxidizing, or spectators.

a. $\text{Cl}_2 + 2\text{KBr} \rightarrow 2\text{KCl} + \text{Br}_2$ Is it redox? _____ Spectator: _____
Reducing: _____ Oxidizing: _____

b. $\text{Cu} + \text{AgNO}_3 \rightarrow \text{CuNO}_3 + \text{Ag}$ Is it redox? _____ Spectator: _____
Reducing: _____ Oxidizing: _____

c. $\text{Zn} + 2\text{HCl} \rightarrow \text{H}_2 + \text{ZnCl}_2$ Is it redox? _____ Spectator: _____
Reducing: _____ Oxidizing: _____

d. $\text{CaCO}_3 + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{CaCl}_2$ Is it redox? _____ Spectator: _____
Reducing: _____ Oxidizing: _____

2. Identify redox reactions. For redox reactions ONLY: Use table J to determine if the reaction is spontaneous.

a. $\text{Cu} + 2\text{HCl} \rightarrow \text{CuCl}_2 + \text{H}_2$ Which element oxidizes? _____
Which element reduces? _____
Spontaneous? _____

b. $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ Which element oxidizes? _____
Which element reduces? _____
Spontaneous? _____

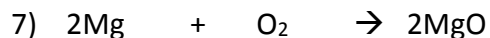
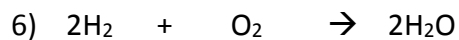
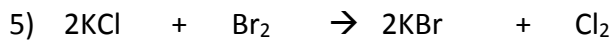
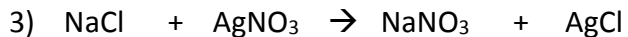
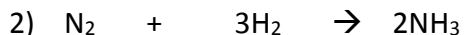
ASSESS YOURSELF ON THIS LESSON: _____/20

If you missed more than 4, complete the Additional Practice. If not, go on to the next hw video!!!

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ADDITIONAL PRACTICE LESSON 2

Determine if the following reactions are REDOX reactions. Then determine which species is oxidized and which is reduced.



8) What type of reaction (S, D, C, SR, or DR) is NEVER redox?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/8

If you missed more than 2 you should see me for extra help and/or re-watch the lesson video assignment

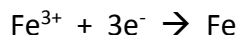
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LESSON 3: Half Reactions

Objective:

- Compose redox half reactions
- Construct a balanced redox reaction

A half reaction shows either the oxidation or reduction portion of a redox equation including if the electrons are gained or lost. A **reduction** half reaction shows an atom or ion gaining one or more e^- :



Notice that the e^- is on the **left**.

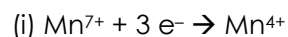
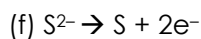
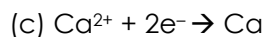
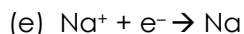
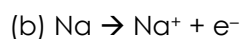
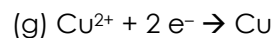
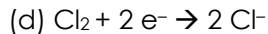
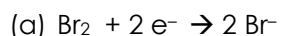
An **oxidation** half reaction shows an atom or ion losing one or more e^- :



Notice that the e^- is on the **right**.

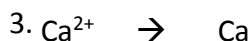
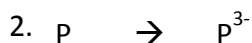
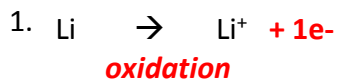
In a half reaction, only one element is shown and the charges must be conserved. To write a half reaction, first assign all the oxidation numbers to all the elements. Second, connect elements that change oxidation state. Determine which are being oxidized (charge increasing) and reduced (charge goes down), then write a half reaction for each, showing a change in oxidation state and label which element is being oxidized and which is being reduced; add in the number of electrons needed to conserve the charge.

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



2. Identify the following half reactions as oxidation or reduction.

THEN, complete the reaction showing electrons in the right place. The first one is done for you.




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Fill in the table below.

		Which element is reducing?	Reducing half Reaction	Oxidizing half reaction
		Which element is oxidizing?		
4	$H_2 + O_2 \rightarrow H_2O$			
5	$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$			

Balancing Redox Equations

Practice: Balance the following redox reactions. Remember that you do not include the spectator ions in your half reactions. Polyatomic ions which remain unchanged can be treated as a single species. The first one is done for you.

First assign oxidation states: 

Example:

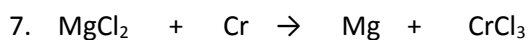
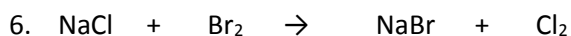
$$\overset{0}{Cu} + \overset{+1}{Ag}\overset{-1}{NO_3} \rightarrow \overset{+2}{Cu}(\overset{-1}{NO_3})_2 + \overset{0}{Ag}$$

Oxidation: $1(Cu^0 \rightarrow Cu^{+2} + 2e^-) =$ ~~$Cu^0 \rightarrow Cu^{+2} + 2e^-$~~

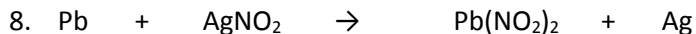
Reduction: $2(Ag^{+1} + 1e^- \rightarrow 2Ag^0) =$ ~~$2Ag^{+1} + 2e^- \rightarrow 2Ag^0$~~

Then plug coefficients back into original equation to balance the reaction.

Answer: $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$



PRACTICE PACKET: ELECTROCHEMISTRY

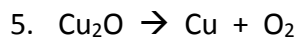
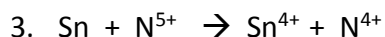
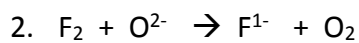
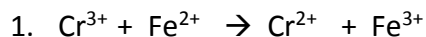


ASSESS YOURSELF ON THIS LESSON: _____/10

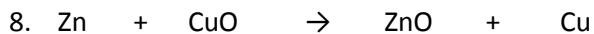
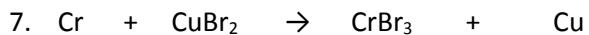
If you missed more than 2, complete the Additional Practice. If not, go on to the next hw video!!!

ADDITIONAL PRACTICE LESSON 4

For each reaction, decide if it is redox. If it is redox, write the half reactions. If they are not redox, write not redox.



Balance the following redox reactions. Remember that you do not include the spectator ions in your half reactions.



ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/8

If you missed more than 1 you should see me for extra help and/or re-watch the lesson video assignment

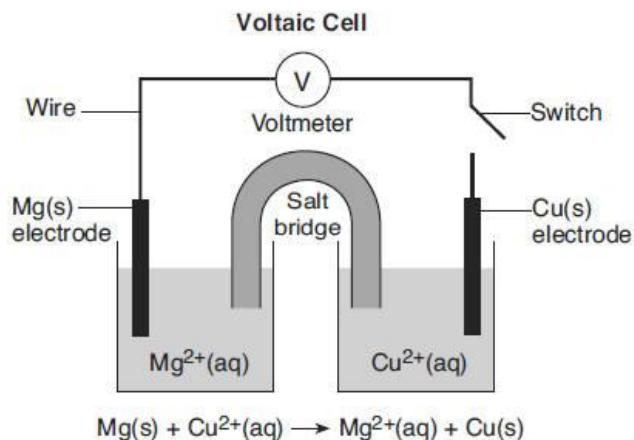
PRACTICE PACKET: ELECTROCHEMISTRY

LESSON 4: Voltaic Cells

Objective:

- Determine the flow of electrons in a battery (voltaic cell)
- Identify the anode and cathode in a voltaic cell

Voltaic Cells (batteries)



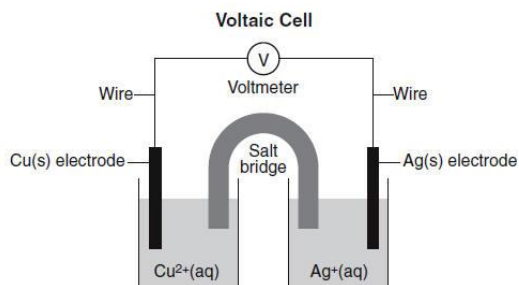
- Identify the oxidation states of each species in the reaction.
- Which element is being oxidized? _____
- Write the half reaction for oxidation (be sure to include the electrons to balance the charge)

- Which element is being reduced? _____
- Write the half reaction for the reduction, including the electrons.

- Which electrode is the anode? _____
- Which electrode is the cathode? _____
- Draw an arrow to show the direction of electron flow in the battery, through the wire.
- Where are spectator ions such as Cl^- located (They are not on the diagram labeled-you have to think about it)? What do they do?

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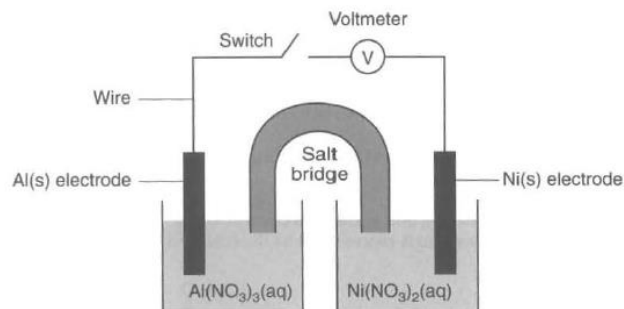
Directions: In each of the following, determine which element oxidizes (higher up on table J). Then label the **anode**, **cathode**, **direction of e⁻ flow**, and then **write the half reactions in the space provided**.



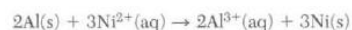
1.



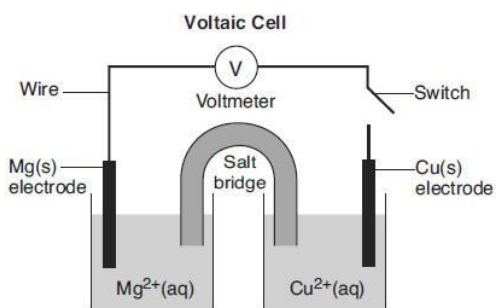
ox:
red:



2.



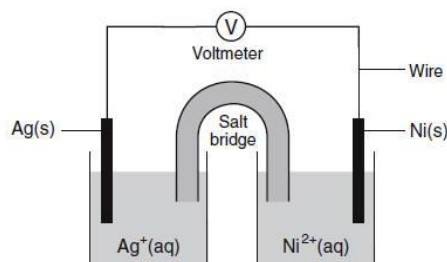
ox:
red:



3.



ox:
red:



4.

ox:
red:

(use the diagrams on above to answer these questions)

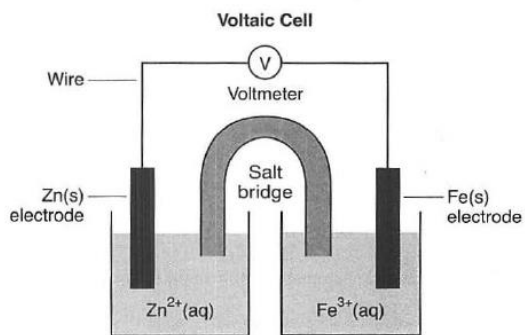
5. On diagram 1, which way will anions travel through the salt bridge? _____
6. On diagram 2 will the Aluminum electrode increase or decrease in mass? _____
7. On diagram 3 will the copper electrode increase or decrease in mass? _____
8. On all diagrams, at which electrode does oxidation occur? _____
9. On all diagrams, at which electrode does reduction occur? _____
10. On all diagrams, from which electrode will electrons travel? _____
11. What is the purpose of the salt bridge? _____
12. In all voltaic cells, _____ energy is converted into _____ energy.

ASSESS YOURSELF ON THIS LESSON: _____/12

If you missed more than 3, complete the Additional Practice. If not, go on to the next hw video!!!

PRACTICE PACKET: ELECTROCHEMISTRY

ADDITIONAL PRACTICE LESSON 5: Use the cell below to answer the following questions



1. What direction do electrons flow?
2. Which electrode is the anode?
3. Which electrode is the cathode?
4. What side is the site of oxidation?
5. What happens to the mass of the Fe electrode?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/5

If you missed more than 1 you should see me for extra help and or re-watch the lesson video assignment

PRACTICE PACKET: ELECTROCHEMISTRY

LESSON 5: Electrolytic Cells

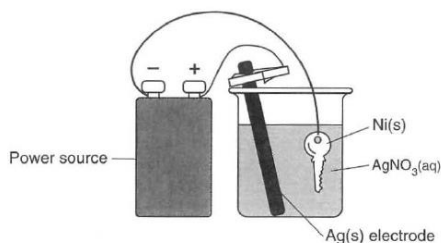
Objective:

- Identify an electrolytic cell
- Differentiate between an electrolytic cell and a voltaic cell

Electrolytic cells use a power source (battery) to force a nonspontaneous reaction. In an electrolytic cell, the anode and cathode are the same as in voltaic cells but the only difference is anode is + and the cathode is – Practical applications of electrolytic cells are electroplating, recharging batteries etc.)

1. In an electrolytic cell, _____ energy is converted to _____ energy.

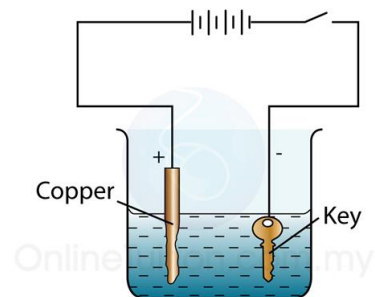
The diagram below represents an operating electrolytic cell used to plate silver onto a nickel key. As the cells operates, oxidation occurs at the silver electrode and the mass of the silver electrode decreases.



2. Identify the cathode in the cell.
3. What is the purpose of the power source in the cell?

Base your answers to the following questions on the diagram below:

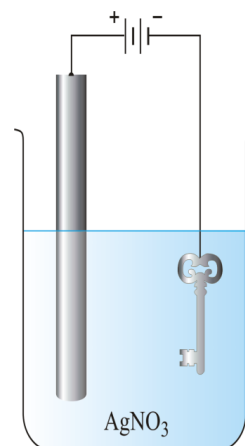
4. Why will the mass of the key increase?
5. Label the anode, cathode, and the direction of e-flow through the wire.
6. State the difference between voltaic and electrolytic cells in terms of spontaneity
7. State the difference between voltaic and electrolytic cells in terms of energy being released or absorbed.



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Base your answers to the following questions on the diagram below:

- Show a half reaction for silver reducing.
- Label the cathode on the diagram to the right.
- What will happen to the mass of the key?
- What will happen to the mass of the silver metal?
- Show the direction of e- flow through the wire on the diagram to the right.



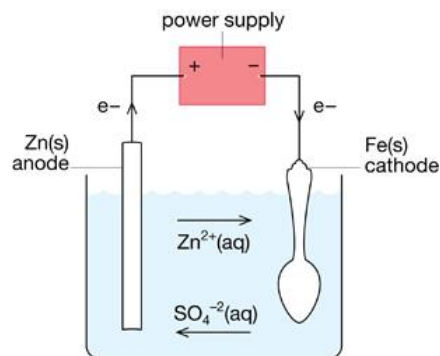
ASSESS YOURSELF ON THIS LESSON: _____/12

If you missed more than 2, complete the Additional Practice. If not, go on to the next hw video!!!

ADDITIONAL PRACTICE LESSON 6

Base your answers to the following questions on the diagram below:

- Only one element is being used in the diagram to the left. The silver plate ionizes and the ions attach to the spoon. Show a half reaction for silver oxidizing.
- Label the anode and cathode with charges on the diagram.
- State the direction of e- flow through the wire.
- Is this reaction spontaneous? _____ How can you tell?



ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/4

If you missed more than 1 you should see me for extra help and re-watch the lesson video assignment.

PRACTICE PACKET: ELECTROCHEMISTRY

RedOx Regents Review Practice

1. Which reaction is an example of an oxidation-reduction reaction?

- (1) $\text{AgNO}_3 + \text{KI} \rightarrow \text{AgI} + \text{KNO}_3$
- (2) $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
- (3) $2\text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
- (4) $\text{Ba}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$

2. In an oxidation-reduction reaction, reduction is defined as the

- (1) loss of protons
- (2) gain of protons
- (3) loss of electrons
- (4) gain of electrons

3. When a lithium atom forms a Li^+ ion, the lithium atom

- (1) gains a proton
- (2) gains an electron
- (3) loses a proton
- (4) loses an electron

4. Which type of reaction occurs when nonmetal atoms become negative nonmetal ions?

- (1) oxidation
- (2) reduction
- (3) substitution
- (4) condensation

5. 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

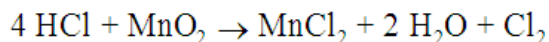
6. In a redox reaction, there is a conservation of

- (1) mass, only
- (2) both mass and charge
- (3) neither mass nor charge

7. In any redox reaction, the substance that undergoes reduction will

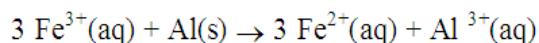
- (1) lose e^- & have a decrease in oxidation number
- (2) lose e^- & have an increase in oxidation number
- (3) gain e^- & have a decrease in oxidation number
- (4) gain e^- & have an increase in oxidation number

8. What occurs during the reaction below?



- (1) The manganese is reduced and its oxidation number changes from +4 to +2.
- (2) The manganese is oxidized and its oxidation number changes from +4 to +2.
- (3) The manganese is reduced and its oxidation number changes from +2 to +4.
- (4) The manganese is oxidized and its oxidation number changes from +2 to +4.

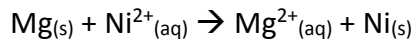
9. Given the balanced equation:



What is the total number of moles of electrons lost by 2 moles of $\text{Al}(\text{s})$?

- (1) 1 mole
- (2) 6 moles
- (3) 3 moles
- (4) 9 moles

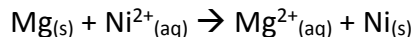
10. Given the balanced equation:



What is the total number of moles of electrons lost by 2 moles of $\text{Mg}(\text{s})$?

- (1) 1.0 mol
- (2) 2.0 mol
- (3) 3.0 mol
- (4) 4.0 mol

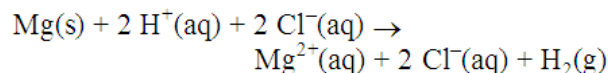
11. Given the equation representing a reaction:



What is the total number of moles of e^- lost by Mg when 2.0 moles of e^- are gained by $\text{Ni}^{2+}(\text{aq})$?

- (1) 1.0 mol
- (2) 2.0 mol
- (3) 3.0 mol
- (4) 4.0 mol

12. Given the reaction:

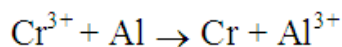


Which species undergoes oxidation?

- (1) $\text{Mg}(\text{s})$
- (2) $\text{H}^+(\text{aq})$
- (3) $\text{Cl}^-(\text{aq})$
- (4) $\text{H}_2(\text{g})$

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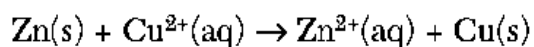
13. Given the redox reaction:



As the reaction takes place, there is a transfer of

- (1) electrons from Al to Cr^{3+}
 - (2) electrons from Cr^{3+} to Al
 - (3) protons from Al to Cr^{3+}
 - (4) protons from Cr^{3+} to Al
14. Which half-reaction correctly represents oxidation?
- (1) $\text{Fe}(\text{s}) \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-}$
 - (2) $\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s}) + 2\text{e}^{-}$
 - (3) $\text{Fe}(\text{s}) + 2\text{e}^{-} \rightarrow \text{Fe}^{2+}(\text{aq})$
 - (4) $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Fe}(\text{s})$
15. Which equation shows a conservation of both mass and charge?
- (1) $\text{Cl}_2 + \text{Br}^{-} \rightarrow \text{Cl}^{-} + \text{Br}_2$
 - (2) $\text{Cu} + 2\text{Ag}^{+} \rightarrow \text{Cu}^{2+} + \text{Ag}^{+}$
 - (3) $\text{Zn} + \text{Cr}^{3+} \rightarrow \text{Zn}^{2+} + \text{Cr}$
 - (4) $\text{Ni} + \text{Pb}^{2+} \rightarrow \text{Ni}^{2+} + \text{Pb}$

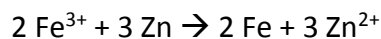
16. Given the balanced ionic equation:



Which equation represents the oxidation half-reaction?

- (1) $\text{Zn}(\text{s}) + 2\text{e}^{-} \rightarrow \text{Zn}^{2+}(\text{aq})$
- (2) $\text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^{-}$
- (3) $\text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu}(\text{s}) + 2\text{e}^{-}$
- (4) $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$

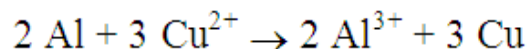
17. Given the redox reaction:



As the reaction takes place, there is a transfer of electrons

- (1) from Fe^{3+} to Zn
 - (2) from Zn to Fe^{3+}
 - (3) from Zn^{2+} to Fe
 - (4) from Fe to Zn^{2+}
18. Which half-reaction equation represents the reduction of a potassium ion?
- (1) $\text{K}^{+} + \text{e}^{-} \rightarrow \text{K}$
 - (2) $\text{K} + \text{e}^{-} \rightarrow \text{K}^{+}$
 - (3) $\text{K}^{+} \rightarrow \text{K} + \text{e}^{-}$
 - (4) $\text{K} \rightarrow \text{K}^{+} + \text{e}^{-}$

19. Given the equation:



The reduction half-reaction is

- (1) $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^{-}$
- (2) $\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$
- (3) $\text{Al} + 3\text{e}^{-} \rightarrow \text{Al}^{3+}$
- (4) $\text{Cu}^{2+} \rightarrow \text{Cu} + 2\text{e}^{-}$

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20. Base your answers to the questions below on the following redox reaction, which occurs in a battery.



- (a) Write the half-reaction for the reduction that occurs.
- (b) Write the half-reaction for the oxidation that occurs.
- (c) Balance the equation below using the *smallest* whole-number coefficients.

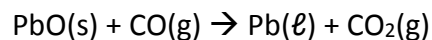


- (d) Which species loses electrons and which species gains electrons?
 - (e) State what happens to the number of protons in a Zn atom when it changes to Zn^{2+} as the redox reaction occurs.
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23. The outer structure of the Statue of Liberty is made 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.
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24. Litharge, PbO , is an ore that can be roasted (heated) in the presence of carbon monoxide, CO , to produce elemental lead. The reaction that takes place during this roasting process is represented by the balanced equation below.



- (a) Write the balanced equation for the reduction half-reaction that occurs during this roasting process.
- (b) Determine the oxidation number of carbon in carbon monoxide. _____

PRACTICE PACKET: ELECTROCHEMISTRY

Electrochemical Cells Regents Questions

1. In a voltaic cell, chemical energy is converted to

- (1) electrical energy, spontaneously
- (2) electrical energy, nonspontaneously
- (3) nuclear energy, spontaneously
- (4) nuclear energy, nonspontaneously

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. A voltaic cell differs from an electrolytic cell in that in a voltaic cell

- (1) energy is produced when the reaction occurs
- (2) energy is required for the reaction to occur
- (3) both oxidation and reduction occur
- (4) neither oxidation nor reduction occurs

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

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

5. Which process requires an external power source?

- (1) neutralization
- (2) synthesis
- (3) fermentation
- (4) electrolysis

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

- (1) chemical energy \rightarrow electrical energy
- (2) electrical energy \rightarrow chemical energy
- (3) light energy \rightarrow heat energy
- (4) light energy \rightarrow chemical energy

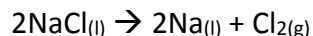
7. What is the purpose of the salt bridge in a voltaic cell?

- (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.

8. 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.

9. Given the balanced equation representing a reaction occurring in an electrolytic cell:

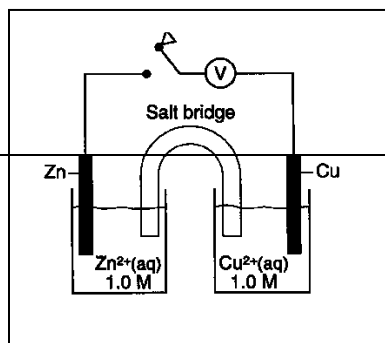


Where is Na(l) produced in the cell?

- (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 occurs

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Answer questions 10 and 11 using the diagram below, which represents an electrochemical cell.

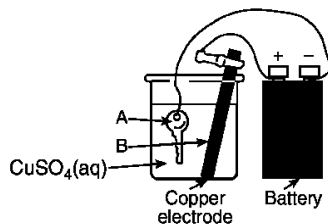


10. When the switch is closed, in which half-cell does oxidation occur?

11. 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.

Use the diagram of a key being plated with copper to answer questions 12 through 15.



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

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

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

15. Given the reduction reaction for this cell: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$

This reduction occurs at

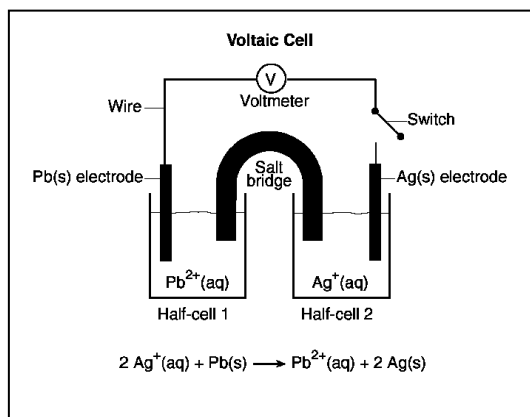
- (1) A, which is the anode
- (2) A, which is the cathode
- (3) B, which is the anode
- (4) B, which is the cathode

16. Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is Al_2O_3 . Over one hundred years ago, it was difficult and expensive to isolate aluminum from bauxite ore. In 1886, a brother and sister team, Charles and Julia Hall, found that molten (melted) cryolite, Na_3AlF_6 , would dissolve bauxite ore. Electrolysis of the resulting mixture caused the aluminum ions in the Al_2O_3 to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

- (a) Write the oxidation state for *each* of the elements in cryolite.
- (b) Write the balanced half-reaction equation for the reduction of Al^{3+} to Al.
- (c) Explain, in terms of ions, why molten cryolite conducts electricity.
- (d) Explain, in terms of electrical energy, how the operation of a voltaic cell differs from the operation of an electrolytic cell used in the Hall process. Include *both* the voltaic cell and the electrolytic cell in your answer.

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



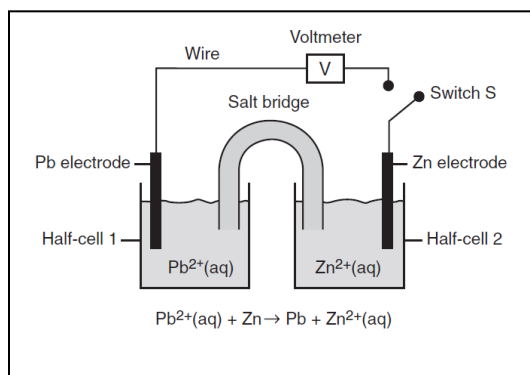
- Identify the anode and the cathode.
- Write the oxidation and reduction half-reactions for this voltaic cell.
- What is the total number of moles of electrons needed to completely reduce 6 moles of Ag⁺(aq) ions?
- Describe the direction of electron flow between the electrodes.

(e) State the purpose of the salt bridge in this 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.

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

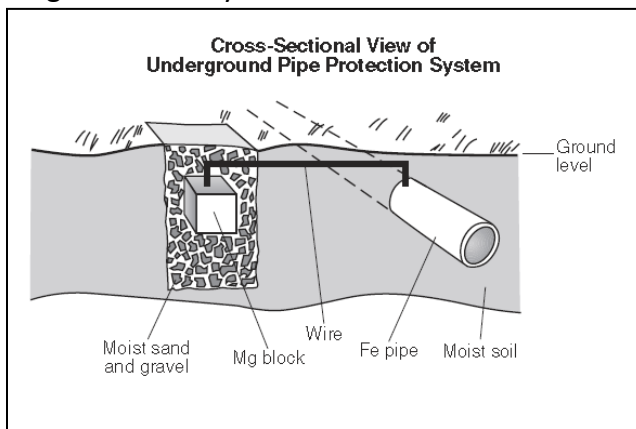


- In which half-cell will oxidation occur when switch S is closed?
- Write the balanced half-reaction equation that will occur in half-cell 1 when switch S is closed.
- Describe the direction of electron flow between the electrodes when switch S is closed.

PRACTICE PACKET: ELECTROCHEMISTRY

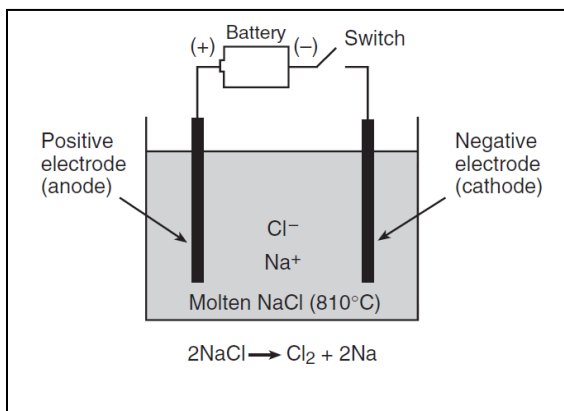
19. Base your answers to the following questions on the information below.

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.

20. Base your answers to the following questions on the diagram and balanced equation below, which represent the electrolysis of molten NaCl.



- (a) When the switch is closed, which electrode will attract the sodium ions?
- (b) What is the purpose of the battery in this electrolytic cell?
- (c) Write the balanced half-reaction for the reduction that occurs in this electrolytic cell.

21. State *two* similarities and *two* differences between voltaic and electrolytic cells.

PRACTICE PACKET: ELECTROCHEMISTRY

22. Which reaction occurs spontaneously?

- (1) $\text{Cl}_{2(g)} + 2\text{NaBr}_{(aq)} \rightarrow \text{Br}_{2(l)} + 2\text{NaCl}_{(aq)}$
(2) $\text{Cl}_{2(g)} + 2\text{NaF}_{(aq)} \rightarrow \text{F}_{2(g)} + 2\text{NaCl}_{(aq)}$
(3) $\text{I}_{2(s)} + 2\text{NaBr}_{(aq)} \rightarrow \text{Br}_{2(l)} + 2\text{NaI}_{(aq)}$
(4) $\text{I}_{2(s)} + 2\text{NaF}_{(aq)} \rightarrow \text{F}_{2(g)} + 2\text{NaI}_{(aq)}$

23. Which metal reacts spontaneously with a solution containing zinc ions?

- (1) magnesium (3) copper
(2) nickel (4) silver

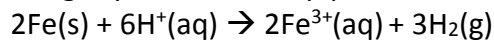
24. Which metal will react with Zn^{2+} spontaneously, but will not react with Mg^{2+} ?

- (1) Al (3) Ni
(2) Cu (4) Ba

25. Which of the following metals has the least tendency to undergo oxidation?

- (1) Ag (3) Zn
(2) Pb (4) Li

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



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

27. Identify one metal that does not react spontaneously with $\text{HCl}(aq)$.