Name Beth "KEY" Period _____

Electrochemical Cells Practice Problems

For a voltaic (spontaneous) cell, the cell potential must be positive.

1. a)Given the following half-reactions, decide which will remain as a reduction reaction and which will be reversed to become an oxidation reaction.

Zn^{2+} (aq) + $2e^-$ → Zn (s) E^o = - 0.76 V *reduction* or *oxidation*
Al^{3+} (aq) + $3e^-$ → Al (s) E^o = - 1.66 V *reduction* or *oxidation* Reverse

b). Write out the overall reaction and calculate E^o_{cell}.

$2(Al \rightarrow Al^{3+} + 3e^-)$ $\quad E^o = 1.66V$
$3(Zn^{2+} + 2e^- \rightarrow Zn)$ $\quad +E^o = -0.76V$
$2Al(s) + 3Zn^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Zn(s)$ $\quad E^o_{cell} = 0.90V$

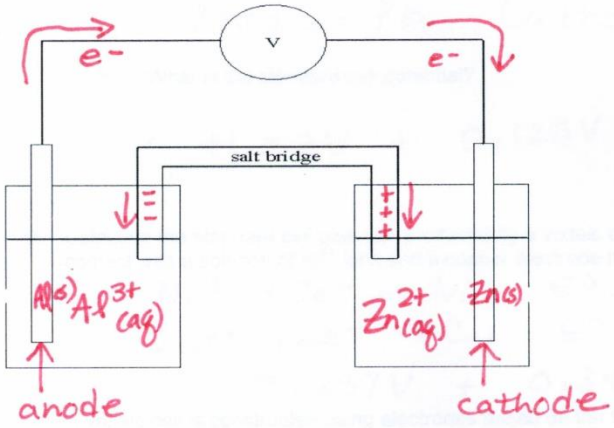
c) Which reaction will occur at the anode?

OXIDATION: $Al(s) \rightarrow Al^{3+}(aq)$

Which reaction will occur at the cathode?

REDUCTION: $Zn^{2+}(aq) \rightarrow Zn(s)$

d) Label the solutions and electrodes in the diagram below. Identify the cathode and the anode. Show the direction of electron flow through the cell. The salt bridge contains KNO_3. Show the direction the cations in the salt bridge move. Show the direction the anions in the salt bridge move. (put the oxidation half-reaction on the left)



2. There is a standard notation for electrochemical cells.
The outermost components in the shorthand notation must be **solids**
If there are no solids in a half-reaction, an **inert electrode**, such as Pt or even C(graphite) can be used.

Fill in the components for the pair of half-reactions given in #1.

$Al(s) \mid Al^{3+}(aq) \parallel Zn^{2+}(aq) \mid Zn(s)$

3. Calculate the standard cell potential produced by a voltaic cell consisting of a nickel electrode in contact with a solution of Ni^{2+} ions and a silver electrode in contact with a solution of Ag^+ ions.

$Ni \rightarrow Ni^{2+} + 2e^- \quad E^o = 0.257V \qquad Ag^+ + e^- \rightarrow Ag \quad E^o = 0.800V$

$0.800V + 0.257V = \boxed{1.057V}$

6. What is the voltage produced by a voltaic cell consisting of an aluminum electrode in contact with a solution of Al^{3+} ions and an iron electrode in contact with a solution of Fe^{2+} ion?

$Al^{3+} + 3e^- \rightarrow Al$ $E^0 = -1.676V$ ← Reverse

$Fe^{2+} + 2e^- \rightarrow Fe$ $E^0 = -0.440V$

$-0.440V + 1.676V = \boxed{1.236V}$

7. Calculate the standard cell potential produced by a voltaic cell consisting of a sodium electrode in contact with a solution of Na^+ ions and a copper electrode in contact with a solution of Cu^{2+} ions

$Na^+ + e^- \rightarrow Na$ $E^0 = -2.713V$ ← Reverse

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^0 = +0.340V$

$2.713V + 0.340V = \boxed{3.053V}$

8. A voltaic cell is constructed using electrodes based on the following half reactions:

Pb^{2+} (aq) + 2e- -> Pb(s) $E^0 = -0.125V$ Reverse

Au^{3+}(aq) +3e- -> Au(s0 $E^0 = +1.52V$

a. Which is the anode and which is the cathode in this cell?

Anode = Pb Cathode = Au

b. What is the standard cell potential?

$+1.52V + 0.125V = \boxed{1.65V}$

9. Calculate the standard cell potential produced by a voltaic cell consisting of a nickel electrode in contact with a solution of Ni^{2+} ions and a copper electrode in contact with a solution of Cu^{2+} ions

$Ni^{2+} + 2e^- \rightarrow Ni$ $E^0 = -0.257V$ Reverse

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^0 = +0.340V$

$0.257V + 0.340V = \boxed{0.597V}$

10. A voltaic cell is constructed using electrodes based on the following half reactions:

Mn^{2+} (aq) + @e- -> Mn(s) $E^0 = -1.18V$ Reverse

Cu^{2+} (aq) +2e- -> Cu(s) $E^0 = 0.340V$

Which is the anode and which is the cathode in this cell?

Anode = Mn Cathode = Cu

What is the standard cell potential?

$0.340V + 1.18V = \boxed{1.52V}$

11. What is the voltage produced by a voltaic cell consisting of a lead electrode in contact with a solution of Pb^{2+} ions and an iron electrode in contact with a solution of Fe^{2+}? Which is anode and which is the cathode?

$Pb^{2+} + 2e^- \rightarrow Pb$ $E^\circ = -0.125V$

$Fe^{2+} + 2e^- \rightarrow Fe$ $E^\circ = -0.440V$ Reverse

$-0.125V + 0.440V = \boxed{0.315V}$

anode = Fe cathode = Pb

12. Calculate the standard cell potential produced by a voltaic cell consisting of a gold electrode in contact with a solution of Au^{3+} ions and a silver electrode in contact with a solution of Ag^+ ions. Which is the anode and which is the cathode?

$Au^{3+} + 3e^- \rightarrow Au$ $E^\circ = 1.52V$

$Ag^+ + 1e^- \rightarrow Ag$ $E^\circ = 0.800V$ Reverse

$1.52V + (-0.800V) = \boxed{0.72V}$

Au = cathode Ag = anode

13 Given the following:

$Fe^{2+} + 2\ e^- \text{ ----> } Fe \quad E^\circ = -0.40$ volt
$Ni^{2+} + 2\ e^- \text{ ----> } Ni \quad E^\circ = -0.25$ volt
$Fe^{3+} + 3\ e^- \text{ ----> } Fe \quad E^\circ = -0.40$ volt
$Fe^{3+} + e^- \text{ ----> } Fe^{2+} \quad E^\circ = +0.77$ volt
$Br_2 + 2\ e^- \text{ ----> } 2\ Br^- \quad E^\circ = +1.09$ volt

Which of the substances listed below is the strongest oxidizing agent?
a) Fe b) Fe^{2+} c) Fe^{3+} d) Br_2 e) Br^-

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14. Given the following:

$Fe^{2+} + 2\ e^- \text{ ----> } Fe \quad E^\circ = -0.40$ volt
$Ni^{2+} + 2\ e^- \text{ ----> } Ni \quad E^\circ = -0.25$ volt
$Fe^{3+} + 3\ e^- \text{ ----> } Fe \quad E^\circ = -0.40$ volt
$Fe^{3+} + e^- \text{ ----> } Fe^{2+} \quad E^\circ = +0.77$ volt
$Br_2 + 2\ e^- \text{ ----> } 2\ Br^- \quad E^\circ = +1.09$ volt

Which of the following reactions is not spontaneous under standard conditions?

a) $Fe^{2+} + Ni \text{ --> } Fe + Ni^{2+}$ (-0.40) + (.25)
b) $2\ Fe^{3+} + 3\ Ni \text{ --> } 2\ Fe + 3\ Ni^{2+}$ (-0.40) + (.25)
c) $2\ Fe^{3+} + Ni \text{ --> } 2\ Fe^{2+} + Ni^{2+}$ (.77) + (.25)
d) $2\ Fe^{3+} + Fe \text{ --> } 3\ Fe^{2+}$ (.77) + (.40)
e) $2\ Fe + 3\ Br_2 \text{ --> } 2\ Fe^{3+} + 6\ Br^-$ (1.09) + (.40)

15. Given the following half cell reactions:

$Cl_2(g) + 2\ e^- \text{ ---> } 2\ Cl^-(aq) \quad E^\circ = +1.36$ V
$Fe^{3+}(aq) + e^- \text{ ---> } Fe^{2+}(aq) \quad E^\circ = +0.77$ V

Which one of the following reactions may occur spontaneously?
a) $Cl_2(g) + 2\ Fe^{2+}(aq) \text{ ---> } 2\ Cl^-(aq) + 2\ Fe^{3+}(aq)$
b) $Cl_2(g) + 2\ Fe^{3+}(aq) \text{ ---> } 2\ Cl^-(aq) + 2\ Fe^{2+}(aq)$ ← TWO REDUCTIONS
c) $2\ Cl^-(aq) + 2\ Fe^{3+}(aq) \text{ ----> } Cl_2(g) + 2\ Fe^{2+}(aq)$
d) $2\ Cl^- + 2\ Fe^{2+}(aq) \text{ ----> } Cl_2(g) + 2\ Fe^{3+}$