Standard Reduction Potentials Worksheet

1. Calculate the standard cell potential produced by a galvanic 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. Which is anode and which is the cathode?

2. What is the voltage produced by a galvanic ell 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+} ions. Which is anode and which is the cathode?

3. Calculate the standard cell potential produced by a galvanic 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. Which is anode and which is the cathode?

4. What is the voltage produced by a voltaic cell consisting of a calcium electrode in contact with a solution of Cu^{2+} ions. Which is anode and which is the cathode?

5. An electrochemical cell is constructed using electrodes based on the following half reactions:

   $Pb^{2+}_{(aq)} + 2e^{-} \rightarrow Pb_{(s)}$ $Au^{3+}_{(aq)} + 3e^{-} \rightarrow Au_{(s)}$

   a) Which is the anode and which is the cathode in this cell?
   b) What is the standard cell potential?

6. 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 . Which is anode and which is the cathode?

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

   $Mg^{2+}_{(aq)} + 2e^{-} \rightarrow Mg_{(s)}$ $Cu^{2+}_{(aq)} + 2e^{-} \rightarrow Cu_{(s)}$

   a) Which is the anode and which is the cathode in this cell?
   b) What is the standard cell potential?

8. 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?

9. What is the voltage produced by a voltaic cell consisting of a zinc electrode in contact with a solution of Zn^{2+} ions and a silver electrode in contact with a solution of Ag^{+} ions? Which is anode and which is the cathode?

10. 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?

11. Use half-reaction potentials to predict whether the following reactions are spontaneous or non-spontaneous in aqueous solutions.

    a) $Ca^{2+}_{(aq)} + 2\ I^{-}_{(aq)} \rightarrow Ca_{(s)} + I_{2(aq)}$
    b) $2\ H_2S_{(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)} + 2\ S_{(s)}$
    c) $SO_{2(g)} + MnO_{2(s)} \rightarrow Mn^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$
    d) $2\ H^{+}_{(aq)} + 2\ Br^{-}_{(aq)} \rightarrow H_{2(g)} + Br_{2(aq)}$
    e) $Ce^{4+}_{(aq)} + Fe^{2+}_{(aq)} \rightarrow Ce^{3+}_{(aq)} + Fe^{3+}_{(aq)}$
    f) $Cr^{2+}_{(aq)} + Cu^{2+}_{(aq)} \rightarrow Cr^{3+}_{(aq)} + Cu^{+}_{(aq)}$

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Electrochemical Cells Worksheet - Key

1. Calculate the standard cell potential produced by a galvanic 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. Which is anode and which is the cathode?

   $Ni^{2+}_{(aq)} + 2e^- \rightleftharpoons Ni_{(s)}$ E° = -0.26 V (must be flipped) $Ag^{+}_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$ E° = 0.80 V

   ANODE: $Ni_{(s)} \rightleftharpoons Ni^{2+}_{(aq)} + 2e^-$ E° = 0.26 V

   CATHODE: $Ag^{+}_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$ E° = 0.80 V

   E° = 1.06 V

2. What is the voltage produced by a galvanic ell 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+} ions. Which is anode and which is the cathode?

   $Al^{3+}_{(aq)} + 3e^- \rightleftharpoons Al_{(s)}$ E° = -1.66 V (must be flipped) $Fe^{2+}_{(aq)} + 2e^- \rightleftharpoons Fe_{(s)}$ E° = -0.44 V

   ANODE: $Al_{(s)} \rightleftharpoons Al^{3+}_{(aq)} + 3e^-$ E° = 1.66 V

   CATHODE: $Fe^{2+}_{(aq)} + 2e^- \rightleftharpoons Fe_{(s)}$ E° = -0.44 V

   E° = 1.22 V

3. Calculate the standard cell potential produced by a galvanic 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. Which is anode and which is the cathode?

   $Na^{+}_{(aq)} + e^- \rightleftharpoons Na_{(s)}$ E° = -2.71 V (must be flipped) $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

   ANODE: $Na_{(s)} \rightleftharpoons Na^{+}_{(aq)} + e^-$ E° = 2.71 V

   CATHODE: $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

   E° = 3.05 V

4. What is the voltage produced by a voltaic cell consisting of a calcium electrode in contact with a solution of Cu^{2+} ions. Which is anode and which is the cathode?

   $Ca^{2+}_{(aq)} + 2e^- \rightleftharpoons Ca_{(s)}$ E° = -2.87 V (must be flipped) $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

   ANODE: $Ca_{(s)} \rightleftharpoons Ca^{+}_{(aq)} + e^-$ E° = 2.87 V

   CATHODE: $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

   E° = 3.21 V

5. An electrochemical cell is constructed using electrodes based on the following half reactions:

   $Pb^{2+}_{(aq)} + 2e^- \rightarrow Pb_{(s)}$ $Au^{3+}_{(aq)} + 3e^- \rightarrow Au_{(s)}$

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

   ANODE: Pb CATHODE: Au

   b) What is the standard cell potential?

   ANODE: $Pb_{(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2e^-$ E° = 0.13 V

   CATHODE: $Au^{3+}_{(aq)} + 3e^- \rightleftharpoons Au_{(s)}$ E° = 1.50 V

   E° = 1.63 V

6. 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 . Which is anode and which is the cathode?

$Ni^{2+}_{(aq)} + 2e^- \rightleftharpoons Ni_{(s)}$ E° = -0.26 V (must be flipped) $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

ANODE: $Ni_{(s)} \rightleftharpoons Ni^{2+}_{(aq)} + 2e^-$ E° = 0.26 V

CATHODE: $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

E° = 0.60 V

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

$Mg^{2+}_{(aq)} + 2e^- \rightarrow Mg_{(s)}$ $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

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

ANODE: Mg CATHODE: Cu

b) What is the standard cell potential?

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$ E° = -2.37 V (must be flipped) $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

ANODE: $Mg_{(s)} \rightleftharpoons Mg^{2+}_{(aq)} + 2e^-$ E° = 2.37 V

CATHODE: $Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$ E° = 0.34 V

E° = 2.71 V

8. 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?

$Pb^{2+}_{(aq)} + 2e^- \rightleftharpoons Pb_{(s)}$ E° = -0.13 V $Fe^{2+}_{(aq)} + 2e^- \rightleftharpoons Fe_{(s)}$ E° = -0.44 V (must be flipped)

ANODE: $Fe_{(s)} \rightleftharpoons Fe^{2+}_{(aq)} + 2e^-$ E° = 0.44 V

CATHODE: $Pb^{2+}_{(aq)} + 2e^- \rightleftharpoons Pb_{(s)}$ E° = -0.13 V

E° = 0.31 V

9. What is the voltage produced by a voltaic cell consisting of a zinc electrode in contact with a solution of Zn^{2+} ions and a silver electrode in contact with a solution of Ag^+ ions? Which is anode and which is the cathode?

$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$ E° = -0.76 V (must be flipped) $Ag^+_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$ E° = 0.80 V

ANODE: $Zn_{(s)} \rightleftharpoons Zn^{2+}_{(aq)} + 2e^-$ E° = 0.76 V

CATHODE: $Ag^+_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$ E° = 0.80 V

E° = 1.56 V

10. 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?

$Au^{3+}_{(aq)} + 3e^- \rightleftharpoons Au_{(s)}$ E° = 1.50 V $Ag^+_{(aq)} + e^- \rightleftharpoons Ag_{(s)}$ E° = 0.80 V (must be flipped)

ANODE: $Ag_{(s)} \rightleftharpoons Ag^+_{(aq)} + e^-$ E° = -0.80 V

CATHODE: $Au^{3+}_{(aq)} + 3e^- \rightleftharpoons Au_{(s)}$ E° = 1.50 V

E° = 0.70 V

11. Use half-reaction potentials to predict whether the following reactions are spontaneous or non-spontaneous in aqueous solutions.

a) $Ca^{2+}_{(aq)} + 2\ I^{-}_{(aq)} \rightarrow Ca_{(s)} + I_{2(aq)}$

ANODE: $2\ I^{-}_{(aq} \rightleftharpoons I_{2(aq)} + 2e^{-}$ E° = 0.54 V

CATHODE: $Ca^{2+}_{(aq)} + 2e^{-} \rightleftharpoons Ca_{(s)}$ E° = -2.87 V

E° = -2.33 V

E° is negative, therefore the cell is non-spontaneous.

b) $2\ H_2S_{(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)} + 2\ S_{(s)}$

ANODE: $H_2S_{(g)} \rightleftharpoons 2\ S_{(s)} + 2H^{+}_{(aq)} + 2e^{-}$ E° = -0.14 V

CATHODE: $O_{2(g)} + 4H^{+}_{(aq)} + 4e^{-} \rightleftharpoons 2\ H_2O_{(l)}$ E° = 1.23 V

E° = 1.09 V

E° is positive, therefore the cell is spontaneous.

c) $SO_{2(g)} + MnO_{2(s)} \rightarrow Mn^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

ANODE: $SO_{2(g)} + 2\ H_2O_{(l)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + 4H^{+}_{(aq)} + 2e^{-}$ E° = -0.18 V

CATHODE: $MnO_{2(s)} + 4H^{+}_{(aq)} + 2e^{-} \rightleftharpoons Mn^{2+}_{(aq)} + 2\ H_2O_{(l)}$ E° = 1.22 V

E° = 1.04 V

E° is positive, therefore the cell is spontaneous.

d) $2\ H^{+}_{(aq)} + 2\ Br^{-}_{(aq)} \rightarrow H_{2(g)} + Br_{2(aq)}$

ANODE: $2\ Br^{-}_{(aq)} \rightleftharpoons Br_{2(l)} + 2e^{-}$ E° = -1.07 V

CATHODE: $2H^{+}_{(aq)} + 2e^{-} \rightleftharpoons H_{2(g)}$ E° = 0.00 V

E° = -1.07 V

E° is negative, therefore the cell is non-spontaneous.

e) $Ce^{4+}_{(aq)} + Fe^{2+}_{(aq)} \rightarrow Ce^{3+}_{(aq)} + Fe^{3+}_{(aq)}$

ANODE: $Fe^{2+}_{(aq)} \rightleftharpoons Fe^{3+}_{(aq)} + e^{-}$ E° = -0.77 V

CATHODE: $Ce^{4+}_{(aq)} + e^{-} \rightleftharpoons Ce^{3+}_{(aq)}$ E° = 1.61 V

E° = -2.38 V

E° is negative, therefore the cell is non-spontaneous.

f) $Cr^{2+}_{(aq)} + Cu^{2+}_{(aq)} \rightarrow Cr^{3+}_{(aq)} + Cu^{+}_{(aq)}$

ANODE: $Cr^{2+}_{(aq)} \rightleftharpoons Cr^{3+}_{(aq)} + e^{-}$ E° = 0.41 V

CATHODE: $Cu^{2+}_{(aq)} + e^{-} \rightleftharpoons Cu^{+}_{(aq)}$ E° = 0.15 V

E° = 0.56 V

E° is positive, therefore the cell is spontaneous.