KEY

AP Chemistry

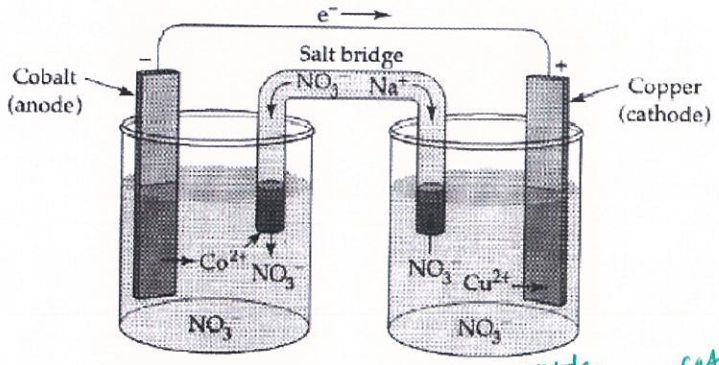
18 • Electron Transfer Reactions

STATION 1 – CELL NOTATION

anode reaction $Co(s) \rightarrow Co^{2+}(aq) + 2\,e^-$

cathode reaction $Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$

overall reaction $Co(s) + Cu^{2+}(aq) \rightarrow Co^{2+}(aq) + Cu(s)$



anode cathode

The "cell notation" for this electrochemical cell is $Co(s) \mid Co^{2+} \parallel Cu^{2+} \mid Cu(s)$

Use the above information to answer the following questions:

1. The left portion of the cell notation represents the _____ (anode / cathode).
2. The "||" represents the _____ (anode / cathode / salt bridge)
3. Write the cell notation for $Cl_2(g) + Zn(s) \rightarrow 2\,Cl^- + Zn^{2+}$ ~~Zn~~ $Zn \mid Zn^{2+} \parallel Cl_2 \mid Cl^-$
4. Write the cell notation for $2Ag(s) + Pt^{2+} \rightarrow Pt(s) + 2Ag^+$ $Ag \mid Ag^+ \parallel Pt^{2+} \mid Pt$

STATION 2 – E° VALUES

1. A cell is made from Sn in 1.0 M $Sn(NO_3)_2$ and Al in 1.0 M $Al(NO_3)_3$. The E° of the cell is +1.52 volts. Sn^{2+} -.14, Al^{3+} -1.66; -.14 -(-1.66) =
2. A cell is made from Sn in 1.0 M $Sn(NO_3)_2$ and Cd in 1.0 M $Cd(NO_3)_2$. The E° of the cell is +.26 volts. Sn^{2+} -.14, Cd^{2+} -.40; -.14 -(-.40) =
3. A cell is made from Ag in 1.0 M $AgNO_3$ and Cu in 1.0 M $Cu(NO_3)_2$. The E° of the cell is +.46 volts. Ag^+ .80, Cu^{2+} .34; .80 -(.34)
4. A cell is made from Zn in 1.0 M $Zn(NO_3)_2$ and Ag in 1.0 M $AgNO_3$. The E° of the cell is 1.56 volts. Zn^{2+} -.76, Ag^+ .80; ~~-.76 -(+.66)~~ .80 -(-.76) =

STATION 3 – GALVANIC CELLS

1. $\overset{0}{Fe}(s) + X^{2+}(aq) \rightarrow Fe^{2+}(aq) + X(s)$ $\quad E° = +0.78$ V

   a) Write the equation for the standard reduction of X.

   $X^{2+} + 2e \rightarrow X$

   b) What is the E° of X?

   $.78 = X + (+.44)$

   $.78 - .44 = .34$ V

2. A cell is made from Sn in 1.0 M $Sn(NO_3)_2$ and Al in 1.0 M $Al(NO_3)_3$ at 25°C. Sn −.14, Al −1.66 $\quad -.14 - (-1.66) =$

   a) The E° of the cell is 1.52 volts.

   b) The reaction at the anode is: $Al \rightarrow Al^{3+} + 3e^-$

   c) The reaction at the cathode is: $Sn^{2+} + 2e \rightarrow Sn$

   d) The overall reaction is: $2Al + 3Sn^{2+} \rightarrow 3Sn + 2Al^{3+}$

   e) If the cell were made with $[Sn^{2+}] = 0.10$ M and $[Al^{3+}] = 3.0$ M, would the voltage increase, decrease, or remain the same?

$$E = 1.52 - \frac{(8.31)(248)}{(6\,mol)(96500)} \ln \frac{(3.0)^3}{(.1)^2} \quad 3.0$$

$$= 1.49$$

STATION 4 – BALANCING REDOX EQ'S (ACIDIC)

Balance the following equations in acidic solution:

$6e^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$+ 14H^+$

$Cr_2O_7^{-2}(aq) + C_2O_4^{-2}(aq) \rightarrow Cr^{+3}(aq) + CO_2(g)$

$3(C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-)$

$14H^+ + 6e^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$3C_2O_4^{2-} \rightarrow 6CO_2 + 6e^-$

$14H^+ + 3C_2O_4^{2-} + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 6CO_2 + 7H_2O$

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^-(aq) + SO_2(g) \rightarrow SO_4^{-2}(aq) + Mn^{+2}(aq)$

$(2H_2O + SO_2 \rightarrow SO_4^{2-} + 2e^- + 4H^+)5$

$2H_2O + 5SO_2 \rightarrow 5SO_4^{2-} + 10e^- + 20H^+$

$10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$

$2H_2O + 5SO_2 + 2MnO_4^- \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$

STATION 5 – BALANCING REDOX EQ'S (BASIC)

Balance the following equations in basic solution:

$2H_2O + Mn^{2+} \rightarrow MnO_2 + 2e^- + 4H^+$

$Mn^{+2}(aq) + ClO_3^-(aq) \rightarrow MnO_2(s) + ClO_2(g)$

$(2H^+ + 1e^- + ClO_3^- \rightarrow ClO_2 + H_2O)2$

$4H^+ + 2e^- + 2ClO_3^- \rightarrow 2ClO_2 + 2H_2O$

$2H_2O + Mn^{2+} \rightarrow MnO_2 + 2e^- + 4H^+$

$Mn^{2+} + 2ClO_3^- \rightarrow 2ClO_2 + MnO_2$

$5(2e^- + Cl_2 \rightarrow 2Cl^-)$

$Cl_2(g) \rightarrow Cl^-(aq) + ClO_3^-(aq)$

$6H_2O + Cl_2 \rightarrow 2ClO_3^- + 10e^- + 12H^+$

$10e^- + 5Cl_2 \rightarrow 10Cl^-$

$6H_2O + 6Cl_2 \rightarrow 2ClO_3^- + 10Cl^- + 12H^+$

$12OH^- + 6H_2O + 6Cl_2 \rightarrow 10Cl^- + 2ClO_3^- + 12H^+ + 12OH^-$

$12OH^- + 6Cl_2 \rightarrow 10Cl^- + 2ClO_3^- + 6H_2O$

STATION 6 – ELECTROLYSIS

How long will it take to electroplate each of the following with a current of 100.0 A? $\frac{100.00\ C}{s}$ $\frac{96500\ C}{mol}$

1.0 g of Al(s) from aqueous Al^{+3}.

$$1.0\,g\,Al \left|\frac{1\,mol\,Al}{26.98\,g}\right|\frac{3\,mol\,e^-}{1\,mol\,Al}\left|\frac{96\,500\,C}{1\,mole^-}\right|\frac{1\,s}{100.00\,C} = 107.28\,sec$$

1.0 g of Ni(s) from aqueous Ni^{+2}

$$1.0\,g\,Ni \left|\frac{1\,mol\,Ni}{58.69\,g\,Ni}\right|\frac{2\,mole^-}{1\,mol\,Ni}\left|\frac{96500\,C}{1\,mole^-}\right|\frac{1\,s}{100.00\,C} = 32.7\,sec$$

STATION 7 – REACTIVITY

Consider the following half-reactions and E° values:

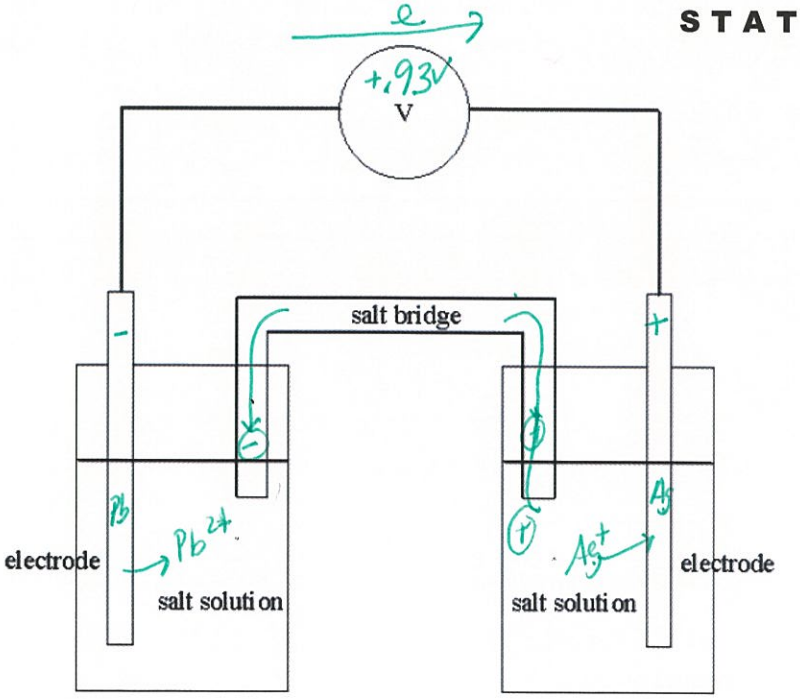
$Ag^+(aq) + e^- \rightarrow Ag(s)$ E° = 0.80 V
$Cu^{+2}(aq) + 2e^- \rightarrow Cu(s)$ E° = 0.34 V
$Pb^{+2}(aq) + 2e^- \rightarrow Pb(s)$ E° = -0.13 V

1. Which of these metals or ions is the strongest **oxidizing agent**? Ag^+
2. Which is the strongest **reducing agent**? Pb

Predict whether each of the following reactions will occur as written:

3. $Cu^{2+} + Pb^\circ \rightarrow Pb^{2+} + Cu^\circ$ Y
4. $Pb^{2+} + 2Ag^\circ \rightarrow 2Ag^+ + Pb^\circ$ N opposite
5. $2Ag^+ + Pb^{2+} \rightarrow 2Ag^\circ + Pb^\circ$ N Buffered

STATION 8 – SKETCH A CELL



Anode oxidation reaction $Pb \rightarrow Pb^{2+} + 2e^-$

Cathode reduction reaction $Ag^+ + e^- \rightarrow Ag$

$Pb + 2Ag^+ \rightarrow 2Ag + Pb^{2+}$

Consider these half-reactions & E° values:

$Ag^+(aq) + e^- \rightarrow Ag(s)$ E° = 0.80 V
$Cu^{+2}(aq) + 2e^- \rightarrow Cu(s)$ E° = 0.34 V
$Pb^{+2}(aq) + 2e^- \rightarrow Pb(s)$ E° = -0.13 V

Which two metals and 1.0 M solutions would give the greatest voltage? Ag Pb

Label:

- the anode reaction $Pb \rightarrow Pb^{2+} + 2e$
- the cathode reaction $Ag^+ + 1e \rightarrow Ag$
- the overall reaction $Pb + 2Ag^+ \rightarrow Pb^{2+} + 2Ag$
- the metals used for each electrode
- the ions in solution
- the expected voltage $.80 - (-.13) = .93$
- the direction of flow of electrons
- the flow of ions in the salt bridge
- the charge on each electrode (+ or –)
- ions you might use in the salt bridge K^+ NO_3^-
- the observed changes in the electrodes

A ↓
C ↑