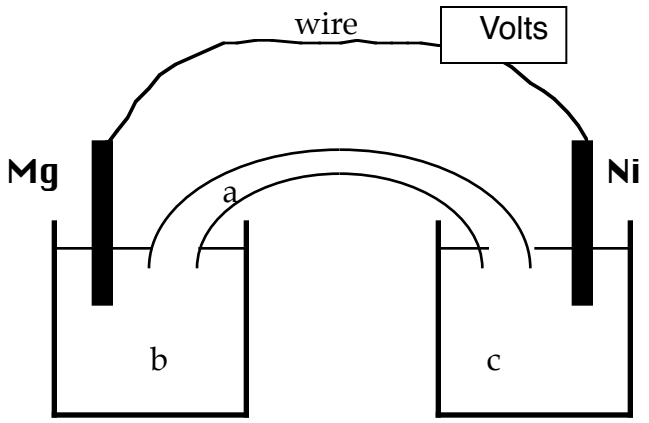
(Handout, p. 685-691, Notice: we calculate E°cell slightly differently than the book!)



1. Consider this voltaic cell made with Mg and Ni:

a. part "a" is called the _____

b. What solution is in container "b"?

$Mg(NO_3)_2$ or $Ni(NO_3)_2$

c. What solution is in container "c"?

$Mg(NO_3)_2$ or $Ni(NO_3)_2$

d. Does the *oxidation* or *reduction* occur at the Mg electrode? Is Mg the *red* wire or *black* wire?

Write the equation for this half reaction _____

e. Does the *oxidation* or *reduction* occur at the Ni electrode? Is Ni the *red* wire or *black* wire?

Write the equation for this half reaction _____

f. Write the overall reaction for the cell _____

g. Which way do electrons flow in the wire? _____

h. Calculate $E°_{cell}$ for this cell.

2. a. For the $Fe \mid Fe^{+2}$ and $Cu \mid Cu^{+2}$ half cells : Which is oxidized?____ Which is reduced? _____
Write the half reactions for the oxidation and the reduction and calculate $E°_{cell}$.

b. For the $Al \mid Al^{+3}$ and $Ag \mid Ag^{+}$ half cells : Which is oxidized?_____ Which is reduced? _____
Write the half reactions for the oxidation and the reduction and calculate $E°_{cell}$.

3. A voltaic cell is made with Paladium ($Pd \mid Pd^{+2}$) = red wire and $I_2 \mid I^-$ = black wire. The measured $E°_{cell}$ is + 0.41 Volts. $I_2 \mid I^-$ is found on your $E°_{red}$ chart. $Pd \mid Pd^{+2}$ is not.

a. Is $Pd \mid Pd^{+2}$ the oxidation or the reduction? Is $I_2 \mid I^-$ the oxidation or the reduction?

b. Calculate $E°_{red}$ for the $Pd^{+2} + 2\ e^- \longrightarrow Pd$ reaction using this data.

c. Determine E°ox for $Pd \longrightarrow Pd^{+2} + 2\ e^-$ _____

(Ans. 1d. ox, black, e. red, red, f. $Mg + Ni^{+2} \longrightarrow Mg^{+2} + Ni$. g, Mg to Ni, h. +2.12 V; 2a. Fe, Cu, +0.78 V, b. Al, Ag, +2.46 V, 3a. red, ox, b. +0.95 V, c. –0.95V; 4a. +0.34 V, b. –0.34 V)

1. In a voltaic cell with red wire $Pb \mid Pb^{+2}$ and black wire $In \mid In^{+2}$, the measured $E°_{cell}$ =+ 0.21 V.
   a. Calculate $E°_{ox}$ for this half reaction: $In \longrightarrow In^{+2} + 2\ e^-$

   b. Determine $E°_{red}$ for $In^{+2} + 2\ e^- \longrightarrow In$ _____

2. In a voltaic cell with red wire $Sn^{+2} \mid Sn^{+4}$ and black wire $Zn \mid Zn^{+2}$, the measured $E°_{cell}$ = + 0.91 V.
   a. Is $Zn \mid Zn^{+2}$ the oxidation or reduction? Write the half reaction, and determine $E°_{ox}$ or $E°_{red}$ (as appropriate) from your E°red chart.

   b. Is $Sn^{+2} \mid Sn^{+4}$ the Oxidation or Reduction? Write the half reaction. Calculate $E°_{ox}$ or $E°_{red}$ (as appropriate).

   c. Where would $Sn^{+2} \mid Sn^{+4}$ go on your $E°_{red}$ chart?

3. In a voltaic cell with red wire $Zn \mid Zn^{+2}$ and black wire $Sc \mid Sc^{+3}$, the measured $E°_{cell}$ =+ 1.32 V.
   a. Calculate $E°_{ox}$ or $E°_{red}$ (as appropriate) for $Sc \mid Sc^{+3}$.

   b. Where would $Sc \mid Sc^{+3}$ go on your $E°_{red}$ chart?

4. Which would produce a higher voltage?
   a. a voltaic cell made using Magnesium and copper, or one using magnesium and silver? _____
   b. a voltaic cell made using Al and Zn, or one made from Al and Pb? _____
5. Would the following combinations react or not react? (Hint: which is more easily oxidized?)

   a. Mg in $FeCl_3$ solution
   b. Fe in Cu^{+2} solution
   c. Zn in $Mg(NO_3)_2$ solution
   d. Ag in Cu^{+2} solution

6. Rank these metals in order of the most easily oxidized (1) to the least easily oxidized (4).

   Cu Mg Ag Al

7. Rank the following in order of the most easily reduced (1) to the least easily reduced (4).

   Cu^{+2} Na^+ MnO_4^- Co^{+2}

(1a. +0.34 V, b. –0.34 V; 2a ox, E°ox=+0.76 V, b. red, E°red=+0.15V, c. below H_2; 3a. E°ox = +2.08 so E°red =-2.08 V, b. below Mg; 4a.Mg&Ag, b. Al&Pb; 5. yes a & b; 6. Mg, Al, Cu, Ag; 7. MnO_4^-, Cu^{+2}, Co^{+2}, Na^+)

8. Would each of the following most likely be *oxidized* or *reduced?*

$Cr_2O_7^{-2}$ Ag Na^+ Mg Cl^- Fe Ag^+

9. Which of these are *oxidizing agents* and which are *reducing agents* ?

MnO_4^- Mg K Cl_2 Fe Ag^+ $Cr_2O_7^{-2}$ I^-

Which is the BEST oxidizing agent? _____ The Best reducing agent?_____

10. Identify the element *oxidized* and *reduced* in these redox reactions. Then calculate the standard cell potential ($E°_{cell}$) for each. Would each react spontaneously as written (+ E°) *or* in the reverse(– E°)?

a. $2\ NaCl + Co \longrightarrow CoCl_2 + 2\ Na$

b. $Cu(NO_3)_2 + Ni \longrightarrow Ni(NO_3)_2 + Cu$

c. $I_2 + 2\ Fe^{+2} \longrightarrow 2\ I^- + 2\ Fe^{+3}$ (For: $Fe^{+3} + e^- \longrightarrow Fe^{+2}$: $E°_{red} = +0.77$ V)

d. $2\ Cr^{+2} + Cu^{+2} \longrightarrow 2\ Cr^{+3} + Cu$ (For: $Cr^{+3} + e^- \longrightarrow Cr^{+2}$: $E°_{red} = -0.41$)

Electrolytic Cells (p. 692-697)

11. One way to produce Chlorine gas is by the electrolysis of melted sodium chloride.

$2\ NaCl$ — electricity—> $2\ Na + Cl_2$ Write in all the oxidation numbers.

a. What is oxidized? Write the half reaction for the oxidation _____

b. What is reduced? Write the half reaction for the reduction _____

12. For the electrolysis of melted $CuBr_2$: $CuBr_2$ ——electricity—> $Cu + Br_2$

a. Write the half reaction for the oxidation _____

b. Write the half reaction for the reduction _____

13. Identify the following as examples or characteristics of a *Voltaic* cell or an *Electrolytic* Cell.

a. Produces electricity _____
b. Produces electrical energy _____
c. Non-spontaneous _____
d. Flashlight battery _____
e. Car battery_____
f. Requires electricity _____
g. Absorbs electrical energy _____
h. Spontaneous _____
i. Ni-Cad battery when recharging _____
j. Turning melted salt into Na and Cl_2 _____

(8. ox = Ag, Mg, Cl^-, Fe, red= $Cr_2O_7^{-2}$, Na^+, Ag^+ ; 9. ox ag = MnO_4^-, Cl_2, Ag^+, $Cr_2O_7^{-2}$, best = MnO_4^-, red ag = Mg, K, Fe, I^-, best = K; 10. a. –2.43 V; b. +0.59 V, c. –0.23 V; d. +0.75 V; 11. a. Cl^- , b. Na^+; 12. Br^-, Cu^{+2}; 13 V=a,b,d,h, E= c,f,g, i, j, Both =e)

1. a. Balance this redox reaction using the oxidation number change method.

$Cr_2O_7^{-2}$ + Ge + H^+ ⟶ Cr^{+3} + Ge^{+2} + H_2O

b. The measured $E°_{cell}$ for the above redox reaction is +1.09 V. Calculate $E°_{red}$ for this half reaction. $Ge^{+2} + 2\ e^- \longrightarrow Ge$

c. Where would Ge go on your $E°_{red}$ chart?_____

2. Balance this redox reaction.

$Sn(SO_4)_2$ + HCl ⟶ Cl_2 + Sn + H_2SO_4

3. a. Balance this redox reaction using the oxidation number change method. **Page 8**

Al + ClO_2^- + H^+ ⟶ Cl^- + Al^{+3} + H_2O

b. E°red for this half reaction is +1.56 V: $ClO_2^- + 4\ H^+ + 4\ e^- \longrightarrow Cl^- + 2\ H_2O$
Calculate E°cell for the reaction in part a.

c. Would the reaction from part a react spontaneously in the forward direction or in reverse? Why?

4. Balance this redox reaction. (Tricky)

MnO_4^- + Cl^- + H^+ ⟶ Cl_2 + MnO_2 + H_2O

(1. a. 1, 3, 14, 2, 3, 7 , b. E°ox = - 0.24 V so E°red = +0.24 V, below H_2; 2. 1, 4, 2, 1, 2) 3. 4, 3, 12, 3, 4, 6, b. E°cell = +3.22 V , c. forward; 4. 2, 6, 8, 3, 2, 4)