Exercise 18.2
Cell Potentials

Name: ______________________

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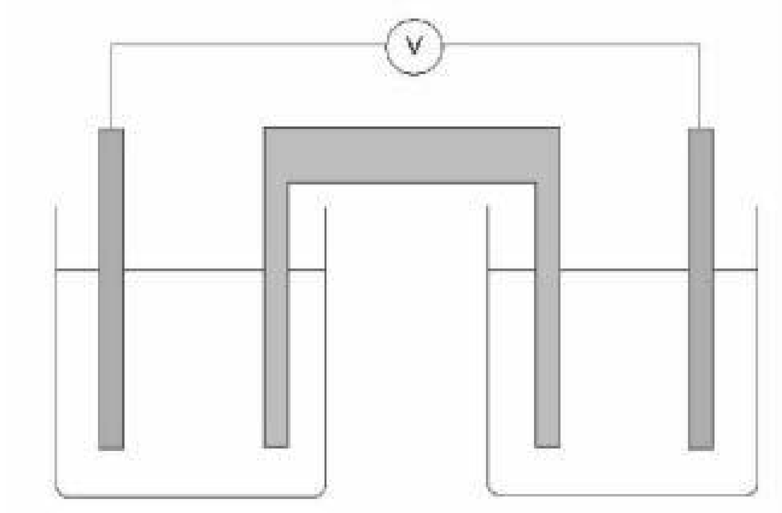
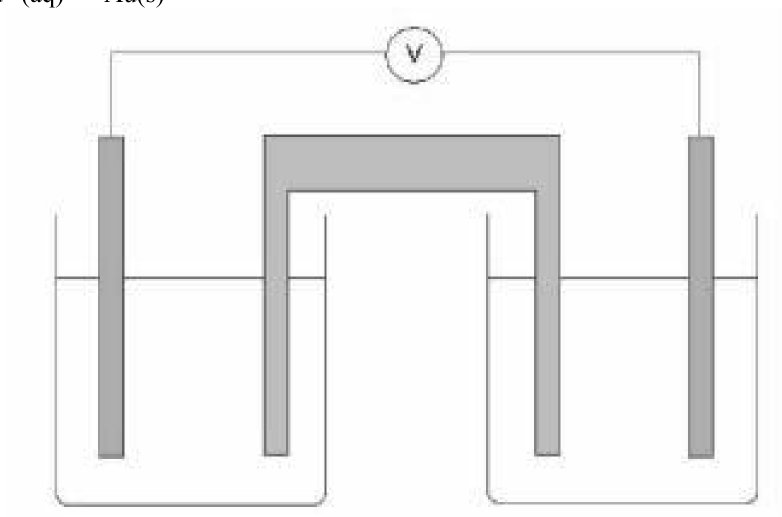
Label the galvanic cells formed from the following components. Show the direction of electron flow and identify the cathode and anode. Identify the ions present in the beakers. Assume the salt bridge contains KNO_3. Label the direction of ion flow from the salt bride. Give the overall balanced equation and calculate E° for the cell. Assume that all concentrations are 1.0 M and the all partial pressures are 1.0 atm. Write the standard line notation for the cell.

1. $Mg^{2+}(aq) \rightarrow Mg(s)$; $Cu^{2+}(aq) \rightarrow Cu(s)$



2. $Ca^{2+}(aq) \rightarrow Ca(s)$; $Au^{3+}(aq) \rightarrow Au(s)$



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Calculating Standard Cell Potentials $E°_{cell}$
The standard cell potential for a pair of electrodes is sum of the reduction potential and oxidation potential of the electrodes at standard conditions (1atm & 25ºC). The value of the $E°_{cell}$ must be positive in a galvanic cell to support the spontaneous movement of electrons between the half-cells.

The steps for calculating $E°_{cell}$ are:

1. Write the oxidation and reduction half-reactions for the cell.
2. Look up the reduction potential, $E°_{red}$, for the reduction half-reaction in a table of reduction potentials.
3. Look up the reduction potential for the reverse of the oxidation half-reaction and reverse the sign to obtain the oxidation potential. For the oxidation half-reaction, $E°_{ox} = –E°_{red}$.
4. Add the two half-cell potentials to get the overall standard cell potential.

$$E°_{cell} = E°_{red} + E°_{ox}$$

A second method of calculating E^{o}_{cell} does not require changing the sign of the oxidation half-reaction potential – changing the operation to subtraction accomplishes the same thing.

$$E°_{cell} = E°_{red(reduction)} - E°_{red(oxidation)}$$

N.B. – When balancing redox reactions, the addition of coefficients in

Standard Electrode Potentials in Aqueous Solution at 25°C	
Cathode (Reduction) Half-Reaction	Standard Potential E° (volts)
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.05
$K^+(aq) + e^- \rightarrow K(s)$	–2.92
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.76
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.37
$Ac^{3+}(aq) + 3e^- \rightarrow Ac(s)$	–2.20
$Be^{2+}(aq) + 2e^- \rightarrow Be(s)$	–1.85
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.66
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	–0.73
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$	–0.40
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$	–0.036
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	0.13
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$	0.16
$Bi^{3+}(aq) + 3e^- \rightarrow Bi(s)$	0.31
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	0.34
$Cu^+(aq) + e^- \rightarrow Cu(s)$	0.52
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	0.54
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	0.77
$Hg_2^{2+}(aq) + 2e^- \rightarrow 2Hg(l)$	0.80
$Ag^+(aq) + e^- \rightarrow Ag(s)$	0.80
$Hg^{2+}(aq) + 2e^- \rightarrow Hg(l)$	0.85
$2Hg^{2+}(aq) + 2e^- \rightarrow Hg_2^{2+}(aq)$	0.91
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	1.09
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36
$Au^{3+}(aq) + 2e^- \rightarrow Au^+(aq)$	1.40
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	1.50
$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$	1.70
$Au^+ + e^- \rightarrow Au(s)$	1.83

DIRECTIONS: *Write the oxidation and reduction half reactions. Calculate the standard cell potential for the following electrochemical cells.*

3. $Ag^+(aq) + Fe(s) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

4. $Br^-(aq) + Hg_2^{2+}(aq) \rightleftharpoons Br_2(l) + Hg(l)$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

5. $Be(s) + Au^{3+}(aq) \rightleftharpoons Be^{2+}(aq) + Au^+(aq)$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

6. $Ag^+(aq) + Cu(s) \rightleftharpoons Cu^{2+}(aq) + Ag(s)$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

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7. $Zn^{2+}(aq) + Ni(s) \rightleftharpoons Ni^{2+}(aq) + Zn(s)$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

DIRECTIONS: *Write the oxidation and reduction half reactions. Calculate the standard cell potential for the following electrochemical cells. Indicate if the reaction is spontaneous.*

8. $Mg + Cl_2 \rightleftharpoons MgCl_2$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

Spontaneous? __________

9. $Na + Cl_2 \rightleftharpoons NaCl$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

Spontaneous? __________

10. $Cu + H^+ \rightleftharpoons Cu^{2+} + H_2$

Process	Equation	Potential
Oxidation		
Reduction		
	$E°_{cell}$	

Spontaneous? __________

11. Write the electrochemical cell equation for the reaction that would have the **greatest** electrical potential based on the values provided above. Calculate the E° for this cell.

12. Write the electrochemical cell equation for the reaction that would have the **lowest** electrical potential based on the values provided above. Calculate the E° for this cell.

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13. Answer the following questions using data from the reduction potentials table (under standard conditions).

a. Is H^+(aq) capable of oxidizing Mg(s)? ________

b. Is Fe^{3+}(aq) capable of oxidizing I^-(aq)? _______

c. Is Fe^{3+}(aq) capable of oxidizing Br^-(aq)? ______

d. Is H_2(g) capable of reducing Ag^+(aq)? ________

e. Is H_2(g) capable of reducing Ni^{2+} (aq)? ________

f. Is H^+(aq) capable of oxidizing Cu(s) to Cu^{2+}(aq)? ________

g. Is Fe^{2+}(aq) capable of reducing Cr^{3+}(aq) to Cr^{2+}(aq)? _____

h. Is Fe^{2+}(aq) capable of reducing Sn^{2+}(aq) to Sn(s)? ________

14. 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? *(E° = 1.06 V)*

15. What is the voltage produced by a galvanic 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+} ions. Which is anode and which is the cathode? *(E° = 1.22 V)*

16. 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? *(E° = 3.05 V)*

17. 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? *(E° = 3.21 V)*

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

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

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

b. What is the standard cell potential? (E° = 1.63 V)

19. 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? (E° = 0.60 V)

Revised: 2019-04-03