

Chem 1B Practice problems for Exam 3

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = -RT \ln K$$

$$\Delta G^\circ = -nFE^\circ$$

$$E_{\text{cell}}^\circ = (0.0592/n) \log K$$

$$\ln K = (nE_{\text{cell}}^\circ)/0.0257 \quad \text{or} \quad \log K = (nE_{\text{cell}}^\circ)/0.0592$$

$$E_{\text{cell}} = E_{\text{cell}}^\circ - (RT/nF) \ln Q$$

$$E_{\text{cell}} = E_{\text{cell}}^\circ - (0.0257/n) \ln Q \quad \text{or} \quad E_{\text{cell}} = E_{\text{cell}}^\circ - (0.0592/n) \log Q$$

$$1V = 1J/1C$$

$$R = 8.314 \text{ J/K}\cdot\text{mol}$$

$$F = 96,485 \text{ C/mol}$$

Thermodynamics (Ch 17.8-17.9)

1. For a chemical reaction, if $\Delta G^\circ < 0$, then _____.
- a) $K=1$ b) $K=0$ c) $K=-1$ d) $K < 0$ e) $K > 1$

2. What is true if $\ln(K)$ is negative?

- A) $\Delta G^\circ_{\text{rxn}}$ is positive and the reaction is spontaneous in the forward direction.
B) $\Delta G^\circ_{\text{rxn}}$ is negative and the reaction is spontaneous in the forward direction.
C) $\Delta G^\circ_{\text{rxn}}$ is negative and the reaction is spontaneous in the reverse direction.
D) $\Delta G^\circ_{\text{rxn}}$ is positive and the reaction is spontaneous in the reverse direction.
E) $\Delta G^\circ_{\text{rxn}}$ is zero and the reaction is at equilibrium.

3. What is the equilibrium constant for reaction below at 25 °C? ($R = 8.314 \text{ J/K}\cdot\text{mol}$)



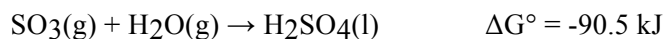
given $\Delta_f G^\circ [\text{MgCO}_3(\text{s})] = -1028.2 \text{ kJ/mol}$, $\Delta_f G^\circ [\text{MgO}(\text{s})] = -568.8 \text{ kJ/mol}$, and $\Delta_f G^\circ [\text{CO}_2(\text{g})] = -394.4 \text{ kJ/mol}$.

- a) 4.0×10^{-12} b) 0.97 c) 1.0 d) 1.0×10^4 e) 2.5×10^{11}

4. Which of the following reactions will have the largest equilibrium constant (K) at 298 K?

- A) $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ $\Delta G^\circ = +131.1 \text{ kJ}$
B) $2 \text{ Hg}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{ HgO}(\text{s})$ $\Delta G^\circ = -180.8 \text{ kJ}$
C) $3 \text{ O}_2(\text{g}) \rightarrow 2 \text{ O}_3(\text{g})$ $\Delta G^\circ = +326 \text{ kJ}$
D) $\text{Fe}_2\text{O}_3(\text{s}) + 3 \text{ CO}(\text{g}) \rightarrow 2 \text{ Fe}(\text{s}) + 3 \text{ CO}_2(\text{g})$ $\Delta G^\circ = -28.0 \text{ kJ}$
E) I don't know.

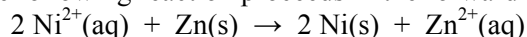
5. Determine the equilibrium constant for the following reaction at 298 K.



- A) 1.37×10^{-16}
B) 4.78×10^{11}
C) 9.11×10^{-8}
D) 7.31×10^{15}
E) 0.964

Electrochemistry (Ch 18)

6. Assuming the following reaction proceeds in the forward direction,

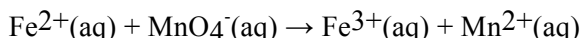


- a) $\text{Ni}^{2+}(\text{aq})$ is the reducing agent and $\text{Zn}(\text{s})$ is the oxidizing agent.
- b) $\text{Zn}(\text{s})$ is the reducing agent and $\text{Ni}(\text{s})$ is the oxidizing agent.
- c) $\text{Ni}^{2+}(\text{aq})$ is the reducing agent and $\text{Ni}(\text{s})$ is the oxidizing agent.
- d) $\text{Zn}(\text{s})$ is the reducing agent and $\text{Zn}^{2+}(\text{aq})$ is the oxidizing agent.
- e) $\text{Zn}(\text{s})$ is the reducing agent and $\text{Ni}^{2+}(\text{aq})$ is the oxidizing agent.

7. What is the oxidation number of Mn in MnO_4^-

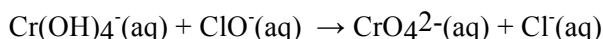
- a) 0
- b) +3
- c) +5
- d) +7

8. Balance the following redox reaction if it occurs in acidic solution. What are the coefficients in front of H^+ and Fe^{3+} in the balanced reaction?



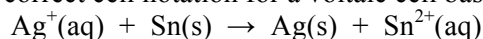
- A) $\text{H}^+ = 2$, $\text{Fe}^{3+} = 3$
- B) $\text{H}^+ = 8$, $\text{Fe}^{3+} = 5$
- C) $\text{H}^+ = 3$, $\text{Fe}^{3+} = 2$
- D) $\text{H}^+ = 5$, $\text{Fe}^{3+} = 1$
- E) $\text{H}^+ = 8$, $\text{Fe}^{3+} = 1$

9. Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of $\text{Cr}(\text{OH})_4^-$ and ClO^- in the balanced reaction?



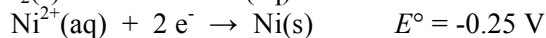
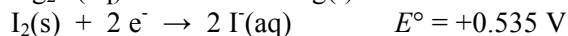
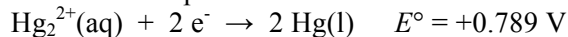
- A) $\text{Cr}(\text{OH})_4^- = 2$, $\text{ClO}^- = 3$
- B) $\text{Cr}(\text{OH})_4^- = 1$, $\text{ClO}^- = 1$
- C) $\text{Cr}(\text{OH})_4^- = 1$, $\text{ClO}^- = 2$
- D) $\text{Cr}(\text{OH})_4^- = 2$, $\text{ClO}^- = 6$
- E) $\text{Cr}(\text{OH})_4^- = 6$, $\text{ClO}^- = 5$

10. What is the correct cell notation for a voltaic cell based on the reaction below?



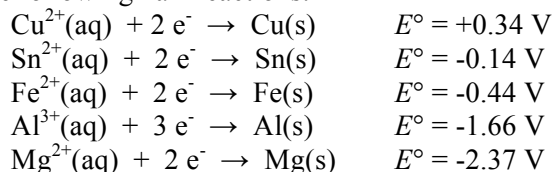
- a) $\text{Ag}(\text{s}) | \text{Ag}^+(\text{aq}) || \text{Sn}^{2+}(\text{aq}) | \text{Sn}(\text{s})$
- b) $\text{Sn}(\text{s}) || \text{Sn}^{2+}(\text{aq}), \text{Ag}^+(\text{aq}) | \text{Ag}(\text{s})$
- c) $\text{Ag}(\text{s}) || \text{Ag}^+(\text{aq}), \text{Sn}^{2+}(\text{aq}) || \text{Sn}(\text{s})$
- d) $\text{Ag}(\text{s}) | \text{Sn}^{2+}(\text{aq}) || \text{Ag}^+(\text{aq}) | \text{Sn}(\text{s})$
- e) $\text{Sn}(\text{s}) | \text{Sn}^{2+}(\text{aq}) || \text{Ag}^+(\text{aq}) | \text{Ag}(\text{s})$

11. Use the standard reduction potentials below to determine which element or ion is the best oxidizing agent.



- a) $\text{I}_2(\text{s})$
- b) $\text{Hg}_2^{2+}(\text{aq})$
- c) $\text{I}^-(\text{aq})$
- d) $\text{Ni}^{2+}(\text{aq})$
- e) $\text{Hg}(\text{l})$

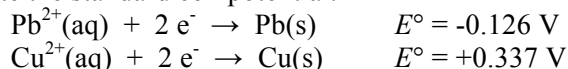
12. Consider the following half-reactions:



Which of the above metals or metal ions will oxidize Fe(s)?

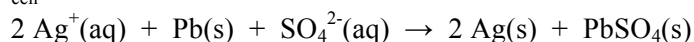
- $\text{Cu}^{2+}(\text{aq})$ and $\text{Sn}^{2+}(\text{aq})$
- $\text{Cu}(\text{s})$ and $\text{Sn}(\text{s})$
- $\text{Al}^{3+}(\text{aq})$ and $\text{Mg}^{2+}(\text{aq})$
- $\text{Al}(\text{s})$ and $\text{Mg}(\text{s})$
- $\text{Sn}(\text{s})$ and $\text{Al}^{3+}(\text{aq})$

13. Given the following two half-reactions, write the overall reaction in the direction in which it is spontaneous and calculate the standard cell potential.

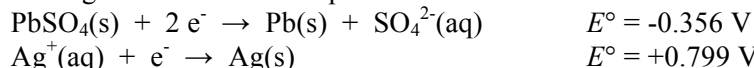


- $\text{Pb}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \rightarrow \text{Pb}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \quad E_{\text{cell}}^{\circ} = +0.463 \text{ V}$
- $\text{Pb}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \rightarrow \text{Pb}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \quad E_{\text{cell}}^{\circ} = +0.211 \text{ V}$
- $\text{Pb}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \quad E_{\text{cell}}^{\circ} = -0.211 \text{ V}$
- $\text{Pb}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \quad E_{\text{cell}}^{\circ} = +0.463 \text{ V}$
- $\text{Pb}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Cu}(\text{s}) \quad E_{\text{cell}}^{\circ} = +0.926 \text{ V}$

14. Calculate E_{cell}° for the reaction below,

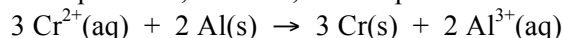


given the following standard reduction potentials.

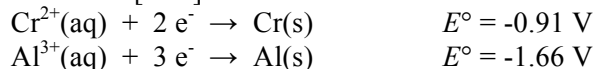


- 1.155 V
- 0.443 V
- +0.443 V
- +1.155 V
- +1.954 V

15. Calculate the cell potential, at 25 °C, based upon the overall reaction

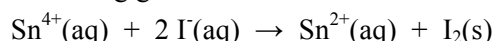


if $[\text{Cr}^{2+}] = 0.15 \text{ M}$ and $[\text{Al}^{3+}] = 0.0040 \text{ M}$. The standard reduction potentials are as follows:



- 2.64 V
- 0.75 V
- +0.44 V
- +0.73 V
- +0.77 V

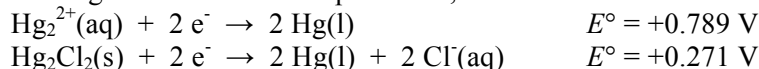
16. E_{cell}° for the following galvanic cell is -0.39 V.



What is $\Delta_r G^{\circ}$ for this reaction?

- 75 kJ
- 38 kJ
- 2.0 kJ
- 38 kJ
- 75 kJ

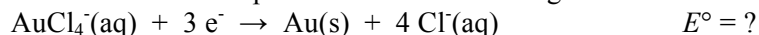
17. Given the following standard reduction potentials,



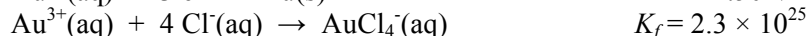
determine K_{sp} for $\text{Hg}_2\text{Cl}_2(\text{s})$ at 25 °C.

- 4.5×10^{-41}
- 9.0×10^{-36}
- 1.4×10^{-36}
- 3.0×10^{-18}
- 7.2×10^{35}

18. Calculate the standard reduction potential for the following reaction at 25 °C,

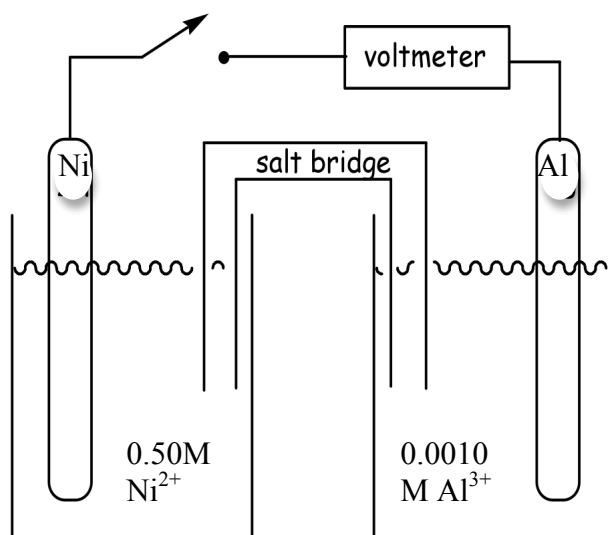


given the following thermodynamic information.



- a) -1.28 V b) -0.50 V c) +1.00 V d) +1.28 V e) +3.85 V

19. Consider the voltaic cell below which is set up at $T = 25^\circ\text{C}$. When the circuit is closed, the cell generates current. Determine the cell potential, E_{cell} , given the information below.

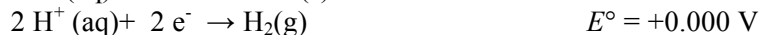


$$E^\circ (\text{Ni}/\text{Ni}^{2+}) = -0.25 \text{ V}$$

$$E^\circ (\text{Al}/\text{Al}^{3+}) = -1.66 \text{ V}$$

Ask yourself, which is the anode and cathode? Which substance is oxidized and which is reduced based on the standard potentials you are given? Which electrode will gain mass? Hint towards the problem, the cell potential, E_{cell} , you calculate will be slightly greater than E°_{cell} . Can you reason why?

20. A voltaic cell is set up with Cu/Cu^{2+} and H_2/H^+ half-cells. The half-cell reactions and reduction potentials are shown below.



When set up, the cell produces electrical current ($E_{\text{cell}} = 0.490 \text{ V}$ at $T = 25^\circ\text{C}$). For the half cells, the Cu^{2+} concentration is 1.0M and molar gas concentration of H_2 is 1.0M, but the concentration of H^+ ions generated is unknown. Determine the pH of the solution H_2/H^+ half-cell.

- a) 3.11
b) 2.59
c) 1.09
d) 4.55

Transition Metal Chemistry Chapter 22

21. What is the highest oxidation state for manganese?

- a) +3 b) +6 c) +7 d) +8 e) +10

22. Ions such as $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ and $[\text{Ag}(\text{CN})_2]^-$ are called _____.
- ligands
 - Lewis bases
 - chelates
 - alloys
 - coordination complexes
23. All of the following molecules or ions can act as polydentate ligands EXCEPT _____.
- phenanthroline; $\text{C}_{12}\text{H}_8\text{N}_2$
 - acetylacetonate ion; $\text{CH}_3\text{COCHCOCH}_3^-$
 - oxalate ion; $\text{C}_2\text{O}_4^{2-}$
 - ethylenediamine; $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$
 - dimethylamine; $(\text{CH}_3)_2\text{NH}$
24. What is the coordination number of the central metal ion in $[\text{Co}(\text{C}_2\text{O}_4)_2(\text{OH})_2]^{3-}$?
- 2
 - 4
 - 6
 - 8
 - 10
25. What is the oxidation state of iron in $\text{K}[\text{Fe}(\text{NH}_3)_2(\text{CN})_4]$?
- 1
 - +1
 - +2
 - +3
 - +6
26. What is the name of the compound having the formula $[\text{Cr}(\text{en})_2(\text{NH}_3)_2]\text{Cl}_2$?
- dihydroxodiethylenediamminechromate(II) chloride
 - diamminebis(ethylenediamine)chlorochromate(II)
 - bis(ethylenediamine)diamminechromium(II) dichloride
 - diamminebis(ethylenediamine)dichlorochromium(II)
 - diamminebis(ethylenediamine)chromium(II) chloride
27. Which of the following species have geometric isomers: $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Fe}(\text{CN})_5\text{H}_2\text{O}]^{2-}$, $[\text{Fe}(\text{CN})_4(\text{H}_2\text{O})_2]^-$, and $[\text{Fe}(\text{CN})_3(\text{H}_2\text{O})_3]$?
- $[\text{Fe}(\text{CN})_6]^{3-}$ only
 - $[\text{Fe}(\text{CN})_5\text{H}_2\text{O}]^{2-}$ only
 - $[\text{Fe}(\text{CN})_3(\text{H}_2\text{O})_3]$ only
 - $[\text{Fe}(\text{CN})_4(\text{H}_2\text{O})_2]^-$ and $[\text{Fe}(\text{CN})_3(\text{H}_2\text{O})_3]$
 - $[\text{Fe}(\text{CN})_5\text{H}_2\text{O}]^{2-}$, $[\text{Fe}(\text{CN})_4(\text{H}_2\text{O})_2]^-$, and $[\text{Fe}(\text{CN})_3(\text{H}_2\text{O})_3]$
28. Which one of the following complex ions has an optical isomer?
- $[\text{Cu}(\text{CN})_4]^{2-}$
 - $[\text{Zn}(\text{Cl})_4]^{2-}$
 - $[\text{Zn}(\text{NH}_3)_2\text{en}]^{2+}$
 - $[\text{Co}(\text{H}_2\text{O})_4\text{en}]^{2+}$
 - $[\text{Ni}(\text{en})_3]^{2+}$
29. What is the number of unpaired electrons in an octahedral, high-spin Mn(II) complex?
- 1
 - 2
 - 3
 - 4
 - 5
30. As bound ligands, which of the following causes the largest splitting of *d*-orbitals?
- en
 - H_2O
 - I^-
 - Cl^-
 - $\text{C}_2\text{O}_4^{2-}$
31. How many unpaired electrons does the following complex, $[\text{Zn}(\text{CN})_6]^{4-}$, have?
- 0
 - 2
 - 4
 - 6
 - 8
32. If $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ absorbs red light. What color do you expect this coordination complex to be?
- red
 - orange
 - yellow
 - green
 - clear
33. Which of the following compounds may have linkage isomers?
- $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$
 - $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{NO}_2$
 - $[\text{Cr}(\text{H}_2\text{O})_5(\text{NO}_2)]\text{SO}_4$
 - $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}](\text{SCN})_2$
 - $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

34. Not multiple choice but good practice.

The complex ion $[\text{Co}(\text{CO}_3)_3]^{3-}$ is an octahedral complex with bidentate carbonate ions as ligands. It has one absorption in the visible region of the spectrum at 640nm.

- Predict the color of the complex.
- What is the energy associated with this wavelength of light?
- Based on your answer, is the carbonate ion a weak or strong field ligand?
- Is $[\text{Co}(\text{CO}_3)_3]^{3-}$ paramagnetic or diamagnetic?

A little Organic (Ch 10). We might or might not get to this...

35. What is the general formula for an alkane?

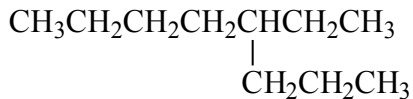
- a) $\text{C}_n\text{H}_{2n+2}$ b) C_nH_{2n} c) C_nH_{n-2} d) C_{n+2}H_n e) $\text{C}_n\text{H}_{2n-2}$

36. What is the molecular formula for nonane?

- a) C_6H_{12} b) C_6H_{14} c) C_8H_{18} d) C_9H_{20} e) $\text{C}_{11}\text{H}_{22}$

37. What is the name of the following?

- 5-ethyloctane
- 3-propylheptane
- 5-propylheptane
- 4-ethyloctane



38. Draw the structure for 2,3,5-Trimethyl-4-propylheptane

39. A saturated hydrocarbon is

- a hydrocarbon that contains oxygen.
- a compound in which all carbon atoms have four single bonds.
- a compound in which one or more carbon atoms have double or triple bonds.
- a hydrocarbon that is dissolved in water.
- a cycloalkane with five or more carbons.