CHM 152 HOUR EXAM 3 Name _____
Spring 2013 Diebolt

TABLE I: Reduction Potentials

$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	$\mathcal{E}^o_{red} = -0.74$ V
$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$	$\mathcal{E}^o_{red} = -0.40$ V
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	$\mathcal{E}^o_{red} = -0.13$ V
$Cu^{+}(aq) + e^- \rightarrow Cu(s)$	$\mathcal{E}^o_{red} = 0.52$ V
$Hg^{2+}(aq) + 2e^- \rightarrow Hg(s)$	$\mathcal{E}^o_{red} = 0.85$ V

Part One: Multiple choice. Make sure that you **bubble the 10 digit phone # for your ID#** on the **answer side** and **write name** on **the information side**. (42 points; 3 points each)

1. Which substance is serving as the oxidizing agent in the following reaction?

   $6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \rightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$

   A. $Fe^{2+}(aq)$ B. $Cr_2O_7^{2-}(aq)$ C. $H^+(aq)$ D. $Fe^{3+}(aq)$ E. $Cr^{3+}(aq)$

2. Which of the following statements is **not** true for the following galvanic cell

   $Cr(s)|Cr^{3+}(aq)||Ag^+(aq)|Ag(s)$?

   A. electrons move through a wire towards the silver electrode during discharge.
   B. the mass of the silver electrode increases during discharge.
   C. anions from the salt bridge move into the compartment containing silver.
   D. the concentration of Cr^{3+} ions increases during discharge.
   E. chromium is oxidized as the reaction proceeds in this voltaic cell.

3. Which of the following will react spontaneously? (Refer to Table I above.)

   A. $Cu^+(aq)$ with $Hg(s)$ B. $Cr^{3+}(aq)$ with $Cd(s)$ C. $Pb(s)$ with $Cd(s)$
   D. $Cd(s)$ with $Cu^+(aq)$ E. $Cd^{2+}(aq)$ with $Pb(s)$

4. Which substance is the **strongest reducing agent?** (Refer to Table I above.)

   A. $Cr(s)$ B. $Pb(s)$ C. $Cr^{3+}(aq)$ D. $Hg^{2+}(aq)$ E. $Hg(s)$

5. Which of the following is TRUE regarding a galvanic cell?

   A. Cations in the salt bridge move into the anode compartment.
   B. The overall cell emf is negative.
   C. Oxidation occurs at the cathode.
   D. Electrons travel from the cathode to the anode via a connecting wire.
   E. The anode electrode is losing mass as the cell runs.

6. Which of the following is true when one mole of $H_2O(l)$ changes to $H_2O(s)$?

   A. ΔS is + and ΔH is + B. ΔS is + and ΔH is –
   C. ΔS is – and ΔH is + D. ΔS is – and ΔH is –

7. Which of the following has the largest absolute entropy at 25 °C?

   A. $H_2O(l)$ B. $Pt(s)$ C. $C_4H_{10}(g)$ D. $Ar(g)$ E. $FePO_4(s)$

8. In which of the following reactions is $\Delta S°$ negative?

   1. $C_4H_{10}(s) \rightarrow C_4H_{10}(g)$
   2. $CS_2(g) + 4H_2(g) \rightarrow CH_4(g) + 2H_2S(g)$
   3. $NH_3(g) + H_2S(g) \rightarrow NH_4HS(s)$

   1 only B. 2 only C. 3 only D. 1 and 2 only E. 2 and 3 only

9. Which of the following does not have a standard free energy of formation of zero?

   A. $Ne(g)$ B. $I_2(l)$ C. $N_2(g)$ D. $Au(s)$ E. $\Delta G_f^\circ = 0$ for all of these

10. Some standard entropies (S°) are given at 25 °C:

$N_2O_5(g)$ 355.2 $\frac{J}{K \cdot mol}$	$NO_2(g)$ 239.9 $\frac{J}{K \cdot mol}$	$O_2(g)$ 204.8 $\frac{J}{K \cdot mol}$

    Calculate $\Delta S°$ in $\frac{J}{K}$ for the reaction: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$

    A. 89.5 $\frac{J}{K}$ B. -89.5 $\frac{J}{K}$ C. -454.0 $\frac{J}{K}$ D. +454.0 $\frac{J}{K}$ E. 227.0 $\frac{J}{K}$

11. $\Delta H° = -90.84$ kJ for the following reaction: $2\,Hg(l) + O_2(g) \rightarrow 2HgO(s)$. This reaction is most likely to be

    A. spontaneous at all temperatures
    B. spontaneous at high temperatures but nonspontaneous at low temperatures
    C. spontaneous at low temperatures but nonspontaneous at high temperatures
    D. nonspontaneous at all temperatures

12. Calculate $\Delta G°$ for the following reaction at 25 °C:

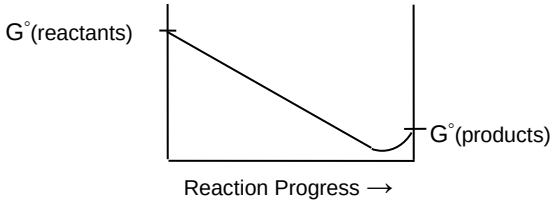
    $I_2(g) + Cl_2(g) \rightarrow 2ICl(g)$; $\Delta H° = -26.9$ kJ; $\Delta S° = 11.3$ J/K

    A. -30.3 kJ B. -23.5 kJ C. -27.2 kJ D. 18.4 kJ E. -3394 kJ

13. $\Delta G° = -36.2$ kJ for a given reaction at 25 °C. Calculate the equilibrium constant, K, at 25 °C.

    A. 0.985 B. 1.01 C. 4.51×10^{-7} D. 2.22×10^{6} E. 4.08×10^{14}

14. The free energy vs. reaction progress diagram below is characteristic of a reaction with:



    A. $\Delta G° > 0$, $\mathscr{E}^o < 0$, $K < 1$ B. $\Delta G° > 0$, $\mathscr{E}^o < 0$, $K > 1$ C. $\Delta G° = 0$, $\mathscr{E}^o = 0$, $K = 1$
    D. $\Delta G° < 0$, $\mathscr{E}^o > 0$, $K < 1$ E. $\Delta G° < 0$, $\mathscr{E}^o > 0$, $K > 1$

Part Two. Short Answer and Numerical Problems. For calculation questions, you must SHOW YOUR WORK, including UNITS, to receive full credit. (58 points)

1. Calculate the molar solubility of $Fe(OH)_3$ in pure water. For $Fe(OH)_3$, $K_{sp} = 1.1 \times 10^{-36}$. (8 pts)

2. If you mix 200.0 mL of 2.40×10^{-3} M $Na_2CO_{3(aq)}$ with 400.0 mL of 1.50×10^{-3} M $AgNO_{3(aq)}$, does Ag_2CO_3 precipitate? Show your work mathematically by calculating the Q value. For Ag_2CO_3, $K_{sp} = 8.5 \times 10^{-12}$. (10 pts)

3. Answer the following questions about this galvanic cell: $Cr(s) \mid Cr^{3+}(aq) \parallel Cd^{2+}(aq) \mid Cd(s)$. Refer to Table I on page 1 for the standard reduction potentials. (20 pts)

   A. What is the overall balanced cell reaction? (3 pts) _____

   B. What is the standard cell potential, $\mathcal{E}^{\circ}_{cell}$? (2 pts) _____

   C. What is the oxidation ½ reaction? (2 pts) _____

   D. Which electrode is gaining mass? (2 pts) _____

   E. Calculate ΔG° for this cell. (5 pts)

   F. Calculate the equilibrium constant, K, for this cell. (6 pts)

4. A certain galvanic cell is constructed based on the following half reactions: (20 pts)

$Cu^{+}_{(aq)} + e^{-} \rightarrow Cu_{(s)}$ $\mathcal{E}^{o}_{red} = 0.52$ V

$Sn^{4+}_{(aq)} + 2e^{-} \rightarrow Sn^{2+}_{(aq)}$ $\mathcal{E}^{o}_{red} = 0.15$ V

A. Assign the anode and cathode half reactions for the cell. (Make sure to write the reactions in the appropriate direction!) (4 pts)

cathode half reaction: _____

anode half reaction: _____

B. Write an overall balanced reaction for the cell and determine the standard cell potential, $\mathcal{E}^{\circ}_{cell}$. (6 pts)

Overall reaction: _____

$\mathcal{E}^{\circ}_{cell}$ **=** _____

C. (1 pt) atom oxidized: _____ (1 pt) atom reduced: _____

D. Calculate the cell potential, $\mathcal{E}_{cell}$, at 25 °C when $[Cu^{+}] = 1.75$ M, $[Sn^{4+}] = 0.45$ M and $[Sn^{2+}] = 1.15$ M. (8 pts)

	pts earned	pts possible
multiple choice		42
Part two		58
Total Pts		100