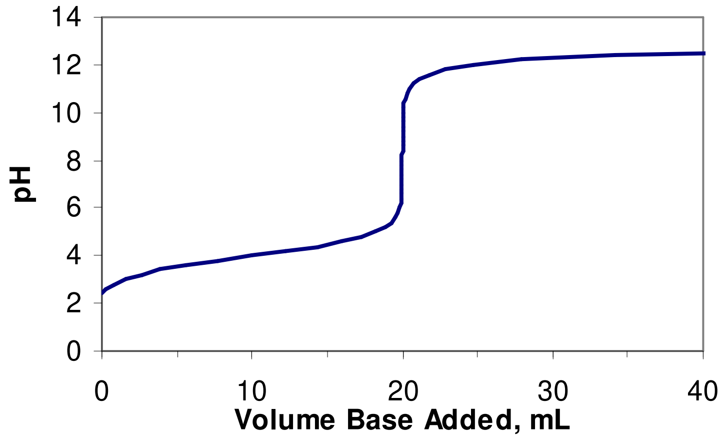
Chem 131 **Name**______________________________
Exam 3, Ch 17, 18, 20, 24 **April 25, 2012**
100 Points

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Part 0: Warmup. 4 points each

1. The titration curve show below is for the titration of 0.10 M acid with 0.10 M NaOH. Which of the acids below must have been titrated to generate this curve?



   a. HCl
   b. HNO_2, $K_a = 4.0 \times 10^{-4}$
   c. $HClO_2$, $K_a = 1.2 \times 10^{-2}$ Answer _____________
   d. HOCl, $K_a = 3.5 \times 10^{-8}$
   e. Not enough information to tell.

2. Consider the following salts: AgI, PbI_2, and CoI_3. If all three salts have the same K_{sp}, which of the salts has the largest solubility?
   a. AgI
   b. PbI_2
   c. CoI_3 Answer _____________
   d. They have the same solubility.

3. Based on the data below, arrange the following in order of increasing strength as a <u>reducing agent</u>. Poorest reducing agent → Best reducing agent.

$Fe^{3+} + 2e^- \rightleftarrows Fe^{2+}$	$E^o = +0.77$ V	$2H^+ + e^- \rightleftarrows H_2$	$E^o = +0.00$ V
$H_2O_2 + 2H^+ + 2e^- \rightleftarrows 2H_2O$	$E^o = +1.78$ V	$ClO_2 + e^- \rightleftarrows ClO_2^-$	$E^o = +0.91$ V

   a. $H_2O < ClO_2^- < H_2 < Fe^{2+}$
   b. $H_2O < Fe^{2+} < H_2 < ClO_2^-$
   c. $H_2 < ClO_2^- < H_2O < Fe^{2+}$ Answer _____________
   d. $H_2 < Fe^{2+} < ClO_2^- < H_2O$

Part I: Complete all of problems 3-7

4. Define **three** of the following in a maximum of three sentences per item: (12 points)

   a. equivalence point:

   b. coordination number:

   c. electrolytic cell:

   d. bidentate:

5. KI(aq) is slowly added to a solution with $[Pb^{2+}] = [Ag^{+}] = 0.10$ M. What precipitate should form first? What $[I^{-}]$ is required for the second cation to begin to precipitate? Justify your answers with calculations. K_{sp} for lead iodide is 7.1×10^{-9}, K_{sp} for silver iodide is 8.5×10^{-17} (12 points)

6. Consider the titration of 20.0 mL of 0.200 M lactic acid ($HC_3H_5O_3$, pK_a = 3.86) with 0.200 M NaOH.
   a. Calculate the pH after the addition of **two** of the following volumes of NaOH: 0.00 mL, 5.00 mL, 10.00 mL, 15.00 mL, 20.00 mL, 25.00 mL, 30.00.mL (10 points)

Volume 1 = _____ mL

Volume 2 = _____ mL

   b. Would methyl orange (pK_{HIn} = 4.0) be an appropriate indicator for this titration? Why or Why not? (4 points)

Part II. Electrochemistry. Answer two (2) of problems 7-9. Clearly mark the problem you do not want graded. 14 points each.

7. In electrorefining, impure metals, such as copper and gold are purified via electrolysis. For copper, an impure piece of copper ore is used as the anode and pure copper as the cathode. Both electrodes are immersed in a solution of copper (II) sulfate and a current is passed through the cell, resulting in deposition of pure copper on the cathode. If a current of 1.75 A is passed for 1 hour and 45 minutes, what mass of copper should deposit?

8. The potential of the electrochemical cell below was measured to be +0.0567 V. What is the K_{sp} for PbI_2? The E° for $Pb^{2+} + 2\ e^- \rightleftarrows Pb^o$ is -0.125 V

$$Pb(s)\ |\ Pb^{2+}\ (\text{sat'd } PbI_2)\ \|\ Pb^{2+}\ (0.100\ M)\ |\ Pb(s)$$

9. Consider a galvanic cell consisting of one half cell with a gold wire dipped in a solution containing Au^{3+}, and a second half cell containing a tin wire immersed in Sn^{2+}. The standard reduction potentials are given below.

$$Au^{3+} + 3e^{-} \rightleftarrows Au^{o} \qquad E^{o} = +1.500\ V$$
$$Sn^{2+} + 2e^{-} \rightleftarrows Sn^{o} \qquad E^{o} = -0.137\ V$$

a. Determine the spontaneous overall cell reaction and calculate E^{o}_{cell}. Indicate which electrode is behaving as the anode and which is behaving as the cathode. (5 points)

b. Calculate K for the cell reaction at 25°C. If you did not get a result for part a, propose a reasonable value. (4 points)

c. Calculate E_{cell} at 25°C when $[Au^{3+}]$ = 0.0100 M and $[Sn^{2+}]$ = 0.00100 M. (5 points)

Part III. Transition Metals and Coordination Chemistry. Complete two (2) of problems 10-12. Clearly mark the problem you do not want graded. (14 points each)

10. Complete the table below.

Formula	*mer*-$[CrCl(ox)(NH_3)_3]$	
Name		*cis*-diamminedichloroplatinum (II)
Metal oxidation state		
Coordination number		
Sketch		

11. Consider the two complexes: $[MnCl_6]^{4-}$ and $[Mn(CN)_6]^{4-}$. What leads to crystal-field splitting in these complex ions? Given that CN^- is a strong-field ligand and Cl^- is a weak-field ligand, sketch the orbital-energy level diagram for each ion. How many unpaired electrons are in each ion?

12. Briefly compare and contrast each of the terms in the following pairs:

a. weak-field ligand vs. strong field ligand

b. low-spin complex vs. high-spin complex

Possibly Useful Information

$R = 8.31441\ J\ mol^{-1}\ K^{-1}$	$^{o}C = K - 273.15$
$\Delta G = \Delta H - T\Delta S$	$\Delta G = \Delta G^{o} - RT\ln Q$
$\Delta G^{o} = -nFE^{o} = -RT\ln K$	$K_aK_b = K_w = 1.00 \times 10^{-14}$
$x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	pi = 3.14159
$pH = pK_a + \log\left(\dfrac{[\text{conjugate base}]}{[\text{weak acid}]}\right)$	pH + pOH = 14
$E = E^{o} - \dfrac{RT}{nF}\ln Q$	$E = E^{o} - \dfrac{0.0591}{n}\log Q$ at 25°C
1 A = 1 C/s	$F = 96485\ C/mol\ e^-$

Weak Field $I^- < Br^- < Cl^- < F^- < OH^- < C_2O_4^{2-} \approx H_2O < NH_3 <$ en $< NO_2^- < CN^-$ **Strong Field**

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)