Chem 131 **Name**_____
Exam 4, Ch 17, 18, 20, 24 **December 4, 2019**
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 I: Complete all of problems 1-10

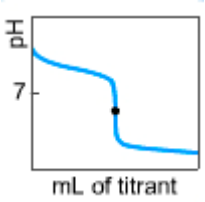
1. What is the oxidizing agent in this reaction: $Mg(s) + Cl_2(g) \longrightarrow Mg^{2+}(aq) + 2Cl^{-}(aq)$? (4 points)

   a. $Mg(s)$ b. $Cl_2(g)$ c. $Mg^{2+}(aq)$ d. $Cl^{-}(aq)$ Answer _____

2. Which of these reagents will oxidize Al to Al^{3+}, but not oxidize Pb to Pb^{2+}. (4 points)

   a. Br_2 b. Ca^{2+} c. Fe^{2+} d. Br^{-} Answer _____

3. Consider the titration curve below. The curve represents (4 points)



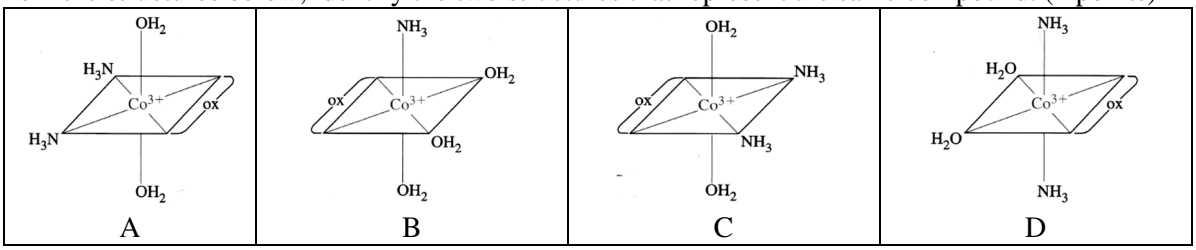
   a. the titration of a strong acid with a strong base.
   b. the titration of a weak acid with a strong base.
   c. the titration of a weak base with a strong acid.
   d. the titration of a strong base with a strong acid.

   Answer _____

4. The equilibrium concentration of barium ion in a saturated solution of barium fluoride is found to be 7.21×10^{-3}M. What is the K_{sp} for barium fluoride? (4 points)

   a. 7.21×10^{-3} b. 1.44×10^{-2} c. 7.50×10^{-7} d. 1.50×10^{-6} Answer _____

5. From the structures below, identify the two structures that represent the same compound. (4 points)



   a. A and B
   b. A and C
   c. B and C
   d. B and D
   e. C and D

   Answer _____

6. Define the following in one or two sentences each. (6 points)
   a. anode

   b. stereoisomer

   c. low spin

7. Complete the table below. (10 points)

Formula of complex	*trans*-$[Co(en)_2Cl_2]^+$	
Name of complex		tris(oxalato)ferrate(III)
Metal oxidation state		
Coordination number		
Sketch		

8. A 0.641 g sample of a monoprotic acid is dissolved in water and titrated with 0.230 M KOH. What is the molar mass of the acid if 14.5 mL of the KOH solution is required to neutralize the sample? (10 points)

Answer_____

9. A galvanic (voltaic) cell consists of an electrode composed of iron immersed in a 1.0 M iron (II) ion solution and another electrode composed of silver immersed in a 1.0 M silver (I) ion solution, connected by a salt bridge. Identify the cathode and anode and calculate the standard potential for this cell at 25 C. (10 points)

Answer_____

10. The K_{sp} of $PbBr_2$ is 6.60×10^{-6}. What is the molar solubility of $PbBr_2$ in 0.511 M sodium bromide? (10 points)

Answer_____

Part II. Answer three (3) of problems 11-14. Clearly mark the problems you do not want graded. 12 points each.

11. Calculate the potential for the galvanic cell below using the given conditions. You may assume a temperature of 298K.

$$Al(s) \,|\, 0.234\ M\ Al^{3+}(aq) \,\|\, 0.0115\ M\ Sn^{2+}(aq) \,|\, Sn(s)$$

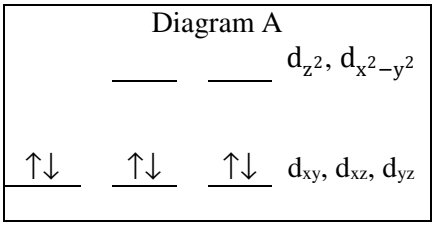
Answer_____

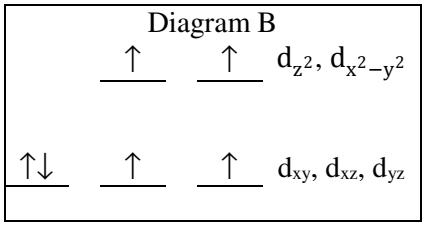
12. Maleic acid ($C_4H_4O_4$, molar mass 116.1 g/mol, $pK_{a1} = 1.92$, $pK_{a2} = 6.27$) is a weak diprotic acid that is often used to increase the stability of drug compounds. Calculate the pH at ***any three (3)*** of the following points in the titration of 20.0 mL of 0.100 M maleic acid with 0.100 M NaOH.
    a. Before the addition of NaOH
    b. After the addition of 10.0 mL NaOH
    c. After the addition of 20.0 mL NaOH
    d. After the addition of 30.0 mL NaOH
    e. After the addition of 50.0 mL NaOH

13. You have a bottle of a white solid that you believe to be either calcium hydroxide ($K_{sp} = 6.5x10^{-6}$) or manganese (II) hydroxide ($K_{sp} = 1.6 \times 10^{-13}$). You prepare a saturated solution of the salt and measure the solution's pH. If the pH of the solution is 9.84, what is the identity of your unknown salt? Justify your answer with a calculation.

Answer_____

14. Cobalt (III) forms octahedral complexes with fluoride ion and ammonia with the formulae $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$, respectively. Below are two possible orbital energy diagrams for these species. Which of the diagrams corresponds to the fluoride complex and which one corresponds to the ammonia complex? Clearly explain your reasoning.



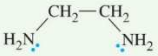
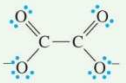
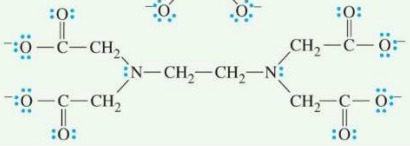


Possibly Useful Information

$R = 8.31441\ J\ mol^{-1}\ K^{-1}$	$^oC = K - 273.15$	$R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$
$F = 96485\ C\ mol^{-1}$	$1\ A = 1\ C\ sec^{-1}$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$\Delta G^o = \Delta H^o - T\Delta S^o = -RT\ln K$	$\Delta G = \Delta G^o - RT\ln Q$	$\Delta G = -nFE$
$pH = pK_a + \log\left(\frac{[conjugate\ base]}{[weak\ acid]}\right)$	$pH + pOH = 14$	$K_aK_b = K_w = 1.00 \times 10^{-14}$
$E^o_{cell} = E^o_{cathode} - E^o_{anode}$ or $E^o_{cell} = E^o_{cathode} - E^o_{anode}$	$E = E^o - \frac{2.303RT}{nF}\log Q$	$E = E^o - \frac{0.05916V}{n}\log Q$

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

TABLE 24.3 Some Common Polydentate Ligands (Chelating Agents)

Abbreviation	Name	Formula
en	Ethylenediamine	
ox^{2-} [a]	Oxalato	
$EDTA^{4-}$ [b]	Ethylenediaminetetraacetato	

Periodic Table of the Elements

IA 1A																	VIIIA 8A
1 H Hydrogen 1.008	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

TABLE 20.1 Some Selected Standard Electrode (Reduction) Potentials at 25 °C

Reduction Half-Reaction	$E°$, V
Acidic solution	
$F_2(g) + 2\,e^- \longrightarrow 2\,F^-(aq)$	+2.866
$O_3(g) + 2\,H^+(aq) + 2\,e^- \longrightarrow O_2(g) + H_2O(l)$	+2.075
$S_2O_8^{2-}(aq) + 2\,e^- \longrightarrow 2\,SO_4^{2-}(aq)$	+2.01
$H_2O_2(aq) + 2\,H^+(aq) + 2\,e^- \longrightarrow 2\,H_2O(l)$	+1.763
$MnO_4^-(aq) + 8\,H^+(aq) + 5\,e^- \longrightarrow Mn^{2+}(aq) + 4\,H_2O(l)$	+1.51
$PbO_2(s) + 4\,H^+(aq) + 2\,e^- \longrightarrow Pb^{2+}(aq) + 2\,H_2O(l)$	+1.455
$Cl_2(g) + 2\,e^- \longrightarrow 2\,Cl^-(aq)$	+1.358
$Cr_2O_7^{2-}(aq) + 14\,H^+(aq) + 6\,e^- \longrightarrow 2\,Cr^{3+}(aq) + 7\,H_2O(l)$	+1.33
$MnO_2(s) + 4\,H^+(aq) + 2\,e^- \longrightarrow Mn^{2+}(aq) + 2\,H_2O(l)$	+1.23
$O_2(g) + 4\,H^+(aq) + 4\,e^- \longrightarrow 2\,H_2O(l)$	+1.229
$2\,IO_3^-(aq) + 12\,H^+(aq) + 10\,e^- \longrightarrow I_2(s) + 6\,H_2O(l)$	+1.20
$Br_2(l) + 2\,e^- \longrightarrow 2\,Br^-(aq)$	+1.065
$NO_3^-(aq) + 4\,H^+(aq) + 3\,e^- \longrightarrow NO(g) + 2\,H_2O(l)$	+0.956
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.800
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.771
$O_2(g) + 2\,H^+(aq) + 2\,e^- \longrightarrow H_2O_2(aq)$	+0.695
$I_2(s) + 2\,e^- \longrightarrow 2\,I^-(aq)$	+0.535
$Cu^{2+}(aq) + 2\,e^- \longrightarrow Cu(s)$	+0.340
$SO_4^{2-}(aq) + 4\,H^+(aq) + 2\,e^- \longrightarrow 2\,H_2O(l) + SO_2(g)$	+0.17
$Sn^{4+}(aq) + 2\,e^- \longrightarrow Sn^{2+}(aq)$	+0.154
$S(s) + 2\,H^+(aq) + 2\,e^- \longrightarrow H_2S(g)$	+0.14
$2\,H^+(aq) + 2\,e^- \longrightarrow H_2(g)$	0
$Pb^{2+}(aq) + 2\,e^- \longrightarrow Pb(s)$	−0.125
$Sn^{2+}(aq) + 2\,e^- \longrightarrow Sn(s)$	−0.137
$Fe^{2+}(aq) + 2\,e^- \longrightarrow Fe(s)$	−0.440
$Zn^{2+}(aq) + 2\,e^- \longrightarrow Zn(s)$	−0.763
$Al^{3+}(aq) + 3\,e^- \longrightarrow Al(s)$	−1.676
$Mg^{2+}(aq) + 2\,e^- \longrightarrow Mg(s)$	−2.356
$Na^+(aq) + e^- \longrightarrow Na(s)$	−2.713
$Ca^{2+}(aq) + 2\,e^- \longrightarrow Ca(s)$	−2.84
$K^+(aq) + e^- \longrightarrow K(s)$	−2.924
$Li^+(aq) + e^- \longrightarrow Li(s)$	−3.040