CHEM 108 (Spring-2008)

Final Exam (106 pts)

Name: ----------, CLID # ----------

LAST NAME, First

(Circle the alphabet segment of your LAST NAME): A-D E-L M-P Q-Z

Please answer the following questions:

Part I: Multiple Choices (45 pts: 15 @ 3 pts each). Circle the ***ONE*** best answer:

1. The average normal concentration of Ca^{2+} in urine is 5.33 g/L. What concentration of oxalate, $C_2O_4^{2-}$ is needed to precipitate calcium oxalate, CaC_2O_4 ($K_{sp} = 2.3 \times 10^{-9}$) to initiate the formation of a kidney stone?

   a) 4.3×10^{-10} b) 1.7×10^{-8}

   c) 5.5×10^{-8} d) no answer was given

2. Which of the following equations DO NOT represent an oxidation?

   a) $SO_2 \longrightarrow SO_3$

   b) $Mg \longrightarrow Mg^{2+}$

   c) $MnO_2 \longrightarrow Mn^{2+}$

   d) $2\ Br^- \longrightarrow Br_2$

3. The oxidation states of chlorine in ClO_2^- and Cl_2O_7 are:

   a) –1 and –7, respectively b) +1 and –7, respectively

   c) –1 and +7, respectively d) +3 and +7, respectively

4. Refer to the data given in the information sheet and with the following information:

   $Fe^{3+}(aq) + H_2(g) \longrightarrow 2\ H^+(aq) + Fe^{2+}(aq)$ $E°_{cell} = 0.77$ V

   Determine E° for the reaction: $Fe^{3+}(aq) + e \longrightarrow Fe^{2+}(aq)$

   a) 1.54 V b) -0.77 V

   c) 0.77 V d) 0.39 V

5. Which of the following statements is FALSE:

   a) Reactions with negative $\Delta H°_{rxn}$ and positive $\Delta S°_{rxn}$ are *product-favored* at all temperatures.
   b) The entropy of a pure, perfect crystal is zero at 0 K.
   c) A sample of pure I_2 vapor has higher entropy than pure solid I_2 (both at room temperature).
   d) At the same temperature a gaseous CH_4 molecule has more entropy than a gaseous C_4H_{10} molecule.

6. The pH of a 0.30 M solution of HCN is 5.20. Calculate the K_a value for HCN.

   a) 1.3×10^{-10} b) 6.3×10^{-6}

   c) 4.8×10^{-2} d) 2.1×10^{-5}

7. Lactic acid, $C_3H_6O_3$, is a weak organic acid present in both sour milk and buttermilk. It is also a product of carbohydrate metabolism and is found in blood after vigorous muscular activity. A buffer is prepared by dissolving 1.00 mol of lactic acid, HLac ($K_a = 1.4 \times 10^{-4}$) and 1.00 mol of sodium lactate, NaLac, in enough water to form 550. mL of solution. Calculate the pH of this solution.

a) 3.85 b) 11.15

c) 0.0 d) 0.260

8. Predict the signs of $\Delta S°$, $\Delta H°$, and $\Delta G°$ for the following process (at 25 °C):

$2\ H_2O\ (l) \longrightarrow 2\ H_2\ (g) + O_2\ (g)$

	$\Delta S°$	$\Delta H°$	$\Delta G°$
a)	-	+	+
b)	+	+	-
c)	+	-	-
d)	+	+	+

9. Which would have the <u>lowest boiling point</u>?

a) CS_2 (linear) b) CCl_4

c) CI_4 d) CH_3OH

10. When a solid NH_4SH is placed in a close flask at 28º C, the solid dissociates according to the equation:

$NH_4SH\ (s) \rightleftharpoons NH_3\ (g) + H_2\ (g)$

The total pressure of the equilibrium mixture is 0.840 atm. Determine K_p at this temperature.

a) 0.147 b) 0.176

c) 0.648 d) 0.420

11. Which plot would not yield the indicated data for the reaction: A $\longrightarrow$ Product (s)

a) ln [A] *vs.* t: rate constant for a first order reaction.

b) 1/ [A] *vs.* t: rate constant for a second order reaction.

c) [A] *vs.* t: rate constant for a zero order reaction.

d) k *vs.* 1/T (K): activation energy

12. Consider 0.10 M solutions of the following substances. Which would have the <u>highest</u> pH?

a) NaCl b) NH_4NO_3

c) HCN d) Na_2CO_3

13. Calculate the pH after 10.0 mL of 0.40 M HCl is added to 20.0 mL of 0.50 M NaOH.

a) 7.00 b) 0.40

c) 13.70 d) 13.30

14. Initial rate data were obtained for the following reaction:

$H_2\,(g) + Cl_2\,(g) \longrightarrow 2\,HCl\,(g)$

Expt No.	Initial $[H_2]$, M	Initial $[Cl_2]$, M	Initial Rate, $M.s^{-1}$
1	0.0020	0.0050	2.5×10^{-3}
2	0.0020	0.0025	1.3×10^{-3}
3	0.0015	0.0025	1.3×10^{-3}
4	0.0050	0.0010	0.5×10^{-3}

What is the rate law for the reaction?

a) Rate = $k\,[Cl_2]^2$ b) Rate = $k[H_2]$

c) Rate = $k[Cl_2]$ d) Rate = $k[H_2][Cl_2]$

15. Consider the reaction:

$2\,SO_2\,(g) + O_2\,(g) \rightleftharpoons 2\,SO_3\,(g)$ $\Delta H° = -198$ kJ

The concentration of O_2 (g) at equilibrium <u>increases</u> if

a) SO_2 is added to the system b) The temperature of the system is lowered

c) SO_3 is added to the system d) Increasing the pressure of the reaction

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<u>Part II</u> (25 pts)

1. (**8 pts**) Balance the following redox equation in <u>acidic solution</u>:

$SO_3^{2-}\,(aq) + MnO_4^-\,(aq) \longrightarrow SO_4^{2-}\,(aq) + Mn^{2+}\,(aq)$

Then identify the oxidizing agent and how many electron(s) are transferred per one mole of the oxidizing agent.

Balanced equation:

Oxidizing agent: ---------- & Number of electrons/mole of oxidizing agent: --------

2. (**5 pts**: 5 @ 1 pt each): Fill the blanks

a) $\Delta H°$ and $\Delta G°$ become equal at ---------- K.

b) $\Delta G°$ and ΔG are equal when Q = ----------.

c) The solubility product for CaF_2 is evaluated by the expression K_{sp} = ----------.

d) The equilibrium constant for the reaction $2\ C\ (s) + O_2\ (g) \rightleftharpoons 2\ CO_2\ (g)$ is evaluated by the expression K = ----------

e) In voltaic cells, the value of $\Delta G°$ is always ----------.

3. (**12 pts**) The following figure depicts the electrochemical cell for the reaction.

$$2\ Ag^+\ (aq) + Pb\ (s) \longrightarrow 2\ Ag\ (s) + Pb^{2+}\ (aq)$$

a) (6 pts) Label the components of the cell (anode, cathode, flow of electrons and ions) and sketch the reaction (oxidation & reduction) at each electrode

b) (6 pts) Using the standard electrode potentials given in the data sheet, calculate $\Delta E°_{cell}$ and $\Delta G°_{cell}$.

$\Delta E°_{cell}$ = + 0.926 V

$\Delta G°_{cell}$ =

<u>Part III</u> (36 pts: 6@ 6 pts each) Calculations: **<u>Show all work for full credit</u>. Please express all answers with <u>proper units</u> and correct number of significant figures**.

1. For how many minutes must the electrolysis of a solution containing Au^{3+} (aq) be carried out with a current of 3.55 A to deposit 1.00 g Au at the cathode {Au^{3+} (aq) + 3 e $\longrightarrow$ Au(s)}?

6.90 min

2. For the following reaction at 298 K:

$$2\ HI\ (g) + Cl_2\ (g) \longrightarrow 2\ HCl\ (g) + I_2\ (s)$$

	HI (g)	Cl_2 (g)	HCl (g)	I_2 (s)
$\Delta H_f°$ (kJ/mol)	+26.5	0	-92.3	0
S° (J/K.mol)	206.5	223.0	186.8	116.1

a) Calculate ΔG° in kilojoules

$\Delta G°_{rxn}$ (kJ)

b) Is the calculated entropy change consistent with what you expected? Why?

c) Calculate the equilibrium constant for the reaction at 298 K.

K =

3. In the titration of 20.0 mL of 0.200 M HOBr ($K_a = 2.5 \times 10^{-9}$) with 0.100 M NaOH, what is the pH at the equivalence point?

pH = 10.71

4. A solution of urea, $(NH_2)_2CO$ that is 15% by mass has a density of 1.12 g/mL. Calculate the molarity and the molality of this solution.

Molarity =

Molality =

5. Nicotine, extracted from tobacco leaves, is a liquid completely miscible with water at temperature below 60 °C. If a solution made by dissolving 1.921 g of nicotine in 48.92 g H_2O starts to freeze at –0.450°C. What must be the molar mass of nicotine? (K_f = 1.86°C/m for water)

Molar mass = 162 g/mol

6. Calculate the solubility, in milligrams of MgF_2 (MM = 62.31 g/mol) in 100. mL of 0.10 M NaF solution. (Ksp = 3.7×10^{-8})

Solubility = 0.37

PREFERENCE SHEET FOR CHEM 108

Final Exam – Spring 2008

You will have <u>120 minutes</u> to complete this exam.
The exam has <u>7 pages plus Periodic Table and Reference page</u>.

When you are told to do so, tear off the Periodic Table cover sheet and use as required during exam.

<u>Useful Information:</u>

Gas Constant: R = 8.3145 J/K.mol = 8.3145 x 10^{-3} kJ/K.mol = 0.0821 L atm/mol.K
K = 273 + °C 1 atm = 760 torr = 760 mmHg Standard temperature = 298.15 K
Faraday`s constant, F = 9.65 x 10^4 C/mol = 9.65 x 10^4 J/K.mol 1 V = 1 J.C^{-1}

<u>Standard electrode potential at 25°C</u>

Fe^{2+} (aq) + 2e ⟶ Fe (s)	E° = -0.44 V
Pb^{2+} (aq) + 2e ⟶ Pb (s)	E° = -0.125 V
2 H^+ (aq) + 2e ⟶ H_2 (g)	E° = 0.0 V
Ag^+ (aq) + e ⟶ Ag (s)	E° = +0.800 V
O_2 + 4 H^+ + 4 e ⟶ 2 H_2O	E° = +1.23 V
Cl_2 (g) + 2e ⟶ 2 Cl^- (aq)	E° = +1.360 V
F_2 (g) + 2e ⟶ 2 F^- (aq)	E° = +2.87 V

<u>Useful Equations:</u>

d (density) = mass (m)/volume (V) $PV = nRT$

$\pi = MRT$ $\Delta T = i.\ Km.$ $P_1 = \chi_1.P_1^o$ $\Delta P = \chi_2.P_1^o$

$\ln (P_1/P_2) = (\Delta H_{vap}/R)\{(T_1-T_2)/T_1T_2\}$ $C_g = k.P_g$ $n_i = P_i/P_t$

Rate = k[A] $\ln \frac{[A]_o}{[A]} = kt$ $\ln[A] = -kt + \ln[A]_o$ $t_{1/2} = \ln 2/k = 0.693/k$

Rate = $k[A]^2$ $1/[A] - 1/[A]_o = kt$ $t_{1/2} = 1/k[A]_o$

Rate = k $[A] = -kt + [A]_o$ $t_{1/2} = [A]_o/2k$

$k = Ae^{-E_a/RT}$ $\ln k = (-E_a/R)(1/T) + \ln A$ $\ln (k_1/k_2) = (E_a/R)\{(T_1-T_2)/T_1T_2\}$

$K_p = K_c\ (0.0821\ T)^{\Delta n}$

$\Delta G° = \Delta H° - T\Delta S°$
$\Delta G°_{rxn} = -nFE° = -RT\ln K$ $E° = (0.0257\ V/n) \ln K$ (at 25° C)
Nernst Equations: $\Delta G_{rxn} = \Delta G°_{rxn} + RT\ln Q$ & $E_{cell} = E°_{cell} - (0.0257\ V/n) \ln Q$ (at 25° C)
$\Delta G°_{rxn} = -RT\ln K$

Charge (coulombs, C) = current (A) x time (s)

Periodic Table of the Elements

1	1 **H** 1.01																2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.08	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.1	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.1
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 181.0	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Uun** (269)	111 **Uuu** (272)	112 **Uub** (277)						

	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	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** (260)