Exam Four **CHM 205 (Dr. Mattson)** **17 April 2012**	***Print your name:*** ***Signature:***	***Circle your section:*** ***8:30 9:30***

Instructions: Show all work whenever a calculation is required! You will receive credit for how you worked each problem as well as for the correct answer. If you need more space, you may use your data sheet — Write: "See attached" in box and then attach the data sheet with your name on it. BOX YOUR ANSWERS! Write legibly.

1. (3 pts) What is the molar solubility of barium sulfate given $K_{sp} = 1.5 \times 10^{-9}$? As always, include units!

2. (3 pts) What is the molar solubility of barium sulfate in a solution that contains 0.230 M sodium sulfate?

3. (4 pts) What is the $[Ag^+]$ in a saturated solution of Ag_3PO_4, given $K_{sp} = 1.8 \times 10^{-18}$?

4. (4 pts) What is the pH of a saturated solution of $Ca(OH)_2$, given $K_{sp} = 2.5 \times 10^{-16}$?

5. (5 pts) For which of these processes is $\Delta S > 0$?
   (a) solid sugar dissolving in hot water
   (b) iodine vapor condensing on a cold surface
   (c) a solution of salt mixing with a solution of sugar when poured together
   (d) crystals growing from a supersaturated solution
   (e) $2\ H_2S(g) + SO_2(g) \rightarrow 3\ S(s) + 2\ H_2O(g)$

6. (5 pts) For which of these processes is $\Delta G^o < 0$?
   (a) ice melting
   (b) water vapor condensing on a cold surface
   (c) a strong acid reacting with a strong base
   (d) $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$
   (e) $2\ H(g) \rightarrow H_2(g)$

7. Consider the following reaction and data:

$$PbS(s) + 2\ O_2(g) \rightarrow PbSO_4(s)$$

	ΔH_f^o (kJ/mol)	S^o (J/mol K)
$PbS(s)$	-100	91
$PbSO_4(s)$	-920	149
$O_2(g)$	0	205

7a. (3 pts) Calculate ΔH^o_{rxn}.

7b. (3 pts) Calculate ΔS^o_{rxn}.

7c. (1 pt) Under what conditions will this reaction be spontaneous?
   (a) all temperatures (b) only at high temperatures
   (c) never (d) only at low temperatures

8. (3 pts) Consider the reactions:

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta G^o = -300.$ kJ

$2\ S(s) + 3\ O_2(g) \rightarrow 2\ SO_3(g)$ $\Delta G^o = -742$ kJ

Calculate ΔG^o for $2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$

As always, show your work.

9. A reaction that destroys ozone in the upper atmosphere is caused by from high-flying jets:

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ $\Delta H^o = -199$ kJ

$\Delta S^o = -5.0$ J/K

9a. (3 pts) Calculate ΔG^o for the reaction

9b. (4 pts) Calculate K_p for the reaction.

9c. (1 pt) How does K_p compare to K_c?

(a) $K_p > K_c$ (b) $K_p < K_c$ (c) $K_p = K_c$

9d. (4 pts) Calculate ΔG at 298 K given $P_{NO} = P_{O_3} =$ 0.00050 atm and $P_{NO_2} = P_{O_2} = 1.0$ atm.

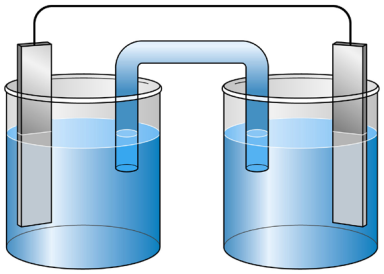
9e. (1 pt) Would increasing the temperature increase ΔG? Circle: Yes No Need more info

10. (3 pts) The phase change $Br_2(l) \rightarrow Br_2(g)$ has $\Delta H_{vap} = 30.9$ kJ/mol and $\Delta S_{vap} = 102.6$ J/mol K. What is the boiling point of bromine?

11. Consider the following Galvanic cell:

$$Cd(s) + Ni^{+2}(aq) \rightarrow Cd^{+2}(aq) + Ni(s)$$

11a. (5 pts) Label the electrodes and metal ions in solutions in the diagram. Indicate electron flow.



anode **cathode**

11b. (3 pts) Determine E^o. As always, show work.

11c. (1 pt) In which cell is the concentration of metal ions increasing? Circle: Anode or Cathode

11d. (1 pt) In which cell is the mass of the electrode increasing? Circle: Anode or Cathode

11e (3 pts) Write the reaction using cell notation assuming all concentrations are 1.0 M

11f. (4 pts) Determine ΔG^o.

11g. (4 pts) Determine K_c.

11h. (4 pts) Determine E if $[Ni^{+2}] = 0.050$ M and $[Cd^{+2}] = 1.00$ M.

12a. (3 pts) Write the balanced reaction for the Galvanic cell made from $Ag|Ag^+$ and $Al|Al^{+3}$.

12b. (2 pts) Determine E^o for the cell.

Subtotal from exam: _____

Homework: _____

Total: _____

Name: (only if you answer yes below): _____

Do you have work to be graded on the back side of this sheet?

YES: If you have done work to be graded on this sheet, you must submit it with your exam and include your name above. Do not clip it to the exam — simply hand them in together.

NO: If there is nothing to grade on this sheet, simply return it to the pile next to the exams.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																1 H 1.01	2 He 4.00
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
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	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
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 97	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Ti 204.37	82 Pb 207.2	83 Bi 208.98	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.03	89 Ac 227															

Useful equations:

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

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

R = 8.314 J/mol K

$\Delta G = \Delta G^o + R\,T \ln Q$

$\Delta G^o = -R\,T \ln K$

$E = E^o - {}^{0.0592}/_{n} \log Q$

$E^o = {}^{0.0592}/_{n} \log K$

$\Delta G = -nFE \quad \Delta G^o = -nFE^o$

1 Faraday(F) = 96500 coul =

1 mol e^- = 96500 J/mol V

Charge = current x time

(coul) = (amps) x (sec)

Standard Reduction Potentials at 25 °C

Reduction Half-Reaction		E^o (V)
$F_2(g) + 2\,e^-$	$\longrightarrow 2\,F^-(aq)$	2.87
$H_2O_2(aq) + 2\,H^+(aq) + 2\,e^-$	$\longrightarrow 2\,H_2O(l)$	1.78
$MnO_4^-(aq) + 8\,H^+(aq) + 5\,e^-$	$\longrightarrow Mn^{2+}(aq) + 4\,H_2O(l)$	1.51
$Cl_2(g) + 2\,e^-$	$\longrightarrow 2\,Cl^-(aq)$	1.36
$Cr_2O_7^{2-}(aq) + 14\,H^+(aq) + 6\,e^-$	$\longrightarrow 2\,Cr^{3+}(aq) + 7\,H_2O(l)$	1.36
$O_2(g) + 4\,H^+(aq) + 4\,e^-$	$\longrightarrow 2\,H_2O(l)$	1.23
$Br_2(aq) + 2\,e^-$	$\longrightarrow 2\,Br^-(aq)$	1.09
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	0.80
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	0.77
$O_2(g) + 2\,H^+(aq) + 2\,e^-$	$\longrightarrow H_2O_2(aq)$	0.70
$I_2(s) + 2\,e^-$	$\longrightarrow 2\,I^-(aq)$	0.54
$O_2(g) + 2\,H_2O(l) + 4\,e^-$	$\longrightarrow 4\,OH^-(aq)$	0.40
$Cu^{2+}(aq) + 2\,e^-$	$\longrightarrow Cu(s)$	0.34
$Sn^{4+}(aq) + 2\,e^-$	$\longrightarrow Sn^{2+}(aq)$	0.15
$2\,H^+(aq) + 2\,e^-$	$\longrightarrow H_2(g)$	0
$Pb^{2+}(aq) + 2\,e^-$	$\longrightarrow Pb(s)$	−0.13
$Ni^{2+}(aq) + 2\,e^-$	$\longrightarrow Ni(s)$	−0.26
$Cd^{2+}(aq) + 2\,e^-$	$\longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\,e^-$	$\longrightarrow Fe(s)$	−0.45
$Zn^{2+}(aq) + 2\,e^-$	$\longrightarrow Zn(s)$	−0.76
$2\,H_2O(l) + 2\,e^-$	$\longrightarrow H_2(g) + 2\,OH^-(aq)$	−0.83
$Al^{3+}(aq) + 3\,e^-$	$\longrightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\,e^-$	$\longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.71
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.04

Answers

1. 3.9×10^{-5}

2. 6.5×10^{-9}

3. 4.8×10^{-5}

4. 8.9

5. a, c
6. all (a, b, c, d, e)

7a. -820 kJ

7b. -352 J/K

7c. d

8. -142 kJ

9a. -197.5 kJ

9b. 4.2×10^{34}

9c. c

9d. -160 kJ

9e. ΔG would become less negative

10. 301 K

11a. $Cd(s)/Cd^{+2}$ in the anode; $Ni(s)/Ni^{+2}$ in the cathode

11b. E^o = 0.14 v

11c. Anode

11d. Cathode

11e $Cd(s)|Cd^{+2}$ (1 M)$||Ni^{+2}$ (1 M)|Ni

11f. ΔG^o = -27 kJ

11g. 5.4×10^4

11h. 0.10 v

12a. $3\ Ag^+ + Al \rightarrow Al^{+3} + 3\ Ag$

12b. E^o = 2.46 v