Exam 4 Chm 205 (Dr Mattson) 23 April 2013

Academic Integrity Pledge: *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.*

(1 pt) Signature:

Instructions: Show all work whenever a calculation box is provided! Write legibly. Include units whenever appropriate. 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 the back of your data sheet — Write: "See data sheet" in the answer box and then hand the data sheet in with your exam. At your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks and purses must be stored in the front of the room. Cell phones must be OFF and placed at the front of the room.

Use this information to answer Questions 1 –6.

Lead(II) fluoride, PbF_2	$K_{sp} = 3.6 \times 10^{-8}$
Copper(I) chloride, CuCl	$K_{sp} = 1.9 \times 10^{-7}$

1. (2 pts) Write the K_{sp} equilibrium expressions for both salts:

for PbF_2 for CuCl

K_{sp} = K_{sp} =

2. (3 pts) Consider a saturated solution of PbF_2 in pure water. What is the molar solubility of PbF_2?

Answer with units:_____

3. (4 pts) Which has the larger molar solubility, PbF_2 or CuCl? Show work.

Answer: Circle PbF_2 OR CuCl

4. (4 pt) Referring again to the saturated solution of PbF_2, circle **all** that are correct.

(a) $[Pb^{+2}] = 2 \times [F^-]$

(b) $[F^-] = 2 \times [Pb^{+2}]$

(c) The system is at equilibrium.

(d) Solid is present.

5. (3 pt) What would happen to the molar solubility of PbF_2 if each of the following happened? Circle I for Increase, D for Decrease, NC for No change

(a) 1.0 M NaF(aq) was added: I D NC
(b) 1.0 M $Pb(NO_3)_2$(aq) was added: I D NC
(c) PbF_2(s) was added: I D NC

6. (3 pts) What is equilibrium $[Cu^+]$ in a solution in which the $[Cl^-] = 0.0250$ M?

Answer with units:_____

7. (10 pts) Predict the signs for ΔG and ΔS for each of the following.

Process:	**ΔG**	**ΔS**
(a) Sugar dissolving in hot tea.	**+ 0 -**	**+ 0 -**
(b) Molten wax solidifying at room temperature.	**+ 0 -**	**+ 0 -**
(c) Exhaled breath condensing in cold weather.	**+ 0 -**	**+ 0 -**
(d) $2\ HCl(aq) + Na_2CO_3(s) \rightarrow H_2O(l) + 2\ NaCl(aq) + CO_2(g)$	**+ 0 -**	**+ 0 -**
(e) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$	**+ 0 -**	**+ 0 -**

8. (2 pts) Which TWO of the processes in Question 7 MUST be exothermic BECAUSE of the signs you chose for ΔG and ΔS? Circle only 2 choices.

(a) (b) (c) (d) (e)

Use the following thermodynamic data to answer Questions 9 - 14, which pertain to the reaction:

$$3\ NO(g) \rightarrow N_2O(g) + NO_2(g)$$

	ΔH_f^o, kJ/mol	S^o, J/mol K
NO(g)	90	211
$N_2O(g)$	82	220
$NO_2(g)$	33	240

9. (4 pts) What is ΔG^o for the reaction?

Answer with units:_____

10. (3 pts) Is this reaction:

(a) entropy-favored? Circle: Yes OR No

(b) exothermic? Circle: Yes OR No

(c) spontaneous at 298K? Circle: Yes OR No

11. (3 pts) At what approximate temperature does this reaction come to equilibrium?

Answer with units:_____

12. (4 pts) What is ΔG given the initial pressures of the gases are P_{NO} = 0.10 atm, P_{N_2O} = 0.10 atm, and P_{NO_2} = 0.10 atm and 298 K?

Answer with units:_____

13. (2 pts) In order for this reaction to reach equilibrium, it must shift: (only one answer)

(a) left because $\Delta G > \Delta G^o$.

(b) left because $Q_p > K_p$.

(c) right because $\Delta G^o > 0$.

(d) right because $Q_p < K_p$.

(e) in neither direction because $\Delta G = 0$.

14. (3 pts) What is the equilibrium constant, K_p, at 298 K?

Answer:_____

Use the table of standard reduction potentials on the data sheet to answer the remaining questions.

15. (6 pts) Consider these chemical species:

Ag^+ Ag Pb^{+2} Pb Zn^{+2} Zn

(a) Which species is the most easily reduced?

Ag^+ Ag Pb^{+2} Pb Zn^{+2} Zn

(b) Which species is the strongest reducing agent?

Ag^+ Ag Pb^{+2} Pb Zn^{+2} Zn

(c) Which species will react spontaneously with Pb?

Ag^+ Ag Pb^{+2} Pb Zn^{+2} Zn

16. (6 pts) The following galvanic cell was constructed: $Al|Al^{+3}||Ni^{+2}|Ni$. Write the balanced net ionic reaction and calculate E^o. Identify the cathode half cell.

Balanced reaction:

E^o with units:_____

Cathode half cell: **Circle:** $Al|Al^{+3}$ OR $Ni|Ni^{+2}$

17. (3 pts) Calculate E^o for the reaction:

$Cu|Cu^{+2}||Ag^+|Ag$

Answer with units:_____

18. (4 pts) Calculate the equilibrium constant, K_c, for the galvanic cell in the previous problem.

Answer:_____

19. (4 pts) Calculate E for the reaction:

$Cu|Cu^{+2}(1.00\ M)||Ag^+(0.010\ M)|Ag$

Answer with units:_____

20. (4 pts) What can you conclude about all galvanic cells? Circle all that apply.

(a) $E^o > 0$ (b) $K > 1$ (c) $Q > K$ (d) $\Delta G^o > 0$

21. (3 pts) How long would it take to electrodeposit 0.40 g cobalt from a solution of $CoSO_4(aq)$ using a current of 3.0 amps? Report answer in seconds.

Answer with units:_____

Subtotal from exam: _____

Folder work: (20 max) _____

Total: _____

Name:

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

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

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

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

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

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

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° (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. $K_{sp} = [Pb^{+2}] \times [F^-]^2$ $K_{sp} = [Cu^+] \times [Cl^-]$

2. $x = 2.1 \times 10^{-3}$ M

3. PbF_2

4. (b), (c), (d)

5. D, D, NC

6. 7.6×10^{-6} M

7. (10 pts) Predict the signs for ΔG and ΔS for each of the following.

Process:	**ΔG**	**ΔS**
(a) Sugar dissolving in hot tea.	**-**	**+**
(b) Molten wax solidifying at room temperature.	**-**	**-**
(c) Exhaled breath condensing in cold weather.	**-**	**-**
(d) $2\ HCl(aq) + Na_2CO_3(s) \rightarrow H_2O(l) + 2\ NaCl(aq) + CO_2(g)$	**-**	**+**
(e) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$	**-**	**+**

8. (b), (c)

9. What is $\Delta G^o = -103.4$ kJ

10. No, Yes, Yes

11. 896 K

12. (4 pts) What is $\Delta G = -97.7$ kJ

13. (d)

14. 1.3×10^{18}

15. (a) Ag^+; (b) Zn; (c) Ag^+

16. (6 pts) The following galvanic cell was constructed: $2\ Al + 3\ Ni^{+2} \rightarrow 2\ Al^{+3} + 3Ni$; $E^o = 1.40$ v; cathode half cell is $Ni|Ni^{+2}$

17. $E^o = 0.46$ v

18. 3.5×10^{15}

19. E = 0.34 v

20. (a) and (b)

21. 437 s