Exam 4 Chm 205 (Dr Mattson) 5 April 2017

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.*

Signature:

Name:

Chemistry Student Number (1 bonus pt): _____

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 the data sheet provided — Write: "See data sheet" in the answer box – then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored in the rear section of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. Carbonates are an important class of minerals. The Group II carbonates, and their K_{sp} values are:

$MgCO_3$	$K_{sp} = 6.82 \times 10^{-6}$	MM = 84.3 g/mol
$CaCO_3$	$K_{sp} = 3.36 \times 10^{-9}$	MM = 100.1 g/mol
$SrCO_3$	$K_{sp} = 5.60 \times 10^{-10}$	MM = 147.6 g/mol
$BaCO_3$	$K_{sp} = 2.58 \times 10^{-9}$	MM = 197.3 g/mol

1a, b. (4 pts) Write a balanced reaction for the dissolution of $SrCO_3$ in water and write a K_{sp} expression. Save most of the space -- Question 1c uses the same box.

1c. (4 pts) Showing your work in the box above (use a MICE table), determine the molar solubility of strontium carbonate. What is $[Sr^{+2}]$? Include units.

Molar solubility = _____ $[Sr^{+2}]$ = _____

1d. (1 pt) Which of these salts has the largest molar solubility? **$MgCO_3$** **$CaCO_3$** **$SrCO_3$** **$BaCO_3$**

1e. (4 pts) What mass $SrCO_3$ dissolves in 400 mL H_2O?

Answer with units: _____

1f. (4 pts) What is the molar solubility of calcium carbonate in a solution containing 0.072 M $Ca(NO_3)_2$?

Answer with units: _____

2a (4 pts). What is the molar solubility, x, of $Co(OH)_2$, given $K_{sp} = 5.9 \times 10^{-15}$

Answer with units: _____

2b. (2 pts) What is the pH of the above solution?

3. (4 pts) If a saturated solution of Ag_2CO_3 has $[Ag^+] = 2.56 \times 10^{-4}$ M, what is the value of K_{sp}?

K_{sp} = _____

4. (4 pts). Will a precipitate form if small amounts of $Mg(NO_3)_2$ and sodium carbonate are added to water so that $[Mg^{2+}] = 5.0 \times 10^{-4}$ M and $[CO_3^{2-}] = 2.0 \times 10^{-4}$ M? You must show work (Q_{sp} calculation) for credit.

Q_{sp} = _____ Precipitate? **Yes** **No**

5. (8 pts) **Alert!** Reactions A-D represent **one example of each** of the 4 combinations of ΔH and ΔS being + or -.

	ΔH	ΔS
A. $H_2O(g) \rightarrow OH(g) + H(g)$		
B. $3\ O_2(g) \rightarrow 2\ O_3(g)$		
C. $2\ Cl(g) \rightarrow Cl_2(g)$		
D. $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4H_2O(g)$		

5a. Which **two** reactions are exothermic? **A B C D**

5b. Which **two** reactions are entropy-favored? **A B C D**

5c. Which reaction is spontaneous only at high temperatures? (one answer) **A B C D**

5d. Which reaction is never spontaneous? (one answer) **A B C D**

6. (5 pts) Classify each of these as spontaneous or non-spontaneous at 1 atm.

ΔG < 0 or **ΔG > 0** Cheese molding.

ΔG < 0 or **ΔG > 0** Diffusion of perfume in a room.

ΔG < 0 or **ΔG > 0** Ice melting in a freezer.

ΔG < 0 or **ΔG > 0** Natural gas burning.

ΔG < 0 or **ΔG > 0** More NaCl dissolving in a saturated solution.

7. (5 pts) Predict the sign of ΔS for each of these.

$\Delta S < 0$ or **$\Delta S > 0$** Water vapor condensing.

$\Delta S < 0$ or **$\Delta S > 0$** Crystals of $CaCO_3$ forming.

$\Delta S < 0$ or **$\Delta S > 0$** A drop of ink dissipating in water

$\Delta S < 0$ or **$\Delta S > 0$** $2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$

$\Delta S < 0$ or **$\Delta S > 0$** $2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$

8. Nitrogen monoxide readily reacts with oxygen to produce nitrogen dioxide, a reddish gas. The reaction is:

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$ $\Delta H^o = ?$ $\Delta S^o = ?$

Thermodynamic data:	**ΔH_f^o kJ/mol**	**ΔS^o J/mol K**
$NO(g)$	+91	211
$O_2(g)$	0	205
$NO_2(g)$	+33	240

8a. (4 pts) Calculate ΔS^o for this reaction.

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$

Answer with units: _____

8b. (4 pts) Calculate ΔH^o for this reaction.

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$

Answer with units: _____

8c. (4 pts) Calculate ΔG^o for this reaction.

Answer with units: _____

8d. (3 pts) At what temperature does this reaction switch from spontaneous to non-spontaneous or visa versa?

Answer with units: _____

8e. (4 pts) Estimate the equilibrium constant at 298 K

Answer: _____

8f. (4 pts) Calculate ΔG at 298 K for this reaction if the initial pressures of $NO(g)$, $O_2(g)$, and $NO_2(g)$ are 2.0 atm, 2.0 atm and 0.20 atm, respectively? Is the reaction spontaneous? Show work for credit!

Answer with units: _____ Is reaction spontaneous? **Yes** or **No**

9a. (4 pts) Balance this redox reaction in aqueous acidic solution. You may need to add H_2O and/or H^+.

9b. (1 pt) What is the value of n (the LCM)?

$NO_3^- + Cu \rightarrow NO_2 + Cu^{2+}$

n = _____ e^-

9c. (2 pts) **Circle** what is reduced. **Box** what is oxidized.

NO_3^- Cu NO Cu^{2+}

10. Given: $Ag^+(aq) + Cr(s) \rightarrow Ag(s) + Cr^{3+}(aq)$ unbalanced

10a. (3 pts) Write the reaction in cell notation for this galvanic cell.

10b. (4 pts) What is E^o for the reaction?

Answer with units: _____

10c. (2 pts) What is the anode half cell?

$Cr|Cr^{3+}$ or **$Ag|Ag^+$**

10d. (2 pts) As reaction proceeds, the cathode **increases** or **decreases** in mass.

11a. (4 pts) Determine E^o for $Pb|Pb^{2+}||H^+|H_2|Pt$.

Answer with units: _____

11b. (4 pts) Calculate ΔG^o for this reaction.

Answer with units: _____

Score _____ + _____ + _____ = _____

A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

Table of Standard Reduction Potentials

	E^o (V)
$Cl_2 + 2\ e^- \rightarrow 2Cl^-$	1.36
$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$	1.23
$Br_2 + 2\ e^- \rightarrow 2\ Br^-$	1.09
$Ag^+ + e^- \rightarrow Ag$	0.80
$I_2 + 2\ e^- \rightarrow 2\ I^-$	0.54
$O_2 + 2\ H_2O + 4\ e^- \rightarrow 4\ OH^-$	0.40
$Cu^{2+} + 2\ e^- \rightarrow Cu$	0.34
$2H^+ + 2\ e^- \rightarrow H_2$	0.00
$Fe^{3+} + 3\ e^- \rightarrow Fe$	-0.036
$Pb^{2+} + 2\ e^- \rightarrow Pb$	-0.13
$Ni^{2+} + 2\ e^- \rightarrow Ni$	-0.26
$Co^{2+} + 2\ e^- \rightarrow Co$	-0.28
$PbSO_4 + 2\ e^- \rightarrow Pb + SO_4^{2-}$	-0.35
$Cd^{2+} + 2\ e^- \rightarrow Cd$	-0.40
$Fe^{2+} + 2\ e^- \rightarrow Fe$	-0.44
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	-0.50
$Cr^{3+} + 3\ e^- \rightarrow Cr$	-0.73
$Zn^{2+} + 2\ e^- \rightarrow Zn$	-0.76
$2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$	-0.83
$Al^{3+} + 3\ e^- \rightarrow Al$	-1.66
$Mg^{+2} + 2\ e^- \rightarrow Mg$	-1.66
$Na^+ + e^- \rightarrow Na$	-2.71
$Ca^{2+} + 2\ e^- \rightarrow Ca$	-2.76
$Ba^{2+} + 2\ e^- \rightarrow Ba$	-2.90
$K^+ + e^- \rightarrow K$	-2.92
$Li^+ + e^- \rightarrow Li$	-3.05

Useful equations for Thermodynamics:

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

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

$\Delta G = \Delta G^o + R\ T\ \ln Q$ $\quad R = 8.314$ J/mol K

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

Useful equations for Electrochemistry:

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

$E^o = {}^{0.0592}/_{n} \log K = {}^{R\ T}/_{n\ F} \ln K$

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

1 F = 96500 coul = 1 mol e^- = 96500 J/mol V

Charge (coul) = current (amps) x time(s)

Useful equations for Nuclear Chemistry:

$\ln({}^{N_o}/_{N_t}) = kt$ $\quad t_{1/2} = 0.693/k$

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															

Answers

1a, b. $SrCO_3 \rightleftharpoons Sr^{2+} + CO_3^{2-}$ $K_{sp} = [Sr^{2+}][CO_3^{2-}]$

1c. Molar solubility = 2.37×10^{-5} M $[Sr^{2+}] = 2.37 \times 10^{-5}$ M

1d. $MgCO_3$

1e. 1.40×10^{-3} g

1f. 4.7×10^{-8} M

2a 1.14×10^{-5} M

2b. 9.36

3. 8.4×10^{-12}

4. $Q_{sp} = 1.0 \times 10^{-7}$, therefore $Q_{sp} < K_{sp}$ and no precipitate forms

5.

	ΔH	ΔS
A. $H_2O(g) \rightarrow OH(g) + H(g)$	+	+
B. $3\ O_2(g) \rightarrow 2\ O_3(g)$	+	-
C. $2\ Cl(g) \rightarrow Cl_2(g)$	-	-
D. $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4H_2O(g)$	-	+

5a. C, D

5b. A, D

5c. A

5d. B

6. $\Delta G < 0$, $\Delta G < 0$, $\Delta G > 0$, $\Delta G < 0$, $\Delta G > 0$

7. $\Delta S < 0$, $\Delta S < 0$, $\Delta S > 0$, $\Delta S > 0$, $\Delta S < 0$

8a. $\Delta S^o = -147$ J/K

8b. $\Delta H^o = -116$ kJ

8c. $\Delta G^o = -72$ kJ

8d. 789 K

8e. $K = 4.5 \times 10^{+12}$ M

8f. $\Delta G = -85$ kJ, so Yes, spontaneous

9a. $4\ H^+ + 2\ NO_3^- + Cu \rightarrow 2\ NO_2 + Cu^{2+} + 2\ H_2O$; n = 2 e^-

9c. Circle NO_3^-; Box Cu

10a. $Cr \mid Cr^{3+} \parallel Ag^+ \mid Ag$

10b. $E^o = 1.53$ V

10c. $Cr|Cr^{3+}$

10d. increases

11a. $E^o = +0.13$ v

11b. $\Delta G^o = -25$ kJ