Chemistry 205 – Inorganic Chemistry I
Exam 2 (May 3, 2002)

Partial credit will be given for work shown. The answer by itself is not satisfactory for full credit.

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INFORMATION THAT MAY BE OF USE TO YOU IN THE EXAM

$$E = E^\circ - \frac{0.059}{n} \log K \text{ (at 25°C)} \qquad \Delta G^\circ = -nFE^\circ$$

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

Periodic Table

IA												IIIA	IVA	VA	VIA	VIIA	0
1 H 1.008	IIA																2 He 4.003
3 Li 6.941	4 Be 9.012											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	IIIB	IVB	VB	VIB	VIIB		VIIIB		IB	IIB	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 (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 131.3
55 Cs 132.9	56 Ba 137.3	57 * La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	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)
87 Fr (223)	88 Ra (226.0)	89 ** Ac (227)	104 Rf	105 Ha	106 Unh	107 Uns	108	109 Une									

* 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 157.3	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)	92 U 238.0	93 Np (244)	94 Pu (242)	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)

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Name:_____

10 pts **1**. I have a theory that only cations that have the same charges and half the size of the sulfate anion will precipitate with the sulfate anion (radius = 244pm. Carefully choose three (and only three) of the following cations to help prove or disprove my theory and tell why they were selected.

M^{n+}	Al^{3+}	Ba^{2+}	Ce^{4+}	Cs^{+}	Hg^{2+}	La^{3+}	K^{+}	Mg^{2+}	Na^{+}
radius	67	149	101	181	116	117	152	86	116

15 pts **2**. Diagram a Born Haber cycle for the formation of AgCl(s).

15 pts **3**. HClO is a weak acid. Write a reaction showing this. Its K_a value is 6.3×10^{-8}, or its pK_a value is 7.2. Is this pK_a value consistent with what you would expect for this oxo anion? (Show me!) Write a reaction and an equilibrium expression for the conjugate base of HClO. Prove, using the expressions for $K_a \times K_b$, that this is in fact equal to K_w. What is the pK_b value for the oxo anion hydrolysis reaction? Is the oxo anion a strong or weak base?

6 pts **4**. Predict which way the following reactions proceed and explain why:

$$Cr(NCS)_3 + CuSCN \rightleftharpoons Cr(SCN)_3 + CuNCS$$

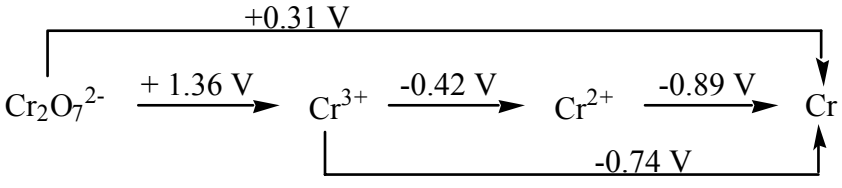
These are called linkage isomers and whichever atom is next to the metal, that is the atom attached to it.

$$NH_3 + CsI \rightleftharpoons HI + CsNH_2$$

9 pts **5**. Given the following reactions and Latimer diagram (in an acidic solution), will any of the chromium species oxidize or reduce water, and if so, which ones? Will any of the species disproportionate?

$2\ H^+ + 2e^- \rightarrow H_2$ 0.00 V

$H_2O \rightarrow {}^1/_2\ O_2 + 2\ H^+ + 2e^-$ -1.23 V



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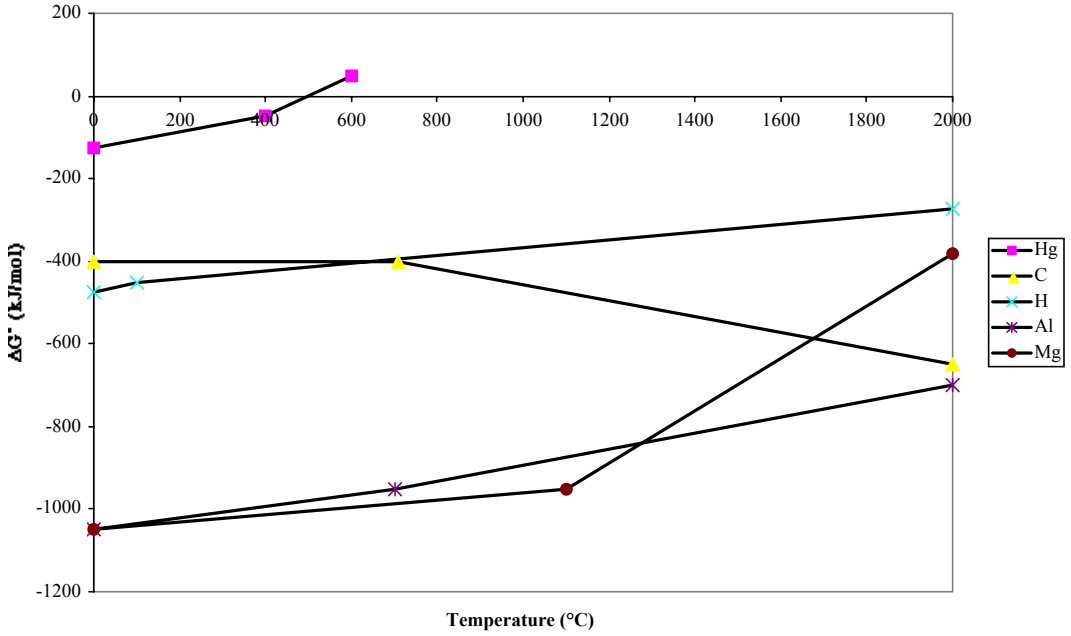
12 pts **6**. The Ellingham Diagram shown below shows the free energy changes for oxides of mercury, carbon, magnesium, and aluminum. Explain how you arrived at each of your conclusions.

a) Explain why most of the lines slope upwards from left to right.
c) Will aluminum reduce water?
d) At what temperature will carbon reduce magnesium oxide?
e) Why is hydrogen gas rarely used for metal reduction?

Ellingham Diagram



$2\ Hg + O_2 \rightarrow 2\ HgO$

$C + O_2 \rightarrow CO_2$
$2\ H_2 + O_2 \rightarrow 2\ H_2O$
$2\ Mg + O_2 \rightarrow 2\ MgO$

$2\ C + O_2 \rightarrow 2\ CO$
$^4/_3\ Al + O_2 \rightarrow {}^2/_3\ Al_2O_3$

9 pts **7**. Explain the importance of the reactants and products in the following three related equations:

$$C + H_2O(g) \xrightarrow{1000°C} CO(g) + H_2(g)$$

$$CO(g) + H_2O(g) \xrightarrow[Fe_2O_3]{450°C} CO_2(g) + H_2(g)$$

$$K_2CO_3 + CO_2 + H_2O \longrightarrow 2\ KHCO_3$$

12 pts **8**. Show reactions between the alkali metals: Li, Na, and K with dioxygen and subsequently with water.

12 pts **9**. Complete 4 of the following 6 reactions (These do not need to be balanced). **State which one should not be graded otherwise the first 4 will be counted.**

a) hydrogen gas and chlorine gas
b) sodium and liquid ammonia – allow the liquid ammonia to eventually evaporate
c) hydrogen gas and sodium metal
d) deuterium oxide and CaC_2
e) lithium metal and air (list two reactions here)

Bonus: (9 pts) The Down's cell is used to obtain pure sodium metal. Describe how this works.