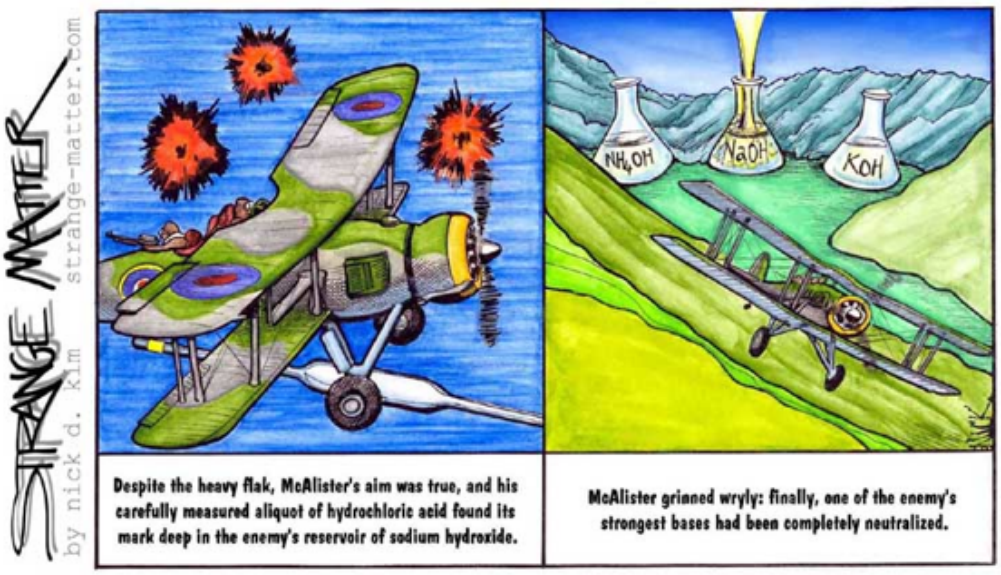
Chemistry 1142
Spring 2013
Exam 4a

Name:_____

Take a deep breath, and relax! First, answer the questions you know how to do and then work on the more difficult problems. Don't forget to show all your work, so I can give you as much credit as possible.

Good Luck!

Andy



Show all work to receive credit. Be sure to include units, and express answers to the correct number of significant figures / decimal places.

Q1. [12 pts.] Predict whether the following reactions have a positive, negative, or ≈0 value of ΔS.

a) $C_3H_8(g) + 7O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

b) $C_2H_5OH(g) \rightarrow C_2H_5OH(l)$

c) $Fe_2O_3(s) + C(s) \rightarrow 2Fe(s) + {}^3\!/_2\, CO_2(g)$

d) $N_2O_4(g) + CO_2(g) \rightarrow N_2O_5(g) + CO(g)$

Q2. [12 pts.] Calculate ΔG^o at 15 °C and 105 °C for the reaction:

$2CH_3CH_2OH(l) + 2O_2(g) \rightarrow 2CH_3CO_2H(l) + 2H_2O(l)$

given the following data:

Compound	ΔH^o_f / kJ ·mol^{-1}	S^o / J ·mol^{-1} ·K^{-1}
$CH_3CH_2OH(l)$	–276.98	161.04
$O_2(g)$	0	205.0
$CH_3CO_2H(l)$	–484.2	159.83
$H_2O(l)$	–285.8	69.9

Q3. [8 pts.] Calculate ΔG^o for the process:
$Ag^+(aq) + NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$, if $K = 1.5 \times 10^7$ at 25 ºC.

Q4. [12 pts.] Using the standard electrode potentials given on the back page of this exam, calculate E^o_{cell} for the following cells:

a) $Zn(s)\,|\,Zn^{2+}(aq)\ ||\ Cu^{2+}(aq)\,|\,Cu(s)$

b) $Cr(s)\,|\,Cr^{3+}(aq)\ ||\ Cd^{2+}(aq)\,|\,Cd(s)$

c) $Al(s)\,|\,Al^{3+}(aq)\ ||\ Cu^{2+}(aq)\,|\,Cu(s)$

"Now, in the second law of thermodynamics..."

Q5. [20 pts.] Balance the following redox reactions using the half-reaction method.

a) $Zn(s) + ClO^-(aq) \rightarrow Zn(OH)_2(s) + Cl^-(aq)$ (BASIC Conditions)

b) $MnO_2(s) + Cl^-(aq) \rightarrow Mn^{2+}(aq) + Cl_2(g)$ (ACIDIC Conditions)

Q6. [16 pts.] Calculate E_{cell} for the following cell:

$Al(s)\,|\,Al^{3+}(aq, 0.010\ M)\ ||\ Zn^{2+}(aq, 2.50\ M)\,|\,Zn(s)$

Be sure to write out the overall balanced equation for the cell reaction as part of your answer. The cell operates at a temperature of 298 K.

Q7. [10 pts.] A particular chemical reaction is non-spontaneous at low temperatures, but becomes spontaneous at high temperatures. What can you say about the signs (+ve or –ve) of ΔS and ΔH? Be sure to explain your answer.

Q8. [10 pts.] Molten aluminum bromide is electrolyzed for 24 hours using an electric current of 35 A. Predict the mass of aluminum formed in the electrolytic cell.

BONUS Question

[5 pts.] CH_3OH has a boiling point of 65 ºC. Predict the sign of ΔG^o, ΔH^o, and ΔS^o for the process: $CH_3OH(g) \longrightarrow CH_3OH(l)$ at a temperature of 63 ºC. Explain your answer.

ble 19.1 Standard Reduction Potentials at 25°C*

Half-Reaction	$E°$(V)
$F_2(g) + 2e^- \longrightarrow 2F^-(aq)$	+2.87
$O_3(g) + 2H^+(aq) + 2e^- \longrightarrow O_2(g) + H_2O$	+2.07
$Co^{3+}(aq) + e^- \longrightarrow Co^{2+}(aq)$	+1.82
$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O$	+1.77
$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \longrightarrow PbSO_4(s) + 2H_2O$	+1.70
$Ce^{4+}(aq) + e^- \longrightarrow Ce^{3+}(aq)$	+1.61
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O$	+1.51
$Au^{3+}(aq) + 3e^- \longrightarrow Au(s)$	+1.50
$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$	+1.36
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O$	+1.33
$MnO_2(s) + 4H^+(aq) + 2e^- \longrightarrow Mn^{2+}(aq) + 2H_2O$	+1.23
$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O$	+1.23
$Br_2(l) + 2e^- \longrightarrow 2Br^-(aq)$	+1.07
$NO_3^-(aq) + 4H^+(aq) + 3e^- \longrightarrow NO(g) + 2H_2O$	+0.96
$2Hg^{2+}(aq) + 2e^- \longrightarrow Hg_2^{2+}(aq)$	+0.92
$Hg_2^{2+}(aq) + 2e^- \longrightarrow 2Hg(l)$	+0.85
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \longrightarrow H_2O_2(aq)$	+0.68
$MnO_4^-(aq) + 2H_2O + 3e^- \longrightarrow MnO_2(s) + 4OH^-(aq)$	+0.59
$I_2(s) + 2e^- \longrightarrow 2I^-(aq)$	+0.53
$O_2(g) + 2H_2O + 4e^- \longrightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$	+0.34
$AgCl(s) + e^- \longrightarrow Ag(s) + Cl^-(aq)$	+0.22
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \longrightarrow SO_2(g) + 2H_2O$	+0.20
$Cu^{2+}(aq) + e^- \longrightarrow Cu^+(aq)$	+0.15
$Sn^{4+}(aq) + 2e^- \longrightarrow Sn^{2+}(aq)$	+0.13
$2H^+(aq) + 2e^- \longrightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \longrightarrow Pb(s)$	−0.13
$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$	−0.25
$Co^{2+}(aq) + 2e^- \longrightarrow Co(s)$	−0.28
$PbSO_4(s) + 2e^- \longrightarrow Pb(s) + SO_4^{2-}(aq)$	−0.31
$Cd^{2+}(aq) + 2e^- \longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$	−0.44
$Cr^{3+}(aq) + 3e^- \longrightarrow Cr(s)$	−0.74
$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$	−0.76
$2H_2O + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$	−0.83
$Mn^{2+}(aq) + 2e^- \longrightarrow Mn(s)$	−1.18
$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$	−1.66
$Be^{2+}(aq) + 2e^- \longrightarrow Be(s)$	−1.85
$Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^- \longrightarrow Na(s)$	−2.71
$Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$	−2.87
$Sr^{2+}(aq) + 2e^- \longrightarrow Sr(s)$	−2.89
$Ba^{2+}(aq) + 2e^- \longrightarrow Ba(s)$	−2.90
$K^+(aq) + e^- \longrightarrow K(s)$	−2.93
$Li^+(aq) + e^- \longrightarrow Li(s)$	−3.05

Useful Information

$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

Given: $ax^2 + bx + c$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ at 25 °C.

$\text{pH} = -\log[H_3O^+]$

$\text{pH} + \text{pOH} = 14.00$ (at 25 °C)

$K_aK_b = K_w$

$R = 8.3145\ \text{J/mol·K} = 0.08206\ \text{L·atm/mol·K}$

$$\text{pH} = \text{p}K_a + \log\frac{[\text{Base}]}{[\text{Acid}]}$$

$M_1V_1 = M_2V_2$

$\Delta G = -nFE_{cell}$ $\quad \Delta G^\circ = -nFE^\circ_{cell}$ $\quad E^o_{cell} = \dfrac{RT}{nF}\ln K$

$$E_{cell} = E^\circ_{cell} - \frac{RT}{nF}\ln Q$$

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$ $\quad F = 96{,}500\ \text{C/mol e}^-$

$R = 8.3145\ \text{J·mol}^{-1}\text{·K}^{-1}$ $\quad Q\ (\text{charge}) = I \cdot t$ $\quad \Delta G = \Delta H - T\Delta S$

$\Delta S = q/T$ $\quad \Delta G = \Delta G^\circ + RT\ln Q$ $\quad \Delta G^\circ = -RT\ln K$

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	*18*
1 H 1.01	*2*											*13*	*14*	*15*	*16*	*17*	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	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92160	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 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba* 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra** [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
**	89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	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]