Exam 4 Chm 205 (Dr Mattson) 2 May 2014

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:

Circle: Section A or Section C **Folder group:**

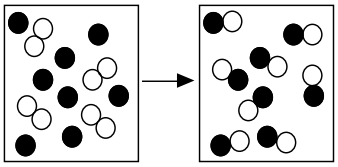
H He Li Be B C N O F Ne Na Mg Al Si

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, use your scratch paper provided — Write: "See attached" in the answer box. Write your name on the scratch paper. On 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 closed and stored on the floor under the table. Cell phones must be OFF and placed in your backpack/purse – not in your pocket.

1. (5 pts) Which process(es) is/are spontaneous under standard conditions. Circle all that apply.

   A. freezing of water
   B. corrosion of an iron nail left outdoors
   C. sodium chloride precipitating from an unsaturated solution
   D. a packet of sugar crystals dissolving in a cup of hot water
   E. a strong acid and strong base reacting when mixed

2. Consider the gas phase reaction represented at right:



2a (2 pts) Write the simplest balanced equation (smallest whole number coefficients) for the reaction, using A for ○ and B for ●.

2b (1 pt) Predict the sign for ΔS^o for the reaction. Circle **+** or **-**

3. (1 pt) What is true regarding ΔH and ΔS for any phase change?

   A. Both ΔH and ΔS are > 0
   B. Both ΔH and ΔS are < 0
   C. Both ΔH and ΔS have the same sign, + or -.
   D. ΔH and ΔS have opposite signs.

4. Consider the combustion of ammonia:

$$4\ NH_3(g) + 3\ O_2(g) \longrightarrow 2\ N_2(g) + 6\ H_2O(g)$$

4a. (3 pts) Use the provided data to determine ΔH^o:

$$4\ NH_3(g) + 3\ O_2(g) \longrightarrow 2\ N_2(g) + 6\ H_2O(g)$$

Answer with units: _____

4b. (3 pts) Use the provided data to determine ΔS^o:

$$4\ NH_3(g) + 3\ O_2(g) \longrightarrow 2\ N_2(g) + 6\ H_2O(g)$$

Answer with units: _____

4c. (3 pts) Use the values determined in 4a and 4b to determine ΔG^o.

Answer with units: _____

4d. (1 pt) Under what conditions of temperature will the reaction be spontaneous?

A. high temperatures only B. low temperatures only
C. all temperatures D. It will never be spontaneous.

5. (3 pts) The combustion of ethanol is:

$$C_2H_5OH(l) + 3\ O_2(g) \longrightarrow 2\ CO_2(g) + 3\ H_2O(g)$$

What are the signs of ΔG^o, ΔH^o, and ΔS^o?

	ΔG^o	ΔH^o	ΔS^o
Circle **+** or **-**	**+** or **-**	**+** or **-**	**+** or **-**

6. Consider the following reaction:

$$2\ HgO(s) + 2\ S(s) \rightleftharpoons 2\ HgS(s) + O_2(g)$$

$$\Delta G^o = +8.0\ kJ$$

6a (3 pts) Determine the equilibrium constant, K_p for this reaction at 298 K.

Answer: _____

6b (6 pts) Under what circumstances would ΔG be negative for this reaction? Circle all that apply.

A. High temperatures only.
B. Low temperatures only.
C. When $Q_p > K_p$
D. When $Q_p < K_p$
E. When P_{O_2} is zero or close to zero
F. This reaction will never be spontaneous.

7. (3 pts) Which of these is a **galvanic** cell under standard conditions? Circle Yes or No.

7a. **Yes** or **No** $Pb|Pb^{+2}||Cd^{+2}|Cd$

7b. **Yes** or **No** $Cu|Cu^{+2}||Ag^{+}|Ag$

7c. **Yes** or **No** $Ni|Ni^{+2}||Sn^{+2}|Sn$

8. A **galvanic** cell is prepared using $Zn|Zn^{+2}$ and $Cr|Cr^{+3}$ half cells.

8a. (3 pts) Determine E^o_{rxn}.

Answer with units: _____

8b. (3 pts) Write and balance the spontaneous reaction that takes place.

8c. (1 pt) What reaction takes place at the anode?

A. $Zn \rightarrow Zn^{+2} + 2\ e^-$ B. $Cr \rightarrow Cr^{+3} + 3\ e^-$

C. $Zn^{+2} + 2\ e^- \rightarrow Zn$ D. $Cr^{+3} + 3\ e^- \rightarrow Cr$

9. Given E^o_{rxn} = +0.12 v for the reaction:

$$Co^{+2}(aq) + Cd(s) \longrightarrow Co(s) + Cd^{+2}(aq)$$

9a. (3 pts) What is the calculated value for E if $[Co^{+2}]$ = 0.020 M and $[Cd^{+2}]$ = 0.80 M?

Answer with units: _____

9b (3 pts) What is ΔG for this reaction using the concentrations given in 9a?

Answer with units of kJ: _____

9c (3 pts) What is ΔG^o for this reaction?

Answer with units of kJ: _____

9d (3 pts) What is the equilibrium constant, K_c, for this reaction?

Answer:_____

10a. (1 pt) Which of these is the most easily reduced?

Pb Co Zn Pb^{+2} Co^{+2} Zn^{+2}

10b. (1 pt) Which of these would oxidize Zn, but not Pb?

Ni Ag Mg Ni^{+2} Ag^+ Mg^{+2}

11. (4 pts) Balance the redox reaction in acidic solution, showing all work.

$$Cr_2O_7^{-2} + Fe^{+2} \longrightarrow Cr^{+3} + Fe^{+3}$$

12. (3 pts) What mass of cobalt can be deposited from $Co^{2+}(aq)$ using a current of 4.00 amps for a period of 20.0 minutes?

Answer with units: _____

13. (3 pts) What nuclear transformation do you expect for ^{18}O, a radioactive isotope of oxygen?

Circle one: ${}^{4}_{2}\alpha$ ${}^{0}_{-1}\beta$ ${}^{0}_{+1}\beta$

14. Cobalt-60 has a half-life of 5.27 years.

14a. (3 pts) Determine the rate constant, k.

Answer with units: _____

14b. (3 pts) Use the rate constant from 14a to determine the percentage of a sample remaining after 25 years.

Answer:_____

15. (3 pts) Bombarding americium-241 with α-particles causes a transformation to two neutrons and another element/isotope. Balance the equation.

16. (3 pts) Americium-241 is also an α-emitter. What isotope is produced?

17. (3 pts) Phosphorus-32 is used in leukemia therapy. It has a half-life of about 14 days. About what fraction of a dose remains P-32 after twelve weeks? Express your answer in the format $^1/_{2^n}$

Score: _____ + _____ = _____

from exam + folder = total

Table of Standard Reduction Potentials

	E^o (V)
$Cl_2 + 2\ e^- \rightarrow 2Cl^-$	1.36
$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2H_2O$	1.23
$Br_2 + 2\ e^- \rightarrow 2Br^-$	1.09
$Ag^+ + e^- \rightarrow Ag$	0.80
$Fe^{+3} + e^- \rightarrow Fe^{+2}$	0.77
$I_2 + 2\ e^- \rightarrow 2\ I^-$	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
$Sn^{2+} + 2\ e^- \rightarrow Sn$	-0.14
$Ni^{2+} + 2\ e^- \rightarrow Ni$	-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
$2\ H_2O + 2\ e^- \rightarrow H_2 + 2OH^-$	-0.83
$Mn^{2+} + 2\ e^- \rightarrow Mn$	-1.18
$Al^{3+} + 3\ e^- \rightarrow Al$	-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:

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

Thermodynamic Values:

Substance	MM (g/mol)	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S° (J/K mol)
C(s) graphite	12	0	0	6
$CO_2(g)$	44	-393.5	-394	214
$C_2H_6(g)$	30	-84.7	-32.9	229.5
$CH_4(g)$	16	-75	-51	186
$CCl_4(l)$	154	-135	-65	216
$Cl_2(g)$	71	0	0	223
$H_2(g)$	2	0	0	131
HCl(g)	36.5	-92	-95	187
$H_2O(l)$	18	-286	-237	70
$H_2O(g)$	18	-242	-229	189
Fe(s)	56	0	0	27
$Fe_2O_3(s)$	160	-826	-740	90
$N_2(g)$	28	0	0	191
$NH_3(g)$	17	-46	-16	193
NO(g)	30	90	87	211
$NO_2(g)$	46	33	51	240
$N_2O(g)$	44	82	104	220
$O_2(g)$	32	0	0	205

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Answers:

1. B, D, E

2. Consider the gas phase reaction represented at right:

2a $A_2(g) + 2\ B(g) \longrightarrow 2\ AB_2(g)$

2b $\Delta S^o < 0$ (-)

3. C

4a. $\Delta H^o = -1268$ kJ

4b. $\Delta S^o = +129$ J/K

$\Delta G^o = -1308$ kJ

4d. C

5. The signs of ΔG^o, ΔH^o, and ΔS^o are all negative

6a $K_p = 0.0396$

6b A, D, E

7. (3 pts) Which of these is a **galvanic** cell under standard conditions? Circle Yes or No.
7. No, Yes, Yes
8. A **galvanic** cell is prepared using $Zn|Zn^{+2}$ and $Cr|Cr^{+3}$ half cells.
8a. $E^o_{rxn.} = 0.03$ v

8b. $2\ Cr^{+3} + 3\ Zn \rightarrow 3\ Zn^{+2} + 2\ Cr$

8c. A

9a. E = 0.073 v

9b $\Delta G = -14$ kJ

9c ΔG^o -23 kJ

9d $K_c, = 1.1 \times 10^{+4}$

10a. Pb^{+2} is the most easily reduced

10b. Ni^{+2} would oxidize Zn, but not Pb

11. $14\ H^+ + Cr_2O_7^{-2} + 6\ Fe^{+2} \longrightarrow 2\ Cr^{+3} + 6\ Fe^{+3} + 7\ H_2O$

12. 1.47 g

13. β

14a. $k = 0.131\ yr^{-1}$

14b. 3.78 %

15. $^{241}_{95}Am + {}^{4}_{2}\alpha \rightarrow 2\ {}^{1}_{0}n + {}^{243}_{97}Bk$

16. $^{241}_{95}Am \rightarrow {}^{4}_{2}\alpha + {}^{237}_{93}Np$

17. $^{1}/_{26}$