Exam Four **CHM 205 (Dr. Mattson)** **26 March 2007**	***Academic Integrity Pledge:*** *In keeping with Creighton University's ideals and with the Academic Integrity Code adopted by the College of Arts and Sciences, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.* **Signature:**

Instructions: Show all work whenever a calculation is required. You will receive credit for <u>how</u> you worked each problem as well as for the correct answer. This exam is worth 100 points. <u>Box your answers.</u>

1. This question refers to titration curve on the data sheet/scratch paper. The volume of the unknown acid, H_2X, being titrated was 50.00 mL and the NaOH used was 0.1225 M.

(a) (4 pts) What is the molarity of the unknown acid?

(b) (4 pts) What are the pK_a values of the acid? No explanation required.

(c) (5 pts) What are the dominant or major species present at the following points along the titration curve? Check (√) all that apply in each case.

Vol OH^- added	H_2X	HX^-	X^{-2}
0 mL			
10 mL			
20 mL			
30 mL			
40 mL			

(d) (5 pts) The polyprotic acid and its anions are not the only species present. There are H_3O^+, OH^- and Na^+. Complete the table.

Vol OH^- added	Add >, = or <	Na^+ present?
0 mL	H_3O^+ [ ] OH^-	Yes No
10 mL	H_3O^+ [ ] OH^-	Yes No
20 mL	H_3O^+ [ ] OH^-	Yes No
30 mL	H_3O^+ [ ] OH^-	Yes No
40 mL	H_3O^+ [ ] OH^-	Yes No

(e) (2 pts) With polyprotic acids, one can estimate the pH at the equivalence point in between two buffer regions by simply averaging the two pK_a values on either side. In this case, we can estimate the pH at the first equivalence point this way. Try it and see if it agrees with the value from the graph.

Answer 1(e):

2. (5 pts) What is the molar solubility of $SrCO_3$ in pure water? [Given: $K_{sp} = 5.6 \times 10^{-10}$ for $SrCO_3$]

Always include units!

3 (a) (5 pts) What is the molar solubility of Ag_2CO_3 in pure water? [Given: $K_{sp} = 8.4 \times 10^{-12}$ for Ag_2CO_3]

(b) (2 pts) Does $SrCO_3$ have a larger molar solubility than Ag_2CO_3? ***Circle:*** **Yes No**

(c) (5 pts) What is the molar solubility of silver(I) carbonate in 0.040 M Na_2CO_3?

4. (12 pts) Write the formula of the expected precipitate ***<u>only</u>*** when each of the following 0.1 M aqueous solutions are mixed? In one case, no precipitate is expected: write "No ppt."

$NaCl + AgNO_3$	$NiCl_2 + CuSO_4$
$Ba(NO_3)_2 + K_2SO_4$	$Na_3PO_4 + Pb(NO_3)_2$
$Na_2S + FeSO_4$	$Ca(NO_3)_2 + NaOH$

5. (5 pts) Determine if a precipitate will form if 50.0 mL 0.0050 M $Cu^{+2}(aq)$ + 50.0 mL of a pH = 9.00 buffer were mixed. [$K_{sp} = 1.6 \times 10^{-19}$ for $Cu(OH)_2$]

6. (6 pts) Determine the molar solubility and the molar concentration of each ion in a saturated solution of $Ca_3(PO_4)_2$. [Given: $K_{sp} = 2.1 \times 10^{-33}$]

x =	$[Ca^{+2}]$ =	$[PO_4^{-3}]$ =

7. (12 pts) Predict the signs of ΔH, ΔS and ΔG for each of these processes. Remember, if you have trouble predicting one of these, use the Gibbs-Helmholtz equation which will often tell you what the troublesome sign must be. In the appropriate box, write "+," "-," or "0."

	ΔH^o	ΔS^o	ΔG^o
Water boiling, $H_2O(l) \rightarrow H_2O(g)$			
Burning propane: (all gases) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O(g)$			
Familiar kinetics equilib rxn: $N_2O_4(g) \rightarrow 2\ NO_2(g)$ *(bond breaks)*			
Forming water from elements: $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$			

8(a) (6 pts) Use the thermodynamic data on the data sheet to determine ΔH^o_{rxn} and ΔS^o_{rxn} for:

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

8(b) (5 pts) Calculate ΔG^o_{rxn} for this reaction. Is it spontaneous under standard conditions?

8(c) (5 pts) If the reaction is spontaneous at all temperatures, check here: [ ]. If the reaction is non-spontaneous at all temperatures, check: [ ]. If the reaction is spontaneous at high (or low) temperatures, determine when $\Delta G = 0$.

8(d) (5 pts) Determine ΔG for the reaction if the initial pressures of NO, O_2, and NO_2, = 0.10 atm.

8(e) (5 pts) Determine the equilibrium constant, K_p for the reaction.

8(f) (2 pts) Would increasing the temperature increase ΔG? ***Circle:*** **Yes No**

Sign the Academic Integrity pledge (on the front) *and* print your name here:

Your exam score (100 possible): _____

Determine your grade:

A+ ≥ 95; A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

Answers

1. (a) 0.03675 M; (b) 3.3 and 7.8

(c)

Vol OH^- added	H_2X	HX^-	X^{-2}

0 mL	√		
10 mL	√	√	
20 mL		√	√
30 mL			√
40 mL			√

(d)

Vol OH^- added	Add >, = or <	Na^+ present?
0 mL	$H_3O^+ > OH^-$	No
10 mL	$H_3O^+ > OH^-$	Yes
20 mL	$H_3O^+ < OH^-$	Yes
30 mL	$H_3O^+ < OH^-$	Yes
40 mL	$H_3O^+ < OH^-$	Yes

(e) 5.55, yes, it agrees

2. molar solubility of $SrCO_3 = 2.3 \times 10^{-5}$

3 (a) molar solubility of $Ag_2CO_3 = 1.3 \times 10^{-4}$

(b) No

(c) molar solubility of $Ag_2CO_3 = 7.2 \times 10^{-6}$

4. (12 pts) Write the formula of the expected precipitate ***only*** when each of the following 0.1 M aqueous solutions are mixed? In one case, no precipitate is expected: write "No ppt."

AgCl	No ppt
$BaSO_4$	$Pb_3(PO_4)_2$
FeS	$Ca(OH)_2$

5. $Q_{sp} = 2{,}5 \times 10^{-13}$, therefore a precipitate is formed

6. molar solubility = 1.1×10^{-7} M; $[Ca^{+2}] = 3.3 \times 10^{-7}$ M; and $[PO_4^{-3}] = 2.2 \times 10^{-7}$ M

7.

	ΔH^o	ΔS^o	ΔG^o
Water boiling, $H_2O(l) \rightarrow H_2O(g)$	+	+	+
Burning propane: (all gases) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O(g)$	-	+	-
Familiar kinetics equilib rxn: $N_2O_4(g) \rightarrow 2\ NO_2(g)$ *(bond breaks)*	+	+	Can't be certain
Forming water from elements: $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$	-	-	-

8(a) $\Delta H^o_{rxn} = -114$ kJ and $\Delta S^o_{rxn} = -147$ J/K

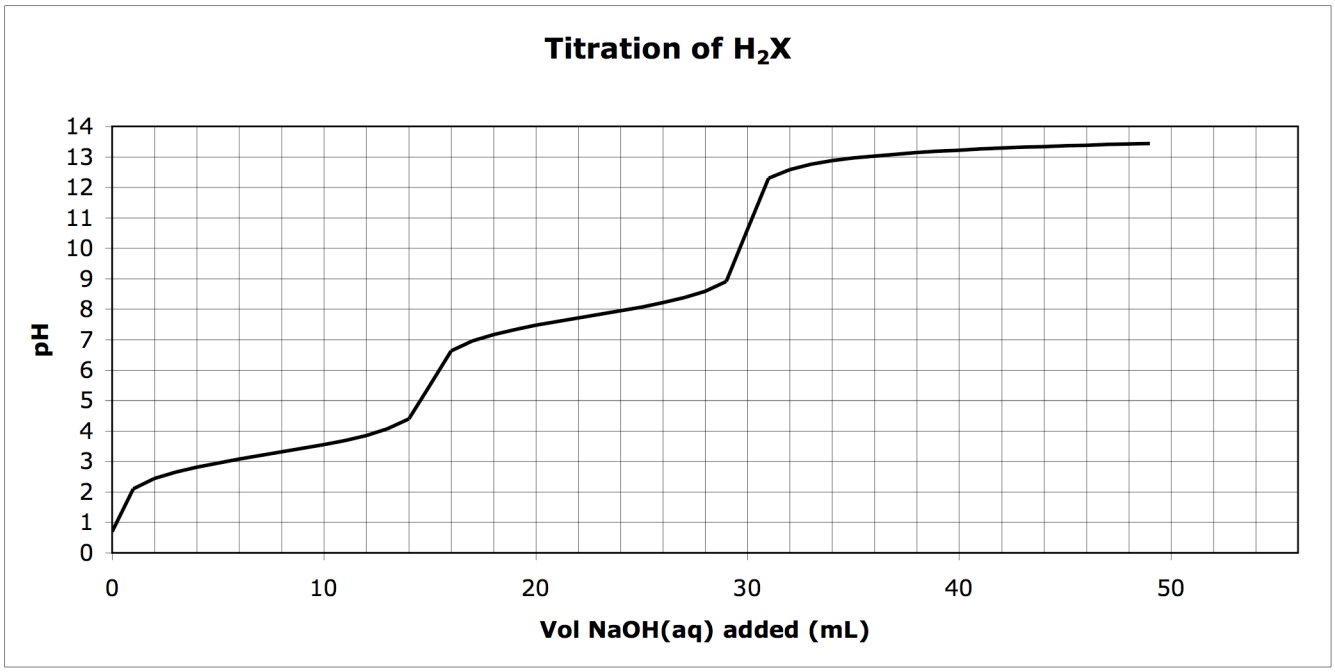
8(b) $\Delta G^o_{rxn} = -70.2$ kJ

8(c) T = 775 K

8(d) $\Delta G = -64.5$ kJ

8(e) 2.0×10^{12}

8(f) Yes



Useful equations

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

$\Delta G^o = -RT\ln K$ $\Delta G = \Delta G^o + RT\ln Q$

R = 8.314 J/mol K = 0.0821 L atm/mol K

	ΔH^o_f (kJ/mol)	S^o (J/mol K)
NO(g)	90.2	211
O_2(g)	0	205
NO_2(g)	33.2	240