Exam 3 Chm 205 (Dr Mattson) 3 April 2019

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: _____

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 on the tables in the back of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. (4 pts each) (a) Write the balanced net ionic equation for the neutralization reactions and include appropriate long/short arrows. (b) Then write the K_n expression in terms of concentration, and (c) calculate the numerical value for K_n. Given: K_a for HF = 3.5×10^{-4}. Remember that net ionic does not include spectator ions.

HF(aq) and NaOH(aq)

K_n =

HCl(aq) and KOH(aq)

K_n =

HNO_3(aq) and NaF(aq)

K_n =

2. (5 pts) Which of these situations would form a buffer if dissolved in water to make 250 mL solution?

Yes No 0.43 mol HNO_2 + 0.19 mol KOH

Yes No 2.5 mol $NaHSO_3$ + 0.70 mol HCl

Yes No 50.0 mL 1.00 M $HClO_2$ + 6.48 g $KClO_2$

Yes No 0.51 mol HNO_2 + 0.68 mol NaOH

Yes No 0.44 mol $NaHSO_3$ + 0.17 mol KOH

3a. (4 pts) What is the pH of a buffer prepared by dissolving 2.90 g Na_2HPO_4 (MM = 142 g/mol) into 250.0 mL of 0.100 M NaH_2PO_4 (pK_a = 6.59)?

Show all work for credit.

Answer to the correct number of significant figures _____

3b. (4 pts) What pH results if 0.010 mol HCl is added to the buffer in Question 3a?

Show all work for credit.

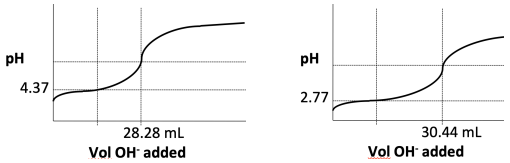
Answer to the correct number of significant figures _____

4. (4 pts) How many moles of NaOH must be added to 250.0 mL 0.1500 M $HC_2H_3O_2$ (pK_a = 4.74) in order to prepare a buffer with a pH = 5.00?

Show all work for credit.

Answer with units _____

5. Consider the titration curve for HA on the left to answer 5a – 5d. The NaOH used **for both** titrations is 0.200 M.



5a. (3 pts) Given 25.00 mL HA was titrated, what is the molarity of HA? Show all work for credit.

Answer with units _____

5b. (1 pt) What is the K_a for the acid? _____

5c. (4 pts) What is the pH after 10.00 mL NaOH have been added?

Show all work for credit.

Answer: _____

5d. (3 pts) Which three of these values would you need to calculate the pH at the equivalence point?

- ☐ [HA] at equiv. point
- ☐ K_b for A^-
- ☐ moles A^- at equiv. point
- ☐ Vol_{tot} at equiv. point
- ☐ Volume associated with pH = 7.00

5e. (5 pts) Consider the titration curve for HB on the right to answer these questions about HB.

T F HB is a stronger weak acid than HA.

T F The concentration of HB is larger than HA.

T F After the equivalence point, the solution contains excess strong base.

T F The pH at the equivalence point equals 7.00.

T F Prior to the equivalence point, the solution is a buffer consisting of HB and B^-.

6. (4 pts) (a) Write the first line of a MICE table for the dissolution process for each of these salts. (b) Also write the K_{sp} expression in terms of concentrations.

6a. $Mg(OH)_2$

6b. $Ba_3(PO_4)_2$

7. (4 pts) What is the molar solubility, **x**, of $CaCO_3$ given $K_{sp} = 5 \times 10^{-9}$?

Show work for credit.

Answer with units: _____

8a. (4 pts) What is the molar solubility, **x**, and pH of $Ca(OH)_2$ given $K_{sp} = 5.5 \times 10^{-6}$?

Watch the sig figs on pH.

Molar solubility with units: _____ pH = _____

8b. (4 pts) What is the molar solubility of pH of $Ca(OH)_2$ in a pH = 12.00 buffer solution?

Show work for credit.

Answer: _____

8c. (3 pts) What would happen to…

K_{sp} if some $Ca(NO_3)_2$ is added? **Shift: R L No shift**

if some Ca^{2+} is added? **Shift: Right Left No shift**

if some H_3O^+ is added? **Shift: Right Left No shift**

8d. (1 pts) Is $Ca(OH)_2$ more soluble than $CaCO_3$ (Question 7) **Yes** or **No**

9. (10 pts) Is ΔG^o spontaneous and ΔS^o favored for these processes? (C_3H_8 is propane, a combustible fuel.)

9a. dissolving sugar in water	**$\Delta G^o < 0$?** **Yes No**	**$\Delta S^o > 0$?** **Yes No**
9b. $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$	**$\Delta G^o < 0$?** **Yes No**	**$\Delta S^o > 0$?** **Yes No**
9c. $C_3H_8(l) \rightarrow C_3H_8(g)$ (normal bp -42°C)	**$\Delta G^o < 0$?** **Yes No**	**$\Delta S^o > 0$?** **Yes No**
9d. $2\ NaCl(s) \rightarrow 2\ Na(s) + Cl_2(g)$	**$\Delta G^o < 0$?** **Yes No**	**$\Delta S^o > 0$?** **Yes No**
9e. Iron rusting in air to form iron oxides such as Fe_2O_3	**$\Delta G^o < 0$?** **Yes No**	**$\Delta S^o > 0$?** **Yes No**

10a. (3 pts) Calculate ΔG^o for the reaction: See data sheet.

$2\ NH_3(g) \rightarrow N_2(g) + 3\ H_2(g)$

Answer with units: _____

10b. (3 pts) Calculate ΔS^o for the same reaction.

$2\ NH_3(g) \rightarrow N_2(g) + 3\ H_2(g)$

Answer with units: _____

10c. (1 pts) Is the sign of ΔS^o what you would have predicted? **Yes** or **No**

10d. (2 pts) Given $\Delta H^o = +91.8$ kJ, what can you conclude about ΔG^o? Check only one box. The reaction is…

- ☐ spontaneous at all temperatures, or
- ☐ never spontaneous at any temperature or
- ☐ spontaneous at low temperatures only or
- ☐ spontaneous at high temperatures only.

10e. (3 pts) If you checked the third or fourth box in the previous question, calculate the temperature at which the reaction switches from spontaneous to non-spontaneous. Otherwise, skip this question.

Show all work for credit.

Answer with units: _____

10f. (4 pts) Estimate ΔG for the reaction at 350 K using the Gibbs-Helmholtz equation: $\Delta G = \Delta H - T\Delta S$

Show all work for credit.

Answer with units: _____

11a. (4 pts) Calculate ΔG for the reaction below at 298 K given $\Delta G^o = +3.4$ kJ, $P_{H_2} = 1.0$ atm, and $P_{HI} = 5.0$ atm.

$H_2(g) + I_2(s) \rightarrow 2\ HI(g)$

Answer: _____

11b. (3 pts) What is the equilibrium constant, K_p, for the above reaction at 298 K?

Show all work for credit.

Answer: _____

12. (2 pts) As a reaction proceeds undisturbed from initial concentrations or pressures (I → C → E), which two of these things happen? Circle only two.

$\Delta G^o \rightarrow 0$	$\Delta G \rightarrow 0$	$Q_p \rightarrow K_p$
$Q_p \rightarrow 0$	$K_p \rightarrow 1$	$\Delta G \rightarrow \Delta G^o$

Answers.

1. $HF(aq) + OH^-(aq) \rightleftharpoons H_2O + F^-$

$K_n = [F^-] / [HF]\,[OH^-]$

$K_n = 1/K_b = K_a/K_w = 3.5 \times 10^{+10}$

$H_3O^+(aq) + OH^-(aq) \rightleftharpoons 2\ H_2O$

$K_n = 1 / [H_3O^+]\,[OH^-]$

$K_n = 1/K_w = 1.0 \times 10^{+14}$

$F^-(aq) + H_3O^+(aq) \rightleftharpoons H_2O + HF$

$K_n = [HF] / [F^-]\,[H_3O^+]$

$1/K_a = 2.9 \times 10^{+3}$

2. Yes Yes Yes No Yes

3a. 6.50 3b. 6.06

4. 0.0242 mol

5a. 0.226 M 5b. 4.27×10^{-5} 5c. 4.11

5d. ☐ K_b for A^- ☐ moles A^- at equiv. point
☐ Vol_{tot} at equiv. point

5e. T T T F T

6a. $Mg(OH)_2 \rightleftharpoons Mg^{2+}$ $2\ OH^-$

$K_{sp} = [Mg^{2+}]\,[OH^-]^2$

6b. $Ba_3(PO_4)_2 \rightleftharpoons 3\ Ba^{2+} + 2\ PO_4^{3-}$

$K_{sp} = [Ba^{2+}]^3\,[PO_4^{3-}]^2$

7. $x = 7.1 \times 10^{-5}$ M

8a. x = 0.0111 M and pH = 12.35

8b. x = 0.056 M

8c. K_{sp} does not change
Shift left
H_3O^+ decreases OH^- due to neutralization, therefore shift to the right.

8d. Yes

9a. $\Delta G^o < 0$? Yes $\Delta S^o > 0$? Yes
9b. $\Delta G^o < 0$? Yes $\Delta S^o > 0$? Yes
9c. $\Delta G^o < 0$? Yes $\Delta S^o > 0$? Yes
9d. $\Delta G^o < 0$? No $\Delta S^o > 0$? Yes
9e. $\Delta G^o < 0$? Yes $\Delta S^o > 0$? No

10a. 33.2 kJ 10b. 197.7 J/K 10c. Yes
10d. ☐ spontaneous at high temperatures only.

10e. 464 K 10f. 22.6 kJ

11a. 11.37 kJ 11b. 0.254

12. $\Delta G \rightarrow 0$ $Q_p \rightarrow K_p$

Data sheet

Useful Formulas:

$\Delta G = \Delta G^o + R\ T\ \ln Q = R\ T\ \ln(Q/K)$

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

$R = 8.314\ J\ mol^{-1}\ K^{-1}$

$R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$

$K_w^{298} = 1 \times 10^{-14}$

	ΔH_f^o kJ/mol	ΔG_f^o kJ/mol	S^o J/mol K
$H_2(g)$	0	0	130.6
$N_2(g)$	0	0	191.5
$O_2(g)$	0	0	205.0
$N_2H_4(g)$	95.4	159.3	238.4
$NH_3(g)$	−45.9	-16.6	192.8
$N_2O(g)$	82.0	104.2	219.7
$H_2O(g)$	-241.8	-228.6	188.7
NO(g)	91.3	87.6	210.7

1 H 1.008																	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 24.30											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 101.1	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	71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	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)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Uun (269)	111 Uuu (272)	112 Uub (277)		114 Uuq (289)		116 Uuh (289)		118 Uuo (293)

57 La 138.9	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
89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	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)	103 Lr (260)