Exam 3 Chm 205 (Dr Mattson) 28 March 2018

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) Write the **net ionic** neutralization reaction for a strong acid with a strong base. Include long/short arrows and a **numerical value** for K_n.

2. (4 pts) Write the **net ionic** neutralization reaction for a weak acid, HA (K_a = 2.0 x 10^{-5}), with a strong base. Include long/short arrows and a **numerical value** for K_n.

3. (4 pts) Write the **net ionic** neutralization reaction for a weak base, A^-, with a strong acid. Include long/short arrows and **numerical value** for K_n (K_a^{HA} = 4.0 x 10^{-4})

4. (5 pts) Which of these are buffers and if so, what recipe produced the buffer: Circle: Recipe 1 (R1): wa + wb mixture, R2: wa + OH^-, R3: wb + H_3O^+ or **Not** a buffer.

5.0 g $NaC_2H_3O_2$ + 3.0 g $HC_2H_3O_2$	R1	R2	R3	Not
2.0 mmol $NaClO_2$ + 1.2 mmol HCl	R1	R2	R3	Not
7.0 mmol HF + 4.0 mmol NaOH	R1	R2	R3	Not
40 mL 1 M KCN + 15 mL 1 M HBr	R1	R2	R3	Not
5.5 mmol KF + 5.5 mmol HNO_3	R1	R2	R3	Not

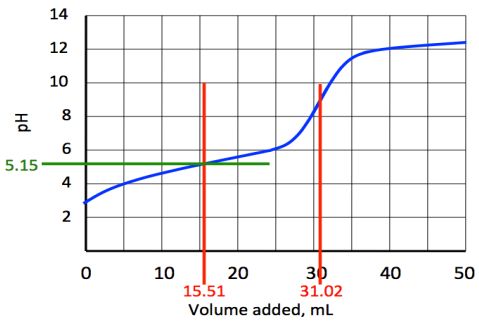
5a. (4 pts) What is the pH of a buffer prepared by combining 1.530 g $NaNO_2$ (MM = 69.00 g/mol) with 250.0 mL 0.100 M HNO_2(aq)? $K_a^{HNO_2}$ = 3.8 x 10^{-4}

Answer with correct significant figures: _____

5b. (4 pts) What is the pH of the buffer from Question 5a if 0.0020 mol HCl is added?

Answer with correct significant figures: _____

6. The following titration curve results when 20.00 mL of an acid it titrated with 0.0987 M NaOH. It takes 31.02 mL to reach the equivalence point.



6a. (4 pts) What was the original concentration of the acid? This is a calculation – do not estimate from graph.

Answer with units and significant figures: _____

6b. (4 pts) What is K_a for the acid?

Answer with correct significant figures: _____

6c. (5 pts) What was the pH after 9.00 mL NaOH has been added? This is a calculation – do not estimate.

Answer: _____

6d. (2 pts) In addition to the information provided above, directly or indirectly, including from the graph, is there any other piece of information needed to calculate the pH at the equivalence point? **Circle: Yes or No**

7. (5 pts) Suppose 25.00 mL of a 0.140 M HNO_3(aq) is titrated with 0.220 M KOH(aq). Calculate the pH after 15.00 mL KOH has been added.

Answer to the hundredths place: _____

8a. (4 pt) Write the equilibrium expression for barium fluoride, BaF_2, a sparingly soluble salt. and define its K_{sp} in terms of concentrations.

8b. (4 pt) What is the molar solubility of barium fluoride if $K_{sp} = 1.8 \times 10^{-7}$? Hint: Set up MICE table.

Answer with units: _____

8c. (4 pts) What is the molar solubility of barium fluoride in a solution that is 0.035 M KF?

Answer with units: _____

8d. (4 pts) Will a precipitate form if equal volumes of 0.0040 M $Ba(NO_3)_2$ and NaF are mixed? Show Q_{sp} calculation! Note: The two solutions dilute each other.

Caution! The solutions dilute each other!

Answer Q_{sp}= _____ Precipitate: **Yes** or **No**

Useful equations:	R = 8.314 J/mol K
$\Delta G^o = \Delta H^o - T\Delta S^o$	$\Delta G = \Delta H - T\Delta S$
$\Delta G = \Delta G^o + R\ T\ \ln Q$	$\Delta G^o = -R\ T\ \ln K$

9. (5 pts) Which of these processes are spontaneous?

a. dissolving sugar in hot coffee
b. mixing of nitrogen gas and bromine vapor
c. ethanol boiling at 25 °C and 1 atm
d. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$
e. $HCl(aq) + NaOH(aq) \rightarrow H_2O(aq) + NaCl(aq)$

10. (5 pts) Which of these processes is entropy-favored?

a. dissolving sugar in hot coffee
b. mixing of nitrogen gas and bromine vapor
c. ethanol boiling
d. $N_2(g) + 2\ H_2(g) \rightarrow N_2H_4(g)$
e. $HCl(aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$

11a. (4 pts) Calculate ΔS^o for the reaction in the box, given these standard entropies. Show units in your calculation.

	S^o (J mol^{-1} K^{-1})
$H_2O_2(aq)$	144
$H_2O(l)$	70
$O_2(g)$:	205

$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$

Answer with units: _____

11b. (4 pts) Given ΔH_f^o = -188 kJ for the reaction above, calculate ΔG^o for the reaction.

Answer with units: _____

11c. (1 pt) This reaction is spontaneous at…

A. high temperatures only B. low temperatures only
C. all temperatures D. never

12a. (4 pts) Estimate the boiling point of benzene, given: ΔH_{vap} = 30.7 kJ/mol and ΔS_{vap} = 87.0 J mol^{-1} K^{-1}.

Answer with units: _____

12b. (4 pts) Estimate ΔG_{vap} at 75 °C for benzene. Is vaporization spontaneous at 75 °C?

Answer with units: _____
Is vaporization spontaneous at this temperature? **Yes** or **No**

13a-d (4 pts). Consider the all-gas reaction at 25 °C.

$P_4 + 6\ H_2 \rightarrow 4\ PH_3$ ΔG^o = +29.5 kJ ΔH^o = -37.3 kJ

13a. Is the reaction spontaneous at 25 °C? **Yes** or **No**
13b. Is the reaction entropy-favored? **Yes** or **No**
13c. Is the reaction enthalpy-favored? **Yes** or **No**
13d. Is the reaction ever spontaneous? Use the same answer choices as in Question 11c: **Circle: A B C D**

13e. (4 pts) Calculate ΔG at 25 °C starting with 1.0 atm $P_4(g)$, 1.0 atm $H_2(g)$ and 3.0 atm $PH_3(g)$.

Answer with units: _____

13f. (4 pts) Calculate K_p for the reaction.

Answer: _____

Total score (out of 100): _____

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

Answers

1. $H_3O^+ + OH^- \rightleftharpoons H_2O$ $K_n = 1 \times 10^{+14}$

2. $HA + OH^- \rightleftharpoons H_2O + A^-$ $K_n = {}^1/_{K_n} = 7.0 \times 10^{+8}$

3. $A^- + H_3O^+ \rightleftharpoons H_2O + HA$ $K_n = {}^1/_{K_a} = 1.6 \times 10^{+4}$

4. R3, Not, R3, R1, R2

5a. 3.00

5b. 3.09

6a. 0.164 M

6b. $K_a = 1.82 \times 10^{-6}$

6c. 5.55

6d. **Yes**

7. 2.14

8a. $BaF_2 \rightleftharpoons Ba^{+2}(aq) + 2\ F^-(aq)$ $K_{sp} = [Ba^{+2}][F^-]^2$

8b. $x = 2.06 \times 10^{-4}$ M

8c. $x = 2.19 \times 10^{-8}$ M

8d. $Q_{sp} = 8.0 \times 10^{-9}$ YES

9. a, b, c, e

10. a, b, d, e

11a. $\Delta S^o = 57$ J/deg

11b. $\Delta G^o = -205$ kJ

11c. A

12a. 353 K

12b. $\Delta G_{vap} = -0.446$ kJ (kJ/mol is also ok this time)

13a-d (4 pts). Consider the all-gas reaction at 25 ^oC.

$P_4 + 6\ H_2 \rightarrow 4\ PH_3$ $\Delta G^o = +29.5$ kJ $\Delta H^o = -37.3$ kJ

13a. **Yes**

13b. **No**

13c. **No**

13d. **D**

13e. $\Delta G = 45.4$ kJ

13f. $K_p = 6.74 \times 10^{-6}$