Exam Three **CHM 205 (Dr. Mattson)** **2 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. (4 pts each for a – e) In the boxes where the equilibrium arrows go, write "L" if the equilibrium lies to the left (big arrow left) or "R" for big arrow right. Then, write the equilibrium constant, K, terms of K_a, K_b and/or K_w for each of these equilibria.

(a) $HC_3H_5O_2 + H_2O$ ☐ $H_3O^+ + C_3H_5O_2^-$ K =

(b) $H_3O^+ + OH^-$ ☐ $2\ H_2O$ K =

(c) $HC_2H_3O_2 + OH^-$ ☐ $H_2O + C_2H_3O_2^-$ K =

(d) $NH_3 + H_3O^+$ ☐ $H_2O + NH_4^+$ K =

(e) $NH_3 + H_2O$ ☐ $OH^- + NH_4^+$ K =

2. (4 pts) Use the appropriate equilibrium constant value provided on the data sheet to give a numerical value for the equilibrium, K_n, in 1(c) above.

3. (8 pts) Which of the following would make a buffer? In each case, you may assume that the compounds listed are dissolved together in water.

(a) 0.40 mol $HC_3H_5O_2$ + 0.30 mol $NaC_3H_5O_2$

(b) 0.40 mol $HC_3H_5O_2$ + 0.30 mol NaOH

(c) 0.30 mol $HC_3H_5O_2$ + 0.40 mol NaOH

(d) 0.20 mol NH_3 + 0.20 mol NH_4Cl

(e) 0.70 mol NH_3 + 0.20 mol HCl

(f) 0.60 mol NaF + 0.50 mol HNO_3

(g) 0.60 mol NaOH + 0.30 mol HNO_3

(h) 0.40 mol $HC_2H_3O_2$ + 0.40 mol NaF

4(a) (5 pts) What is the pH of a buffer prepared by dissolving 0.28 mol $HC_7H_5O_2$ (benzoic acid) with 0.19 mol $NaC_7H_5O_2$?

(b) (5 pts) What is the resulting pH if 0.03 mol of NaOH were added to the buffer?

(c) (2 pts) Does the original buffer, prior to adding NaOH in (b), have a larger buffer capacity towards strong acid or strong base? Circle: **sa** or **sb**

5. (5 pts) What is the pH of a solution that results from adding 0.050 mol NaOH to 500.0 mL 0.400 M HNO_2?

6. (4 pts) Pick the <u>best two</u> choices: Which pair of wa/wb would be suited for preparing a buffer with pH of 6.5?

(a) HA (pK_a = 3.4) + NaA (b) HB (pK_a = 5.9) + NaB

(c) HC (pK_a = 6.9) + NaC (d) HD (pK_a = 8.8) + NaD

(e) HE (pK_a = 9.2) + NaE

7. (5 pts) What would be the theoretical ratio of HPO_4^{-2} to $H_2PO_4^-$ in order to make a buffer with a pH of 7.00?

8. Consider the titration of 25.00 mL HCl(aq) with 0.1299 M NaOH (See Titration Curve A on data sheet.)

(a) (3 pts) What volume of NaOH solution is required to reach the equivalence point?

(b) (5 pts) What is the molarity of the acid?

(c) (9 pts) What is in the flask? Circle one choice per box.

Prior to equivalence point	At equivalence point	After equivalence point
$H_3O^+ > OH^-$	$H_3O^+ > OH^-$	$H_3O^+ > OH^-$
$H_3O^+ = OH^-$	$H_3O^+ = OH^-$	$H_3O^+ = OH^-$
$H_3O^+ < OH^-$	$H_3O^+ < OH^-$	$H_3O^+ < OH^-$
$Na^+ > Cl^-$	$Na^+ > Cl^-$	$Na^+ > Cl^-$
$Na^+ = Cl^-$	$Na^+ = Cl^-$	$Na^+ = Cl^-$
$Na^+ < Cl^-$	$Na^+ < Cl^-$	$Na^+ < Cl^-$
pH < 7	pH < 7	pH < 7
pH = 7	pH = 7	pH = 7
pH > 7	pH > 7	pH > 7

(d) (5 pts) What is the <u>calculated</u> pH after 15.00 mL of the NaOH solution has been added?

9. This question refers to Titration Curve B on the data sheet/scratch paper. The volume of the unknown acid being titrated was 25.00 mL and the NaOH used was 0.1188 M. *Remember to show all work in the calculation boxes. The data sheet will not be graded.*

(a) (5 pts) What is the molarity of the unknown acid?

(b) (5 pts) What is the pK_a of the unknown acid? Explain in a few words how this was determined.

(c) (5 pts) How would you solve for the pH at various points along the titration curve? Box your choices, A – E. You can use one method more than once.

Box only one choice:	**Vol OH^- added**	**Method to solve for the pH:**
A B C D E	0 mL	A. buffer problem, use Henderson-Hasselbalch
A B C D E	10 mL	B. ICE: excess strong base to solve $[OH^-]$, then pH
A B C D E	20 mL	C. weak acid K_a problem, just like in Chapter 15
A B C D E	30 mL	D. weak base K_b problem, use total volume
A B C D E	40 mL	E. No calc, pH = 7

(d) (5 pts) Calculate the pH at the equivalence point using data from the data sheet and from other parts of this problem as necessary.

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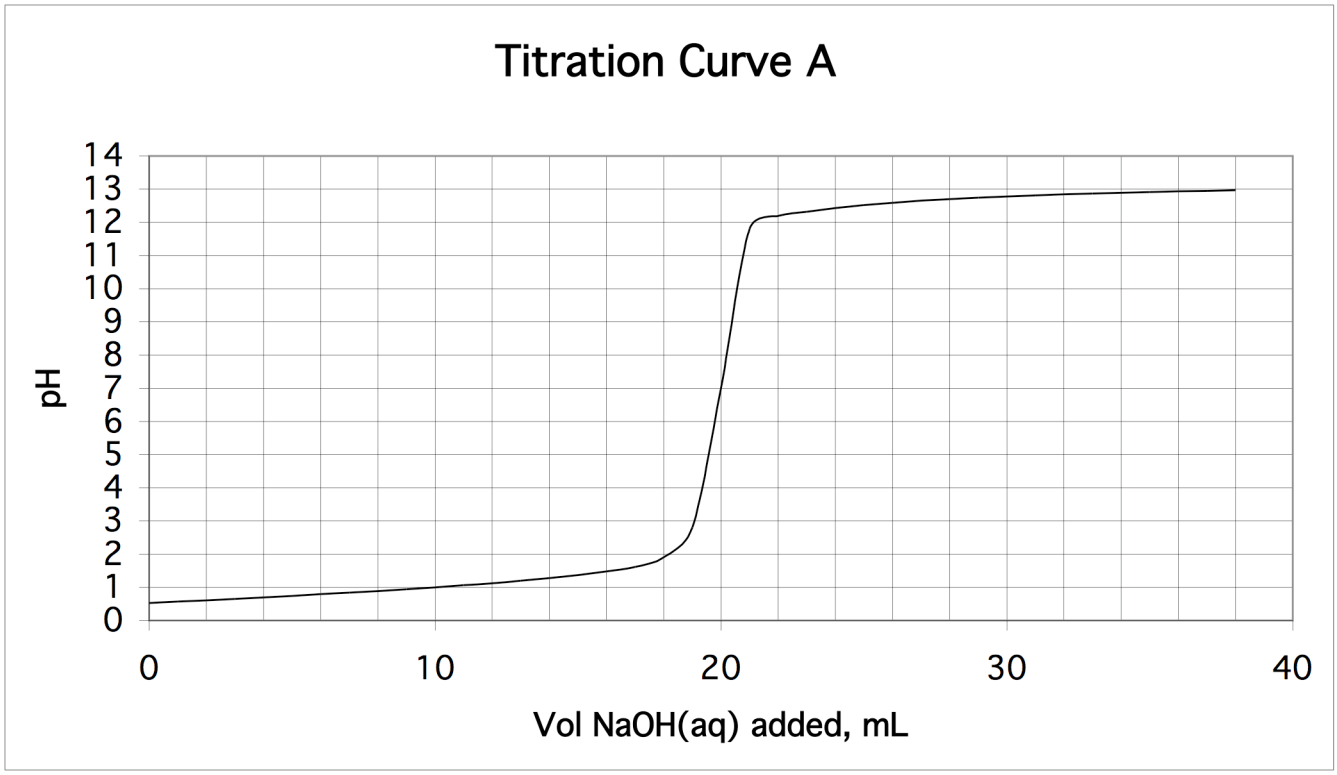
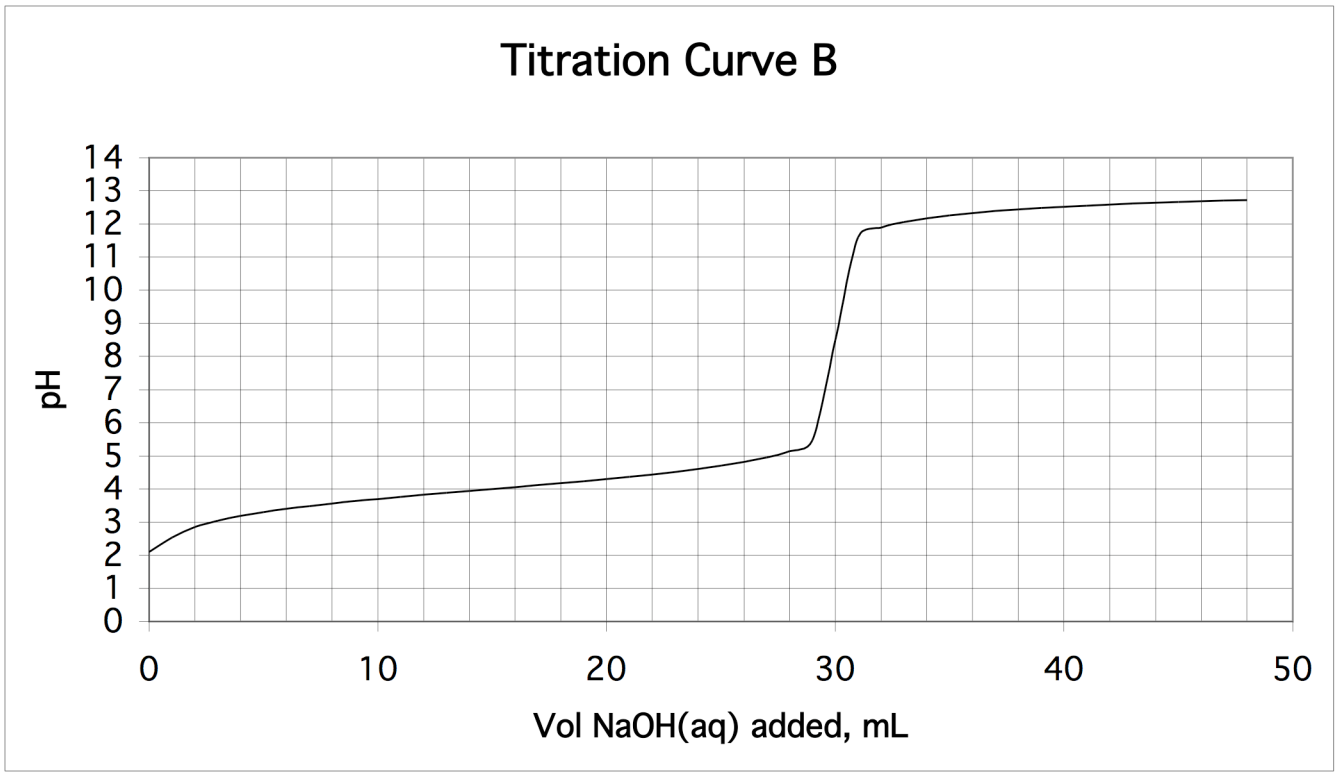
Your exam score (100 possible): _____

Determine your grade:
A+ ≥ 95; A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60


Titration Curve A
pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
Vol NaOH(aq) added, mL


Titration Curve B
pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
Vol NaOH(aq) added, mL

Acid Dissociation Constants

Acetic acid, $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$, $pK_a = 4.74$

Benzoic acid, $HC_7H_5O_2$, $K_a = 6.5 \times 10^{-5}$, $pK_a = 4.19$

Formic acid, HCOOH, $K_a = 1.8 \times 10^{-4}$, $pK_a = 3.74$

Hydrofluoric acid, HF, $K_a = 7.2 \times 10^{-4}$, $pK_a = 3.14$

Nitrous acid, HNO_2, $K_a = 4.0 \times 10^{-4}$, $pK_a = 3.40$

Phosphoric acid, H_3PO_4, $K_{a1} = 7.5 \times 10^{-3}$ $K_{a2} = 6.2 \times 10^{-8}$ $K_{a3} = 4.8 \times 10^{-13}$

$pK_{a1} = 2.12$, $pK_{a2} = 7.21$, $pK_{a3} = 12.32$

Propionic acid, $K_a = 1.3 \times 10^{-5}$, $pK_a = 4.89$

Sulfurous acid, H_2SO_3, $K_{a1} = 1.5 \times 10^{-2}$ $K_{a2} = 6.3 \times 10^{-8}$

$pK_{a1} = 1.82$, $pK_{a2} = 7.20$

Base Dissociation Constants

Ammonia, NH_3, $K_b = 1.8 \times 10^{-5}$, $pK_b = 4.74$

Answers:

1. (a) L; $K = K_a$; (b) R; $K = 1/K_w$ (c) R; $K = 1/K_b = K_a/K_w$
(d) R; $K = 1/K_a = K_b/K_w$ (e) L; $K = K_b$

2. $K_n = 1.8 \times 10^{+9}$

3. a, b, d, e, f

4. (a) 4.02; (b) 4.13; (c) sb

5. 2.92

6. b, c

7. 0.617:1 or 0.617

8. (a) 20.0 mL; (b) 0.104 M; (c) see table below; (d) 1.79

Prior	At	After
$H_3O^+ > OH^-$	$H_3O^+ = OH^-$	$H_3O^+ < OH^-$
$Na^+ < Cl^-$	$Na^+ = Cl^-$	$Na^+ > Cl^-$
pH < 7	pH = 7	pH > 7

9. (a) 0.1426 M; (b) 4.0; (c) C, A, A, D, B; (d) 8.41