Exam 3 Chm 205 (Dr Mattson) 7 April 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.

Question 1 refers to Lewis acids and bases

1a. (2 pt) Which of the following is a Lewis acid, but not a Brønsted-Lowry acid?

A. NO_2^- B. NH_4^+ C. SO_3^{2-} D. Fe^{2+}

1b-d. (2 pts each) Sketch the Lewis dot diagrams in order to determine whether each is a Lewis acid or base. Correct Lewis structure required – no partial credit.

	Lewis dot structure	Lewis acid, base or neither
1b. AlH_4^-		Lewis acid Lewis base Neither
1c. AlH_3		Lewis acid Lewis base Neither
1d. PF_3		Lewis acid Lewis base Neither

Question 2 refers to tellurous acid, H_2TeO_3, an unstable compound about which little is known aside from its pK_a values, 2.48 and 7.70.

2a. (2 pt) Write the equilibrium expression (with appropriate arrows) for H_2TeO_3.

2b. (2 pts) Write the K_a expression for H_2TeO_3 in terms of concentrations and give its numerical value.

2c. (2 pts) The anion $HTeO_3^-$ can function as either an acid or a base. What is the value of K_a for $HTeO_3^-$?

2d. (3 pts) What is the numerical value of K_b for $HTeO_3^-$?

2e. (2 pts) Would a solution of $HTeO_3^-$ be acidic, basic, or neutral? Circle: Acidic Basic Neutral

Question 3 refers to equilibria between acids and bases. Benzoic acid, C_6H_5COOH (we will abbreviate it HBz), is an important organic compound used to manufacture many products, including plasticizers. Its pK_a is 4.202.

3a. (1 pt) Convert pK_a to K_a. Your answer must have the correct number of significant figures for credit.

3b-e. (3 pts each) Write the correct descriptive arrow (either $\rightleftharpoons$ or $\longrightarrow$ or $\longleftarrow$) in the space between the square parentheses. Then provide the numerical value for the equilibrium constant for each.

3b. $HBz + OH^-$ [ ] $H_2O + Bz^-$	K =
3c. $H_3O^+ + OH^-$ [ ] $2\ H_2O$	K =
3d. $Bz^- + H_2O$ [ ] $OH^- + HBz$	K =
3e. $Bz^- + H_3O^+$ [ ] $H_2O + HBz$	K =
3f. $HBz + H_2O$ [ ] $H_3O^+ + Bz^-$	K =

3g. (1 pt) Ethanoic acid, CH_3COOH, has a pKa = 4.745. Which is a stronger acid? **Circle Ethanoic or Benzoic**

3h. (3 pts) Determine the equilibrium constant for:

$CH_3COOH + C_6H_5COO^-$ [ ] $CH_3COO^- + C_6H_5COOH$

4. (4 pts) Identify each of these as a weak acid, strong acid, weak base, strong base, or neither.

A. NaCN WA SA WB SB N

B. $HClO_2$ WA SA WB SB N

C. Na_2SO_4 WA SA WB SB N

D. KBr WA SA WB SB N

Question 5 pertains to buffers. Use the following data.

Nitrous acid, HNO_2	$K_a = 4.5 \times 10^{-4}$
Acetic acid, $HC_2H_3O_2$	$K_a = 1.8 \times 10^{-5}$
Hypochlorous acid, HOCl	$K_a = 3.5 \times 10^{-8}$
Hypoiodous acid, HOI	$K_a = 2.3 \times 10^{-11}$

5a. (5 pts) Which of the following solutions is a buffer when dissolved to make 100 mL solution?

Yes No 4.2 g HNO_2 + 7.0 g KNO_2

Yes No 5.1 mmol $HC_2H_3O_2$ + 3.6 mmol LiOH

Yes No 0.24 mol HNO_3 + 0.39 mol NaOI

Yes No 2.7 g HOI + 1.8 g NaOCl

Yes No 0.79 mmol $HC_2H_3O_2$ + 1.21 mmol KOH

5b. (3 pts) What is the pH of a solution prepared by mixing 4.1 mmol $HC_2H_3O_2$ ($pK_a = 4.74$) and 2.5 mmol $NaC_2H_3O_2$ in water to make 100.0 mL solution?

Answer:_____

5c. (1 pt) Does this buffer have a greater buffer capacity towards strong acids or strong bases?

A. strong acids B. strong bases C. equal

5d. (1 pt) How does the pH change if the volume increases by the addition of water?

A. pH goes up B. pH goes down C. pH is unchanged

5e. (1 pt) Which acid when reacted with approximately one half-equivalent of NaOH would produce a buffer close to pH = 7.5?

A. nitrous acid B. acetic acid

C. hypochlorous acid D. hypoiodous acid

5f. (3 pts) What is the pH of the solution described in 5b if 0.50 mmol of NaOH were added?

Answer:_____

Question 6 pertains to the titration of 25.00 mL 0.1111 M HCl(aq) with NaOH(aq). Suppose it took 19.40 mL Na(OH) to reach the phenolphthalein endpoint.

6a. (3 pts) What it the molar concentration of the NaOH(aq)?

Answer:_____

6b. (3 pts) What it the pH of the solution after 10.0 mL NaOH(aq) has been added?

Answer:_____

Question 7. Refers to the titration of 50.00 mL 0.100 M HOCl acid with 0.200 M NaOH(aq).

7a. (1 pt) What is the pH before any OH^- is added?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7b. (1 pt) What is the pH after 12.50 mL OH^- is added?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7c. (1 pt) What is the pH at the equivalence point?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7d. (4 pts) What is the pH after 10.0 mL OH^- is added?

Answer:_____

Question 8 pertains to solubility. Use the following data.

magnesium fluoride, MgF_2	$K_{sp} = 7.4 \times 10^{-11}$
magnesium carbonate, $MgCO_3$	$K_{sp} = 6.8 \times 10^{-6}$

8a. (3 pts) What is the molar solubility of MgF_2?

Answer:_____

8b. (3 pts) What is the molar solubility of MgF_2 in a solution that is 0.050 M $Mg(NO_3)_2$?

Answer:_____

8c. (3 pts) Will a precipitate form if 1.0 mmol $Mg(NO_3)_2$ were added to 1.0 L of 0.040 M Na_2CO_3? Show work for credit.

Answer:_____

8d (1 pt) Which is more soluble? Circle: MgF_2 or $MgCO_3$

Score: _____ + _____ = _____

from exam + folder = total

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Question 1 refers to Lewis acids and bases

1a. (2 pt) Which of the following is a Lewis acid, but not a Brønsted-Lowry acid?

A. NO_2^- B. Fe^{+2} C. SO_3^{2-} D. NH_4^+

1b-d. (2 pts each) Sketch the Lewis dot diagrams in order to determine whether each is a Lewis acid or base. Correct Lewis structure required – no partial credit.

	Lewis dot structure	Lewis acid, base or neither
1b. AlH_3		Lewis acid Lewis base Neither
1c. AlH_4^-		Lewis acid Lewis base Neither
1d. PF_3		Lewis acid Lewis base Neither

Question 2 refers to tellurous acid, H_2TeO_3, an unstable compound about which little is known aside from its pK_a values, 2.48 and 7.70.

2a. (2 pt) Write the equilibrium expression (with appropriate arrows) for H_2TeO_3.

2b. (2 pts) Write the K_a expression for H_2TeO_3 in terms of concentrations and give its numerical value.

2c. (2 pts) The anion $HTeO_3^-$ can function as either an acid or a base. What is the value of K_a for $HTeO_3^-$?

2d. (3 pts) What is the numerical value of K_b for $HTeO_3^-$?

2e. (2 pts) Would a solution of $HTeO_3^-$ be acidic, basic, or neutral? Circle: Acidic Basic Neutral

Question 3 refers to equilibria between acids and bases. Benzoic acid, C_6H_5COOH (we will abbreviate it HBz), is an important organic compound used to manufacture many products, including plasticizers. Its pK_a is 4.202.

3a. (1 pt) Convert pK_a to K_a. Your answer must have the correct number of significant figures for credit.

3b-e. (3 pts each) Write the correct descriptive arrow (either $\rightleftharpoons$ or $\longrightarrow$ or $\longleftarrow$) in the space between the square parentheses. Then provide the numerical value for the equilibrium constant for each.

3b. $H_3O^+ + OH^-$ [ ] $2\ H_2O$	K =
3c. $Bz^- + H_2O$ [ ] $OH^- + HBz$	K =
3d. $Bz^- + H_3O^+$ [ ] $H_2O + HBz$	K =
3e. $HBz + H_2O$ [ ] $H_3O^+ + Bz^-$	K =
3f. HBz + OH- [ ] H2O + Bz-	K =

3g. (1 pt) Ethanoic acid, CH_3COOH, has a pKa = 4.745. Which is a stronger acid? **Circle Benzoic or Ethanoic**

3h. (3 pts) Determine the equilibrium constant for:

$CH_3COO^- + C_6H_5COOH$ [ ] $CH_3COOH + C_6H_5COO^-$

4. (4 pts) Identify each of these as a weak acid, strong acid, weak base, strong base, or neither.

A. KBr WA SA WB SB N

B. NaCN WA SA WB SB N

C. $HClO_2$ WA SA WB SB N

D. Na_2SO_4 WA SA WB SB N

Question 5 pertains to buffers. Use the following data.

Nitrous acid, HNO_2	$K_a = 4.5 \times 10^{-4}$
Acetic acid, $HC_2H_3O_2$	$K_a = 1.8 \times 10^{-5}$
Hypochlorous acid, HOCl	$K_a = 3.5 \times 10^{-8}$
Hypoiodous acid, HOI	$K_a = 2.3 \times 10^{-11}$

5a. (5 pts) Which of the following solutions is a buffer when dissolved to make 100 mL solution?

Yes No 2.7 g HOI + 1.8 g NaOCl

Yes No 0.79 mmol $HC_2H_3O_2$ + 1.21 mmol KOH

Yes No 4.2 g HNO_2 + 7.0 g KNO_2

Yes No 5.1 mmol $HC_2H_3O_2$ + 3.6 mmol LiOH

Yes No 0.24 mol HNO_3 + 0.39 mol NaOI

5b. (3 pts) What is the pH of a solution prepared by mixing 2.1 mmol $HC_2H_3O_2$ ($pK_a = 4.74$) and 4.0 mmol $NaC_2H_3O_2$ in water to make 100.0 mL solution?

Answer:_____

5c. (1 pt) Does this buffer have a greater buffer capacity towards strong acids or strong bases?

A. strong acids B. strong bases C. equal

5d. (1 pt) How does the pH change if the volume increases by the addition of water?

A. pH goes up B. pH goes down C. pH is unchanged

5e. (1 pt) Which acid when reacted with approximately one half-equivalent of NaOH would produce a buffer close to pH = 4.8?

A. nitrous acid B. acetic acid

C. hypochlorous acid D. hypoiodous acid

5f. (3 pts) What is the pH of the solution described in 5b if 0.50 mmol of NaOH were added?

Answer:_____

Question 6 pertains to the titration of 25.00 mL 0.1111 M HCl(aq) with NaOH(aq). Suppose it took 22.20 mL Na(OH) to reach the phenolphthalein endpoint.

6a. (3 pts) What it the molar concentration of the NaOH(aq)?

Answer:_____

6b. (3 pts) What it the pH of the solution after 15.0 mL NaOH(aq) has been added?

Answer:_____

Question 7. Refers to the titration of 50.00 mL 0.100 M HOCl acid with 0.200 M NaOH(aq).

7a. (1 pt) What is the pH before any OH^- is added?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7b. (1 pt) What is the pH after 12.50 mL OH^- is added?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7c. (1 pt) What is the pH at the equivalence point?

A. 1.00 B. 4.23 C. 7.00 D. 7.45 E. 10.14

7d. (4 pts) What is the pH after 20.0 mL OH^- is added?

Answer:_____

Question 8 pertains to solubility. Use the following data.

calcium fluoride, CaF_2	$K_{sp} = 3.5 \times 10^{-11}$
calcium carbonate, $CaCO_3$	$K_{sp} = 5.0 \times 10^{-9}$

8a. (3 pts) What is the molar solubility of CaF_2?

Answer:_____

8b. (3 pts) What is the molar solubility of CaF_2 in a solution that is 0.040 M $Ca(NO_3)_2$?

Answer:_____

8c. (3 pts) Will a precipitate form if 1.0 mmol $Ca(NO_3)_2$ were added to 1.0 L of 0.040 M Na_2CO_3? Show work for credit.

Answer:_____

8d (1 pt) Which is more soluble? Circle: CaF_2 or $CaCO_3$

Score: _____ + _____ = _____

from exam + folder = total

Answers: (there were two forms to the exam)

1a. Fe^{2+}

1b-d.

AlH_4^-	AB_4	Neither
AlH_3	AB_3	Lewis acid
PF_3	AB_3E	Lewis base

Question 2 refers to tellurous acid, H_2TeO_3, an unstable compound about which little is known aside from its pK_a values, 2.48 and 7.70.

2a. (2 pt) $H_2TeO_3 + H_2O \rightleftharpoons H_3O^+ + HTeO_3^-$

1a. Fe^{2+}
1a. Fe^{2+}

2b. $K_a = [H_3O^+][HTeO_3^-]/[H_2TeO_3] = 3.3 \times 10^{-3}$

2c. . $K_{a2} = 2.0 \times 10^{-8}$

2d. $K_b = 3.0 \times 10^{-12}$ (Remember that the conjugate acid for the weak base $HTeO_3^-$ is H_2TeO_3!)

2e. Acidic

3a. $K_a = 6.28 \times 10^{-5}$ (three significant figures – the same as $pK_a = 4.202$)

3b-e.

$HBz + OH^- \rightleftharpoons H_2O + Bz^-$	$K = 6.3 \times 10^{+9}$
$H_3O^+ + OH^- \rightleftharpoons 2\ H_2O$	$K = 1.0 \times 10^{+14}$
$Bz^- + H_2O \rightleftharpoons OH^- + HBz$	$K = 1.6 \times 10^{-10}$
$Bz^- + H_3O^+ \rightleftharpoons H_2O + HBz$	$K = 1.6 \times 10^{+4}$
$HBz + H_2O \rightleftharpoons H_3O^+ + Bz^-$	$K = 6.3 \times 10^{-5}$

3g. Benzoic

3h. 0.29

4.

A. NaCN	WB
B. $HClO_2$	WA
C. Na_2SO_4	WB
D. KBr	N

5a.

Yes	4.2 g HNO_2 + 7.0 g KNO_2
Yes	5.1 mmol $HC_2H_3O_2$ + 3.6 mmol LiOH
Yes	0.24 mol HNO_3 + 0.39 mol NaOI
No	2.7 g HOI + 1.8 g NaOCl
No	0.79 mmol $HC_2H_3O_2$ + 1.21 mmol KOH

5b. 4.53 Other form: 5.02

5c. B. strong bases (Other form: strong acids)

5d. C. pH is unchanged

5e. pH = 7.5: hypochlorous acid; Other form pH = 4.8 Use acetic acid

5f. 4.66; Other form: 5.19

6a. 0.143 M; Other form: 0.125 M

6b. pH = 1.41; Other form: 1.65

Question 7. B, D, E

7d. pH = 7.28; Other form: 8.06

Question 8 pertains to solubility. Use the following data.

magnesium fluoride, MgF_2	$K_{sp} = 7.4 \times 10^{-11}$
magnesium carbonate, $MgCO_3$	$K_{sp} = 6.8 \times 10^{-6}$

8a. $x = 2.7 \times 10^{-4}$ M

8b. 1.9×10^{-5} M

8c. $Q_{sp} = 4 \times 10^{-5}$ so a precipitate forms

8d $MgCO_3$

Other form:
Question 8 pertains to solubility. Use the following data.

calcium fluoride, CaF_2	$K_{sp} = 3.5 \times 10^{-11}$
calcium carbonate, $CaCO_3$	$K_{sp} = 5.0 \times 10^{-9}$

8a. $x = 2.1 \times 10^{-4}$ M

8b. 1.5×10^{-5} M

8c. $Q_{sp} = 4 \times 10^{-6}$ so a precipitate forms

8d CaF_2