Exam 3 Chm 205 (Dr Mattson) 1 April 2015

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 your section: Section A or Section C

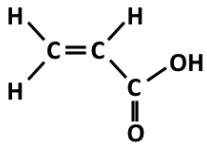
Circle your Folder group:

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, you may use the back of the data sheet provided — Write: "See Data Sheet" in the answer box and then submit data sheet with your exam. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks and bags must be closed and on the floor under the table. Cell phones must be OFF and placed in your backpack/bag – not in your pocket.

Note: All of these questions refer to aqueous solutions.

1. Acrylic acid, $HC_3H_3O_2$, shown here, is an important industrial chemical used in the production of polymers including plastics, coatings, adhesives, polishes, and paints. Over 10^9 kg acrylic acid are produced annually. Acrylic acid is miscible with water and has a $pK_a = 4.25$. You may refer to acrylic acid as HAcr or by its formula $HC_3H_3O_2$.



1a. (2 pts) What is the numerical value of K_a?

$K_a =$

1b. (4 pts) What is the conjugate base of acrylic acid and what is the numerical value of pK_b?

Conjugate base: _____

$pK_b =$

1c. (10 pts) Write the equilibrium constants, K, expressed in terms of K_a and/or K_w only. Fill in the arrows, either ⟵⟶ or ⟵⟶ for each. The first one is done.

$HC_3H_3O_2 + OH^-$	⟵⟶	$H_2O + C_3H_3O_2^-$	$K = K_a/K_w$
$HC_3H_3O_2 + H_2O$		$H_3O^+ + C_3H_3O_2^-$	K =
$H_3O^+ + OH^-$		$2\ H_2O$	K =
$C_3H_3O_2^- + H_2O$		$OH^- + HC_3H_3O_2$	K =
$C_3H_3O_2^- + H_3O^+$		$H_2O + HC_3H_3O_2$	K =
$2\ H_2O$		$H_3O^+ + OH^-$	K =

1d. (3 pts) Solve for x. No partial credit.

$$5.50 = 5.70 + \log\left(\frac{0.15}{x}\right)$$

Answer (a numerical value): _____

1e. (5 pts) Which would form a buffer? More than one!

A. 0.10 mol HAcr + 0.10 mol Acr^- in 500 mL H_2O

B. 0.10 mol HAcr + 0.04 mol OH^- in 250 mL H_2O

C. 0.10 mol HAcr + 0.14 mol OH^- in 100 mL H_2O

D. 0.10 mol H_3O^+ + 0.10 mol Acr^- in 500 mL H_2O

E. 5.0 g HAcr + 4.0 g NaAcr in 400 mL H_2O

1f. (3 pts) What is the pH of a solution prepared by dissolving 0.40 mol HAcr and 0.35 mol Acr^- in 250 mL water?

Answer: _____

1g. (1 pt) What will happen to the pH if another 50 mL water is added to the solution in the previous problem?

It will: ❑ Increase ❑ Decrease ❑ Stay the same

1h. (1 pt) The solution in Question 1f has a larger buffer capacity towards the addition of…

Circle one: ❑ Strong acid ❑ Strong base ❑ Both

1i. (4 pts) What is the pH of the solution in Question 1f if 0.020 mol NaOH were added?

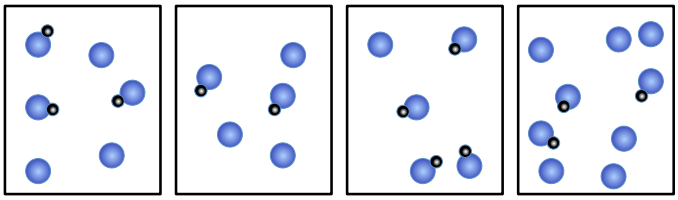
Answer: _____

2. (4 pts) HF has a $K_a = 3.6 \times 10^{-4}$ and HCO_2H has a $K_a = 1.8 \times 10^{-4}$. What is the equilibrium constant, K_c for:

$$HCO_2H + F^- \rightleftharpoons HF + CO_2H^- \quad K_c = ?$$

Answer: _____

3. These solutions are all buffers of the weak acid HB and its conjugate base, B^-.



A **B** **C** **D**

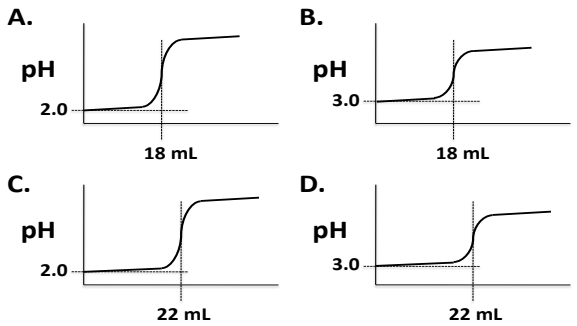
3a. (3 points) Suppose pK_a = 4.00 for HB. What is the pH of Solution B?

Answer: _____

3b. (1 pt) Which buffer has the lowest pH? **A B C D**

3c. (1 pt) Which solution has the largest buffer capacity towards the addition of HCl? **Circle: A B C D**

4. Consider these four titrations curves, A, B, C, and D.



4a. (1 pt) What might be in the flask with the pH meter?

$HNO_3(aq)$ $HClO_2(aq)$ $NaOH(aq)$ $NH_3(aq)$

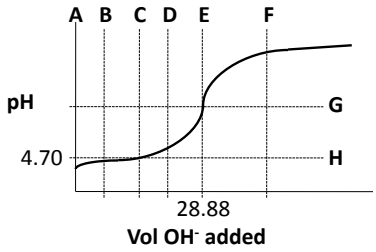
4b. (1 pt) Which of these chemicals might be in the buret?

$HNO_3(aq)$ $HClO_2(aq)$ $NaOH(aq)$ $NH_3(aq)$

4c. (2 pt) Which curve represents the largest concentration of acid and smallest concentration of base?

❑ Curve A ❑ Curve B ❑ Curve C ❑ Curve D

5. An unknown weak acid, HA, with a mass of 0.615 g was dissolved in about 25 mL water and titrated with 0.1016 M NaOH as shown in the figure.



5a (3 pts) How many moles of OH^- did it take to reach the equivalence point?

Answer: _____

5b (3 pts) What is the molar mass of the acid?

Answer: _____

5c. (2 pts) At what volume of NaOH added would you look to determine pK_a?

5d. (2 pts) Which lines designate volumes of OH^- added where we have a buffer solution? Circle all that apply.

Line A **Line B** **Line C** **Line D** **Line E**

5e. (10 pts) What is/are the prominent species present (> 0.01 M) in the titration at these points? (Do not include minor species. Hint: Acid and base are both ~0.1 M)

Line A:	HA	H_3O^+	A^-	Na^+	OH^-
Line B:	HA	H_3O^+	A^-	Na^+	OH^-
Line C:	HA	H_3O^+	A^-	Na^+	OH^-
Line E:	HA	H_3O^+	A^-	Na^+	OH^-
Line F:	HA	H_3O^+	A^-	Na^+	OH^-

5f. (4 pts) Suppose Line D represented a volume of 23.00 mL. What is the pH of the solution at this point?

Answer: _____

6a. (4 pt) What is the molar solubility of barium carbonate if $K_{sp} = 2.6 \times 10^{-9}$?

Answer with units: _____

6b. (3 pts) What is the molar solubility of barium carbonate in a solution that is 0.050 M Na_2CO_3?

Answer with units: _____

6c. (3 pts) Will a precipitate form if equal volumes of 1.0×10^{-5} M $BaCl_2$ and Na_2CO_3 are mixed? Show Q_{sp} calc!

Caution! The solutions dilute each other!

Answer Qsp= _____ Precipitate: **Yes or No**

Exam Subtotal:	Folder (20 max):	Total:
_____	_____	_____

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

Answers

1a. $K_a = 5.6 \times 10^{-5}$

1b. $C_3H_3O_2^-$, of pK_b? $pK_b = 9.75$

1c.

$HC_3H_3O_2 + OH^-$	⇌	$H_2O + C_3H_3O_2^-$	$K = K_a/K_w$
$HC_3H_3O_2 + H_2O$	⇌	$H_3O^+ + C_3H_3O_2^-$	$K = K_a$
$H_3O^+ + OH^-$	⇌	$2\ H_2O$	$K = 1/K_w$
$C_3H_3O_2^- + H_2O$	⇌	$OH^- + HC_3H_3O_2$	$K = K_w/K_a$
$C_3H_3O_2^- + H_3O^+$	⇌	$H_2O + HC_3H_3O_2$	$K = 1/K_a$
$2\ H_2O$	⇌	$H_3O^+ + OH^-$	$K = K_w$

1d. 0.24; 1e. A, B, E; 1f. 4.19; 1g. Stay the same; 1h. Strong base; 1i. 4.24

2. 0.50

3a. 4.18; 3b. C ; 3c. D

4a. $HNO_3(aq)$; 4b. NaOH(aq); 4c. Curve C

5a 0.002934 mol; 5b 210 g/mol; 5c. 14.44 mL; 5d. **Line B** **Line C** **Line D**

5e.

Line A:	**HA**	H_3O^+	A^-	Na^+	OH^-
Line B:	**HA**	H_3O^+	**A^-**	**Na^+**	OH^-
Line C:	**HA**	H_3O^+	**A^-**	**Na^+**	OH^-
Line E:	HA	H_3O^+	**A^-**	**Na^+**	OH^-
Line F:	HA	H_3O^+	**A^-**	**Na^+**	**OH^-**

5f. 5.29

6a. 5.1×10^{-5} M

6b. 5.2×10^{-8} M

6c. $Q_{sp} = 2.5 \times 10^{-11}$; no precipitate