

Exam 3 Chm 205 (Dr Mattson) 1 April 2015

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Signature: _____

Name: _____

Circle your section: **Section A or Section C**

Circle your Folder group:

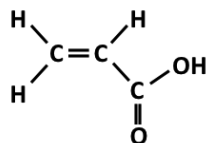
H He Li Be B C N O F Ne Na Mg Al Si

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, $\text{HC}_3\text{H}_3\text{O}_2$, 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 $\text{p}K_a = 4.25$. You may refer to acrylic acid as HAc or by its formula $\text{HC}_3\text{H}_3\text{O}_2$.



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

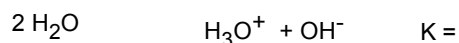
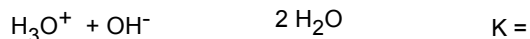
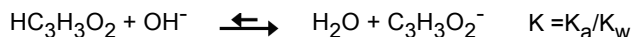
$K_a =$ _____

1b. (4 pts) What is the conjugate base of acrylic acid and what is the numerical value of $\text{p}K_b$?

Conjugate base: _____

$\text{p}K_b =$ _____

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



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 HAc + 0.10 mol Ac^- in 500 mL H_2O
 B. 0.10 mol HAc + 0.04 mol OH^- in 250 mL H_2O
 C. 0.10 mol HAc + 0.14 mol OH^- in 100 mL H_2O
 D. 0.10 mol H_3O^+ + 0.10 mol Ac^- in 500 mL H_2O
 E. 5.0 g HAc + 4.0 g NaAc in 400 mL H_2O

1f. (3 pts) What is the pH of a solution prepared by dissolving 0.40 mol HAc and 0.35 mol Ac^- 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

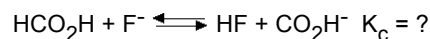
1h. (1 pt) The solution in Question 1f has a larger buffer capacity towards the addition of...

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?

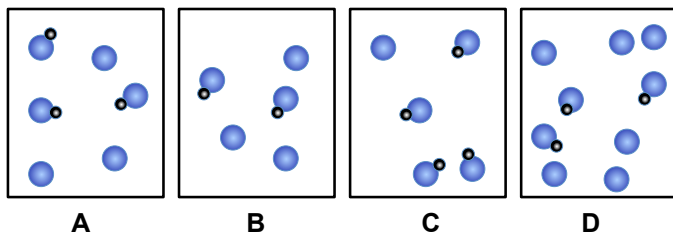
Answer: _____

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:



Answer: _____

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



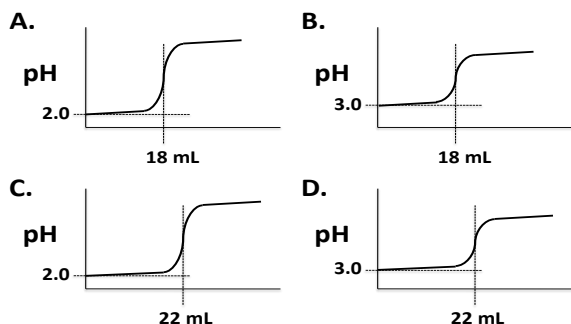
3a. (3 points) Suppose $pK_a = 4.00$ for HB. What is the pH of Solution B?

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?

HNO₃(aq) HClO₂(aq) NaOH(aq) NH₃(aq)

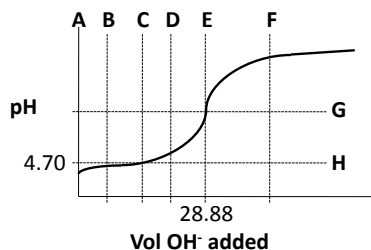
4b. (1 pt) Which of these chemicals might be in the buret?

HNO₃(aq) HClO₂(aq) NaOH(aq) NH₃(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 H₃O⁺ A⁻ Na⁺ OH⁻

Line B: HA H₃O⁺ A⁻ Na⁺ OH⁻

Line C: HA H₃O⁺ A⁻ Na⁺ OH⁻

Line E: HA H₃O⁺ A⁻ Na⁺ OH⁻

Line F: HA H₃O⁺ 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 Na₂CO₃?

Answer with units: _____

6c. (3 pts) Will a precipitate form if equal volumes of 1.0×10^{-5} M BaCl₂ and Na₂CO₃ are mixed? Show Q_{sp} calc!

Caution! The solutions dilute each other!

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

Exam Subtotal: Folder (20 max): Total:

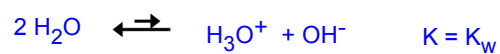
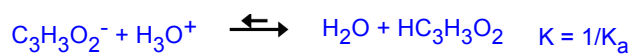
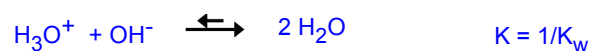
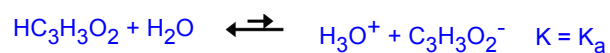
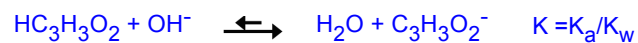
A > 90; B+ > 85; B > 80; C+ > 75; C > 70; D > 60

Answers

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

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

1c.



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. $5.1 \times 10^{-5} M$

6b. $5.2 \times 10^{-8} M$

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