Exam 3 Chm 205 (Dr Mattson) 17 March 2017

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*

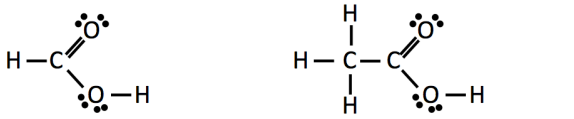
Signature:

Name:

Chemistry Student Number: _____

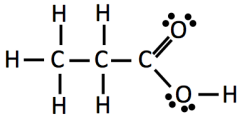
Instructions: **Show all work whenever a calculation box is provided!** Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See 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 floor the front section of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

Consider the first four members of the carboxylic acid series to answer Questions 1 and 5 – 8. Note the acids are referred to here as HMe, HEt, HPr, and HBu.

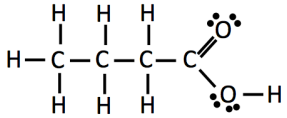


methanoic acid, HMe
$K_a = 1.8 \times 10^{-4}$

ethanoic acid, HEt
$K_a = 1.8 \times 10^{-5}$



propanoic acid, HPr
$K_a = 1.3 \times 10^{-5}$



butanoic acid, HBu
$K_a = 1.5 \times 10^{-5}$

1a. (2 pt) Which acid is the weakest?

HMe HEt HPr HBu

1b. (2 pt) Which acid is the most likely to need the quadratic in order to solve for pH?

HMe HEt HPr HBu

1c. (2 pt) Which acid has the strongest conjugate base?

HMe HEt HPr HBu

1d. (5 pts) What is the pH of a 0.200 M HPr solution? Use a MICE table. In this and future pH questions, report pH and pK answers to two places past the decimal. For best results regarding rounding, save your answers in your calculator rather than re-enter them every time to avoid propagating errors from multiple roundings.

Answer: _____

1e. (5 pts) What is the percent dissociation of the HPr in the previous question?

Answer: _____

1e. (2 pts) What is the pK_a value for HPr?

1f. (3 pts) What is the pK_b value for Et^-?

1g. (5 pts) What is the pH of a 0.200 M Et^-?

Answer: _____

2. (4 pts) Arsenic acid, H_3AsO_4, has these K_a values:

$K_{a1} = 5.6 \times 10^{-3}$, $K_{a2} = 1.7 \times 10^{-7}$, $K_{a3} = 4.0 \times 10^{-12}$

Determine the two equilibrium constant **values** (one K_a and one K_b) used to predict if Na_2HAsO_4, is a better acid or weak base.

Must show work for credit.

Answer: Better weak acid or Better weak base

3. (6 pts) Classify each of the following substances as strong acid, SA, weak acid, WA, strong base, WB, weak base, WB, or neutral, N.

A. HCN SA WA N WB SB
B. KOH SA WA N WB SB
C. KBr SA WA N WB SB
D. NH_3 SA WA N WB SB
E. HNO_3 SA WA N WB SB
F. KNO_2 SA WA N WB SB

4a. (4 pts) Sketch a Lewis dot structure of boron trifluoride and another one of ammonia. Both are gases.

4b. (2 pt) Which is the Lewis base?

4c. (2 pts) Sketch the product that results from the reaction of these two compounds.

5. (8 pts) Use the K_a values given in Question 1 to determine equilibrium constant values for these reactions: **The answer in each box will be a number.** Arrows are omitted – you will add them in the next question.

5a. $HPr + H_2O$ $H_3O^+ + Pr^-$

5b. $Bu^- + H_3O^+$ $H_2O + HBu$

5c. $HMe + OH^-$ $H_2O + Me^-$

5d. $Et^- + H_2O$ $OH^- + HEt$

5e. (4 pts) Add appropriate long/short arrows to each equilibrium 5a – 5d.

6a. (4 pts) What is the pH of a buffer prepared by mixing 0.220 mol HEt with 0.190 mol NaEt in 700 mL water?

Answer: _____

6b. (4 pts) What is the pH of this buffer (in 6a) if 0.030 mol HNO_3 is added?

Answer: _____

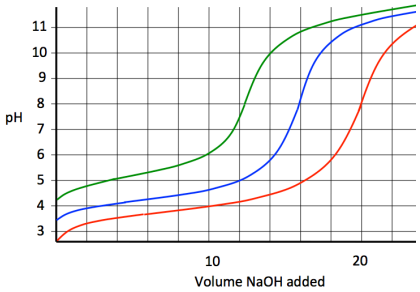
7. (6 pts) Which of these would produce a buffer?

A. 0.050 mol HBu + 0.040 mol NaPr
B. 0.300 mol HMe + 0.100 mol NaOH
C. 0.090 mol HCl + 0.140 mol NaPr
D. 5.20 g HEt + 6.30 g NaEt
E. 0.110 mol HBu + 0.120 mol NaOH
F. 0.050 mol HPr + 0.040 mol NaPr

8. (4 pts) How many moles of NaOH must be added to 1.0 L of 0.050 M butanoic acid in order to make a buffer with a pH of 4.00?

Answer with units: _____

9. Consider these three titrations with 0.100 M NaOH, superimposed on the same graph. The acids are **HG**, **HB**, and **HR**, represented by the green, blue and red lines, respectively.



9a. (2 pts) Which acid has the smallest pK_a?

HG HB HR
All have the same pK_a

9b. (2 pts) Which acid has the smallest K_a?

HG HB HR
All have the same K_a

9c. (2 pts) Which acid has the largest concentration?

HG HB HR
All have the same

9d. (2 pts) Which acid is best for making a pH 4.50 buffer?

HG HB HR
None of these

9e. (2 pts) Which acid would have the strongest conjugate base?

HG HB HR
None of these

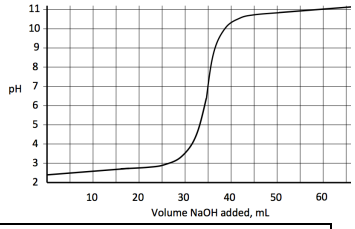
9f. (2 pts) What volume would you use for the equivalence point in the titration of **HR**?

9g, 9h. (4 pts) What volume would you use to estimate pK_a for **HR**? What is pK_a for **HR**?

9i. (4 pts) Using your answer to 9f, and given that the [NaOH] = [HR] = 0.100 M, calculate the pH of the solution after 5.00 mL base has been added to 20.00 mL of the acid.

Answer: _____

10a. (4 pts) Refer to the titration curve. Given [NaOH] = 0.1434 M, and that 20.00 mL acid was titrated, what is the concentration of the acid in the original solution?



Answer with units: _____

10b. (2 pts) What sort of acid is this?

Strong acid or Weak acid

Total score (out of 100): _____

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

Answers

1a. HPr

1b. HMe

1c. HPr

1d. 2.79

1e. 0.81 %

1e. 4.89

1f. 9.26

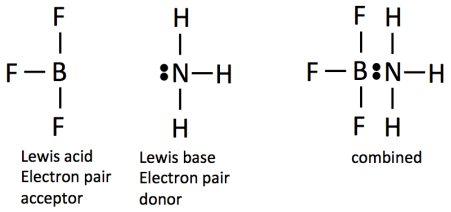
1g. 9.02

2. $HAsO_4^{2-}$, is a weak acid $K_{a3} = 4.0 \times 10^{-12}$

$HAsO_4^{2-}$, is a weak base $K_{a3} = 5.9 \times 10^{-8}$

3. WA SB N WB SA WB

4a-c



5a. $HPr + H_2O \rightleftharpoons H_3O^+ + Pr^-$ $K_a = 1.3 \times 10^{-5}$

5b. $Bu^- + H_3O^+ \rightleftharpoons H_2O + HBu$ $K_n = 6.7 \times 10^{+4}$

5c. $HMe + OH^- \rightleftharpoons H_2O + Me^-$ $K_n = 1.8 \times 10^{+10}$

5d. $Et^- + H_2O \rightleftharpoons OH^- + Het$ $K_b = 5.6 \times 10^{-10}$

5e. see above

6a. 4.68

6b. 4.55

7. B C D F

8. 6.57×10^{-3}

9a-e. HR, HG, HR, HB, HG

9f, g, h 20 mL, 10 mL, pKa = 4.0

9i. 3.52

10a. 0.251 M

10b. strong acid