

Exam 2 Chm 205 (Dr Mattson) 26 March 2013

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.*

(1 pt) Signature: _____

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 your data sheet — Write: "See data sheet" in the answer box and then hand the data sheet in with your exam. At 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 stored in the front of the room. Cell phones must be OFF and placed at the front of the room.

Use this information to answer Questions 1 –11.

Chloroacetic acid, $\text{HCO}_2\text{CH}_2\text{Cl}$ $K_a = 1.36 \times 10^{-3}$

Hydrazoic acid, HN_3 $K_a = 2.20 \times 10^{-5}$

1. (4 pts) What is the pH of a 0.150 M solution of hydrazoic acid?

Answer: _____

2. (2 pt) Which acid is a stronger weak acid?

(a) chloroacetic acid (b) hydrazoic acid (c) same

3. (2 pt) Which acid is more likely to require use of the quadratic formula in order to answer a question such as Question 1?

(a) chloroacetic acid (b) hydrazoic acid (c) same

4. (3 pts) What is the $\text{p}K_b$ for $\text{CO}_2\text{CH}_2\text{Cl}^-$?

Answer: _____

5. (4 pts) What is the pH of a 0.080 M solution of $\text{NaCO}_2\text{CH}_2\text{Cl}$?

Answer: _____

6. (2 pts) As a 0.10 M solution, which of these would give the highest pH?

(a) $\text{HCO}_2\text{CH}_2\text{Cl}$ (b) $\text{NaCO}_2\text{CH}_2\text{Cl}$

(c) HN_3 (d) KN_3

7. (5 pts) Which of these would produce a buffer when mixed in about 1 L water? Circle all that would.

(a) 400 mL 0.15 M $\text{HCO}_2\text{CH}_2\text{Cl}$ + 600 mL 0.25 M $\text{NaCO}_2\text{CH}_2\text{Cl}$

(b) 0.25 mol $\text{NaCO}_2\text{CH}_2\text{Cl}$ + 0.15 mol $\text{HCl}(\text{aq})$

(c) 0.15 mol $\text{HCO}_2\text{CH}_2\text{Cl}$ + 0.15 mol $\text{NaOH}(\text{s})$

(d) 0.44 mol $\text{NaOH}(\text{s})$ + 0.22 mol $\text{HCl}(\text{aq})$

(e) 50 mL 0.19 M $\text{HCO}_2\text{CH}_2\text{Cl}$ + 75 mL 0.10 M $\text{NaOH}(\text{aq})$

8. (4 pts) What is the pH of a solution prepared by adding 100.0 mL 0.358 M $\text{HCO}_2\text{CH}_2\text{Cl}$ to 200.0 mL 0.208 M $\text{NaCO}_2\text{CH}_2\text{Cl}$?

Answer: _____

9. (2 pts) Referring again to the buffer in the previous problem, does this solution have a larger buffer capacity towards strong acid or strong base?

(a) strong acid (b) strong base (c) same

10. (4 pts) A buffer contains 0.0473 mol $\text{HCO}_2\text{CH}_2\text{Cl}$ and 0.0711 mol $\text{NaCO}_2\text{CH}_2\text{Cl}$. What pH results when 0.0050 mol $\text{NaOH}(\text{s})$ is added to the buffer?

Answer: _____

11. (4 pts) What is the pH of a solution prepared by adding 0.0300 mol NaOH(s) to 200 mL 0.208 M $\text{HCO}_2\text{CH}_2\text{Cl}$?

Answer with units: _____

12. (6 pts) Identify the following solutions as being a strong acid, weak acid, neutral, weak base, or strong base.

- | | | | | | |
|------------------------------|----|----|---|----|----|
| (a) HNO_3 | sa | wa | n | wb | sb |
| (b) NaNO_3 | sa | wa | n | wb | sb |
| (c) KNO_2 | sa | wa | n | wb | sb |
| (d) HNO_2 | sa | wa | n | wb | sb |
| (e) NaOH | sa | wa | n | wb | sb |
| (f) NH_4NO_3 | sa | wa | n | wb | sb |

13. (9 pts) Refer again to the K_a value given for hydrazoic acid in the green box on the front. What is the **numerical** value of K for each of these? Sketch appropriate arrows (\rightleftharpoons or \leftarrow).

13a. $\text{HN}_3 + \text{OH}^-$ () $\text{H}_2\text{O} + \text{N}_3^-$

13b. $\text{N}_3^- + \text{H}_3\text{O}^+$ () $\text{H}_2\text{O} + \text{HN}_3$

13c. $\text{N}_3^- + \text{H}_2\text{O}$ () $\text{OH}^- + \text{HN}_3$

Use the titration curve on the data sheet to answer Questions 14 – 18. Assume Na^+ is spectator ion.

14. (2 pts) In this titration, what is in the flask and what is in the buret? HX represents a strong acid and HA represents a weak acid.

In flask: HX HA H_3O^+ OH^-
 In buret: HX HA H_3O^+ OH^-

15. (3 pts) What volume of titrating solution is added to get to the equivalence point? Report this number to the nearest 0.1 mL. Accuracy counts. Include units.

16. (3 pts) What is the $\text{p}K_a$ of the acid involved? Report this number to the nearest 0.1. Be accurate!

17. (4 pts) How would you calculate the pH of the solution after the following volumes of titrating solution have been added? Choose from the choices at right.

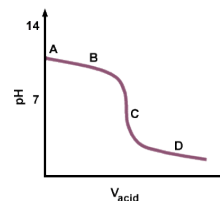
- | | |
|----------------|---|
| _____ 0 mL | A. Use Henderson-Hasselbach, and work in moles. |
| _____ 10 mL | B. Use K_a and do a weak acid calculation. |
| _____ equiv pt | C. Use K_a to find K_b and do a weak base calculation using V_{tot} |
| _____ 30 mL | D. Determine moles of excess OH^- divide by V_{tot} , convert to pH |
| | E. Use $M_a V_a = M_b V_b$ |

18. (9 pts) What is/are the major species* present in the flask after these amounts of titrating solution have been added? Note: Each part will have 1 – 3 correct answers. (*representing at least 10% of the concentration of the most concentrated species)

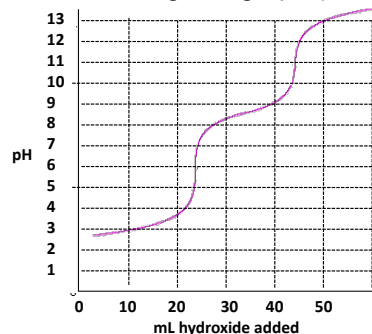
- (a) 0 mL: HA HX H_3O^+ OH^- Na^+ A^- X^-
 (b) 10 mL: HA HX H_3O^+ OH^- Na^+ A^- X^-
 (c) 30 mL: HA HX H_3O^+ OH^- Na^+ A^- X^-

19. (2 pts) Consider this titration curve. The pH at Point B is 10.5. Which of these is true?

- (a) $\text{p}K_a = 10.5$ (b) $\text{p}K_b = 10.5$
 (c) $\text{p}K_b = 3.5$ (d) $\text{p}K_a = 7$



20a. (3 pts) Estimate the $\text{p}K_a$ values for this acid. Write answers to the right of graph (± 0.1).



20b. (3 pts) What are the major weak acid and weak base species present in the flask after these amounts of titrating solution have been added?

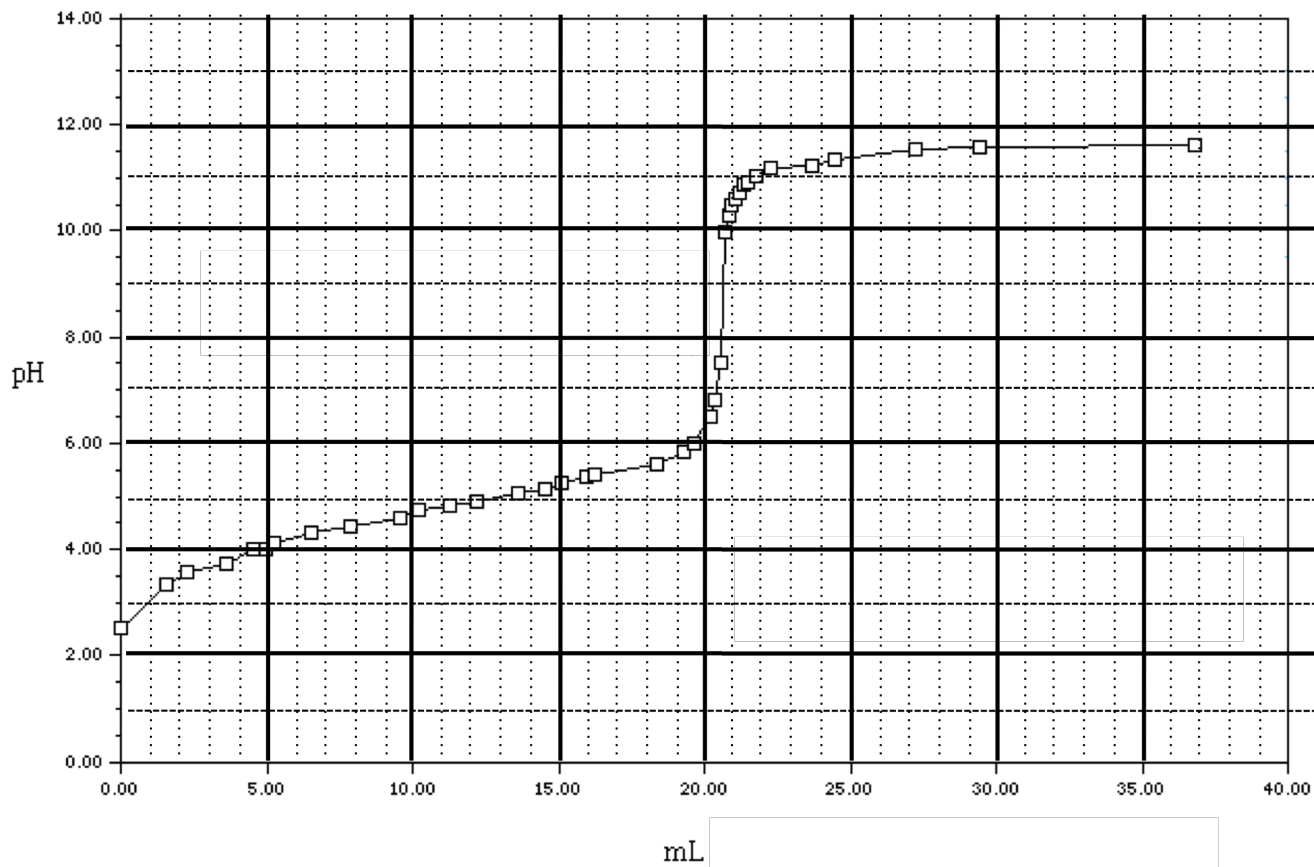
- (a) 10 mL: H_2A HA^- A^{2-}
 (b) 30 mL: H_2A HA^- A^{2-}
 (c) 50 mL: H_2A HA^- A^{2-}

Subtotal from exam: _____

Folder work: (20 max) _____

Total: _____

Name:



| | | | | | | | | | | | | | | | | | |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|--------------------------|---------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 1 H 1.01 | | | | | | | | | | | | | | | | 1 H 1.01 | 2 He 4.00 |
| 3 Li 6.94 | 4 Be 9.01 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 |
| 11 Na 22.99 | 12 Mg 24.31 | | | | | | | | | | | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.06 | 17 Cl 35.45 | 18 Ar 39.95 |
| 19 K 39.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.90 | 23 V 50.94 | 24 Cr 52.00 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.70 | 29 Cu 63.55 | 30 Zn 65.38 | 31 Ga 69.72 | 32 Ge 72.59 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | 43 Tc 97 | 44 Ru 101.07 | 45 Rh 102.91 | 46 Pd 106.4 | 47 Ag 107.87 | 48 Cd 112.41 | 49 In 114.82 | 50 Sn 118.69 | 51 Sb 121.75 | 52 Te 127.60 | 53 I 126.90 | 54 Xe 131.30 |
| 55 Cs 132.91 | 56 Ba 137.33 | 57 La 138.91 | 72 Hf 178.49 | 73 Ta 180.95 | 74 W 183.85 | 75 Re 186.21 | 76 Os 190.2 | 77 Ir 192.22 | 78 Pt 195.09 | 79 Au 196.97 | 80 Hg 200.59 | 81 Tl 204.37 | 82 Pb 207.2 | 83 Bi 208.98 | 84 Po 209 | 85 At 210 | 86 Rn 222 |
| 87 Fr 223 | 88 Ra 226.03 | 89 Ac 227 | | | | | | | | | | | | | | | |

Answers:

1. 2.74

2. (a)

3. (a)

4. 11.13

5. 7.88

6. (d)

7. (a), (b), and (e)

8. 2.93

9. (a)

10. 3.13

11. 3.28

12.

(a) HNO_3 sa

(b) NaNO_3 n

(c) KNO_2 wb

(d) HNO_2 wa

(e) NaOH sb

(f) NH_4NO_3 wa

13. a. $\text{HN}_3 + \text{OH}^- \rightleftharpoons \text{H}_2\text{O} + \text{N}_3^-$ $K_n = 2.2 \times 10^{+9}$

13b. $\text{N}_3^- + \text{H}_3\text{O}^+ \rightleftharpoons \text{H}_2\text{O} + \text{HN}_3$ $K_n = 4.5 \times 10^{+4}$

13c. $\text{N}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- + \text{HN}_3$ $K_b = 4.5 \times 10^{-10}$

14. In flask: HA; In buret: OH^-

15. 20.6 – 20.8 mL

16. 4.7 – 4.8

17. B, A, C (although one would also have to determine moles wb using $n = MV$), D

18. (a) 0 mL: HA

(b) 10 mL: HA Na^+ A^-

(c) 30 mL: OH^- Na^+ A^-

19. (a) and (c)

20a. $\text{pK}_{a1} = 3.1 - 3.2$ and $\text{pK}_{a2} = 8.5 - 8.7$.

20b.

(a) 10 mL: H_2A HA^-

(b) 30 mL: HA^- A^{2-}

(c) 50 mL: A^{2-}