Exam Three CHM 205 (Dr. Mattson) 20 March 2012	*Print your name:* *Signature:*	*Circle your section:* 8:30 9:30

Instructions: Show all work whenever a calculation is required! You will receive credit for <u>how</u> you worked each problem as well as for the correct answer. If you need more space, you may use your scratch paper — Write: "See attached" in box and then attach the scratch paper <u>with your name on it</u>. BOX YOUR ANSWERS! Write legibly.

1. (6 pts) Identify the following substances as acidic, basic or neutral. (Hint: Scratch out a table of wa and cwb on your data sheet to help you with some of these.)

   (a) HOCl   acidic   basic   neutral

   (b) KCN   acidic   basic   neutral

   (c) NaBr   acidic   basic   neutral

   (d) NH_4Cl acidic   basic   neutral

   (e) LiOH   acidic   basic   neutral

   (f) $NaC_2H_3O_2$ acidic   basic   neutral

2a. (6 pts) Complete the following table by providing the conjugate bases for phosphoric acid, H_3PO_4.

acid	pK_a	cwb	pK_b
H_3PO_4	2.15		
$H_2PO_4^-$	7.20		
HPO_4^{-2}	12.37		

2b. (1 pt) What is the strongest weak base of the six species listed in the table.

3. (9 pts) What is K_n for these reactions? Answer should be numerical. [K_a for $HCO_2H = 1.8 \times 10^{-4}$]

(a) $H_3O^+ + OH^- \rightleftharpoons 2\, H_2O$

(b) $HCO_2H + OH^- \rightleftharpoons H_2O + CO_2H^-$

(c) $CO_2H^- + H_3O^+ \rightleftharpoons H_2O + HCO_2H$
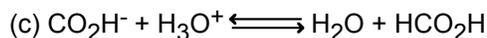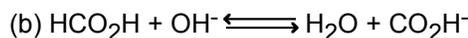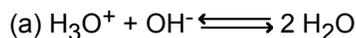
4. (6 pts) Which of the following solutions would produce a buffer when mixed?

   (a) 40 mL 0.20 M HOCl + 40 mL 0.30 M NaOCl

   (b) 40 mL 0.30 M HOCl + 40 mL 0.20 M HCl

   (c) 50 mL 0.20 M HCl + 20 mL 0.40 M NaCl

   (d) 70 mL 0.20 M HF + 40 mL 0.30 M NaOCl

   (e) 50 mL 0.20 M HCN + 20 mL 0.10 M NaOH

   (f) 40 mL 0.20 M $NaC_2H_3O_2$ + 40 mL 0.30 M HCl

5a. (4 pts) Calculate the pH of a solution prepared by dissolving 0.022 mol $HC_7H_5O_2$ ($pK_a = 4.21$) and 0.051 mol $NaC_7H_5O_2$ in a suitable amount of water.

5b. (1 pts) Does this buffer (in 5a) have a larger buffer capacity towards strong acid or strong base? Circle: **Strong acid** or **Strong base** or **the same**

5c. (4 pts) What is the pH upon adding 0.005 mol HCl to the solution described in 5a?

6. (4 pts) What is the pH of a buffer prepared by reacting 40.0 mL 0.14 M $HC_2H_3O_2$ ($pK_a = 4.74$) with 20 mL 0.20 M NaOH.

7. (3 pts) Consider the titration of 50.00 mL 0.1119 M HNO_3 with NaOH(aq). Suppose it takes 38.24 mL of NaOH(aq) to reach a phenolphthalein endpoint. What is the molarity of the NaOH(aq)?

8. Consider the titration of 25.00 mL 0.2040 M HNO_3 with 0.1882 M NaOH(aq).

8a. (3 pts) What volume of NaOH(aq) does it take to reach the equivalence point?

8b. (4 pts) What is the pH after 30.00 mL NaOH has been added?

8c. (2 pts) What is the pH at the equivalence point?

9. Consider the titration of 20.00 mL 0.0890 M HOBr(aq) (K_a = 2.0 x 10^{-9}) with 0.1100 M NaOH.

9a. (4 pts) What volume of NaOH is required to reach the equivalence point?

9b. (4 pts) What is the pH before any NaOH has been added?

9c. (4 pts) What is the pH after 10.00 mL NaOH has been added?

9d. (4 pts) What is the pH after 20.00 mL NaOH has been added?

9e. (4 pts) What is the pH at the equivalence point?

9f. (2 pts) What is the pH half-way to the equivalence point?

10. Consider the titration curve shown below.

10a. (2 pts) Give numerical values for pK_{a1} and pK_{a2}.

10b. (3 pts) Circle all possible substances that could give this sort of titration curve.

(a) $HClO_2$ (b) H_2TeO_4 (c) H_3AsO_3 (d) H_2SO_3
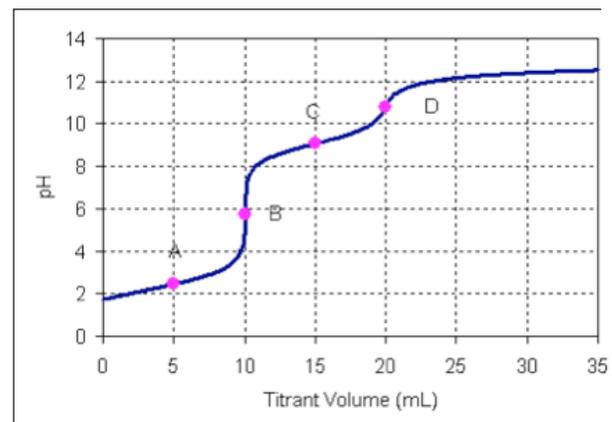
Answers

1. acidic, basic, neutral, acidic, basic, basic

2a.

acid	pK_a	cwb	pK_b
H_3PO_4	2.15	$H_2PO_4^-$	11.85
$H_2PO_4^-$	7.20	HPO_4^{-2}	6.80
HPO_4^{-2}	12.37	PO_4^{-3}	1.63

2b. PO_4^{-3}

3. (a) $K_n = 1 \times 10^{+14}$

(b) $K_n = 1.8 \times 10^{+10}$

(c) $K_n = 5.6 \times 10^{+3}$

4. (a) and (e)

5a. 4.57

5b. Strong acid

5c. 4.44

6. 5.14

7. 0.146 M

8a. 27.10 mL

8b. 12.00

8c. 7

9a. 16.18 mL

9b. 4.87

9c. 8.91

9d. 12.02

9e. 10.70

9f. 8.70

10a. (2 pts) Give numerical values for pK_{a1} is about 2.5 and pK_{a2} is close to 9. I accepted values that were within +/- 0.2 pH units.

10b. (b) and (d)