Exam 3

MULTIPLE CHOICE (3pts each): Write the ONE letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

1.) Which of the following would be the conjugate base of C_8H_7COOH? 1.) B

a.) $C_8H_7COOH_2^-$ (b.) $C_8H_7COO^-$ c.) $C_8H_6COOH^-$ d.) $C_8H_7COOH_2^-$

2.) What is the concentration of hydronium ions in a solution with a hydroxide ion concentration of 3.67×10^{-5}? 2.) C

a.) 3.67×10^{-9} b.) 2.72×10^{-3} (c.) 2.72×10^{-10} d.) 3.67×10^{-19}

3.) Which of the following salts would be the best conjugate base to make a buffer with nitrous acid (HNO_2)? 3.) B

a.) $NaNO_3$ (b.) KNO_2 c.) KCN d.) $NaCH_3COO$

4.) What is the pOH of a solution with a pH of 6.37? 4.) A

(a.) 7.63 b.) 0.63 c.) 13.37 d.) 2.20

5.) Which of the following salts would form a basic solution when dissolved in water? 5.) C

a.) NH_4Cl b.) NaI (c.) KF d.) $Fe(NO_3)_2$

6.) What is the pH of a 2.45×10^{-5} M solution of $Ba(OH)_2$? 6.) C

a.) 4.611 b.) 4.310 (c.) 9.690 d.) 9.389

7.) What is the pH of a 0.000786M solution of HBr? 7.) B

a.) 10.895 (b.) 3.105 c.) 1.552 d.) 12.448

8.) Which of the following would be the conjugate acid of $C_6H_{10}NH$? 8.) D

a.) $C_6H_{11}NH^+$ b.) $C_6H_{10}N^+$ $C_6H_{11}N^+$ (d.) $C_6H_{10}NH_2^+$

9.) If the K_a of an acid is 5.3×10^{-6}, what is the K_b of its conjugate base? 9.) C

a.) 5.3×10^{-6} b.) 5.3×10^{8} (c.) 1.9×10^{-9} d.) 5.28

10.) What volume of 0.150M sodium hydroxide would be needed to reach the equivalence point if the NaOH was being used to titrate 28.6mL of 0.450M acetic acid? 10.) B

a.) 28.6mL (b.) 85.8mL c.) 9.53mL d.) 1.93mL

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! SHOW ALL WORK. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1. A 0.500L buffer is made of 0.400M formic acid (HCOOH, $K_a = 1.77 \times 10^{-4}$) and 0.450M potassium formate (KHCOO).

   a.) What is the pH of the buffer?

   Answer: 3.803

   $pH = 3.75202647 + \log\left(\frac{0.450}{0.400}\right)$

   $= 3.75202647 + 0.0511525 = 3.803179$

   b.) What is the pH of the buffer after adding 0.0800 mol NaOH? Answer: 4.157

   HA $\frac{0.400\text{mol}}{\text{L}} \times 0.5\text{L} = 0.2\text{mol} - 0.08\text{mol} = \frac{0.12\text{mol}}{0.5\text{L}} = 0.24\text{M}$

   A^- $\frac{0.450\text{mol}}{\text{L}} \times 0.5\text{L} = 0.225\text{mol} + 0.08\text{mol} = \frac{0.305\text{mol}}{0.5\text{L}} = 0.61\text{M}$

   $pH = 3.75202647 + \log\left(\frac{0.61}{0.24}\right)$

   $= 3.75202647 + 0.4061186 = 4.158145$

2. A 25.00mL sample of 0.360M NaOH is being titrated with 0.425M HNO_3.

   a.) What is the pH of the 0.360M NaOH solution at the start of the titration (before any HNO_3 is added)?

   $pOH = -\log(0.360) = 0.4436975$ Answer: 13.556

   $pH = 14 - 0.4436975 = 13.5563$

   b.) What is the pH of the solution after 24.0mL HNO_3 has been added?

   Answer: 1.611

   OH^-: $\frac{0.360\text{mol}}{\text{L}} \times 0.025\text{L} = 0.009\text{ mol}$

   H^+: $\frac{0.425\text{mol}}{\text{L}} \times 0.024\text{L} = 0.0102\text{mol}$ ← more

   H^+: $0.0102\text{ mol} - 0.009\text{ mol} = \frac{0.0012\text{ mol}}{0.049\text{L}} = 0.0244898\text{M}$

   $0.025\text{L} + 0.024\text{L} = 0.049\text{L}$

   $pH = -\log(0.0244898) = 1.611018$

3. The K_a for benzoic acid (C_6H_5COOH) is 6.46×10^{-5}. For a 0.236M solution of benzoic acid:

a.) What is the hydronium ion concentration? Answer: 3.90×10^{-3} M

$$6.46 \times 10^{-5} = \frac{x^2}{0.236}$$

$$x^2 = 1.52456 \times 10^{-5}$$

$$x = 3.90456 \times 10^{-3} \text{ M}$$

b.) What is the pH? Answer: 2.408

$$-\log(3.90456 \times 10^{-3}) = 2.408428$$

4. A solution is made containing 0.948M ethylammonium chloride ($C_2H_5NH_3Cl$, K_b for ethylamine is 5.6×10^{-4})

a.) Write the balanced equation for this salt reacting with water.

$$C_2H_5NH_3^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_5NH_2(aq)$$

b.) Is this salt acidic or basic? Answer: acidic

c.) Briefly explain your answer to part B.

produces H_3O^+ in water or
conjugate acid of a weak base (ethylamine)

d.) Calculate the pH of the solution: Answer: 5.39

$$K_a = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-4}} = 1.7857 \times 10^{-11}$$

$$1.7857 \times 10^{-11} = \frac{x^2}{0.948}$$

$$x^2 = 1.692857 \times 10^{-11}$$

$$x = [H_3O^+] = 4.1144345 \times 10^{-6}$$

$$pH = -\log(4.1144345 \times 10^{-6}) = 5.38569$$

5. If a 0.250M solution of a weak base has a pH = 11.28,

a.) What is the value K_b for the base? Answer: 1.46×10^{-5}

$pOH = 14 - 11.28 = 2.72$

$[OH^-] = 10^{-2.72} = 1.90546 \times 10^{-3}$

$$K_b = \frac{[1.90546 \times 10^{-3}]^2}{0.250 - 1.90546 \times 10^{-3}} = \frac{3.63078 \times 10^{-6}}{2.4809454 \times 10^{-1}} = 1.46346463 \times 10^{-5}$$

b.) What is the hydroxide ion concentration of the solution? Answer: 1.91×10^{-3} M

→ 1.90546×10^{-3} M

c.) What is the value of pK_b for this base? Answer: 4.835

$-\log(1.46346463 \times 10^{-5}) = 4.8346$

6. A solution of a weak base has pH = 11.421. If the K_b for this base is 2.37×10^{-6}, what is the initial concentration of the solution?

a.) What is the initial concentration of the solution? Answer: 2.94 M

$pOH = 14 - 11.421 = 2.579$

$[OH^-] = 10^{-2.579} = 2.63633 \times 10^{-3}$

$$2.37 \times 10^{-6} = \frac{(2.63633 \times 10^{-3})^2}{C - 2.63633 \times 10^{-3}}$$

$6.950236 \times 10^{-6} = 2.37 \times 10^{-6} C - 6.2481 \times 10^{-9}$

$6.956484 \times 10^{-6} = 2.37 \times 10^{-6} C$

$C = 2.9352$

b.) 2 point bonus. This may take a little thought. What is the percent ionization for this base?

$$\frac{[OH^-]}{[Base]} \times 100 = \left[\frac{[2.63633 \times 10^{-3}]}{[2.9352]}\right] \times 100$$

Answer: 0.089890

$= 0.0898290$

7. A 25.00mL sample of 0.250M acetic acid ($K_a = 1.76 \times 10^{-5}$) is being titrated with 0.300M KOH.

a.) What is the pH of the 0.250M acetic acid solution at the start of the titration (before any KOH is added)?

$$1.76 \times 10^{-5} = \frac{x^2}{0.250}$$

Answer: 2.678

$$x^2 = 4.4 \times 10^{-6}$$

$$x = [H_3O^+] = 2.0976 \times 10^{-3}$$

$$pH = -\log(2.0976 \times 10^{-3}) = 2.678277$$

b.) What is the pH after 14.0mL of KOH has been added?

Answer: 5.066

HA: $\frac{0.250 mol}{L} \times 0.025L = 6.25 \times 10^{-3} mol$ ← more

OH: $\frac{0.300 mol}{L} \times 0.014L = 4.2 \times 10^{-3} mol$

HA remaining: $6.25 \times 10^{-3} mol - 4.2 \times 10^{-3} mol = \frac{2.05 \times 10^{-3} mol}{(0.025L + 0.014L)}$

$$= 5.256411 \times 10^{-2} M$$

A^- $\frac{4.2 \times 10^{-3} mol}{(0.025L + 0.014L)} = 1.0769923 \times 10^{-1} M$

$$pKa = -\log(1.76 \times 10^{-5}) = 4.754487$$

$$pH = 4.754487 + \log\left(\frac{0.1076923}{0.0525641}\right)$$

$$= 4.754487 + 0.3114954 = 5.06598$$