EXAM 3 Chemistry 102

NAME: PRINT KEY Sign

## PART A ( Titration) (10pts)

Draw a reasonable titration curve for the reaction of 200 ml 0.25M Pyruvic acid ($pK_a$= 2.39) with 0.10M Potassium hydroxide (assume totally soluble). Contrast this with the titration curve for a 0.25M Hydrochloric acid

Note **the THREE(3)** important pH's that help define the shape of this graph

**GRAPH TO INCLUDE S shaped surve for weak acid with 3 key pH points at 0, 100 200mls of KOH**

=0.5*(2.39-LOG(0.25)) 1.50

= **Pyruvic Acid=1.50 and need 500 ml for equivalence (250 for ½ equivalence)**

**HCl= pH=0.602**

pH= $pK_a$ –log( [HA]/[A])=$pK_a$ **2.39 (1/2 EQUIVALENCE)**

pH(salt)= 7+ ½ (pKa+log[A-] =7+0.5*(2.39+LOG((0.05/0.7))) **7.62** **(REMEMBER DILUTION for A)**

## PART B ( Acid-Base Chemistry ) (10x5=50 pts)

3) What is the pH of an aqueous solution of 0.747 M 2,3 dichloro-pyridine ($K_b$= 1.288x $10^{-7}$)

(a weak base with the formula $C_5Cl_2H_5N$)

BASE: pOH= ½($K_b$-log(0.747) =0.5*(6.89-LOG(0.747)) 3.508➔ **pH=10.49**

**1) Using the fact that Acetic Acid $pK_a$= 4.75; show Three ways to construct a BUFFER solution at pH=4.75 using the following:** ***(Hint be careful all of the concentrations are not equal)***

| |
|---|
| **0.10M solution of Sodium Hydroxide** |
| **0.20M solution of Sodium Acetate** |
| **0.30M solution of Sodium Fluoride** |
| **0.30M solution of Hydrochloric Acid** |
| **0.20M solution of Hydrofluoric Acid** |
| **0.20M solution of Sodium Lactate** |
| **0.10M solution of Acetic Acid** |

2 volumes of 0.1 M HAc + 1 volume of 0.2M NaA

3 volumes of 0.2M NaAc + 1 volume of 0.3 HCl

2 volumes of 0.1M HAc + 1 volume of NaOH

2) Which of the following acids, if in solutions of equal concentration, is the MOST acidic?

a) 0.1M octanoic acid pKa=4.89
b) 0.1M uric acid, pKa=3.89
c) 0.1M propanoic acid pKa=4.86

d) 0.1M acetic acid pKa=4.75
e) All of these acids are equally acidic because they are all of equal concentration.

**0.1M octanoic acid pKa=4.89 least**
**0.1M uric pKa=3.89 most**

5) If the pH of a solution of NaF is adjusted with a strong acid or base. Using the fact that $pK_a(HF) = 3.17$; when is 40% of the total fluoride in the form of $F^-$?
pH = pKa - log(0.60/0.40) = 2.99

4) How many milligrams of **Magnesium hydroxide(Molar Mass=58.305) would be need to be added to one liter of solution (assume STRONG and it all dissolves)** to give an aqueous solution with a pH of **10.00**

| | | |
|---|---|---|
| pOH= | 14-10.73 | 3.27 |
| [OH] = | =10^-4 | 0.0001 |
| **but [$Mg(OH)_2$]** = 0.5[OH]= | | 5.0E-05 |
| | | **2.91E-3 g ➔ 2.915 mg** |

7) What is the pH of a solution contains 0.402 M di-methylamine chloride and 0.389 M di-methylamine. ($pK_b(CH_3NH_2)$= 3.21)

pH of BASE BUFFER: pOH= pKb - log ([B]/[BH+]) = 3.21 - log(0.389/0.402) = 3.22 ➔ pH= **10.78**

8-9) A nitrous acid buffer is prepared by adding 150ml of 0.481 M nitrous acid (pKa = 3.35) to 100 ml of 0.314 M sodium nitrite. What is the pH of this buffer?

=3.35-LOG((0.15*0.481)/(0.1*0.314))=2.99

Now 100 ml of 0.2M sodium hydroxide is added, what is the final pH

=3.35-LOG((0.15*0.481-0.1*0.2)/(0.1*0.314+0.1*0.2)) 3.343709

10) What volume of a 0.25 M Sulfuric acid solution is required to titrate to equivalence 36.0 mL of a 0.225 M ammonium hydroxide ($pK_b$= 4.75) solution ? **And** what is the resulting pH

MV=MV
(0.5)*x = 0.225*0.036 0.0162 L 16.2 ml
Strong Acid/WEAK base ==> No excess Acid/Base and BUT contains Salt of Weak Base (Acidic)
Molarity of $NH_4^+$ = moles of $NH_4$/(Total Volume) = (0.036*0.225)/(0.0162+0.036) = 0.155 M
pH= 7- ½ *(4.75+log(0.155)) = **5.03**

6) Which of the following aqueous solutions are good buffer systems AND WHY!!?

| | |
|---|---|
| 0.45 M hydrocyanic acid + 0.22 M sodium hydroxide | YES(SB converts HCN=>CN-) |
| 0.24 M nitric acid + 0.22 M potassium nitrate | NO(strong acid) |

| | |
|---|---|
| 0.36 M potassium nitrate + 0.26 M barium sulfate | NO(both salts) |
| 0.40 M sodium lactate + 0.47 M hydrofluoric acid | NO(needs conjugate pair) |
| 0.31 M sulfuric acid + 1.24 M ammonia | YES(Half of the base will be converted to conjugate acid |
| 0.61 M ammonia + 0.034 M amonium chloride | NO insufficient ammonium ion |

## POLYPROTONIC ACID TITRATION (10 pts)

**Draw a rough titration curve for 500ml of 0.1M Phosphoric Acid with 0.1M Sodium Hydroxide. Identify which forms of Phosphate are present at the each of the Equivalence points!**
**pKa's = 2.15, 7.2, 12.35**

## SOLUBILITY (5 pts)

**What is the solubility in grams per liter of Sodium Phosphate if its Ksp = 2.24?**

## Part C. Consider the following Titration Conditions (8x5=40pts)

:

| 0.25 M ACID | 0.35 M BASE | Equation/work | pH |
|---|---|---|---|
| | | | |
| 35 ml Formic Acid (pKa)=3.17 | 25 ml of NaOH | moles of acid = MaVa **0.0088**<br>moles of base = MbVb **0.0088**<br>Total Volume= 0.060 L<br>If Salt(WA/SB) **8.17** | |
| 50 ml HCl | 50 ml $NH_3$ ($pK_b$ = 4.75) | moles of acid = MaVa **0.0125**<br>moles of base = MbVb **0.0175**<br>Total Volume= 0.100 Ll<br>WEAK Base (HH Eq) pH= **8.85** | |
| 50 ml Chloroacetic Acid (pKa=2.85) | 15 ml $Ca(OH)_2$ | moles of acid = MaVa **0.0125**<br>moles of base = MbVb **0.0105**<br>Total Volume= 0.0650 L<br>Weak Acid (HH Eq) pH= **3.57** | |
| 120 ml Nitrous Acid ($pK_a$)=3.35 | 40 ml NaOH | moles of acid = MaVa **0.030**<br>moles of base = MbVb **0.014**<br>Total Volume= 0.160 L<br>WEAK Base (HH Eq) pH= **3.29** | |
| 35 ml of HCl | 25 ml of Methylamine $pK_b$=3.34 | moles of acid = MaVa **0.0075**<br>moles of base = MbVb **0.0075**<br>Total Volume= 0.060 ml<br>Salt (WB/SA) **5.75** | |
| No Acid | 25 ml of Methylamine $pK_b$=3.34 | moles of acid = MaVa **0.000**<br>moles of base = MbVb **0.0088**<br>Total Volume= 0.025 ml<br>pH(WB alone)= **12.10** | |
| 20 ml of Cyanic Acid (HCNO) pKa = 3.46 | No Base | moles of acid = MaVa **0.0088**<br>moles of base = MbVb **0.000**<br>Total Volume= 0.020 L<br>pH(WA alone)= **2.03** | |
| 70ml of Sulfuric Acid | 40 ml of NaOH | moles of acid = MaVa **0.035**<br>moles of base = MbVb **0.014**<br>Total Volume= 0.110 Ll<br>STRONG Acid Won pH= **0.72** | |

## Part C. Consider the following Titration Conditions (8x5=40pts)

:

| 0.20 M ACID | 0.40 M BASE | Equation/work | pH |
|---|---|---|---|
| | | | |
| 40 ml Formic Acid (pKa)=3.17 | 20 ml of NaOH | moles of acid = MaVa **0.008**<br>moles of base = MbVb **0.008**<br>Total Volume= 0.060 L<br>If Salt(WA/SB) **8.16** | done |
| 60 ml HCl | 30 ml $NH_3$ ($pK_b$ = 4.75) | moles of acid = MaVa **0.0120**<br>moles of base = MbVb **0.0120**<br>Total Volume= 0.090 L<br>Salt WEAK Base (HH Eq) pH= **5.06** | done |
| 50 ml Chloroacetic Acid (pKa=2.85) | 12.5 ml $Ca(OH)_2$ | moles of acid = MaVa **0.0100**<br>moles of base = MbVb **0.0100**<br>Total Volume= 0.062.5 L<br>Salt pH= **8.03** | done |
| 120 ml Nitrous Acid ($pK_a$)=3.35 | 50 ml NaOH | moles of acid = MaVa **0.024**<br>moles of base = MbVb **0.020**<br>Total Volume= 0.160 L<br>WEAK Base (HH Eq) pH= **4.05** | done |
| 20 ml of HCl | 25 ml of Methylamine $pK_b$=3.34 | moles of acid = MaVa **0.0040**<br>moles of base = MbVb **0.0100**<br>Total Volume= 0.060 ml<br>HH (WB/SA) **10.84** | done |
| No Acid | 35 ml of Methylamine $pK_b$=3.34 | moles of acid = MaVa **0.000**<br>moles of base = MbVb **0.010**<br>Total Volume= 0.025 ml<br>pH(WB alone)= **12.13** | done |
| 30 ml of Cyanic Acid (HCNO) pKa = 3.46 | No Base | moles of acid = MaVa **0.024**<br>moles of base = MbVb **0.000**<br>Total Volume= 0.020 L<br>pH(WA alone)= **2.08** | done |
| 70ml of Sulfuric Acid | 40 ml of $Ba(OH)_2$ | moles of acid = MaVa **0.014**<br>moles of base = MbVb **0.032**<br>Total Volume= 0.110 Ll<br>STRONG Acid Won pH= **13.21** | done |