Name _____ **CHE152**
Instructor: Sherman Henzel **Test #4D** **December 8, 2011**

SHOW YOUR WORK. NO WORK, NO CREDIT!

1. The pH of a buffer in which the concentration of $HC_7H_4IO_2$ is 0.1375 M and the concentration of $C_7H_4IO_2^-$ is 0.1725 is 3.89. If 0.004469 moles of NaOH are added to 325.00 mL of this buffer, what is the change in pH (ΔpH)? (10 points)

$HC_7H_4IO_2 + H_2O \rightleftharpoons H_3O^+ + C_7H_4IO_2^-$ 1.6×10^{-4}

$[OH^-] = 0.004469 \text{ mol}/0.32500 \text{ L} = 0.01375$

	$HC_7H_4IO_2$	+ OH^-	$\rightleftharpoons$	H_2O	+	$C_7H_4IO_2^-$
I	0.1375	0.01375				0.1725
C	-0.01375	-0.01375				+0.01375
I	0.1237_5	0				0.1862_5
C	+x	+x				-x
E_x	$0.1237_5 + x$	x				$0.1862_5 - x$
E	$\approx 0.1237_5$					$\approx 0.1862_5$

$$K_b = \frac{1.00 \times 10^{-14}}{1.6 \times 10^{-4}} = 6.2_5 \times 10^{-11} = \frac{0.1237_5 x}{0.1862_5}; \; x = 9.4_1 \times 10^{-11}$$

$$[OH^-] = 9.4_1 \times 10^{-11} \text{ M}; \; pOH = 10.03; \; pH = 3.97$$

$$\Delta pH = 3.97 - 3.89$$

ΔpH = ____0.08_____

2. Determine the pH of a buffer that is 0.1250 M in CH_3NH_2 and 0.1750 M in CH_3NH_3Cl.

(8 points)

$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$ $K_b = 4.2 \times 10^{-4}$

I	0.1250	0.1750	0
C	-x	+x	+x
E_x	0.1250 - x	0.1750 + x	x
E	≈ 0.1250	=0.1750	

$$K_b = \frac{0.1750x}{0.1250} = 4.2 \times 10^{-4}; \; x = 3.0 \times 10^{-4}; \; [OH^-] = 3.0 \times 10^{-4} \text{ M}$$

$$pOH = 3.52$$

pH = _____10.48_____

3. Describe the preparation of 750.0 mL of a buffer with a pH of 3.16 if solutions of 0.1650 M $HC_2H_2ClO_2$ and 0.1275 M $NaC_2H_2ClO_2$ are to be used. (10 points)

$HC_2H_2ClO_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_2ClO_2^-$ 1.35×10^{-3}

$[H_3O^+] = 0.00069_2$ M

$$\frac{[C_2H_2ClO_2^-]\,0.00069_2}{[HC_2H_2ClO_2]} = 1.35 \times 10^{-3}; \frac{[C_2H_2ClO_2^-]}{[HC_2H_2ClO_2]} = 1.9_5$$

$$[HC_2H_2ClO_2] = \frac{x \bullet 0.1650}{750.0}; [C_2H_2ClO_2^-] = \frac{y \bullet 0.1275}{750.0}$$

$$x + y = 750.0;\ x = 750.0 - y$$

$$[HC_2H_2ClO_2] = \frac{(750.0 - y) \bullet 0.1650}{750.0}$$

$$\frac{\frac{y \bullet 0.1275}{750.0}}{\frac{(750.0 - y) \bullet 0.1650}{750.0}} = 1.9_5; \frac{y \bullet 0.1275}{(750.0 - y) \bullet 0.1650} = 1.9_5$$

$$0.1275y = 241.31 - 0.3218y$$

$$y = 537;\ x = 213$$

volume of $HC_2H_2ClO_2$ = ___213 mL_____ volume of $NaC_2H_2ClO_2$ = ____537 mL_____

4. HCl is titrated with NaOH. Determine the pH of 65.00 mL of 0.1815 M HCl after 80.00 mL of 0.1650 M NaOH have been added. (8 points)

$$[H_3O^+] = 0.1815\ \text{M x}\ \frac{65.00\ \text{mL}}{145.00\ \text{mL}} = 0.08136\ \text{M}$$

$$[OH^-] = 0.1650\ \text{x}\ \frac{80.00\ \text{mL}}{145.00\ \text{mL}} = 0.09103\ \text{M}$$

$$0.09103\ \text{M} - 0.08136\ \text{M} = 0.00967\ \text{M}\ OH^-$$

$$\text{pOH} = 2.01$$

pH = _____11.99_____

5. $HC_7H_5O_2$ is titrated with NaOH. Determine the pH of 45.00 mL of 0.1150 M HNO_2 after 55.00 mL of 0.07500 M NaOH have been added.

$HC_7H_5O_2 + H_2O \rightleftharpoons H_3O^+ + C_7H_5O_2^-$ 6.3×10^{-5} (10 points)

$$[HC_7H_5O_2] = 0.1150\ \text{M x}\ \frac{45.00\ \text{mL}}{100.00\ \text{mL}} = 0.05175\ \text{M}$$

$$[OH^-] = 0.07500\ \text{M x}\ \frac{55.00\ \text{mL}}{100.00\ \text{mL}} = 0.04125\ \text{M}$$

	$HC_7H_5O_2$	+ OH^-	$\rightleftharpoons$	$C_7H_5O_2^-$	+ H_2O
I	0.05175	0.04125		0	
C	-0.04125	-0.04125		+0.04125	
I	0.01050	0		0.04125	
C	+x	+x		-x	
E_x	0.01050 + x	x		0.04125 - x	
E	≈ 0.01050			≈ 0.04125	

$$K_b = \frac{1.00 \times 10^{-14}}{6.3 \times 10^{-5}} = 1.5_8\ \text{x}10^{-10} = \frac{0.01050\text{x}}{0.04125};\ \text{x} = 6.2_4\ \text{x}\ 10^{-10}$$

$$[OH^-] = 6.2_4\ \text{x}\ 10^{-10}\ \text{M};\ \text{pOH} = 9.21$$

pH = _____4.79_____

6.

Indicator	pK_a	Acid color	Base color
Methyl Orange	3.46	Red	Orange
Bromocresol Green	4.66	Yellow	Blue
Methyl Red	5.00	Red	Yellow
Phenol Red	7.81	Yellow	Red
Phenolphthalein	9.90	Colorless	Red

A solution has a pH of 4.25. What color will each indicator exhibit in this solution? (6 points)

phenolphthalein ____colorless_____

phenol red ____yellow_____

methyl red ____red-orange_____

bromocresol green ____yellow-green_____

methyl orange ____orange_____

7. Calculate the solubility of $Li_3(PO_4)_2$ in a solution that is 0.01350 M in Li_2SO_4. (8 points)

$Li_3PO_4\,(s) \rightleftharpoons 3\,Li^+\,(aq) + PO_4^{-3}\,(aq)$ 3.2×10^{-9}

$$\frac{0.01350 \text{ mol } Li_2SO_4}{L} \times \frac{2 \text{ mol } Li^+}{1 \text{ mol } Li_2SO_4} = 0.02700 \text{ M } Li^+$$

$Li_3PO_4\,(s) \rightleftharpoons 3\,Li^+\,(aq) + PO_4^{-3}\,(aq)$

I	0.02700	0
C	+3x	x
E_x	0.02700+3x	x
E	≈ 0.02700	

$(0.02700)^3 x = 3.2 \times 10^{-9}$; $x = 1.6 \times 10^{-4}$

S = __1.6 x 10^{-4} M_____

8. The concentration of Ba^{2+} in a water sample is 0.00008500 M and the concentration of Ca^{2+} in the water sample is 0.0950 M. It is desired to separate these two ions in this sample by the slow addition of NaF. $MgF_2\ (s) \rightleftharpoons Ba^{+2}\ (aq) + 2\ F^-\ (aq)$ $K_{sp} = 5.3 \times 10^{-9}$

$CaF_2\ (s) \rightleftharpoons Ca^{+2}\ (aq) + 2\ F^-\ (aq)$ $K_{sp} = 5.5 \times 10^{-8}$

(a) Which ion will precipitate first and at what $[F^-]$? (6 points)

$0.0008500[F^-]^2 = 5.3 \times 10^{-9}$; $[F^-] = 0.0079$ M

$0.0950[F^-]^2 = 5.5 \times 10^{-8}$; $[F^-] = 0.0076$ M

ion = _____Ca^{2+}_____ $[F^-]$ = _____0.00076 M_____

(b) What will be the concentration of the first ion to precipitate when the second ion just begins to precipitate?

(4 points)

$[Ca^{+2}]\ (0.0.0079)^2 = 5.5 \times 10^{-8}$

concentration = __8.8×10^{-4} M_____

(c) Is the separation effective?

(2 points)

$>10^{-6}$ M

Answer _____No_____

9. Calculate the solubility of $BaCO_3$ in a solution that is buffered to a pH of 4.75. (10 points)

$SrCO_3$ (s) $\rightleftharpoons$ Sr^{+2} (aq) + CO_3^{-2} (aq)); $K_{sp} = 1.1 \times 10^{-10}$

$CO_3^{2-} + H_3O^+ \rightleftharpoons HCO_3^- + H_2O$; $1/K_{a2} = 1.8 \times 10^{10}$

$HCO_3^- + H_3O^+ \rightleftharpoons H_2CO_3 + H_2O$; $1/K_{a1} = 2.4 \times 10^{6}$

	$SrCO_3$ (s) + 2 H_3O^+	$\rightleftharpoons$ Sr^{+2} (aq) + H_2CO_3 + 2 H_2O		$K = 4.75 \times 10^6$
I	1.78×10^{-5}	0	0	
C	----------	+x	+x	
E_x	----------	x	x	
E	1.78×10^{-5}			

$$\frac{x^2}{(1.78 \times 10^{-5})^2} = 4.75 \times 10^6; \; x = 0.039$$

S = _____0.039 M_____

10. What concentration of NH_4^+ must be maintained in order to prevent the precipitation of $Ca(OH)_2$ from a solution that is 0.2250 M in $Ca(NO_3)_2$ and 0.01625 M in NH_3? (10 points)

$Ca(OH)_2$ (s) $\rightleftharpoons$ Ca^{+2} (aq) + 2 OH^- (aq); $K_{sp} = 5.5 \times 10^{-6}$

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$; $K_b = 1.74 \times 10^{-5}$

$0.2250[OH^-]^2 = 5.5 \times 10^{-6}$; $[OH^-] = 4.9_4 \times 10^{-3}$ M

$$\frac{[NH_4^+] \times 4.9_4 \times 10^{-3}}{0.01625} = 1.74 \times 10^{-5}$$

$[NH_4^+]$ = ____5.75×10^{-5} M_____

11. What H_3O^+ concentration must be maintained in a saturated H_2S solution in order to separate 0.395 M Zn^{+2} and 0.175 M Ni^{+2} as their sulfide salts? ZnS (s) will precipitate when $[S^{-2}] = 2.53 \times 10^{-21}$ M and NiS (s) will precipitate when $[S^{-2}] = 1.71 \times 10^{-18}$ M. (8 points)

$$K = \frac{[S^{-2}][H_3O^+]^2}{0.10} = 1.1 \times 10^{-21}$$

$$\frac{2.53 \times 10^{-21}\,[H_3O^+]^2}{0.10} = 1.1 \times 10^{-21};\ [H_3O^+] = 0.21\ M$$

$$\frac{1.71 \times 10^{-18}\,[H_3O^+]^2}{0.10} = 1.1 \times 10^{-21};\ [H_3O^+] = 0.0080\ M$$

_____0.0080 M_____ < $[H_3O^+]$ < ____0.21 M_____