Buffers and Titrations Cheat Sheet

Relationships

$[H_3O^+] = K_a \frac{[\text{Acid}]}{[\text{Base}]}$

$K_a = \frac{x^2}{M}$ where $x = [H_3O^+]$

$K_b = \frac{x^2}{M}$ where $x = [OH^-]$

$K_a \times K_b = 1 \times 10^{-14}$

pH = –log[H^+]

pOH = –log[OH^-]

4 ZONES OF INTEREST ALONG A TITRATION CURVE for a Weak Acid and Strong Base

1. Initial pH – simply a weak acid/weak base problem $K_a = \frac{x^2}{M}$ where $x = [H_3O^+]$ or $K_b = \frac{x^2}{M}$ where $x = [OH^-]$
2. During the titration – BUFFER, BUFFER, IT'S A BUFFER! $[H_3O^+] = K_a \frac{[\text{Acid}]}{[\text{Base}]}$ where the weak and its conjugate salt are what we need to know about.
3. Equivalence Pt. – only salt and water left; the salt is either a weak base (if a weak acid was titrated) or a weak acid (if a weak base was titrated); work it as such: $K_a = \frac{x^2}{M}$ where $x = [H_3O^+]$ or $K_b = \frac{x^2}{M}$ where $x = [OH^-]$ BUT you have to convert K_a to K_b or vise versa!!!
4. Beyond the Equivalence Pt. – This is a stoichiometry problem; find out how much STRONG (acid or base) is left after equivalence, recalculate its molarity (remember the volume increased during the titration), and use pH = –log[H^+] or pOH = –log[OH^-]

Be aware of where the volume of STRONG added in the titration is ½ way to equivalence point!

- Here $[H_3O^+] = K_a$ because the $\frac{[\text{Acid}]}{[\text{Base}]}$ is 1 (same amount of weak acid (base) and its conjugate are present. HUGE time saver and easy way to find the K_a or K_b of the weak acid or base.
- In a titration problem ALWAYS know where the equivalence point is!!!!!!

BUFFERS: Only need to use the equation: $[H_3O^+] = K_a \frac{[\text{Acid}]}{[\text{Base}]}$; read carefully and know who is the weak acid (base) and who is the conjugate salt (it plays the other role!).

Don't be tricked – NEVER select a strong acid or base as a part of a buffer solution; it HAS TO BE WEAK

When a buffered solution is "attacked" remember:

- If the attacker is a strong acid; the base component of the buffer "sacrifices" and reacts with the invading acid, converting it to water and more weak acid – thus resisting large decreases in the pH
- If the attacker is a strong base; the acid component of the buffer "sacrifices" and reacts with the invading base, converting it to water and more weak base – thus resisting large increases in the pH

Connections

Equilibrium	Stoichiometry

Potential Pitfalls and Things to Watch For

Knowing when you need K_a or K_b	Recognizing the weak organic bases

BE AWARE of when a weak acid (base) is present with its conjugate salt – HELLO! YOU ARE IN THE BUFFER ZONE!!!!

NMSI SUPER PROBLEM

$NH_3(aq) + H_2O(\ell)$ ☐ $NH_4^+(aq) + OH^-(aq)$ $K_b = 1.80 \times 10^{-5}$

Ammonia reacts with water as indicated in the reaction above.

(a) Write the equilibrium constant expression for the reaction represented above.

$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$	**1 point** is earned for the correct expression

(b) Calculate the pH of a 0.150 *M* solution of NH_3

$K_b = \frac{x^2}{M}$ where x = $[OH^-]$ $1.80x10^{-5} = \frac{x^2}{0.150}$ $1.64x10^{-3} = x$ $-\log x = \text{pOH} = 2.784$ $\text{pH} = 11.216$	**1 point** is earned for the correct set up and for calculating the concentration of hydroxide ions **1 point** is earned for the correct pH

A 20 mL sample of the 0.150 *M* solution of NH_3 is titrated with 0.100 *M* HCl

(c) Determine the volume of HCl required to reach the equivalence point.

$(20\,\text{mL})(0.150\,M) = 3.00\,\text{mmol NH}_3$ $(X\,\text{mL})(0.100\,M) = 3.00\,\text{mmol HCl}$ X = 30 mL HCl	**1 point** is earned for the volume of HCl required to reach equivalence

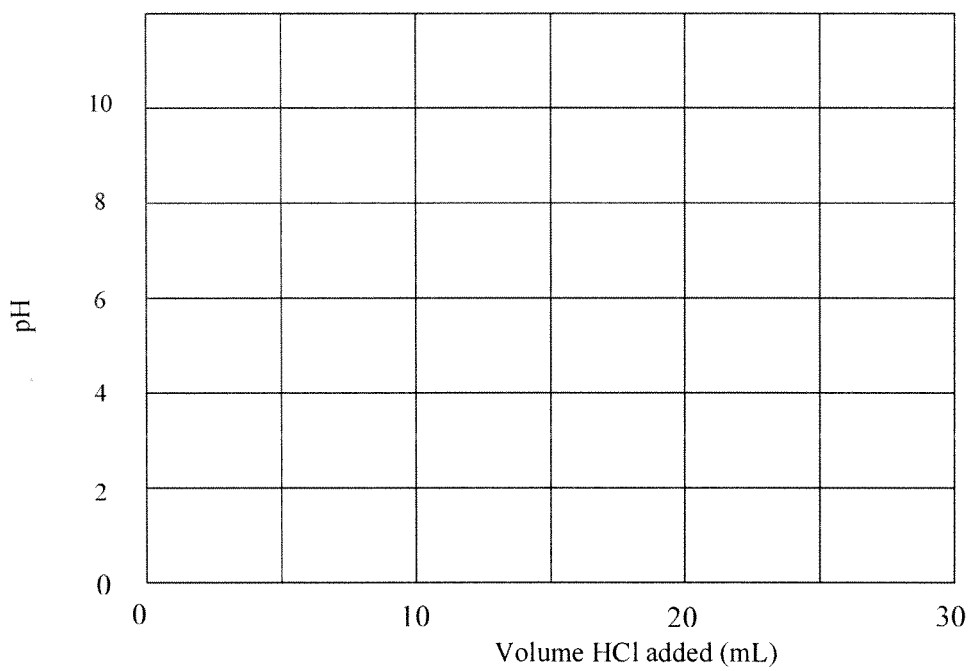
(d) Calculate the pH of the solution after the addition of 15 mL of HCl.

After adding 15 mL of HCl you are at the ½ equivalence point – at this point $\left[H_3O^+\right] = K_a$ $K_a = \frac{1.0 \times 10^{-14}}{K_b}$ $K_a = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$ $[H_3O]^+ = K_a$ $\text{pH} = -\log[K_a] = -\log 5.6 \times 10^{-10} = 9.25$	**1 point** is earned for converting K_b to K_a (or finding pOH and subtracting to get pH) **1 point** is earned for the correct set up and pH calculation

(e) Calculate the pH of the solution at the equivalence point of the titration.

At equivalence the pH depends on the [salt]: NH_4^+ At equivalence: 3 mmol acid added, 3 mmol of base reacted, 3 mmol of salt NH_4^+ formed 50 mL total volume (20 mL of base + 30 mL of acid added) $\therefore\ [NH_4^+] = \frac{3\text{ mmol}}{50\text{ mL}} = 0.060\,M$ $K_a = \frac{x^2}{M}$ $5.56\times10^{-10} = \frac{x^2}{0.060}$ $5.77\times10^{-6} = x$ $\text{pH} = -\log x = 5.239$	**1 point** is earned for the concentration of ammonium ions **1 point** is earned for using K_a **1 point** is earned for the correct set up and pH calculation

(f) Using the axes provided below, sketch the titration curve that would result if the student had used 0.200 *M* HCl instead of the 0.100 *M* used above, to perform the titration. The equivalence point must be clearly marked.



Curve must have the following features: Initial pH around 11.22 Vertical slope at 15.00 mL and the equivalence point marked at 15 mL of HCl added with pH around 5 Shape of curve must resemble titration curve	**1 point** for any 2 features **2 points** for all 4 features

When ammonia is reacted with methanol with a specific catalyst, the colorless gas methylamine (along with dimethyamine and trimethlyamine) can be produced. While trimethylamine is the favored product, adjusting the reactant ratios can help alter the amount of the three 'amines' produced. The process is complex but is used to industrially produce methylamine – which is listed as a controlled substance by the US Drug Enforcement Agency, because of its uses in the production of methamphetamine.

$$CH_3OH + NH_3 \rightarrow CH_3NH_2 + H_2O$$

When methylamine is isolated and dissolved in water it acts as a weak base according to the reaction below.

$$CH_3NH_2 + H_2O \square CH_3NH_3^+ + OH^- \qquad K_b = 4.40 \times 10^{-4}$$

The methylamine above was dissolved in 150 mL of water, resulting in a solution had a methylamine concentration of 0.150 *M*.

(g) Calculate the pH of the methylamine solution

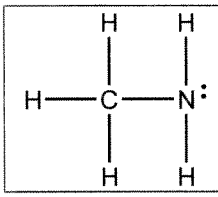
$K_b = \frac{x^2}{M}$ where x = $[OH^-]$ $4.40 \times 10^{-4} = \frac{x^2}{0.150}$ $x = 0.00812M$ $\text{pOH} = -\log(0.00812) = 2.090$ $\text{pH} = 11.910$	**1 point** for the correct set up and for calculating the concentration of hydroxide ions **1 point** is earned for the correct molar concentration of methylamine

(h) To the above solution of methylamine, 0.120 mole of methylammonium chloride was added. Calculate the pH of the solution after the addition of the methylammonium chloride, CH_3NH_3Cl.

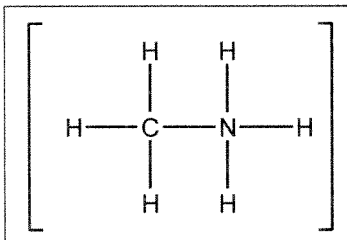
$0.150\text{L} \times 0.150M = 0.225\,\text{mole methylamine}$ $0.120\,\text{mole methylammonium chloride}$ $K_a \times K_b = 1.00 \times 10^{-14}$ $K_a = \frac{1.00 \times 10^{-14}}{4.40 \times 10^{-4}} = 2.27 \times 10^{-11}$ $[H_3O^+] = K_a \frac{[\text{Acid}]}{[\text{Base}]} = (2.27 \times 10^{-11})\frac{[0.120]}{[0.225]} = 1.21 \times 10^{-11}$ $\text{pH} = -\log(1.21 \times 10^{-11}) = 10.917$	**1 point** for the correct number of moles of methylamine or the correct molarity of methylammonium ion **1 point** for the correct K_a for methylammonium ion **1 point** for the correct $[H_3O^+]$ ions and correct pH

(i) Draw the Lewis structure for

i. methylamine, CH_3NH_2.

	**1 point** for the correct Lewis structure; lone pair must be present on N

ii. methylammonium ion, $CH_3NH_3^+$.

	**1 point** for the correct Lewis structure; positive charge must be included for credit.

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Question 1 (10 points)

Answer the following questions that relate to the chemistry of halogen oxoacids.

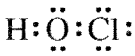
(a) Use the information in the table below to answer part (a)(i).

Acid	K_a at 298 K
HOCl	2.9×10^{-8}
HOBr	2.4×10^{-9}

(i) Which of the two acids is stronger, HOCl or HOBr ? Justify your answer in terms of K_a .

HOCl is the stronger acid because its K_a value is greater than the K_a value of HOBr.	One point is earned for the correct answer with justification.

(ii) Draw a complete Lewis electron-dot diagram for the acid that you identified in part (a)(i).

	One point is earned for a correct diagram.

(iii) Hypoiodous acid has the formula HOI. Predict whether HOI is a stronger acid or a weaker acid than the acid that you identified in part (a)(i). Justify your prediction in terms of chemical bonding.

HOI is a weaker acid than HOCl because the O–H bond in HOI is stronger than the O–H bond in HOCl. The lower electronegativity (electron-drawing ability) of I compared with that of Cl results in an electron density that is higher (hence a bond that is stronger) between the H and O atoms in HOI compared with the electron density between the H and O atoms in HOCl. **OR** The conjugate base OCl^- is more stable than OI^- because Cl, being more electronegative, is better able to accommodate the negative charge.	One point is earned for predicting that HOI is a weaker acid than HOCl <u>and</u> stating that iodine has a lower electronegativity than chlorine **and EITHER** • stating that this results in a stronger O–H bond in HOI **OR** • stating that this decreases the stability of the OI^- ion in solution.

Question 1 (continued)

(b) Write the equation for the reaction that occurs between hypochlorous acid and water.

$HOCl + H_2O \rightleftarrows OCl^- + H_3O^+$ **OR** $HOCl \rightleftarrows OCl^- + H^+$	One point is earned for the correct equation.

(c) A 1.2 M NaOCl solution is prepared by dissolving solid NaOCl in distilled water at 298 K. The hydrolysis reaction $OCl^-(aq) + H_2O(l) \rightleftarrows HOCl(aq) + OH^-(aq)$ occurs.

(i) Write the equilibrium-constant expression for the hydrolysis reaction that occurs between $OCl^-(aq)$ and $H_2O(l)$.

$K_b = \dfrac{[HOCl][OH^-]}{[OCl^-]}$	One point is earned for the correct expression.

(ii) Calculate the value of the equilibrium constant at 298 K for the hydrolysis reaction.

$K_b = \dfrac{K_w}{K_a} = \dfrac{1.0 \times 10^{-14}}{2.9 \times 10^{-8}} = \mathbf{3.4 \times 10^{-7}}$	One point is earned for the correct value with supporting work.

(iii) Calculate the value of $[OH^-]$ in the 1.2 M NaOCl solution at 298 K.

	$[OCl^-]$	$[HOCl]$	$[OH^-]$
initial value	1.2	0	≈ 0
change	$-x$	x	x
equilibrium value	$1.2 - x$	x	x

One point is earned for the correct setup.

$$K_{hyd} = 3.4 \times 10^{-7} = \frac{[OH^-][HOCl]}{[OCl^-]} = \frac{(x)(x)}{(1.2 - x)} \approx \frac{x^2}{1.2}$$

$$\Rightarrow (1.2)(3.4 \times 10^{-7}) = x^2 \Rightarrow$$

$$x = [OH^-] = \mathbf{6.4 \times 10^{-4}\ M}$$

One point is earned for the correct answer with supporting calculations.

Question 1 (continued)

(d) A buffer solution is prepared by dissolving some solid NaOCl in a solution of HOCl at 298 K. The pH of the buffer solution is determined to be 6.48.

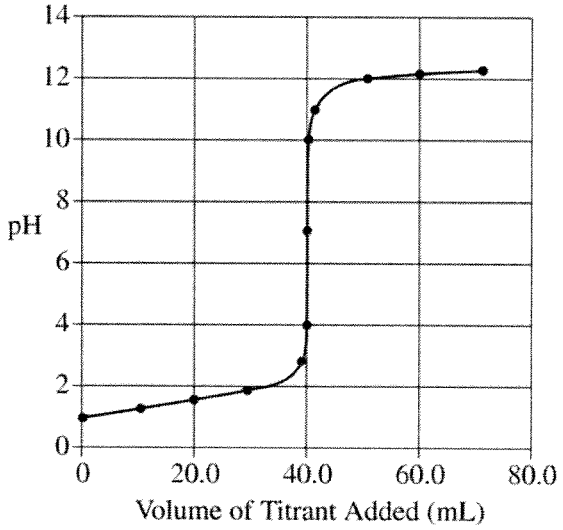
(i) Calculate the value of $[H_3O^+]$ in the buffer solution.

$[H^+] = 10^{-6.48} = \mathbf{3.3 \times 10^{-7}}\ \boldsymbol{M}$	One point is earned for the correct value.

(ii) Indicate which of HOCl(aq) or OCl^-(aq) is present at the higher concentration in the buffer solution. Support your answer with a calculation.

$[H^+] = 3.3 \times 10^{-7}\ M$ and K_a for HOCl $= 2.9 \times 10^{-8}$ $K_a = \dfrac{[H^+][OCl^-]}{[HOCl]}$ $2.9 \times 10^{-8} = \dfrac{(3.3 \times 10^{-7})[OCl^-]}{[HOCl]}$ $\dfrac{[OCl^-]}{[HOCl]} = \dfrac{2.9 \times 10^{-8}}{3.3 \times 10^{-7}} = 0.088 \quad \Rightarrow \quad [HOCl] > [OCl^-]$	One point is earned for the correct answer with supporting buffer calculations.

Question 5
(9 points)



A solution of 0.100 *M* HCl and a solution of 0.100 *M* NaOH are prepared. A 40.0 mL sample of one of the solutions is added to a beaker and then titrated with the other solution. A pH electrode is used to obtain the data that are plotted in the titration curve shown above.

(a) Identify the solution that was initially added to the beaker. Explain your reasoning.

The solution in the beaker was the 0.100 *M* HCl because the initial pH was 1 (the pH of 0.100 *M* HCl).	One point is earned for the correct identification with rationale.

(b) On the titration curve above, circle the point that corresponds to the equivalence point.

The point with coordinates (40.0, 7) is circled.	One point is earned for the correct choice of point.

(c) At the equivalence point, how many moles of titrant have been added?

$0.0400\ \text{L} \times \dfrac{0.100\ \text{mol NaOH}}{1.00\ \text{L}} = 0.00400\ \text{mol NaOH}$	One point is earned for the correct numerical answer.

(d) The same titration is to be performed again, this time using an indicator. Use the information in the table below to select the best indicator for the titration. Explain your choice.

Methyl red would be best because its color change will occur closest to the equivalence point (when the pH changes from about 4 to 10).	One point is earned for the correct selection of indicator. One point is earned for the explanation.

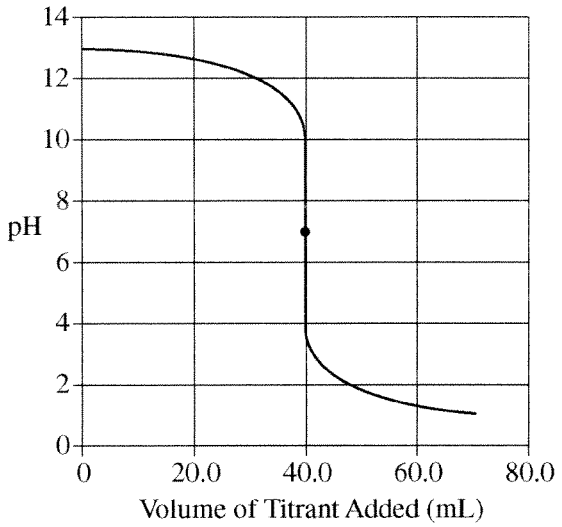
Question 5 (continued)

Indicator	pH Range of Color Change
Methyl violet	0 – 1.6
Methyl red	4 – 6
Alizarin yellow	10 – 12

(e) What is the difference between the equivalence point of a titration and the end point of a titration?

The equivalence point in a titration occurs when the number of moles of titrant added is exactly sufficient to react completely with the number of moles of the titrated species present in the sample being titrated. The end point of a titration is the point in a titration at which the indicator undergoes its color change.	One point is earned for each correct definition.

(f) On the grid provided below, sketch the titration curve that would result if the solutions in the beaker and buret were reversed (i.e., if 40.0 mL of the solution used in the buret in the previous titration were titrated with the solution that was in the beaker).



One point is earned for starting between pH 12 and 14 and for finishing below pH 2.

One point is earned for locating the equivalence point at pH 7 and volume 40.0 mL.

One point is earned for the overall shape of the curve.

Question 1

$$C_6H_5NH_2(aq) + H_2O(l) \rightleftarrows C_6H_5NH_3^+(aq) + OH^-(aq)$$

1. Aniline, a weak base, reacts with water according to the reaction represented above.

(a) Write the equilibrium expression, K_b, for the reaction represented above.

$K_b = \dfrac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$	1 point for correct expression

(b) A sample of aniline is dissolved in water to produce 25.0 mL of a 0.10 M solution. The pH of the solution is 8.82. Calculate the equilibrium constant, K_b, for this reaction.

pH = 8.82	
pOH = 14 – 8.82 = 5.18	
$[OH^-] = 10^{-5.18} = 6.61 \times 10^{-6}\ M$	1 point for calculation of $[OH^-]$
$[C_6H_5NH_3^+] = [OH^-] = 6.6 \times 10^{-6}\ M$	1 point for $[C_6H_5NH_3^+] = [OH^-]$
$K_b = \dfrac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]} = \dfrac{(6.6 \times 10^{-6})^2}{0.10}$	
$K_b = 4.4 \times 10^{-10}$	1 point for calculation of K_b

Note: Following this point, any value of K_b obtained must be carried through.

Question 1 (cont'd.)

(c) The solution prepared in part (b) is titrated with 0.10 *M* HCl. Calculate the pH of the solution when 5.0 mL of the acid has been added.

$n_{C_6H_5NH_2} = 0.025\ \text{L}\left(\frac{0.10\ \text{mol}}{1\ \text{L}}\right) = 0.0025\ \text{mol}\ C_6H_5NH_2$ $n_{HCl} = 0.0050\ \text{L}\left(\frac{0.10\ \text{mol}}{1\ \text{L}}\right) = 0.00050\ \text{mol HCl (or } H^+)$ $C_6H_5NH_2(aq) + H^+(aq) \rightleftarrows C_6H_5NH_3^+(aq)$ I 0.0025 mol 0.00050 mol 0 mol C −0.00050 −0.00050 +0.00050 E 0.0020 0 0.00050	1 point for <u>initial</u> number of moles or molarities of $C_6H_5NH_2$ and HCl/H^+
$C_6H_5NH_2(aq) + H_2O(l) \rightleftarrows C_6H_5NH_3^+(aq) + OH^-(aq)$ $\frac{0.0020\ \text{mol}}{0.030\ \text{L}} = 0.0667\ M$ $\frac{0.00050\ \text{mol}}{0.030\ \text{L}} = 0.0167\ M$ I 0.0667 0.0167 ~0 C $-x$ $+x$ $+x$ E $0.0667 - x$ $0.0167 + x$ x $K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]} = 4.37 \times 10^{-10}$ $4.37 \times 10^{-10} = \frac{(0.0167 + x)(x)}{(0.0667 - x)}$ assume that $x << 0.0667\ M$: $4.37 \times 10^{-10} = \frac{(0.0167)(x)}{0.0667}$ $x = [OH^-] = 1.75 \times 10^{-9}\ M$ $\text{pOH} = -\log(1.75 \times 10^{-9}) = 8.76$ $\text{pH} = 14 - 8.76 = 5.24$	1 point for <u>final</u> number of moles or molarities of $C_6H_5NH_2$ and $C_6H_5NH_3^+$ after mixing
OR $\text{pOH} = \text{p}K_b + \log\frac{[C_6H_5NH_3^+]}{[C_6H_5NH_2]}$ $\text{pOH} = -\log(4.37 \times 10^{-10}) + \log\frac{0.0167}{0.0667}$ $\text{pOH} = 9.36 + \log 0.25$ $\text{pOH} = 9.36 + (-0.60) = 8.76$ $\text{pH} = 14 - 8.76 = 5.24$	1 point for pH

Question 1 (cont'd.)

(d) Calculate the pH at the equivalence point of the titration in part (c).

At the equivalence point, moles of $C_6H_5NH_2$ = moles of H^+ $C_6H_5NH_2(aq) + H^+(aq) \rightleftarrows C_6H_5NH_3^+(aq)$ I 0.0025 mol 0.0025 mol 0 mol C −0.0025 −0.0025 +0.0025 E 0 0 0.0025 Need 25 mL of 0.1 *M* HCl to reach the equivalence point of this titration. The total volume of the solution is 50.0 mL $[C_6H_5NH_3^+] = \frac{0.0025 \text{ mol}}{0.050 \text{ L}} = 0.050\ M$	1 point for number of moles or molarity of $C_6H_5NH_3^+$
$C_6H_5NH_3^+(aq) \rightleftarrows C_6H_5NH_2(aq) + H^+(aq)$ I $0.050\ M$ 0 0 C $-x$ $+x$ $+x$ E $0.050 - x$ x x $K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{4.4 \times 10^{-10}} = 2.3 \times 10^{-5}$ $\frac{[C_6H_5NH_2][H^+]}{[C_6H_5NH_3^+]} = 2.3 \times 10^{-5} = \frac{(x)(x)}{(0.050 - x)}$ assume that $x << 0.050\ M$: $2.3 \times 10^{-5} = \frac{(x)(x)}{0.050}$ $x = [H^+] = 1.1 \times 10^{-3}\ M$ pH = 2.96	1 point for pH

(e) The pK_a values for several indicators are given below. Which of the indicators listed is most suitable for this titration? Justify your answer.

Indicator	pK_a
Erythrosine	3
Litmus	7
Thymolphthalein	10

The pH at the equivalence point is acidic. The best indicator is erythrosine, for which the value of pK_a is closest to the pH at the equivalence point.	1 point for correct indicator and justification

Question 1

10 points

$$HC_3H_5O_3(aq) \rightleftarrows H^+(aq) + C_3H_5O_3^-(aq)$$

1. Lactic acid, $HC_3H_5O_3$, is a monoprotic acid that dissociates in aqueous solution, as represented by the equation above. Lactic acid is 1.66 percent dissociated in 0.50 M $HC_3H_5O_3(aq)$ at 298 K. For parts (a) through (d) below, assume the temperature remains at 298 K.

(a) Write the expression for the acid-dissociation constant, K_a, for lactic acid and calculate its value.

$K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]}$	1 point earned for equilibrium expression
$0.50\ M \times 0.0166 = 0.0083\ M = x$	1 point earned for amount of $HC_3H_5O_3$ dissociating
$HC_3H_5O_3(aq) \rightarrow H^+(aq) + C_3H_5O_3^-(aq)$ I 0.50 ~0 0 C −x +x +x E 0.50 − x +x +x	
$K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]} = \frac{[0.0083][0.0083]}{[0.50 - 0.0083]}$ $K_a = 1.4 \times 10^{-4}$	1 point earned for $[H^+] = [C_3H_5O_3^-]$ set up and solution

(b) Calculate the pH of 0.50 M $HC_3H_5O_3$.

From part (a): $[H^+] = 0.0083\ M$ $pH = -\log [H^+] = -\log (0.0083) = 2.08$	1 point earned for correctly calculating pH

Question 1 (cont'd.)

(c) Calculate the pH of a solution formed by dissolving 0.045 mole of solid sodium lactate, $NaC_3H_5O_3$, in 250. mL of 0.50 M $HC_3H_5O_3$. Assume that volume change is negligible.

$\frac{0.045 \text{ mol } NaC_3H_5O_3}{0.250 \text{ L}} = 0.18\ M\ C_3H_5O_3^-$	1 point earned for $[C_3H_5O_3^-]$ (or 0.250 L × 0.50 mol/L = 0.125 mol $HC_3H_5O_3$ and 0.045 mol $C_3H_5O_3^-$)
$HC_3H_5O_3(aq) \rightarrow H^+(aq) + C_3H_5O_3^-(aq)$ I: 0.50 ~0 0.18 C: −x +x +x E: 0.50 − x +x 0.18 + x	
$K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]} = \frac{[x][0.18+x]}{[0.50-x]}$	
Assume that $x << 0.18\ M$ $K_a = 1.4 \times 10^{-4} = \frac{[x][0.18]}{[0.50]}$ $x = 3.9 \times 10^{-4}\ M = [H^+]$	1 point earned for $[H^+]$ (set up and calculation) 1 point earned for calculating the value of pH
$pH = -\log [H^+] = -\log (3.9 \times 10^{-4}) = 3.41$ **OR** $pH = pK_a + \log \frac{0.18}{0.50}$ or $\frac{0.045}{0.125} = 3.41$	

Question 1 (cont'd.)

(d) A 100. mL sample of 0.10 M HCl is added to 100. mL of 0.50 M $HC_3H_5O_3$. Calculate the molar concentration of lactate ion, $C_3H_5O_3^-$, in the resulting solution.

$0.50\ M\ HC_3H_5O_3 \left(\frac{100\ \text{mL}}{200\ \text{mL}}\right) = 0.25\ M\ HC_3H_5O_3$ $0.10\ M\ HCl \left(\frac{100\ \text{mL}}{200\ \text{mL}}\right) = 0.050\ M\ H^+$	1 point earned for initial $[H^+]$ and $[HC_3H_5O_3]$ **OR** (10 mmol H^+; 50 mmol $HC_3H_5O_3$)
$HC_3H_5O_3(aq) \rightarrow H^+(aq) + C_3H_5O_3^-(aq)$ I 0.25 0.050 0 C −x +x + x E 0.25 − x 0.050 + x + x	1 point earned for showing dilution or moles of each
$K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]} = \frac{[0.050+x][x]}{[0.25-x]}$ Assume $x << 0.050\ M$ $K_a = 1.4 \times 10^{-4} = \frac{[0.050][x]}{[0.25]}$ $x = 7.0 \times 10^{-4}\ M = [C_3H_5O_3^-]$	1 point earned for $[C_3H_5O_3^-]$ setup and calculation