AP® Chemistry
2002 Sample Student Responses
Form B

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1A

CHEMISTRY

Section II

(Total time—90 minutes)

Part A

Time—40 minutes

YOU MAY USE YOUR CALCULATOR FOR PART A.

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the goldenrod cover. Do NOT write your answers on the lavender insert.

Answer Question 1 below. The Section II score weighting for this question is 20 percent.

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

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.

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

   (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.

   (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.

a) $K_a = \dfrac{[C_3H_5O_3^-][H^+]}{[HC_3H_5O_3]}$ → $K_a = \dfrac{(.0083)^2}{(.4917)}$

$K_a = 1.4 \times 10^{-4}$

.5M is 1.66% dissociated.
.0083M is dissociated.
.4917M is not

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

equil: .4917M .0083M .0083M

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b) (Find pH.) $pH = -\log[H^+]$ $[H^+] = .0083M$.

$pH = -\log[.0083]$ **$pH = 2.08$**

c) $HC_3H_5O_3(aq) \rightleftharpoons H^+(aq) + C_3H_5O_3^-(aq)$

	$HC_3H_5O_3$	H^+	$C_3H_5O_3^-$
start:	.5M	0	.18M
change:	$-x$	x	$+x$
equil:	$.5-x$	x.	$.18+x$

$0.045 \text{ moles} \div 0.25 \text{ L} = 0.18M \; Na(C_3H_5O_3)$.

$K_a = \frac{[C_3H_5O_3^-][H^+]}{[HC_3H_5O_3]}$. $K_a = \frac{x(.18+x)}{(.5-x)}$. x is very small and is negligible

$K_a = \frac{.18x}{.5} \rightarrow 1.4 \times 10^{-4} = \frac{.18x}{5}$

$[H^+] = x = .0039$

$pH = -\log[H^+] = -\log(.0039)$

$pH = 2.4$

d) $.1L \times .1M = .01$ moles HCl volume = 100mL + 100mL

$.1L \times .5M = .05$ moles $HC_3H_5O_3$ = 200mL = 1.2L

$\frac{.01 \text{ moles}}{.2L} = .05M \; HCl$ $\frac{.05 \text{ moles}}{.2L} = .25M \; HC_3H_5O_3$

HCl ionizes completely (100%)

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

	$HC_3H_5O_3$	H^+	$C_3H_5O_3^-$
start	.25M	.05M	0
equilib:	.25M	.05M	x

x = small + negligible

$K_a = \frac{(.05)x}{.25}$

$1.4 \times 10^{-4} = \frac{.05x}{.25}$ $x = 7 \times 10^{-4}$ **$[C_3H_5O_3^-] = 7 \times 10^{-4} M$**

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1 B

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

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

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   (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.

1a. EXPRESSION: $K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]}$

CALCULATION FOR Ka:

.016 · .50 = .008 M

$\frac{[.008M][.008M]}{.50\ M} = \frac{.000064}{.0078}$

Ka = .0013

$K_a = 1.3 \times 10^{-4}$

b. $-\log(.008)$

pH = 2.1

c. $1.3 \times 10^{-4} = \frac{[H^+][NaC_3H_5O_3^-]}{[HC_3H_5O_3]}$

$1.3 \times 10^{-4} = \frac{[X][\frac{.17}{.250} + X]}{[.5 - X]}$

$= 1.3 \times 10^{-4} = \frac{[X][.68 + X]}{[.08 - X]}$

.250 · .5 = .125 mol + .045 = .17

.125 − .08 = .05

X = .000015

pH = 4.8

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1.

d.

$1.3\times10^{-4} = \dfrac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]}$ $\quad .1-.1\ M. = .01$

$1.3\times10^{-4} = \dfrac{[x+.05][x]}{[.25-x]}$

$x = .000064$

$\boxed{6.4\times10^{-4}\ M \text{ of } C_3H_5O_3}$