Scoring Guide for AP14.60 C15-C16 FRQ Test

An excellent method for improving FRQ performance is to learn how the FRQ's are graded. This is best done by self-grading your FRQ's.

Use this scoring guide and the associated WebAssign video to grade your FRQ and then enter your raw score in the WebAssignment corresponding to this test, *AP14.60 C15-C16 FRQ*.

Tally Sheet

AP14 C15-C16 Acid-Base 60 MC 1 FRQ question

	Answer	Possible	Score
(a) Net ionic equation	$H^+ + C_6H_7O_2^- \leftrightarrows HC_6H_7O_2$	1	
(b) Vol HCl	29.95 mL +/- 0.5	1	
(b) moles HCl	4 sig figs	1	
(c)$[KC_6H_7O_2]$	0.0374 mol sorbic, 0.832 *M*	2	
(d) pH at half-equivalence point	pK_a sorbic acid = -log(K_a) = 4.77	1	
(e) x at half-equivalence point	x at (d) answer and 15 mL	1	
(e) leveling at buffered region	between 10-20 mL	1	
(e) steep slope at equivalence point	at 30 mL \	1	
(f) more acid than base	because pH < pK_a sorbic acid	1	
	Total Raw Score	10	

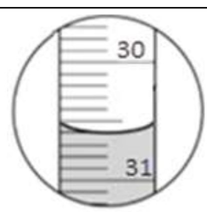
Raw	AP Level
10	5
9	5
8	5
7	4
6	4
5	3
4	3
3	2
2	2
1	1

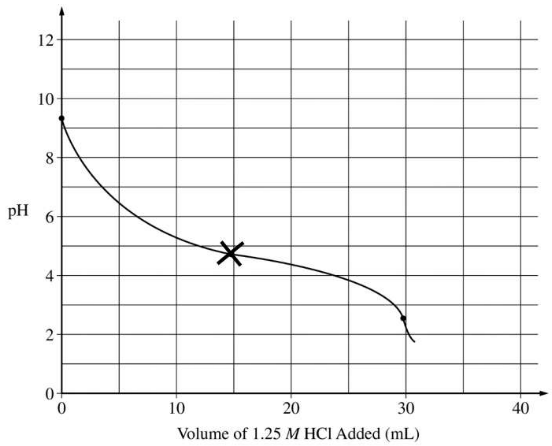
The actual AP Exam FRQ that was the basis for this question was slightly different (easier). The global test average for the original AP Exam FRQ question was 3.7 points out of 10.

Getting four points on this test would be the equivalent of level 3 (passing) on the AP exam.

Once you have self-graded your FRQ, enter your scores in WebAssign for this test.

1. Potassium sorbate, $KC_6H_7O_2$ (molar mass 150. g/mol) is commonly used as an antimicrobial agent for foods. The parent acid is found in berries, so it is considered a natural additive. A stock solution of $KC_6H_7O_2(aq)$ of known concentration must be prepared. A student titrates 45.00 mL of the stock solution with 1.25 *M* HCl(*aq*) using both an indicator and a pH meter. The value of K_a for scorbic acid, $HC_6H_7O_2$, is 1.7×10^{-5}.

A. Write the net-ionic equation between $KC_6H_7O_2(aq)$ and HCl(*aq*). $H^+ + C_6H_7O_2^- \rightleftarrows HC_6H_7O_2$ or $H_3O^+ + C_6H_7O_2^- \rightleftarrows H_2O + HC_6H_7O_2$ Note from an AP Grader on net ionic equation grading: "When I was a reader, I was assigned was a net ionic equation. Even if a student demonstrated they understood the concept quite well if they left off a single sign (or a single subscript), they lost the entire one point for that question." Always go back and carefully proofread your answer for net ionic equations looking carefully for errors in copying formulas and get those charges right. The reverse reaction would be accepted too. A regular single arrow would be accepted. No answer with the spectator ions, potassium or chloride would be acceptable.	1 point is earned the net-ionic equation
B. The images below show the buret before the titration begins (below left) and at the endpoint (below right). What should the student record as the volume of HCl(*aq*) required to reach the endpoint? When reading an analog scale, you are expected to estimate (read) the values between the lines. The lines are 0.1 mL so the estimated readings should be to the 0.01  0.65 mL  30.60 mL 30.60 mL – 0.65 mL 29.95 mL HCl	1 point is earned for the correct volume of HCl with a latitude of +/- 0.05. 1 point for the answer shown to the correct net volume to four significant figures.
C. Assuming that the endpoint is equal to the equivalence point, calculate C_{base} in the stock solution. $C_{acid} \times V_{acid} = C_{base} \times V_{base}$ $(1.25\ M\ HCl)(29.95\ ml\ HCl) = (C_{base})(45.0\ ml\ C_6H_7O_2^-)$ $C_{base} = 0.832\ M$	1 point is earned for moles of HCl or setup at the equivalence point. 1 point is earned for the correct answer.

D. Calculate the pH at the half-equivalence point. At the half equivalence point pH = pK_a = -log(1.7 × 10^{-5}) = 4.77	1 point is earned for the correct pH with calc
E. The initial pH and the equivalence point are plotted on the graph below. Accurately sketch the titration curve on the graph below. Mark the position of the half-equivalence point on the curve with an X.  The pH curve should have the correct shape starting with a steep slope, changing to a buffered more horizontal line with the half-equivalence	1 point is earned for a half-equivalence point consistent with the answer to part(d) and the correct volume. No matter what the shape of the curve. 1 point is earned for a curve that levels off to a relatively horizontal shape through the half-equivalence point. No matter where the curve starts. 1 point is earned for a relatively steep negative slope through the equivalence point.

F. The pH of a soft drink is 3.37 after the addition of $KC_6H_7O_2(aq)$. Which species $HC_6H_7O_2$ or $C_6H_7O_2^-$, has a higher concentration in the soft drink? Justify your answer.

The soft drink has a higher concentration of acid than conjugate base.

$$K_a = \frac{[H+][C_6H_7O_2^-]}{[HC_6H_7O_2^-]} \qquad 1.7\times10^{-5} = \frac{[10^{-3.37}][C_6H_7O_2^-]}{[HC_6H_7O_2^-]}$$

$$\frac{1.7\times10^{-5}}{[4.3\times10^{-5}]} = \frac{[C_6H_7O_2^-]}{[HC_6H_7O_2^-]} \qquad 0.040 = \frac{[C_6H_7O_2^-]}{[HC_6H_7O_2^-]}$$

or the Henderson Hasselbalch can be used for this buffered mixture

$$pH = pK_a + \log\left(\frac{[C_6H_7O_2^-]}{[HC_6H_7O_2]}\right) \qquad 3.37 = -\log(1.7\times10^{-5}) + \log\left(\frac{[C_6H_7O_2^-]}{[HC_6H_7O_2]}\right)$$

$$3.37 = 4.77 + \log\left(\frac{[C_6H_7O_2^-]}{[HC_6H_7O_2]}\right) \qquad -1.40 = \log\left(\frac{[C_6H_7O_2^-]}{[HC_6H_7O_2]}\right)$$

$$10^{-1.4} = \frac{[C_6H_7O_2^-]}{[HC_6H_7O_2^-]} \qquad \therefore\ [HC_6H_7O_2] > [C_6H_7O_2^-]$$

OR

[$HC_6H_7O_2$ (acid)] and [$C_6H_7O_2^-$ (base)] are equal in a perfectly buffered solution where the pH at the half-equivalence point is 4.77.
The soft drink with a pH of 3.37 was more acidic than 4.77, therefore there was a greater amount of acid than the conjugate base.

1 point is earned for identifying the correct species <u>and</u> for making a comparison involving the pH (or with or without calculation).

A model paper using the old lined format.

a) $H^+ + C_6H_7O_2^- \rightleftarrows HC_6H_7O_2$

b) $30.6 - .65 = \boxed{29.95}$ mL

c) END POINT = 1.25 mol HCL = $\frac{1.25 \text{ mol HCL}}{1000 \text{ mL}} = \frac{x \text{ mol HCL}}{29.95} =$

$x = \boxed{.0374}$ mol HCL → 45 mL = total →

$\frac{.0374 \text{ mol } C_6H_7O_2^-}{45 \text{ mL}} = \frac{x \text{ mol } C_6H_7O_2}{1000} =$

$x = \boxed{.832}$ mol $C_6H_7O_2^-$

d) $Ka = 1.7 \times 10^{-5}$ pH = pKa = $-\log(1.7 \times 10^{-5}) =$ $\boxed{4.77}$

f) $C_6H_7O_2^-$ and $HC_6H_7O_2$ both have the same concentrations at the half equivalence point, but a 3.37 pH level is in fact lower than the pH of the half-equivalence point. This indicateds a higher level of H^+ ions, and a more acidic drink, therefore $HC_6H_7O_2$ has the higher concentration.

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