Name: _____ Period: _____ Assigned on Friday, April 03, 2026

12.4: Acid-Base Review So Far Part 2 (answers on website) **Due Monday, April 06, 2026**

Actual AP FRQ

$$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons C_2H_3O_2^-(aq) + H_3O^+(aq)$$

The dissociation of ethanoic acid, $HC_2H_3O_2(aq)$, is represented above. A student is given the task of determining the value of K_a for $HC_2H_3O_2(aq)$ using two different experimental procedures.

a. Label the acid, base, conjugate acid, and conjugate base in the following reaction.

$$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons C_2H_3O_2^-(aq) + H_3O^+(aq)$$

b. The student is first asked to prepare 100.0 mL of 0.115 M $HC_2H_3O_2(aq)$ using a 2.000 M standard solution. Calculate the volume, in mL, of 2.000 M $HC_2H_3O_2(aq)$ the student needs to prepare 100.0 mL of 0.115 M $HC_2H_3O_2(aq)$.

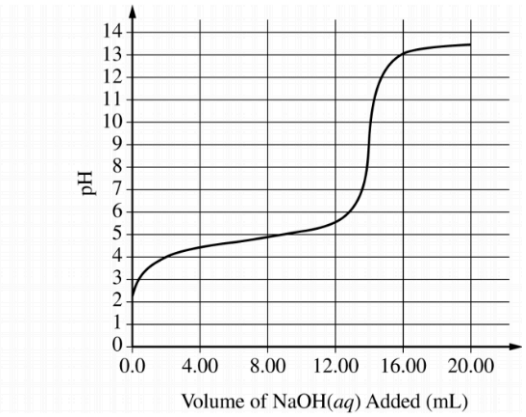
c. Using a pH probe, the student determines that the pH of 0.115 M $HC_2H_3O_2(aq)$ is 2.92.

i. Using the pH value, calculate the value of K_a for $HC_2H_3O_2(aq)$

ii. Calculate the percent dissociation of ethanoic acid in 0.115 M $HC_2H_3O_2(aq)$.

In a separate experimental procedure, the student titrates 10.0 mL of the 2.000 M $HC_2H_3O_2(aq)$ with an NaOH(aq) solution of unknown concentration. The student monitors the pH during the titration. The following titration curve was created using the experimental data presented in the table.

Volume of NaOH(*aq*) Added (mL)	pH
0.00	2.23
2.00	3.99
4.00	4.37
6.00	4.65
8.00	4.90
10.00	5.17
12.00	5.55
14.00	9.35
16.00	13.04
18.00	13.31
20.00	13.46



d. Write the balanced net ionic equation for the reaction that occurs when $HC_2H_3O_2(aq)$ and NaOH(aq) are combined.

e. Calculate the molar concentration of the NaOH(aq) solution.

f. Use the titration curve to calculate an approximate value of K_a for $HC_2H_3O_2(aq)$.

Grading Criteria (9 points total)

Part A

1 point maximum

1 point is earned for labelling all substances correctly

$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons C_2H_3O_2^-(aq) + H_3O^+(aq)$

acid base conj base conj acid

Part B

1 point maximum

1 point is earned for the correct volume.

> *Mi Vi = Mf Vf*
>
> $V_i = \frac{(0.115M)(100.0\,mL)}{2.000M} = 5.75$ mL

Part C

3 point(s) maximum

Part (i)

1 point is earned for correct conversion of pH to [H3O+].

> pH = 2.92 ⇒ [H3O+] = 10-2.92 = 0.0012 *M*

1 point is earned for a value of Ka consistent with the student's value of [H3O+].

> $K_a = \frac{[H^3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$
>
> Since [H3O+] = [C2H3O2-], then
>
> $K_a = \frac{(0.0012)(0.0012)}{(0.115-0.0012)} = \frac{(0.0012)^2}{(0.114)} = 1.3 \times 10^{-5}$

Part (ii)

1 point is earned for the correct percent dissociation.

> Percent dissociation = $\frac{[C_2H_3O_2^-]}{[HC_2H_3O_2]_o} = \frac{0.0012}{0.115} \times 100 = 1.0\%$

Part D

1 point(s) maximum

1 point is earned for the correct equation.

> HC2H3O2(*aq*) + OH-(aq) → C2H3O2-(*aq*) + H2O(l)

Part E

2 point(s) maximum

1 point is earned for determining the moles of acid.

> From the pH curve, the equivalence point occurs at 14.0 mL.
>
> $10\,\text{mL} \times \frac{2.000\,\text{mol}\,HC_2H_3O_2}{1000\,\text{mL}} = 0.0200\,mol\,HC_2H_3O_2(aq)$

1 point is earned for determining the molar concentration of the base.

> $0.0200\,mol\,HC_2H_3O_2(aq) \times \frac{1\,\text{mol NaOH}}{1\,\text{mol}\,HC_2H_3O_2} = 0.0200\,\text{mol NaOH}$
>
> $\frac{0.0200\,\text{mol NaOH}}{0.0140\,\text{L solution}} = 1.43\,M\,\text{NaOH}(aq)$

Part F

1 point maximum

At the half-equivalence point, pH = pK_a.

pH = 4.8 (approx.) = pKa

Ka = 10^-4.8 = 1.58×10^{-5}