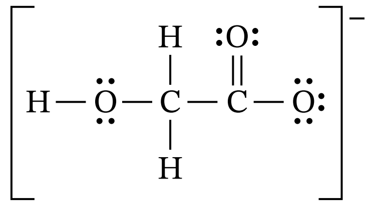
7. Answer the following questions about the glycolate ion, $C_2H_3O_3^-$, which acts as a base in aqueous solution. A Lewis diagram for the ion is provided.



A. On the Lewis diagram in part A, circle the atom that accepts the proton when the glycolate ion reacts with water.

When the glycolate ion reacts with water, it forms glycolic acid, $HC_2H_3O_3$, according to the following equation. The K_b expression for the reaction is provided.

$$C_2H_3O_3^-(aq) + H_2O(l) \rightleftharpoons HC_2H_3O_3(aq) + OH^-(aq) \qquad K_b = \frac{[HC_2H_3O_3][OH^-]}{[C_2H_3O_3^-]}$$

B. At 25°C, a 2.5 M solution of glycolate is found to have $[OH^-] = 1.3 \times 10^{-5}\ M$.

i. Calculate the value of K_b for the glycolate ion.

ii. Using your answer to part B (i), calculate the value of K_a for glycolic acid at 25°C.

Glycolic acid can be produced from the hydrolysis of methyl glycolate, $C_3H_6O_3$. A proposed mechanism for the reaction is given.

Step 1: $C_3H_6O_3 + H_3O^+ \rightleftharpoons C_2H_5O_3^+ + CH_3OH$

Step 2: $\underline{C_2H_5O_3^+ + H_2O \rightleftharpoons HC_2H_3O_3 + H_3O^+}$

Overall: $C_3H_6O_3 + H_2O \rightleftharpoons HC_2H_3O_3 + CH_3OH$

C. A student claims that H_3O^+ is a catalyst for the reaction. Do you agree or disagree? Justify your answer based on the mechanism given.

STOP

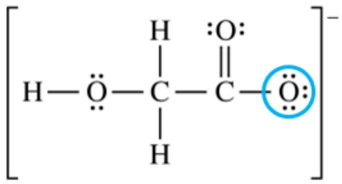
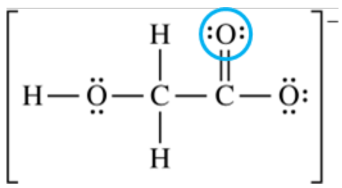
END OF EXAM

C	(i) For a correct explanation. Examples of acceptable responses may include the following: • $\dfrac{4.914 \times 10^{-4}}{2.457 \times 10^{-4}} = \left(\dfrac{0.900}{0.450}\right)^{a}$, thus $a = 1$ • *Comparing trials 1 and 3, the rate doubles when the concentration of ascorbic acid is doubled and the triiodide ion concentration is constant, indicating that the process is first order with respect to ascorbic acid.*	**Point 07**
	(ii) For the correct calculated value: $rate = k[\mathrm{HAsc}][\mathrm{I_3}^-]$ *Using trial 1 data:* $k = \dfrac{rate}{[\mathrm{HAsc}][\mathrm{I_3}^-]} = \dfrac{2.457 \times 10^{-4}\ M/\mathrm{s}}{(0.450\ M)(1.200\ M)} = 4.55 \times 10^{-4} M^{-1}\ \mathrm{s}^{-1}$	**Point 08**
	For the correct units: $M^{-1}\ \mathrm{s}^{-1}$	**Point 09**
D	For the correct answer: *Ion-dipole attractions are present between* $\mathrm{I_3}^-$ *ions and water but not between* $\mathrm{I_2}$ *molecules and water.*	**Point 10**

Question 7: Short Answer — 4 points

A For a correct circled atom. **Point 01**

Accept one of the following:

- 
- 

(Because of resonance, the two C–O bonds on the right are equivalent.)

B (i) For the correct calculated value: **Point 02**

$$K_b = \frac{[HC_2H_3O_3][OH^-]}{[C_2H_3O_3{}^-]} = \frac{(1.3 \times 10^{-5})(1.3 \times 10^{-5})}{(2.5 - 1.3 \times 10^{-5})} \approx \frac{(1.3 \times 10^{-5})^2}{(2.5)} = 6.8 \times 10^{-11}$$

(ii) For the correct calculated value, consistent with part B (i): **Point 03**

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-11}} = 1.5 \times 10^{-4}$$

C For the correct answer and a valid justification: **Point 04**

Agree. H_3O^+ *is consumed in step 1 and regenerated in step 2, which is consistent with the behavior of a catalyst.*