

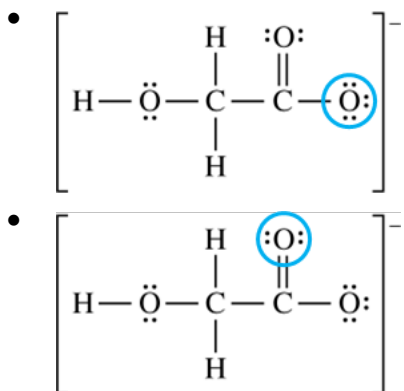
Question 7: Short Answer

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

$$K_b = \frac{[\text{HC}_2\text{H}_3\text{O}_3][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_3^-]} = \frac{(1.3 \times 10^{-5})(1.3 \times 10^{-5})}{(2.5 - 1.3 \times 10^{-5})} \approx \frac{(1.3 \times 10^{-5})^2}{(2.5)} = 6.8 \times 10^{-11}$$

(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.

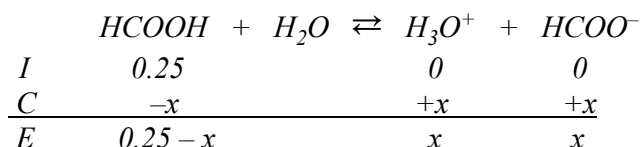
Question 1: Long Answer

10 points

- (a) For the correct expression: 1 point

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HCOO}^-]}{[\text{HCOOH}]}$$

- (b) For the correct calculated concentration of H_3O^+ : 1 point



Let $[\text{H}_3\text{O}^+] = x$, then $1.8 \times 10^{-4} = \frac{x^2}{(0.25 - x)}$

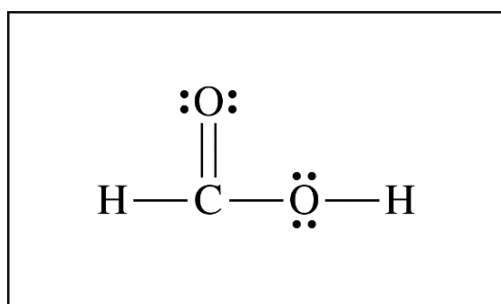
Assume $x \ll 0.25$, then $1.8 \times 10^{-4} = \frac{x^2}{0.25} \Rightarrow x = 0.0067 \text{ M}$

- For the correct calculated value of pH: 1 point

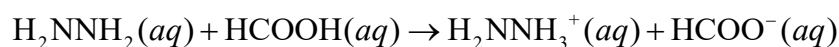
$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(0.0067) = 2.17$$

Total for part (b) 2 points

- (c) For the correct diagram: 1 point



- (d) (i) For the correct balanced equation (state symbols not required): 1 point



- (ii) For the correct answer and a valid justification: 1 point

Acidic. The K_a of H_2NNH_3^+ is greater than the K_b of HCOO^- , so the production of $\text{H}_3\text{O}^+(aq)$ occurs to a greater extent than the production of $\text{OH}^-(aq)$.

Total for part (d) 2 points

- (e) For the correct answer and a valid justification: 1 point

Accept one of the following:

- Yes. The oxidation number of hydrogen changes from +1 in HCOOH to zero in H_2 .
- Yes. The oxidation number of carbon changes from +2 in HCOOH to +4 in CO_2 .

(f) For the correct calculated value of the pressure of CO₂ (may be implicit): **1 point**

$$24 \text{ atm total} \times 1 \text{ atm CO}_2 / 2 \text{ atm of product} = 12 \text{ atm CO}_2$$

For the correct calculated number of moles of CO₂: **1 point**

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(12 \text{ atm})(4.3 \text{ L})}{(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(298 \text{ K})} = 2.1 \text{ mol CO}_2$$

Total for part (f) 2 points

(g) For the correct answer and a valid justification: **1 point**

It would remain the same. In a catalyzed reaction the net amount of catalyst is constant.

Total for question 1 10 points