Question 1: Long Answer — 10 points

(a) For the correct expression: **1 point**

$$K_a = \frac{[H_3O^+][HCOO^-]}{[HCOOH]}$$

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

	$HCOOH$	+ H_2O	⇄ H_3O^+	+ $HCOO^-$
I	*0.25*		*0*	*0*
C	*–x*		*+x*	*+x*
E	*0.25 – x*		*x*	*x*

Let $[H_3O^+] = x$, *then* $1.8\times10^{-4} = \frac{x^2}{(0.25-x)}$

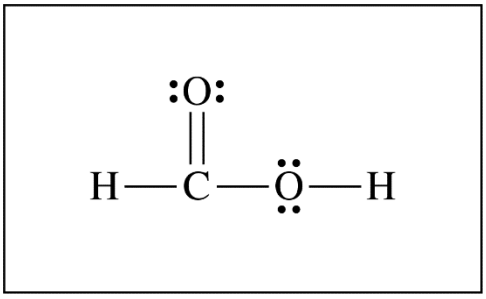
Assume $x << 0.25$, *then* $1.8\times10^{-4} = \frac{x^2}{0.25} \Rightarrow x = 0.0067\ M$

For the correct calculated value of pH: **1 point**

$$pH = -\log[H_3O^+] = -\log(0.0067) = 2.17$$

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**

$$H_2NNH_2(aq) + HCOOH(aq) \rightarrow H_2NNH_3^+(aq) + HCOO^-(aq)$$

(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* $H_3O^+(aq)$ *occurs to a greater extent than the production of* $OH^-(aq)$.

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 CO_2 (may be implicit): *24 atm total × 1 atm CO_2 / 2 atm of product = 12 atm CO_2*	**1 point**
	For the correct calculated number of moles of CO_2: $PV = nRT$ $n = \frac{PV}{RT} = \frac{(12\text{ atm})(4.3\text{ L})}{(0.08206\text{ L atm mol}^{-1}\text{ K}^{-1})(298\text{ K})} = 2.1\text{ mol CO}_2$	**1 point**
	Total for part (f)	**2 points**
(g)	For the correct answer and a valid justification: *It would remain the same. In a catalyzed reaction the net amount of catalyst is constant.*	**1 point**
	Total for question 1	**10 points**