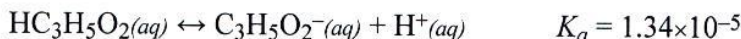


18 • Acid-Base Equilibria

PRACTICE FRQ

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.



Propanoic acid, $\text{HC}_3\text{H}_5\text{O}_2$, ionizes in water according to the equation above.

(a) Write the equilibrium constant expression for the reaction.

$$K_a = \frac{[\text{C}_3\text{H}_5\text{O}_2^-][\text{H}^+]}{[\text{HC}_3\text{H}_5\text{O}_2]}$$

NOTE: INCLUDING THE "K_a" IS IMPORTANT.

(b) Calculate the pH of a 0.265 M solution of propanoic acid.

$$\text{HC}_3\text{H}_5\text{O}_2 \rightleftharpoons \text{C}_3\text{H}_5\text{O}_2^- + \text{H}^+$$

I	0.265 M	0	0
C	-x	+x	+x
E	(.265 - x)	x	x

$$K_a = \frac{x^2}{.265} = 1.34 \times 10^{-5}$$

$$x = \sqrt{x^2} = \sqrt{(.265)(1.34 \times 10^{-5})}$$

$$[\text{H}^+] = 1.88 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log[\text{H}^+] = \boxed{2.725} \leftarrow \text{3 sig. figs.}$$

assume $x \ll .265$
 $\therefore (.265 - x) \approx .265$

(c) A 0.496 g sample of sodium propanoate, $\text{NaC}_3\text{H}_5\text{O}_2$, is added to a 50.0 mL sample of a 0.265 M solution of propanoic acid. Assuming that no change in the volume of the solution occurs, calculate each of the following.

(i) The concentration of the propanoate ion, $\text{C}_3\text{H}_5\text{O}_2^-(aq)$ in the solution

$$\frac{0.496 \text{ g NaC}_3\text{H}_5\text{O}_2}{50.0 \text{ mL}} \times \frac{1 \text{ mol NaC}_3\text{H}_5\text{O}_2}{96.07 \text{ g NaC}_3\text{H}_5\text{O}_2} \times \frac{1 \text{ mol C}_3\text{H}_5\text{O}_2^-}{1 \text{ mol NaC}_3\text{H}_5\text{O}_2} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 0.103 \text{ M}$$

Na	22.99
C ₃	36.03
H ₅	5.05
O ₂	32.00
	<hr/>
	96.07

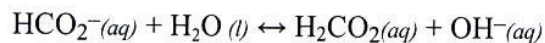
(ii) The concentration of the $\text{H}^+(aq)$ ion in the solution. (THIS IS A BUFFER)

$$K_a = \frac{[\text{C}_3\text{H}_5\text{O}_2^-][\text{H}^+]}{[\text{HC}_3\text{H}_5\text{O}_2]} = 1.34 \times 10^{-5}$$

$$0.265 \text{ M}$$

$$[\text{H}^+] = \frac{(1.34 \times 10^{-5})(0.265 \text{ M})}{(0.103 \text{ M})} = \boxed{3.45 \times 10^{-5} \text{ M}}$$

The methanoate ion, $\text{HCO}_2^-(\text{aq})$ reacts with water to form methanoic acid and hydroxide ion, as shown in the following equation.



(d) Given that $[\text{OH}^-]$ is $4.18 \times 10^{-6} \text{ M}$ in a 0.309 M solution of sodium methanoate, calculate each of the following.

(i) The value of K_b for the methanoate ion, $\text{HCO}_2^-(\text{aq})$

$$\text{HCO}_2^- + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_2 + \text{OH}^-$$

$.309 \text{ M}$		0	0
-4.18×10^{-6}		$+4.18 \times 10^{-6}$	$+4.18 \times 10^{-6}$
0.308996		4.18×10^{-6}	4.18×10^{-6}

$$K_b = \frac{[\text{H}_2\text{CO}_2][\text{OH}^-]}{[\text{HCO}_2^-]}$$

$$= \frac{(4.18 \times 10^{-6})^2}{0.308996}$$

$$= 5.65 \times 10^{-11}$$

(ii) The value of K_a for methanoic acid, HCO_2H

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{5.65 \times 10^{-11}} = 1.77 \times 10^{-4}$$

(e) Which acid is stronger, propanoic acid or methanoic acid? Justify your answer.

$$1.34 \times 10^{-5}$$

$$K_a = 1.77 \times 10^{-4}$$

methanoic acid is stronger because it has the larger K_a value.