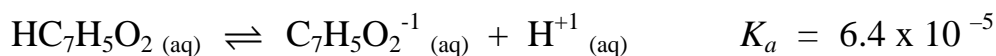


AP CHEMISTRY

TOPIC 7: ACIDS & BASES,

Day 82:

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS.



1. Benzoic acid, $\text{HC}_7\text{H}_5\text{O}_2$, ionizes in water according to the equation above.

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

$$K_a = \frac{[\text{C}_7\text{H}_5\text{O}_2^{-1}][\text{H}^{+1}]}{[\text{HC}_7\text{H}_5\text{O}_2]}$$

(b) Calculate the pH of 0.567 M solution of benzoic acid.

	$[\text{HC}_7\text{H}_5\text{O}_2]$	\rightleftharpoons	$[\text{C}_7\text{H}_5\text{O}_2^{-1}]$	+	$[\text{H}^{+1}]$
I	0.567 M		0		0
C	-x		+x		+x
E	0.567 M - x		x		x

$$K_a = \frac{[\text{C}_7\text{H}_5\text{O}_2^{-1}][\text{H}^{+1}]}{[\text{HC}_7\text{H}_5\text{O}_2]} = \frac{x^2}{0.567 - x} = \frac{x^2}{0.567} = 6.4 \times 10^{-5}$$

$$x^2 = (0.567)(6.4 \times 10^{-5}), \quad x = \sqrt{3.63 \times 10^{-5}} = 6.02 \times 10^{-3}$$

$$[\text{H}^{+1}] = 6.02 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log(6.02 \times 10^{-3}) = 2.22$$

(c) A 0.763 g sample of lithium benzoate, $\text{LiC}_7\text{H}_5\text{O}_2$, is added to a 75.0 mL sample of a 0.567 M solution of benzoic acid. Assuming that no change in the volume of the solution occurs, calculate each of the following.

(i) The concentration of the benzoate ion, $\text{C}_7\text{H}_5\text{O}_2^{-1} \text{ (aq)}$, in the solution.

$$\# \text{ mol LiC}_7\text{H}_5\text{O}_2 = \frac{0.763 \text{ g LiC}_7\text{H}_5\text{O}_2}{128.05 \text{ g}} \times \frac{1 \text{ mol LiC}_7\text{H}_5\text{O}_2}{1} = 5.96 \times 10^{-3} \text{ mol}$$



(Li^{+1} is a conjugate of a strong base, $\text{C}_7\text{H}_5\text{O}_2^{-1}$ is a conjugate of weak acid)

$$[\text{C}_7\text{H}_5\text{O}_2^{-1}] = \frac{5.96 \times 10^{-3} \text{ mol}}{0.075 \text{ L}} = 0.0794 \text{ M}$$

(ii) The concentration of the H^+ (aq) ion in the solution.

	$[C_7H_5O_2^{-1}]$	+	HOH	\rightleftharpoons	$[HC_7H_5O_2]$	+	$[OH^{-1}]$
I	0.0794 M		-		0.567 M		~ 0
C	- x		-		+ x		+ x
E	0.0794 - x		-		0.567 - x		$[OH^{-1}]$

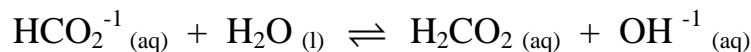
$$K_b = \frac{K_w}{K_a} = \frac{1.00 \times 10^{-14}}{6.40 \times 10^{-5}} = 1.56 \times 10^{-10}$$

$$K_b = \frac{[HC_7H_5O_2][OH^{-1}]}{[C_7H_5O_2^{-1}]} = \frac{(0.567 + x)[OH^{-1}]}{(0.0794 - x)} = \frac{(0.567)[OH^{-1}]}{(0.0794)} = 1.56 \times 10^{-10}$$

$$[OH^{-1}] = \frac{(1.56 \times 10^{-10})(0.0794)}{(0.567)} = 2.19 \times 10^{-11}$$

$$[H^{+1}] = \frac{K_w}{[OH^{-1}]} = \frac{1.00 \times 10^{-14}}{2.19 \times 10^{-11}} = 4.57 \times 10^{-4}$$

The methanoate ion, HCO_2^{-1} (aq), reacts with water to form methanoic acid and hydroxide, as shown in the following equation.



(d) Given that $[OH^{-1}]$ is $4.18 \times 10^{-6} M$ in a $0.309 M$ solution of sodium methanoate, calculate each of the following.

(i) The value of K_b for the methanoate ion, HCO_2^{-1} (aq).



(Na^{+1} is a conjugate of a strong base, HCO_2^{-1} is a conjugate of weak acid)

	$[HCO_2^{-1}]$	+	HOH	\rightleftharpoons	$[H_2CO_2]$	+	$[OH^{-1}]$
I	0.309 M		-		0		0
C	- x		-		+ x = 4.18×10^{-6}		+ x = 4.18×10^{-6}
E	$0.309 - 4.18 \times 10^{-6}$		-		4.18×10^{-6}		4.18×10^{-6}

$$K_b = \frac{[H_2CO_2][OH^{-1}]}{[HCO_2^{-1}]} = \frac{(4.18 \times 10^{-6})^2}{(0.309 - 4.18 \times 10^{-6})} = 5.65 \times 10^{-11}$$

(ii) The value of K_a for methanoic acid, H_2CO_2 (aq)

$$K_a = \frac{K_w}{K_b} = \frac{1.00 \times 10^{-14}}{5.65 \times 10^{-11}} = 1.77 \times 10^{-4}$$

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

$K_a = 6.40 \times 10^{-5}$ = benzoic acid (see given K_a at the beginning of the question)

$K_a = 1.77 \times 10^{-4}$ = methanoic acid (calculated value from above)

Methanoic acid. For acids, the larger the K_a , the greater the strength (dissociation).