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[TP] Which of the following is true about the a weak base?

13% 1. $K_b \ll 1$
 13% 2. $K_b \approx 1$
 13% 3. $K_b \gg 1$
 13% 4. $K_b \gg K_w$
 13% 5. $K_b \ll K_w$
 13% 6. 1 and 4
 13% 7. 1 and 5
 13% 8. 1, 4, and 5

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Lecture 18 CH102 A2 (MWF 11:15 am)
 Wednesday, March 6, 2019

- Complete: $[H_3O^+]$ when “too little” base added

Next: $[H_3O^+]$ when “just enough” base added; $[H_3O^+]$ when “too much” base added; Practice: Too little, just enough, too much?; How much strong acid remains unreacted?; Recipe for calculating combinations of acids and bases; $[H_3O^+]$ when different amounts of “not enough” base added

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Step 2: $[H_3O^+]$ when “too little” base added

After “too little” base is added, there are present both some acid, HA, and its conjugate base, A^- .

This means there are two possible ways the system can come to equilibrium,

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Step 2: $[H_3O^+]$ when “too little” base added

After “too little” base is added, there are present both some acid, HA, and its conjugate base, A^- .

This means there are two possible ways the system can come to equilibrium,

$$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq), K = K_a$$

$$A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH^-(aq), K = K_b = K_w/K_a$$

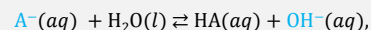
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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

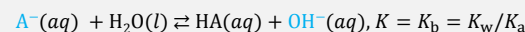
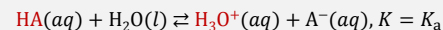
Show why the equilibrium constant for

is $K = K_b = K_w/K_a$ 

9

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base addedAfter “too little” base is added, there are present both some acid, HA, and its conjugate base, A^- .This means there are **two possible ways the system can come to equilibrium**,One way will result in an **acidic solution**, and the other will result in a **basic solution**.

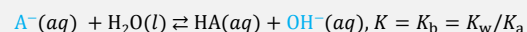
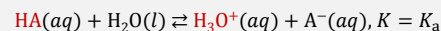
Which one to use?



10

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base addedAfter “too little” base is added, there are present both some acid, HA, and its conjugate base, A^- .This means there are **two possible ways the system can come to equilibrium**,One way will result in an **acidic solution**, and the other will result in a **basic solution**.Use the equilibrium that has **the larger K** !

11

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base addedUse the equilibrium that has **the larger K** !

$$\text{Say } K_a = 1.0 \times 10^{-5} \gg K_b = K_w/K_a = \frac{10^{-14}}{1.0 \times 10^{-5}} = 1.0 \times 10^{-9}$$

Then use ...



12

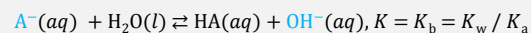
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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base addedUse the equilibrium that has the larger K !

Say $K_a = 1.0 \times 10^{-9} \ll K_b = K_w / K_a = \frac{10^{-14}}{1.0 \times 10^{-9}} = 1.0 \times 10^{-5}$

Then use ...



13

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

Step 1 results:

$$\text{HA} =$$

$$\text{A}^- =$$

$$\text{OH}^- =$$



16

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

Step 1 results:

$$\text{HA} = c_a V_a - c_b V_b = 0.020 \text{ mol}$$

$$\text{A}^- = c_b V_b = 0.020 \text{ mol}$$

$$\text{OH}^- = 0 \text{ (“too little” base added)}$$



17

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

In step 2, we need molarity, so here are step 1 results converted to concentrations:

$$[\text{HA}] = \frac{c_a V_a - c_b V_b}{V_a + V_b} = \frac{0.020 \text{ mol}}{0.200 \text{ L}} = 0.10 \text{ M}$$

$$[\text{A}^-] = \frac{c_b V_b}{V_a + V_b} = \frac{0.020 \text{ mol}}{0.200 \text{ L}} = 0.10 \text{ M}$$

$$[\text{OH}^-] = 0$$



18

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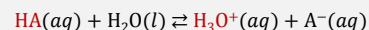
Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

Which equilibrium to use?

$$K_a = 1.0 \times 10^{-5} \gg K_b = K_w / K_a = \frac{10^{-14}}{1.0 \times 10^{-5}} = 1.0 \times 10^{-9}$$

So in this case, when “too little” base has been added, we find $[\text{H}_3\text{O}^+]$ using the ICE table for

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19

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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

	HA(aq)	H ₃ O ⁺ (aq)	A ⁻ (aq)	Q
Initial				
Change				
Equilibrium				
Approximate				

 $[\text{H}_3\text{O}^+] = ?$ BOSTON
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Step 2: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 100.$ mL of $c_a = 0.40$ M of HA, $K_a = 1.0 \times 10^{-5}$.

	HA(aq)	H ₃ O ⁺ (aq)	A ⁻ (aq)	Q
Initial	0.10	10^{-7}	0.10	$10^{-7} < K_a$
Change	$-x$	$+x$	$+x$	
Equilibrium	$0.10 - x$	$10^{-7} + x$	$0.10 + x$	K_a
Approximate	≈ 0.10	$\approx x$	≈ 0.10	K_a

$$[\text{H}_3\text{O}^+] = x = \frac{K_a[\text{HA}]}{[\text{A}^-]} = \frac{1.0 \times 10^{-5} \times 0.10}{0.10} = 1.0 \times 10^{-5}$$

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21

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Try now: $[\text{H}_3\text{O}^+]$ when “too little” base added

$V_b = 100.$ mL of $c_b = 0.20$ M of OH^- is combined with $V_a = 300.$ mL of $c_a = 0.10$ M of HA, $K_a = 1.0 \times 10^{-4}$.

 $[\text{H}_3\text{O}^+] = ?$ BOSTON
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22