

[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: [H3O+] 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,

$$\mathrm{HA}(aq) + \mathrm{H_2O}(l) \rightleftarrows \mathrm{H_3O^+}(aq) + \mathrm{A^-}(aq),\ K = K_\mathrm{a}$$

$$\mathrm{A^-}(aq) + \mathrm{H_2O}(l) \rightleftarrows \mathrm{HA}(aq) + \mathrm{OH^-}(aq),\ K = K_\mathrm{b} = K_\mathrm{w}/K_\mathrm{a}$$

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Step 2: [H_3O^+] when "too little" base added

Show why the equilibrium constant for

$A^-(aq) + H_2O(l) \rightleftarrows HA(aq) + OH^-(aq)$,

is $K = K_b = K_w/K_a$

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Step 2: [H_3O^+] when "too little" base added

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

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

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

One way will result in an acidic solution, and the other will result in a basic solution.

Which one to use?

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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,

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

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

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 !

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Step 2: [H_3O^+] when "too little" base added

Use the equilibrium that has the larger K !

Say $K_a = 1.0 \times 10^{-5} \gg K_b = K_w/K_a = \frac{10^{-14}}{1.0\times10^{-5}} = 1.0 \times 10^{-9}$

Then use …

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

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

Use the equilibrium that has the larger K !

Say $K_a = 1.0 \times 10^{-9} \ll K_b = K_w / K_a = \frac{10^{-14}}{1.0\times10^{-9}} = 1.0 \times 10^{-5}$

Then use ...

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

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Step 2: $[H_3O^+]$ 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:

HA =

A^- =

OH^- =

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Step 2: $[H_3O^+]$ 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:

HA $= c_aV_a - c_bV_b = 0.020$ mol

$A^- = c_bV_b = 0.020$ mol

$OH^- = 0$ ("too little" base added)

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Step 2: $[H_3O^+]$ 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:

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

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

$[OH^-] = 0$

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Step 2: $[H_3O^+]$ 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?

$$K_a = 1.0 \times 10^{-5} \gg K_b = K_w / K_a = \frac{10^{-14}}{1.0\times10^{-5}} = 1.0 \times 10^{-9}$$

So in this case, when "too little" base has been added, we find $[H_3O^+]$ using the ICE table for

$$HA(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + A^-(aq)$$

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Step 2: $[H_3O^+]$ 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, $K_a = 1.0 \times 10^{-5}$.

	$HA(aq)$	$H_3O^+(aq)$	$A^-(aq)$	Q
Initial				
Change				
Equilibrium				
Approximate				

$[H_3O^+] = ?$

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Step 2: $[H_3O^+]$ 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, $K_a = 1.0 \times 10^{-5}$.

	$HA(aq)$	$H_3O^+(aq)$	$A^-(aq)$	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

$$[H_3O^+] = x = \frac{K_a[HA]}{[A^-]} = \frac{1.0\times10^{-5}\times0.10}{0.10} = 1.0 \times 10^{-5}$$

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Try now: $[H_3O^+]$ 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, $K_a = 1.0 \times 10^{-4}$.

$[H_3O^+] = ?$

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