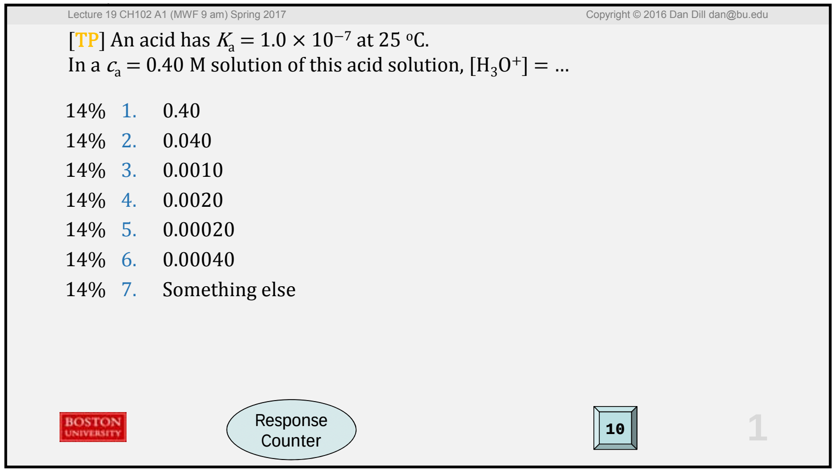
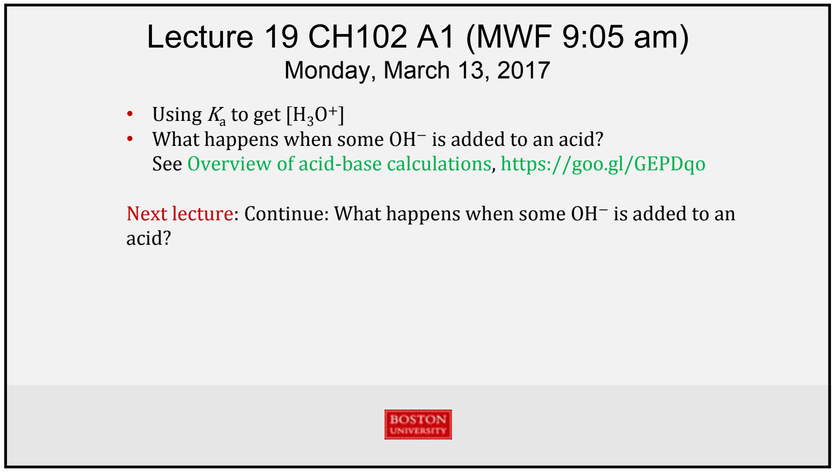


[TP] An acid has $K_a = 1.0 \times 10^{-7}$ at 25 °C.
In a $c_a = 0.40$ M solution of this acid solution, $[H_3O^+]$ = …

14%	1.	0.40
14%	2.	0.040
14%	3.	0.0010
14%	4.	0.0020
14%	5.	0.00020
14%	6.	0.00040
14%	7.	Something else

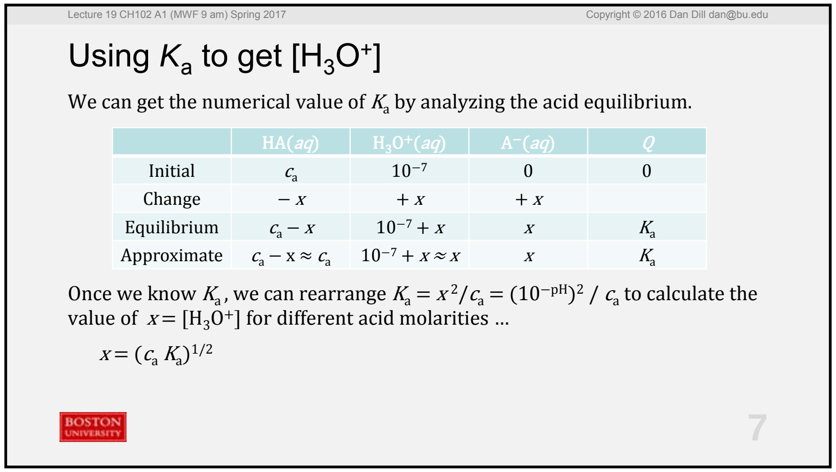


Lecture 19 CH102 A1 (MWF 9:05 am)

Monday, March 13, 2017

- Using K_a to get $[H_3O^+]$
- What happens when some OH^- is added to an acid?
  See Overview of acid-base calculations, https://goo.gl/GEPDqo

Next lecture: Continue: What happens when some OH^- is added to an acid?



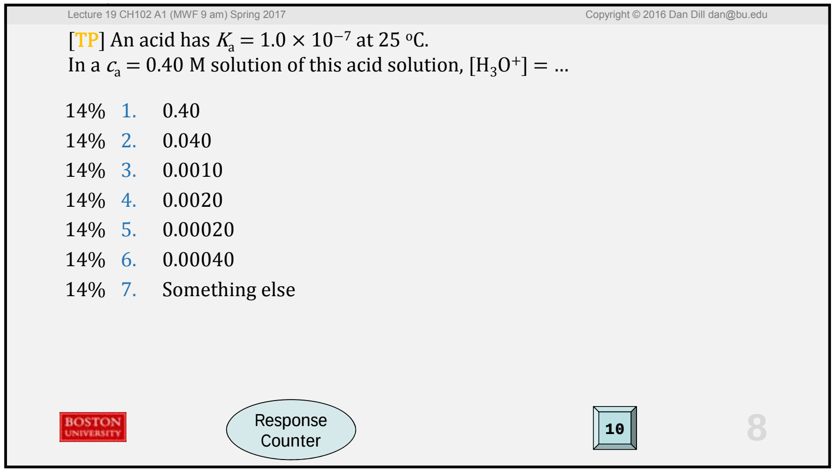
Using K_a to get $[H_3O^+]$

We can get the numerical value of K_a by analyzing the acid equilibrium.

	$HA(aq)$	$H_3O^+(aq)$	$A^-(aq)$	Q
Initial	c_a	10^{-7}	0	0
Change	$-x$	$+x$	$+x$	
Equilibrium	$c_a - x$	$10^{-7} + x$	x	K_a
Approximate	$c_a - x \approx c_a$	$10^{-7} + x \approx x$	x	K_a

Once we know K_a, we can rearrange $K_a = x^2/c_a = (10^{-pH})^2 / c_a$ to calculate the value of $x = [H_3O^+]$ for different acid molarities …

$$x = (c_a K_a)^{1/2}$$



[TP] An acid has $K_a = 1.0 \times 10^{-7}$ at 25 °C.
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Equilibrium	$c_a - x$	$10^{-7} + x$	x	K_a
Approximate	$c_a - x \approx c_a$	$10^{-7} + x \approx x$	x	K_a

For example, if $c_a = 0.40$ and $K_a = 1.0 \times 10^{-7}$, then …

$$x = (c_a K_a)^{1/2} = (4 \times 10^{-8})^{1/2} = 2.0 \times 10^{-4}$$

What happens when some OH^- is added to an acid?

[Quiz] An acid has $K_a = 1.0 \times 10^{-7}$ at 25 °C. The hydronium concentration of a $c_a = 0.40$ M solution of this acid solution is $[H_3O^+] = 2.0 \times 10^{-4}$. After adding some 0.20 M OH^-, $[H_3O^+]$ must be …

20% 1. smaller than 2.0×10^{-4}
20% 2. less than 1.0×10^{-7} (basic)
20% 3. equal to 1.0×10^{-7} (neutral)
20% 4. greater than 1.0×10^{-7} (acidic)
20% 5. More information needed

Add “some” OH^- to an acid

When some OH^- solution is added to an HA solution, some HA will be converted to conjugate base A^-.

Therefore, [HA] will be less, the equilibrium

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

will shift toward reactants, and so, by Le Chatelier, $[H_3O^+]$ must decrease.

Add “some” OH^- to an acid

When some OH^- solution is added to an HA solution, some HA will be converted to conjugate base A^-, and so $[H_3O^+]$ must decrease.

There are two steps to find the new value of $[H_3O^+]$.

Step 1: Assume the acid HA and the added OH^- react 100%, as a limiting reagent problem.

Step 2: Use the results of step 1 to re-solve the equilibrium.

To begin, let’s learn about the results of step 1.

Step 1: HA + OH^- limiting reagent reaction

There are three possible results of step 1.

“Too little” base: If fewer moles of OH^- are added than the moles of acid present, then only some of the acid HA will be converted to conjugate base A^-.

Step 1: HA + OH^- limiting reagent reaction

There are three possible results of step 1.

“Just enough” base: If the moles of OH^- added is the same as the moles of acid present, then all of the acid HA will be converted to conjugate base A^-.

Step 1: HA + OH^- limiting reagent reaction

There are three possible results of step 1.

“Too much” base: If the moles of OH^- added is more than the moles of acid present, then all of the acid HA will be converted to conjugate base A^- and unused OH^- will be left over.

[TP] V_b = 100. mL of c_b = 0.40 M of OH^- is combined with V_a = 100. mL of c_a = 0.40 M of HA. The result is …

25% 1. “too little” OH^-
25% 2. “just enough” OH^-
25% 3. “too much” OH^-
25% 4. Further information needed

[Quiz] 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. The result is …

25% 1. “too little” OH^-
25% 2. “just enough” OH^-
25% 3. “too much” OH^-
25% 4. Further information needed

[TP] V_b = 200. mL of c_b = 0.30 M of OH^- is combined with V_a = 200. mL of c_a = 0.20 M of HA. The result is …

25% 1. “too little” OH^-
25% 2. “just enough” OH^-
25% 3. “too much” OH^-
25% 4. Further information needed

Add “some” OH^- to an acid

There are two steps to find the new value of $[H_3O^+]$.

Step 1: Assume the acid HA and the added OH^- react 100%, as a limiting reagent problem (ignoring equilibrium!).

Step 2: Based on whether we have added “too little”, “just enough”, or “too much” OH^-, we use the results of step 1 to calculate the equilibrium concentration of $[H_3O^+]$.

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

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

After “too little” base is added there is 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 will result in an acidic solution, and the other will result in a basic solution.

Which one to use?

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

After “too little” base is added there is present both some acid, HA, and its conjugate base, A^-. This means there are two possible ways the system can come to equilibrium,

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

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

Use the one that has the larger K!

Say $K_a = 1.0 \times 10^{-5} \gg K_b = K_w / K_a = 10^{-14} / (1.0 \times 10^{-5}) = 1.0 \times 10^{-9}$, use ...

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

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

After “too little” base is added there is 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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Use the one that has the larger K!

Say $K_a = 1.0 \times 10^{-9} \ll K_b = K_w / K_a = 10^{-14} / (1.0 \times 10^{-9}) = 1.0 \times 10^{-5}$, use ...

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