

Acids and Bases review

Friday, March 17, 2023 10:03 AM

Strong acids

SO	I	Brought	NO	Clean	CLOTHES
H <sub>2</sub> SO <sub>4</sub>	HCl	HBr	HNO <sub>3</sub>	HCl	HClO <sub>4</sub> & HClO <sub>3</sub>

Strong bases

- group 1 hydroxides
- alkaline earth metals
- hydroxides
- group 2 oxides
- examples: LiOH, NaOH, KOH, Ca(OH)<sub>2</sub>, Sr(OH)<sub>2</sub>, Ba(OH)<sub>2</sub>

Strong acids and bases dissociate completely

.1M NaOH → .1M Na<sup>+</sup> .1M OH<sup>-</sup>  
pOH = -log[OH<sup>-</sup>]  
pOH = -log(.1M) = 1  
pH = 14 - pOH  
pH = 13  
higher pH = more basic solution  
lower pH = more acidic solution

Using K<sub>a</sub> and K<sub>b</sub> for weak acids and bases

<sup>↑ basicity constant</sup>  
K<sub>a</sub> =  $\frac{[H^+][A^-]}{[HA]}$  use K<sub>a</sub> for weak acids  
K<sub>b</sub> =  $\frac{[BH^+][OH^-]}{[B]}$  use K<sub>b</sub> for weak bases  
if given K<sub>a</sub>, can find K<sub>b</sub>  
K<sub>a</sub> · K<sub>b</sub> = K<sub>w</sub> = 1.0 × 10<sup>-14</sup>  
pK<sub>a</sub> + pK<sub>b</sub> = pK<sub>w</sub> = -log 10<sup>-14</sup> = -(-14) = 14 at 25°C

Solving pH of weak acid → doesn't dissociate completely, use ICE table

K<sub>a</sub> of a monoprotic acid is 2.5 × 10<sup>-6</sup> what is the pH of a .30M solution?  
<sup>↑ releases 1 H<sup>+</sup></sup>

- write out hypothetical equation  
HA (aq) ⇌ H<sub>3</sub>O<sup>+</sup> (aq) + A<sup>-</sup> (aq)
- create an ICE table  

	HA	H <sub>3</sub> O <sup>+</sup>	A <sup>-</sup>
I	.30M	0	0
C	-x	+x	+x
E	.30-x	x	x
- set up K<sub>a</sub> to find x  
K<sub>a</sub> =  $\frac{[H_3O^+][A^-]}{[HA]}$   
2.5 × 10<sup>-6</sup> =  $\frac{(x)(x)}{(.30-x)}$  \*can we estimate? yes! K<sub>a</sub> < 10<sup>-3</sup>  
(.30-x) 2.5 × 10<sup>-6</sup> = x<sup>2</sup>  
7.5 × 10<sup>-7</sup> - 2.5 × 10<sup>-6</sup> x = x<sup>2</sup>  
x<sup>2</sup> + 2.5 × 10<sup>-6</sup> x - 7.5 × 10<sup>-7</sup>  
4. use quadratic formula  
$$\frac{-2.5 \times 10^{-6} \pm \sqrt{(2.5 \times 10^{-6})^2 - 4(1)(-7.5 \times 10^{-7})}}{2}$$
  
x = 8.65 × 10<sup>-4</sup>  
5. find concentration of [H<sub>3</sub>O<sup>+</sup>]  
[H<sub>3</sub>O<sup>+</sup>] = x = 8.6 × 10<sup>-4</sup>  
6. solve for pH  
pH = -log [H<sub>3</sub>O<sup>+</sup>] = -log (8.6 × 10<sup>-4</sup>) = 3.1

If we had same amount of strong acid and weak acid, the pH of the weak acid is higher.

weak acid doesn't dissociate completely, not as much [H<sup>+</sup>], higher pH, less acidic

conjugates

- HCl → Cl<sup>-</sup>
- acid conjugate base
- strong acid weak conjugate base
- strong acids dissociate completely, the conjugate base would not want to be protonated again → weak base

K<sub>a</sub> values and strength of acids

- higher K<sub>a</sub> → more strong acid
- K<sub>a</sub> =  $\frac{[A^-][H^+]}{[HA]}$  <sup>products</sup> / <sup>reactants</sup> ← larger number on top ⇒ larger K<sub>a</sub> value
- HA → H<sup>+</sup> + A<sup>-</sup>
- pK<sub>a</sub> = -log (K<sub>a</sub>)
- inverse relationship
- lower pK<sub>a</sub> (pH) ⇒ more strong acid

K<sub>b</sub> values and strength of bases

- higher K<sub>b</sub> → more strong base
- K<sub>b</sub> =  $\frac{[HB]}{[B^-][H^+]}$
- H<sup>+</sup> + B<sup>-</sup> → HB
- pK<sub>b</sub> = -log (K<sub>b</sub>)
- lower pK<sub>b</sub> ⇒ more strong base

Percent ionization

percent ionization =  $\frac{[H_3O^+]}{[HA]}$  × 100%

polyprotic acid

an acid that can give off 2 H<sup>+</sup>

example BE.1

find the pH of .15M H<sub>2</sub>SO<sub>4</sub> <sup>↑ \*this is a strong acid, so not K<sub>a</sub></sup>  
H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ⇌ HSO<sub>4</sub><sup>-</sup> + H<sub>3</sub>O<sup>+</sup>  
<sup>↑ weak acid</sup>  
HSO<sub>4</sub><sup>-</sup> + H<sub>2</sub>O ⇌ SO<sub>4</sub><sup>2-</sup> + H<sub>3</sub>O<sup>+</sup> K<sub>a</sub> = 1.2 × 10<sup>-2</sup>

- set up ICE table  

	H <sub>2</sub> SO <sub>4</sub>	HSO <sub>4</sub> <sup>-</sup>	H <sub>3</sub> O <sup>+</sup>
I	.15	0	.15 ← from dissociation of strong acid
C	-x	+x	+x
E	.15-x	x	.15+x
- set up K<sub>a</sub>  
K<sub>a</sub> =  $\frac{[SO_4^{2-}][H_3O^+]}{[HSO_4^-]}$  <sup>↑ can we estimate? no!</sup>  
1.2 × 10<sup>-2</sup> =  $\frac{x(.15+x)}{(.15-x)}$
- solve for x  
1.2 × 10<sup>-2</sup> =  $\frac{x(.15+x)}{.15-x}$   
1.2 × 10<sup>-2</sup> =  $\frac{.15x + x^2}{.15 - x}$   
.15 - x (1.2 × 10<sup>-2</sup>) = .15x + x<sup>2</sup>  
.0018 - 1.2 × 10<sup>-2</sup> x = .15x + x<sup>2</sup>  
x<sup>2</sup> + .162x - .0018  
$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
  
$$\frac{-.162 \pm \sqrt{(.162)^2 - 4(1)(-.0018)}}{2}$$
  
$$\frac{-.162 \pm \sqrt{.0334}}{2}$$
 ← add since we started w a neg  
$$\frac{-.162 + .183}{2} = .0105$$
- calculate pH  
\* pH includes the H<sup>+</sup> ions from the dissociated strong acid  
[H<sub>3</sub>O<sup>+</sup>] = .15M + x = .15 + .0105 = .1605  
pH = -log [H<sub>3</sub>O<sup>+</sup>] = -log (.1605) = .79 ← pretty acidic since we had a strong acid

Salts weak CB

- weak CA → NaCl ← strong acid HCl
- strong base NaOH
- if both are weak, neutral salt
- ex: KCl, LiNO<sub>3</sub>
- KOH strong base strong acid HCl <sup>↑ super</sup>
- weak conjugate acid weak conjugate base <sup>↑ super</sup>
- \* since they're super weak, wouldn't react w water to make significant H<sub>3</sub>O<sup>+</sup> or OH<sup>-</sup>

ACIDIC

stronger conjugate acid, really weak conjugate base

ex: NH<sub>4</sub>Br <sup>↑ strong acid HBr</sup>  
NH<sub>3</sub> weak base <sup>↑</sup>  
strong conjugate acid ⇒ solution is acidic NH<sub>4</sub><sup>+</sup> + H<sub>2</sub>O ⇌ NH<sub>3</sub> + H<sub>3</sub>O<sup>+</sup> <sup>↑ proton in solution = acidic</sup>

BASIC

stronger conjugate base really weak conjugate acid

ex: K<sub>2</sub>CO<sub>3</sub>, Na<sub>2</sub>S <sup>↑</sup>  
KOH strong base weak acid HCO<sub>3</sub><sup>-</sup> <sup>↑</sup>  
strong conjugate base ⇒ solution is basic CO<sub>3</sub><sup>2-</sup> + H<sub>2</sub>O ⇌ HCO<sub>3</sub><sup>-</sup> + OH<sup>-</sup> <sup>↑ makes solution basic</sup>

pH of a salt solution

<sup>↑ K<sub>b</sub> given for NH<sub>3</sub></sup>  
K<sub>b</sub> = 1.8 × 10<sup>-5</sup> NH<sub>3</sub> what is pH of .15M NH<sub>4</sub>Cl <sup>↑ Cl<sup>-</sup> dissociates</sup>

- write out ICE table and equation  
→ NH<sub>4</sub><sup>+</sup> (aq) + H<sub>2</sub>O (l) ⇌ H<sub>3</sub>O<sup>+</sup> (aq) + NH<sub>3</sub> (aq)  

I	.15M	0	0
C	-x	+x	+x
E	.15M-x	x	x

<sup>NH<sub>4</sub><sup>+</sup></sup>
- do we have an acid or base? H<sub>3</sub>O<sup>+</sup> is a product so... acid  
we're given K<sub>b</sub> → find K<sub>a</sub> for the acid.  
K<sub>a</sub> =  $\frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.56 \times 10^{-10}$
- set up K<sub>a</sub>  
K<sub>a</sub> =  $\frac{[H_3O^+][NH_3]}{[NH_4^+]}$  =  $\frac{x^2}{.15M-x}$  \*can estimate K<sub>a</sub> < 10<sup>-3</sup>  
5.56 × 10<sup>-10</sup> ≈  $\frac{x^2}{.15M}$   
9.13 × 10<sup>-6</sup> = x
- find the pH  
pH = -log (H<sub>3</sub>O<sup>+</sup>) = -log (9.13 × 10<sup>-6</sup>) = 5.04  
<sup>check if 10<sup>-6</sup> correlates to roughly a 6 pH</sup>