General Chemistry II

RR # 8 Answer Key
Summer 2022

1. A student prepares a 0.45 M solution of a monoprotic weak acid and determines the pH to be 3.68. What is the K_a of the weak acid?

① $pH = -\log[H_3O^+]$ so $[H_3O^+] = 10^{-3.68} = 2.09e{-4}\ M$

② $HA_{(aq)} + H_2O_{(l)} \rightleftharpoons A^- + H_3O^+$

	HA	H_2O	A^-	H_3O^+
I	.45 M	–	0	
C	−x	–	+x	+x
E	.45−x	–	x	x

x = 2.09e−4 so [HA] = .45 − 2.09e−4
[HA] = .4498 M

③ $K_a = \frac{[A^-]_{eq}[H_3O^+]_{eq}}{[HA]_{eq}} = \frac{(2.09e{-4}\ M)^2}{.4498\ M} =$ Ka = 9.7e−8

2. In the lab you make a solution that is 0.0048 M HNO_2 and 0.00056 M $LiNO_2$. What is the pH of your solution? $K_a = 4.5 \times 10^{-4}$

Li^+ NO_2^-

$LiNO_2$ in H_2O, so initial $[NO_2^-] = [LiNO_2] = .00056\ M$. HNO_2 is a weak acid and will ionize in H_2O.

Acid/B: equation: $HNO_{2(aq)} + H_2O_{(l)} \rightleftharpoons NO_{2(aq)}^- + H_3O^+_{aq}$

	HNO_2	H_2O	NO_2^-	H_3O^+
I	.0048	–	.00056	0
C	−x	–	+x	+x
E	.0048−x	–	.00056+x	x

$K_a = \frac{[NO_2^-][H_3O^+]}{[HNO_2]} = \frac{(.00056+x)(x)}{.0048-x} = 4.5e{-4}$

$x^2 + .00056x = 2.16e{-6} - 4.5e{-4}x$

$x^2 + .00101x - 2.16e{-6} = 0$

$x = [H_3O^+] = .001049\ M$

$pH = -\log[.001049] = 2.98 = pH$

3. Lactate, $CH_3CH(OH)CO_2^-$, is constantly produced from pyruvate during normal metabolism. When the citric acid cycle backs up due to insufficient oxygen supply, lactate builds up in your exercising muscles and you feel that painful burning sensation. Lactate has $K_b = 7.24 \times 10^{-11}$ at 25 ℃.

a. Write the reaction equation described by this K_b.

$CH_3CH(OH)CO_2^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH(OH)CO_2H_{(aq)} + OH^-_{(aq)}$

b. What is the K_a of lactic acid at 25 ℃?

$K_w = K_a \cdot K_b$

$1.00 \times 10^{-14} = K_a \cdot 7.24e{-11}$

$K_a = 1.38e{-4}$

c. If a solution is initially 0.210 M lactic acid, what is the pH at 25 ℃?

You can assume that the K_a is considered very small.

	$[CH_3CH(OH)CO_2H]$	$[H_2O]$	$[CH_3CH(OH)CO_2^-]$	H_3O^+
I	.210 M	—	0	0
C	− X	—	+ X	+X
E	.210−X ← we are told Ka is small so we can ignore	—	X	X

$K_a = \frac{x^2}{.210}$

$1.38e{-4} = \frac{x^2}{.210}$

$X = 5.39e{-3}M = [H_3O^+]$

pH = −log 5.39e−3 = 2.27

4. Determine whether an aqueous solution of each of the following salts will be acidic, basic, or neutral. You may have to look up and compare K_as and K_bs for a few of these.

$KClO_4$ neutral	NaCN basic	NH_4CH_3COO neutral
NaBr neutral	NH_4ClO basic	K_2CO_3 basic
$CaBr_2$ neutral	NaF basic	$LiClO_4$ neutral
NH_4Br acidic	$NaHCO_3$ basic	$Al_2(SO_4)_3$ acidic

5. A 0.150 M solution of morphine ($C_{17}H_{19}NO_3$) has a pH of 10.5 at 25ºC. What is morphine's?

$pH = 10.5 \quad pOH = 14 - 10.5 = 3.5$

$[OH^-] = 10^{-3.5} = 3.6e{-4}\ M$

Now set up an equation for hydrolysis of morphine:

$$C_{17}H_{19}NO_{3(aq)} + H_2O(l) \rightleftharpoons C_{17}H_{19}NO_3H^+_{(aq)} + OH^-_{(aq)}$$

	$C_{17}H_{19}NO_{3(aq)}$	$H_2O(l)$	$C_{17}H_{19}NO_3H^+$	OH^-
I	.150	—	0	0
C	-X	—	+X	+X
E	.150-X	—	X	X

We know [OH] from pOH so $X = 3.16e-4\,M$

$$K_b = \frac{[C_{17}H_{19}NO_3H^+][OH^-]}{[C_{17}H_{19}NO_3]} = \frac{X^2}{.150 - X} =$$

$$\frac{(3.16e-4\,M)^2}{.150 - 3.16e-4} = 6.67e-7$$