Today ♥ Feb 14 ♥: Review sections 1-10, 12 Sections 16.11 and 16.13

Friday: Sections 15.14 and 15.15

Sunday: Problem club with Ali

Monday: catch up, review

What is the conc of all species and the pH of a 0.25M (HNO_2 (weak acid)) soln?

$K_a^{HNO_2} = 4.5 \times 10^{-4}$

M	HNO_2	+ H_2O ⟷	H_3O^+	+	NO_2^-
I	0.25		0		0
C	$-x$		$+x$		$+x$
E	$0.25-x \approx .24$		$x = 0.0106 \approx x$		

$K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]} = 4.5\times10^{-4}$

$K_a = \frac{x^2}{0.25} = 4.5\times10^{-4}$

$K_a = \frac{x^2}{0.25} = 4.5\times10^{-4}$

400 Rule: $\frac{0.25}{4.5\times10^{-4}} = 556 > 400$ ✓ (x is small)

$x^2 = .0001125$

$x = 0.0106$

$[H_3O^+] = 0.0106M$

$pH = -\log(0.0106M) = \boxed{1.97}$

What is the conc. of all species and the pH of 0.30M NO_2^- soln?

M	NO_2^-	+ H_2O ⟷	OH^-	+	HNO_2
I	0.30		0		0
C	$-x$		x		x
E	$0.30-x$		$x =$ $2.58\times10^{-6}M$		$x =$ $2.58\times10^{-6}M$

$K_b = \frac{[OH^-][HNO_2]}{[NO_2^-]}$

$K_w = K_a * K_b$

$1\times10^{-14} = 4.5\times10^{-4} * K_b$

$\frac{1\times10^{-14}}{4.5\times10^{-4}} = K_b$

$K_b = 2.2\times10^{-11}$

-very small so passes the 400 rule

$K_b = \frac{[OH^-][HNO_2]}{[NO_2^-]} = 2.2\times10^{-11}$

$K_b = \frac{x^2}{0.30} = 2.2\times10^{-11}$

$x^2 = 6.67\times10^{-12}$

$x = 2.58\times10^{-6}$

$[OH^-] = 2.58\times10^{-6}M$

$pOH = -\log(2.58\times10^{-6})$

$pOH = 5.59$

$pH = 14 - 5.59$

$\boxed{pH = 8.41}$

strongest weak acid ↑ ACID STRENGTH INCR

$K_a^{HA} \times K_b^{A^-} = K_w = 1 \times 10^{-14}$

Wa	cwb	K_a^{HA}	pKa	pH of 0.25 M sol'n HA	K_b	pKb	
HNO_2	NO_2^-	4.5×10^{-4}	3.35	1.97	2.2×10^{-11}	10.66	base strength increases ↓
$HC_7H_5O_2$	$C_7H_5O_2^-$	6.5×10^{-5}	4.19	2.39	1.54×10^{-10}	9.81	
$HC_2H_3O_2$	$C_2H_3O_2^-$	1.8×10^{-5}	4.74	2.67	5.56×10^{-10}	9.25	
$HOCl$	OCl^-	3.6×10^{-8}	7.46	4.03	2.86×10^{-7}	6.54	
NH_4^+	NH_3	5.6×10^{-10}	9.25	4.93	1.79×10^{-5}	4.75	
HCN	CN^-	4.9×10^{-10}	9.31	4.96	2.04×10^{-5}	4.69	

$pK_a = -\log K_a \quad K_a = 10^{-pK_a}$

small pKa = stronger acid

Polyprotic acids

H_2SO_4 K_{a1}

K_{a2}

H_2SO_3 $K_{a1}^{H_2SO_3} = 1.5 \times 10^{-2}$ $\quad H_2SO_3 + H_2O \rightleftharpoons H_3O^+ + HSO_3^-$

$K_{a2}^{HSO_3^-} = 6.3 \times 10^{-8}$ $\quad HSO_3^- + H_2O \rightleftharpoons H_3O^+ + SO_3^{2-}$

- What is the pH of a 0.10 M $NaHSO_3$ sol'n? (Na^+, HSO_3^-)

M	HSO_3^-	+ H_2O ⇌	H_3O^+	+	SO_3^{2-}
I	.10 M		0		0
C	$-x$		$+x$		$+x$
E	$.10-x$		x		x

$K_{a2}^{HSO_3^-} = 6.3 \times 10^{-8} = \frac{[H_3O^+][SO_3^{2-}]}{[HSO_3^-]}$

$6.3 \times 10^{-8} = \frac{x^2}{.10 - x}$

400 Rule: $\frac{.10}{6.3 \times 10^{-8}} = 1.59 \times 10^6$ ✓

$6.3 \times 10^{-8} = \frac{x^2}{.10}$

$6.3 \times 10^{-9} = x^2$

$x = 7.94 \times 10^{-5}$

$[H_3O^+] = 7.9 \times 10^{-5} M$

$pH = -\log(7.9 \times 10^{-5} M)$

$pH = 4.10$

What is the pH of a 0.10 M H_2SO_3 solution?

M	H_2SO_3	+ H_2O ⇌	H_3O^+	+ HSO_3^-	$K_a = 1.5\times10^{-2}$
I	0.10		0	0	400 rule: $\frac{.10}{1.5\times10^{-2}}$ ✗
C	−x		+x	+x	
E	0.10 − x		x	x	$1.5\times10^{-2} = \frac{x^2}{0.10-x}$
	.0681 M		.0319 M	.0319 M	$(1.5\times10^{-2})(0.10-x) = x^2$

$[H_3O^+] = .0319M$

$pH = -\log(.0319M)$

$pH = 1.50$ (estimate of step 1)

$x^2 = 0.0015 - 0.015x$

$0 = x^2 + 0.015x - 0.0015$

$x = 3.19\times10^{-2}$ ~~-4.69×10^{-2}~~ (not negative)

check: $K_a = \frac{(3.19\times10^{-2})^2}{.10 - 3.19\times10^{-2}} = 1.5\times10^{-2}$ ✓

M	HSO_3^-	+ H_2O ⇌	H_3O^+	+ SO_3^{2-}	$K_a = 6.3\times10^{-8}$
I	.0319 M		.0319	0	400 rule: $\frac{.0319}{6.3\times10^{-8}} = 5.06\times10^5$ ✓ passes
C	−y		+y	+y	
E	.0319 − y		.0319 + y	y	$6.3\times10^{-8} = \frac{[H_3O^+][SO_3^{2-}]}{[HSO_3^-]}$
	.0319 M		.0319 M	6.3×10^{-8} M	$6.3\times10^{-8} = \frac{(.0319+y)(y)}{.0319-y}$

concentration of H_3O^+ did not change so pH is the same (pH = 1.50)

$y = 6.3\times10^{-8}$

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wa	wb
H_3PO_4	$H_2PO_4^-$
$H_2PO_4^-$	HPO_4^{2-}
HPO_4^{2-}	PO_4^{3-}

H_3PO_4 $K_{a_1} = 7.5\times10^{-3}$ $H_3PO_4 + H_2O \rightleftharpoons H_3O^+ + H_2PO_4^-$

$H_2PO_4^-$ $K_{a_2} = 6.2\times10^{-8}$ $H_2PO_4^- + H_2O \rightleftharpoons H_3O^+ + HPO_4^{2-}$

HPO_4^{2-} $K_{a_3} = 4.8\times10^{-13}$ $HPO_4^{2-} + H_2O \rightleftharpoons H_3O^+ + PO_4^{3-}$

Is $H_2PO_4^-$ a better weak acid or weak base?

Try it as a weak acid:

$H_2PO_4^- + H_2O \rightleftharpoons H_3O^+ + HPO_4^{2-}$ $K_a = 6.2\times10^{-8}$ ← Compare

try it as a weak base:

$H_2PO_4^- + H_2O \rightleftharpoons OH^- + H_3PO_4$ $\frac{K_w}{K_a} = K_b = \frac{1\times10^{-14}}{7.5\times10^{-3}} = 1.33\times10^{-12}$

- K_a is bigger so it is a better weak acid