Acid-base problems

1) pH of a soln of a weak acid
2) pH/pOH of a soln of a weak base
3) pH of a soln of a conjugate of a weak base
4) pH/OH of a soln of a conjugate of a weak acid

Problem 1: pH of a soln of a weak acid

Assume 0.1M

Dissociation of the acid

$$HOCl(aq) \rightleftharpoons H^+(aq) + OCl^-(aq)$$

$$K_a = \frac{[H^+][OCl^-]}{[HOCl]} = 3.5\times10^{-8}$$

K_a from a table

	HOCl	H^+	OCl^-
I	0.1	0	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	x	x

$$K_a = \frac{x^2}{0.1 - x} = 3.5 \times 10^{-8}$$

If $x \ll 1$, $0.1 - x \approx 0.1$

$$K_a = \frac{x^2}{0.1} = 3.5 \times 10^{-8}$$

$$x^2 = 3.5 \times 10^{-9}$$

$$x = 5.91 \times 10^{-5} = [H^+]$$

$$pH = -\log_{10}[H^+] = -\log_{10} 5.91 \times 10^{-5} = 4.23$$

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pH/pOH of a soln of a weak base

CH_3NH_2

methylamine

$pK_b = 3.36$

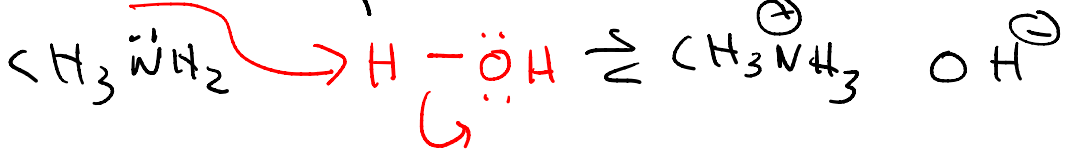
$pH \equiv -\log_{10}[H^+]$

$pOH \equiv -\log_{10}[OH^-]$

$pK_a \equiv -\log_{10} K_a$

$pK_b \equiv -\log_{10} K_b$

What is the pH of 0.1M CH_3NH_2?



$$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = \frac{[HB^+][OH^-]}{[B]}$$

$pK_b \equiv -\log_{10} K_b$ $\quad K_b = 10^{-pK_b}$

$K_b = 10^{-3.36} = 4.37 \times 10^{-4} = \dfrac{[CH_3\overset{+}{N}H_3][OH^-]}{[CH_3NH_2]}$

$CH_3NH_2 + H_2O \rightleftharpoons CH_3\overset{+}{N}H_3 + OH^-$

I	0.1M	0	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	x	x

$K_b = \dfrac{x^2}{0.1-x} = 4.37 \times 10^{-4}$

assume x is small

$\dfrac{x^2}{1} = 4.37 \times 10^{-4}$ $\quad x^2 = 4.37 \times 10^{-5}$

$x = 6.61 \times 10^{-3}$ (smallish compared to 0.1..... should use quadratic.....

$= [OH^-]$

$K_w = [H^+][OH^-]$

$-\log_{10} K_w = -\log_{10}([H^+][OH^-])$

$pK_w = -(\log_{10}[H^+] + \log_{10}[OH^-])$

$pK_w = -\log_{10}[H^+] - \log_{10}[OH^-] = pH + pOH$

Assume 25°C → $K_w = 1.0 \times 10^{-14}$

$[H^+] = 1.0 \times 10^{-14} / [OH^-]$

$pH = 14 - pOH$

$[OH^-] = 6.61 \times 10^{-3}$

$pOH = -\log_{10}(6.61 \times 10^{-3}) = 2.18$

$pH = 14 - 2.18 = 11.72$

$pH + pOH = pK_w = 14$

Problem 3 - pH of soln of conjugate of a weak base.

Given a 0.1 M aqueous solution of NH_4NO_3, calculate the pH of the solution, K_b of $NH_3 = 1.76 \times 10^{-5}$

$NH_4^{\oplus}$ is the conjugate acid of NH_3, and NH_3 is a weak base, therefore NH_4^+ is acidic.

Nitrate can be ignored since is a spectator.

$NH_4^+(aq) \rightleftharpoons H^+_{(aq)} + NH_3(aq)$

$K_a = K_w / K_b = 1.0\times10^{-14} / K_b = 1.0\times10^{-14} / 1.76\times10^{-5} = 5.71\times10^{-10}$

$K_a \cdot K_b = K_w$

conjugates

$pK_w = pK_a + pK_b$

conjugates

$0.1\ M\ NH_4NO_3 \longrightarrow 0.1\ M\ NH_4^+$

	NH_4^+	H^+	NH_3
I	0.1	0	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	x	x