AP CHEMISTRY

TOPIC 7: ACIDS & BASES, PART C

Day 77:

- Bases
- Weak bases

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1. Write the reaction and the corresponding K_b equilibrium expression for each of the following substances acting as bases in water.

   a) NH_3 $\quad$ $NH_{3\,(aq)} + H_2O_{(l)} \leftrightarrow NH_4^{+1}{}_{(aq)} + OH^{-1}{}_{(aq)}$, $\dfrac{[NH_4^{+1}][OH^{-1}]}{[NH_3]}$

   b) C_5H_5N $\quad$ $C_5H_5N_{(aq)} + H_2O_{(l)} \leftrightarrow C_5H_5NH^{+1}{}_{(aq)} + OH^{-1}{}_{(aq)}$, $\dfrac{[C_5H_5NH^{+1}][OH^{-1}]}{[C_5H_5N]}$

   c) Aniline, $C_6H_5NH_2$ $\quad$ $C_6H_5NH_{2\,(aq)} + H_2O_{(l)} \leftrightarrow C_6H_5NH_3^{+1}{}_{(aq)} + OH^{-1}{}_{(aq)}$, $\dfrac{[C_6H_5NH_3^{+1}][OH^{-1}]}{[C_6H_5NH_2]}$

2. Calculate the pH of the following substance.

   a) 0.10 *M* NaOH $\quad$ **[OH^{-1}] = 0.10 *M* ; *pOH = - log (0.10) = 1.00, pH = 14 – 1 = 13.00***

   b) 1.0×10^{-10} *M* LiOH $\quad$ **[OH^{-1}] = 1.0×10^{-10} *M* ; *pOH = - log (1.0×10^{-10}) = 10.00, pH = 14 – 10 = 4.00***

   c) 4.0×10^{-5} *M* KOH $\quad$ **[OH^{-1}] = 4.0×10^{-5} *M* ; *pOH = - log (4.0×10^{-5}) = 4.40, pH = 14 – 4.4 = 9.60***

3. Calculate the concentration of an aqueous NaOH solution that has a pH = 10.50.

***pH = 10.50, pOH = 14 – 10.50 = 3.50,* [OH^{-1}] = *antilog (- 3.50)* = 3.16×10^{-4} *M* = [NaOH]**

NaOH is a strong base = 100% dissociation.

4. For the reaction of hydrazine (N_2H_4) in water.

$$H_2NNH_{2\,(aq)} + H_2O_{(l)} \leftrightarrow H_2NNH_3^{+1}{}_{(aq)} + OH^{-1}{}_{(aq)}$$

$K_b = 3.0 \times 10^{-6}$. Calculate the concentration of all the species and the pH of a 2.0 *M* solution of hydrazine in water.

Hydrazine is a WEAK BASE …

	[H_2NNH_2]	+	[H_2O]	$\rightleftharpoons$	[$H_2NNH_3^{+1}$]	+	[OH^{-1}]
I	2.0 *M*		-		0		0
C	- x		-		+ x		+ x
E	2.0 - x		-		x		x

$$K_b = 3.0 \times 10^{-6} = \frac{[H_2NNH_3^{+1}][OH^{-1}]}{[H_2NNH_3]} = \frac{x^2}{2.0 - x} = \frac{x^2}{2.0}$$

$$3.0 \times 10^{-6}\ (2.0) = x^2 \ ; \ x = \sqrt{6.0 \times 10^{-6}} = 2.45 \times 10^{-3}\ M$$

[OH^{-1}] = 2.45×10^{-3}; pOH = - log (2.45×10^{-3}) = 2.61; **pH** = 14 – 2.61 = **11.39**

5. Calculate the pOH for a 2.75 *M* solution of an aniline, $C_6H_5NH_2$, solution. $K_b = 3.8 \times 10^{-10}$.

Answers: ***WEAK BASE …***

	[$C_6H_5NH_2$]	+	[H_2O]	$\rightleftharpoons$	[$C_6H_5NH_3^{+1}$]	+	[OH^{-1}]
I	2.75 *M*		-		0		0
C	- *x*		-		+ *x*		+ *x*
E	2.75 - *x*		-		*x*		*x*

$$K_b = 3.8 \times 10^{-10} = \frac{[C_6H_5NH_3^{+1}][OH^{-1}]}{[C_6H_5NH_2]} = \frac{(x)(x)}{2.75-x} = \frac{x^2}{2.75}$$

$$K_b = 3.8 \times 10^{-10} = \frac{x^2}{2.75}; \quad (3.8 \times 10^{-10})(2.75) = x^2$$

$$x = \sqrt{1.045\times10^{-9}} = 3.23\times10^{-5}\ M = [OH^{-1}]$$

$$\text{pOH} = -\log(3.23 \times 10^{-5}) = 4.49$$

6. Calculate the pH of a 0.0045 *M* solution of $C_2H_5NH_2$ solution. $K_b = 5.6 \times 10^{-4}$. (you may **NOT** use the 5 % rule for this problem.)

Answers: ***WEAK BASE …***

	[$C_2H_5NH_2$]	+	[H_2O]	$\rightleftharpoons$	[$C_2H_5NH_3^{+1}$]	+	[OH^{-1}]
I	0.0045 *M*		-		0		0
C	- *x*		-		+ *x*		+ *x*
E	0.0045 - *x*		-		*x*		*x*

$$K_b = 5.6 \times 10^{-4} = \frac{[C_2H_5NH_3^{+1}][OH^{-1}]}{[C_2H_5NH_2]} = \frac{x^2}{0.0045-x}$$

We cannot "drop" the ***x*** in this problem, the percent of error is greater than 5 %

You need to know how to do equilibrium problems that use the quadratic equation – I will place a question like this on the quiz !!! Everyone SHOULD know how to use the quadratic equation (WITHOUT a graphing calculator !!!)

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$K_b = 5.6 \times 10^{-4} = \frac{x^2}{0.0045 - x}$$

$$\left(5.6 \times 10^{-4} \right) \left(0.0045 - x \right) = x^2$$

$$2.52 \times 10^{-6} - 5.6 \times 10^{-4} = x^2$$

$$0 = x^2 + 5.6 \times 10^{-4} x - 2.52 \times 10^{-6}$$

$$\frac{-\left(5.6 \times 10^{-4} \right) + \sqrt{\left(5.6 \times 10^{-4} \right)^2 - 4\left(1 \right)\left(-2.52 \times 10^{-6} \right)}}{2 \left(1 \right)}$$

$$x = 1.33 \times 10^{-3}$$

pOH = - log (0.00133) = 2.88

pH = 14 – 2.88 = 11.12

If you did not use the quadratic equation, x = 1.58 x 10^{-3} (15.8 % error), and your WRONG pH would have been equal to 11.20