General Chemistry II (CHEM 102) Dr. Naleway – Discussion 9

Name _____

Strong acid and strong base titration problems:

1. 15 mL of 0.25 M H_2SO_4 is reacted with 40 mL of 0.25 M NaOH. Determine the final pH of the solution.

Weak base and strong acid titration problems:

2. 50 mL of 0.25 M NH_3 ($pK_b = 4.75$) is reacted with 50 mL of 0.25 M HCl. Determine the final pH of the solution.

3. 25 mL of 0.25 M methylamine (CH_3NH_2; $pK_b = 3.34$) is reacted with 25 mL of 0.25 M HCl. Determine the final pH of the solution.

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4. 25 mL of 0.25 M methylamine (CH_3NH_2; $pK_b = 3.34$) is in solution but is NOT reacted with any acid. Determine the final pH.

5. The pK_b of hypoiodite ion, IO^-, is 3.36. Determine the pH of a 2.0 M solution of lithium hypoiodite.

6. The pK_b of the sulfide ion, S^{2-}, is 2.04. Determine the pH of a 1.50 M solution of sodium sulfide.

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Strong Acid / Strong Base Titrations

(1) $0.015\,L \times \frac{0.25\ mol}{L} \times 2 = 0.0075\ mol\ H^+$

$0.040\,L \times \frac{0.25\ mol}{L} = 0.01\ mol\ ^-OH$

$0.01 - 0.0075 = 0.0025\ mol$ excess ^-OH

$\frac{.0025\ mol}{0.055\,L} = 0.045\ M$ excess ^-OH

$pOH = -\log(0.045) = 1.35$

$pH = 14 - 1.35 = \boxed{12.65}$

Weak Base / Strong Acid Titrations

(2) $0.050\,L \times \frac{0.25\ mol}{L} = 0.0125\ mol\ NH_3$

$0.0125\ mol\ H^+$

	NH_3	+ H_3O^+	$\rightleftharpoons$ NH_4^+	+ H_2O
B	0.0125	0.0125	0	—
C	−0.0125	−0.0125	+0.0125	
A	0	0	0.0125 mol	

→

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$\frac{0.0125 \text{ mol}}{0.1 \text{ L}} = 0.125 \text{ M } NH_4^+$

$NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$

	NH_4^+		H_3O^+	NH_3
I	0.125 M	—	0	0
C	$-x$		$+x$	$+x$
E	$0.125 - x$		x	x

$\frac{x^2}{0.125 - x} = K_a$

NH_3 $pK_b = 4.75$

NH_4^+ $pK_a = 14 - 4.75 = 9.25$

$K_a = 10^{-9.25} = 5.62 \times 10^{-10}$

$x = \sqrt{(5.62 \times 10^{-10})(0.125)} =$

$8.38 \times 10^{-6} = H^+$

$pH = \boxed{5.08}$

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(3) ~~0.25 mL~~

$0.025\,L \times \frac{0.25\ mol}{L} = 0.00625\ mol$ base

$0.025\,L \times \frac{0.25\ mol}{L} = 0.00625\ mol\ H^+$

	CH_3NH_2	+ H_3O^+	⇌ $CH_3\overset{+}{N}H_3$	+ H_2O
B	0.00625	0.00625	0	—
C	−0.00625	−0.00625	+0.00625	
A	0	0	0.00625	

$\frac{0.00625\ mol}{.050\,L} = 0.125\ M$ ~~base~~ $CH_3\overset{+}{N}H_3$ (weak acid)

	$CH_3\overset{+}{N}H_3$	+ H_2O	⇌ CH_3NH_2	+ H_3O^+
I	0.125	—	0	0
C	−x		+x	+x
E	0.125 − x		x	x

$\frac{x^2}{0.125 - x} = K_a = 2.19 \times 10^{-11}$

$pK_b = 3.34$

$pK_a = 14 - 3.34 = 10.66$

$K_a = 10^{-10.66} = 2.19 \times 10^{-11}$

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$$x = \sqrt{(.125)(2.19 \times 10^{-11})} =$$

$$1.65 \times 10^{-6} = H^+$$

$$pH = -\log(1.65 \times 10^{-6}) =$$

$$\boxed{5.78}$$

(4.) $CH_3NH_2 + H_2O \rightleftharpoons CH_3\overset{+}{N}H_3 + {}^{-}OH$

	CH_3NH_2		$CH_3\overset{+}{N}H_3$	^{-}OH
I	0.25	—	0	0
C	$-x$		x	x
E	$0.25-x$		x	x

$$\frac{x^2}{0.25-x} = K_b = 4.57 \times 10^{-4}$$

$$K_b = 10^{-3.34}$$

$$x = \sqrt{(0.25)(4.57 \times 10^{-4})} = -OH =$$

$$0.0107$$

$$pOH = -\log(0.0107) = 1.97$$

$$pH = 14 - 1.97 \simeq \boxed{12.03}$$

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(5.)

$IO^- + H_2O \rightleftharpoons HIO + {}^-OH$

	IO^-	H_2O	HIO	^-OH
I	2.0	—	0	0
C	$-x$		$+x$	$+x$
E	$2-x$		x	x

$10^{-3.36} = K_b = 4.37 \times 10^{-4}$

$\frac{x^2}{2-x} = 4.37 \times 10^{-4}$

$x = .0296 = [^-OH]$

~~$x = 6.17 \times 10^{-4}$~~

$pOH = 1.53$ $\boxed{pH = 12.47}$

(6.)

$S^{2-} + H_2O \rightleftharpoons HS^- + {}^-OH$

	S^{2-}	H_2O	HS^-	^-OH
I	1.5	—	0	0
C	$-x$		$+x$	$+x$
E	$1.5-x$		x	x

$\frac{x^2}{1.5-x} = K_b$ 9.12×10^{-3} $x = .1196$

$10^{-2.04} = 9.12 \times 10^{-3}$ $\frac{.1194}{1.5} \times 100 = 7.96\%$

use quadratic

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$$\frac{-K_b + \sqrt{(K_b)^2 + 4(K_b)(Conc)}}{2}$$

$$\frac{-.00912 + \sqrt{(.00912)^2 + 4(.00912)(1.5)}}{2}$$

$X = 0.11249 = -OH$

$pOH = -\log(0.11249) =$

0.95

$\boxed{pH = 13.05}$