AP CHEMISTRY

TOPIC 7: ACIDS & BASES, PART F, EXAMPLES, PART II

Day 93:

- Titrations
- pH curve
- Indicators

Practice Problem #1: Similar to a past AP Exam question:

$$C_6H_5NH_2 + H_2O \rightleftharpoons C_6H_5NH_3^{+1} + OH^{-1}$$

Aniline, a weak base, reacts with water according to the reaction represented above.

(a) Write the equilibrium expression, K_b, for the reaction above.

$$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

6.61×10^{-6}

$pOH = 14 - 8.82$

$pOH = 5.18$

$[OH^-] = X = ANTILOG(-5.18) =$

(b) A sample of aniline is dissolved in water to produce 25.0 mL of a 0.10 *M* solution. The pH of the solution is 8.82. Calculate the equilibrium constant, K_b, for this reaction.

	$C_6H_5NH_2$	+ HOH	$\rightleftharpoons$	$C_6H_5NH_3^+$	+ OH^-
	0.10	–		0	0
	$-x$	–		$+x$	$+x$
	$0.1 - 6.61\times10^{-6}$	–		6.61×10^{-6}	6.61×10^{-6}

$$K_b = \frac{(6.61\times10^{-6})^2}{(0.1 - 6.61\times10^{-6})} =$$

$$K_b = 4.37\times10^{-10}$$

(c) The solution prepared in part (b) is titrated with 0.10 *M* HCl. Calculate the pH of the solution when 5.0 mL of the acid has been added.

mol HCl $\quad \frac{5.0\,mL}{} \left| \frac{1\,L}{1000\,mL} \right| \frac{0.1\,mol}{L} = 0.0005\,mol$

mol B $\quad \frac{25\,mL}{} \left| \frac{1\,L}{1000\,mL} \right| \frac{0.1\,mol}{L} = 0.0025\,mol.$

$$K_a = \frac{K_w}{K_b}$$

$$[H^+] = \frac{0.0005\,mol}{30\,mL} \left| \frac{1000\,mL}{L} \right| = 0.0\bar{16}\,M$$

$$[B] = \frac{0.0025\,mol}{30\,mL} \left| \frac{1000\,mL}{L} \right| = 0.0\bar{83}\,M = 0.083\,M$$

$$\frac{1.00\times10^{-14}}{4.37\times10^{-10}} = 2.29\times10^{-5}$$

	$C_6H_5NH_3^+$	$\rightleftharpoons$	H^+	+	$C_6H_5NH_2$
	~0		0.016		0.083 M
	+0.016		−0.016		−0.016
	0.016		~0		0.06

$$K_a = \frac{[H^+][C_6H_5NH_2]}{[C_6H_5NH_3^+]}$$

$$2.29\times10^{-5} = \frac{[H^+](0.06)}{0.016}$$

$$[H^+] = \frac{(2.29\times10^{-5})(0.016)}{0.06} = 5.72\times10^{-6}$$

EQ PT. ⇒ MOLES BASE = MOLE ACID

(d) Calculate the pH at the equivalence point of the titration in part (c).

$$0.0025 \text{ mol HCl} \left| \frac{1 \text{ L}}{0.1 \text{ mol}} \right| \frac{1000 \text{ mL}}{\text{L}} = 25 \text{ mL}$$

TOTAL VOL. $25 \text{ mL} + 25 \text{ mL} = 50 \text{ mL}$

$$[H^+] \quad \frac{0.0025 \text{ mol}}{50 \text{ mL}} \left| \frac{1000 \text{ mL}}{1 \text{ L}} \right. = 0.05 \text{ M}$$

$$[B] \quad \frac{0.0025 \text{ mol}}{50 \text{ mL}} \left| \frac{1000 \text{ mL}}{1 \text{ L}} \right. = 0.05 \text{ M}$$

$$C_6H_5NH_3^+ \rightleftharpoons C_6H_5NH_2 + H^+$$

~0.	0.05	0.05
+0.05	−0.05	−0.05
0.05	~0	~0
	y	y

$$\frac{y^2}{0.05} = 2.29 \times 10^{-5} \; ; \; y^2 = (0.05)(2.29 \times 10^{-5})$$

$$y^2 = 1.15 \times 10^{-6} \qquad y = \sqrt{1.15 \times 10^{-6}} =$$

$$[H^+] = y = 1.07 \times 10^{-3}$$

$$pH = -\log [H^+] = -\log 1.07 \times 10^{-3} = 2.97$$

(e) The pK_a values for several indicators are given below. Which of the indicators listed is most suitable for this titration? Justify your answer.

Indicator	pK_a
Erythrosine	3
Litmus	7
Thymolpthalein	10