

AP CHEMISTRY

TOPIC 7: ACIDS & BASES, PART F,

EXAMPLES, PART II

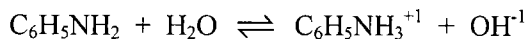
Day 93:

• Titrations

• pH curve

• Indicators

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



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

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

$$K_b = \frac{[\text{C}_6\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{NH}_2]}$$

$$6.61 \times 10^{-6}$$

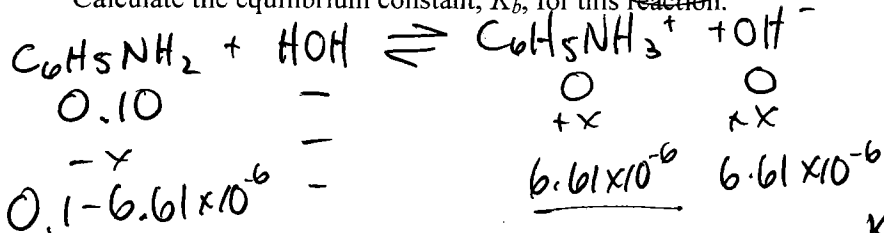
$$\text{pOH} = 14 - 8.82$$

$$\text{pOH} = 5.18$$

$$[\text{OH}^-] = X = \text{ANTILOG}(-5.18) =$$

(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.



$$K_b = \frac{(6.61 \times 10^{-6})^2}{(0.1 - 6.61 \times 10^{-6})}$$

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

(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.

$$\text{mol HCl} = \frac{5.0 \text{ mL}}{1000 \text{ mL}} \times 0.1 \text{ mol/L} = 0.0005 \text{ mol}$$

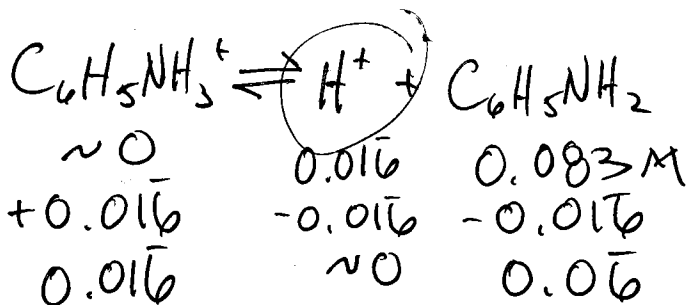
$$\text{mol B} = \frac{25 \text{ mL}}{1000 \text{ mL}} \times 0.1 \text{ mol/L} = 0.0025 \text{ mol}$$

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

$$[\text{H}^+] = \frac{0.0005 \text{ mol}}{30 \text{ mL}} = 0.01\bar{6} \text{ M}$$

$$[\text{B}] = \frac{0.0025 \text{ mol}}{30 \text{ mL}} = 0.08\bar{3} \text{ M}$$

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



$$K_a = \frac{[\text{H}^+][\text{C}_6\text{H}_5\text{NH}_2]}{[\text{C}_6\text{H}_5\text{NH}_3^+]}$$

$$2.29 \times 10^{-5} = \frac{[\text{H}^+](0.0\bar{6})}{0.01\bar{6}}$$

$$[\text{H}^+] = \frac{(2.29 \times 10^{-5})(0.01\bar{6})}{0.0\bar{6}} = 5.72 \times 10^{-6}$$

EQ PT. \Rightarrow MOLES BASE = MOLES ACID

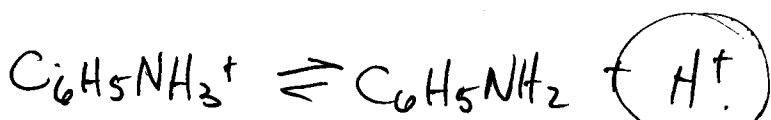
(d) Calculate the pH at the equivalence point of the titration in part (c).

$$\frac{0.0025 \text{ mol HCl}}{1 \text{ L}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = \frac{2.5 \text{ mmol}}{1 \text{ L}} = 2.5 \text{ mmol/L}$$

TOTAL VOL. $\frac{25 \text{ mL}}{1000 \text{ mL/L}} + \frac{25 \text{ mL}}{1000 \text{ mL/L}} = \frac{50 \text{ mL}}{1000 \text{ mL/L}} = 0.05 \text{ L}$

$$[\text{H}^+] = \frac{0.0025 \text{ mol}}{0.05 \text{ L}} = 0.05 \text{ M}$$

$$[\text{B}] = \frac{0.0025 \text{ mol}}{0.05 \text{ L}} = 0.05 \text{ M}$$



~ 0	0.05	0.05
+0.05	-0.05	-0.05
0.05	~ 0	~ 0
	y	y

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

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

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

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

(e) The $\text{p}K_a$ values for several indicators are given below. Which of the indicators listed is most suitable for this titration? Justify your answer.

Indicator	$\text{p}K_a$
Erythrosine	3
Litmus	7
Thymolphthalein	10