



AP[®] Chemistry 2003 Sample Student Responses

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1A

CHEMISTRY
Section II
(Total time—90 minutes)

Part A

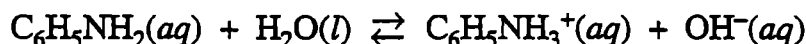
Time—40 minutes

YOU MAY USE YOUR CALCULATOR FOR PART A.

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the pink cover. Do NOT write your answers on the green insert.

Answer Question 1 below. The Section II score weighting for this question is 20 percent.



1. Aniline, a weak base, reacts with water according to the reaction represented above.
 - (a) Write the equilibrium constant expression, K_b , for the reaction represented above.
 - (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) 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.
 - (d) Calculate the pH at the equivalence point of the titration in part (c).
 - (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

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

$$b) .0250\text{L} \times .10\text{M} = .0025\text{ mol aniline}$$

$$\text{pH} = 8.82$$

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

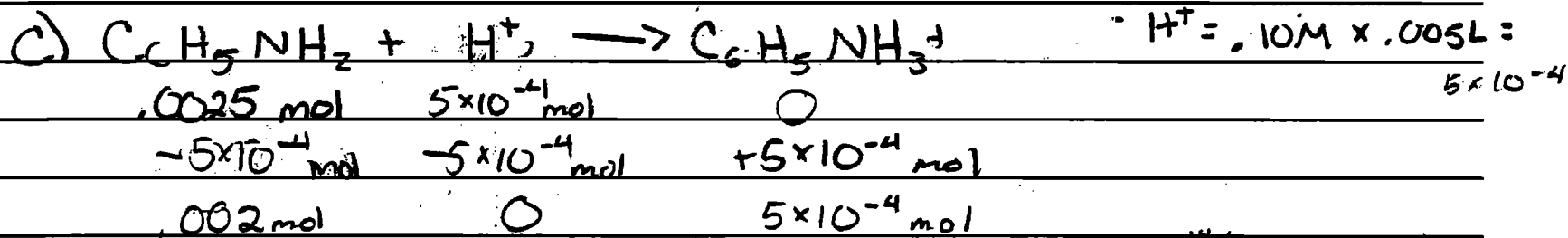
$$= 5.18$$

$$[\text{OH}^-] = 6.607 \times 10^{-6}\text{M}$$

$$K_b = \frac{[6.607 \times 10^{-6}][6.607 \times 10^{-6}]}{[.10]}$$

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

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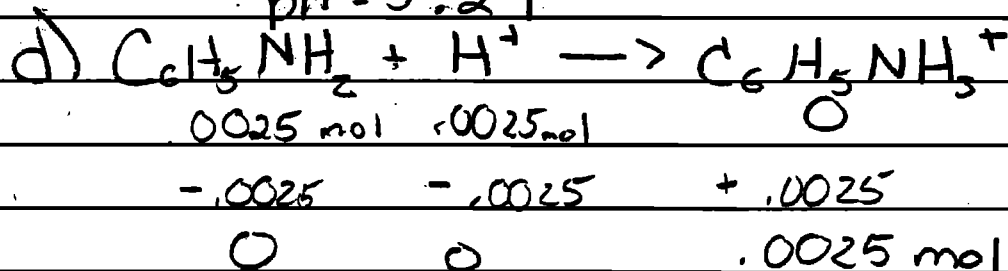


$$pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$$

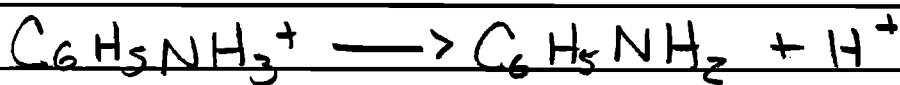
$$pH = 4.64 + \log\left(\frac{.002}{5 \times 10^{-4}}\right)$$

$$pH = 5.24$$

$K_a = 1.0 \times 10^{-10} / 4.37 \times 10^{-10} = 2.29 \times 10^{-5}$



$$\frac{.0025 \text{ mol}}{25 \text{ mL} + 25 \text{ mL}} = .05 M$$



i	.05 M	0	0
c	-x	+x	+x
e	.05 - x	x	x

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

$$2.29 \times 10^{-5} = \frac{[x][x]}{[.05-x]}$$

$$1.145 \times 10^{-6} = x^2$$

$$.00107 = x = [H^+]$$

$$pH = 2.97$$

e) Erythrosine is most suitable because its pK_a is closest to the pH of the equivalence point of the titration.

1B₁

CHEMISTRY
Section II
 (Total time—90 minutes)

Part A

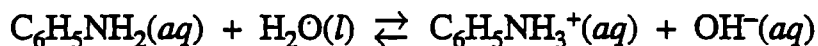
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Indicator	$\text{p}K_a$
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Litmus	7
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a)
$$K_b = \frac{[\text{OH}^-][\text{C}_6\text{H}_5\text{NH}_3^+]}{[\text{C}_6\text{H}_5\text{NH}_2]}$$

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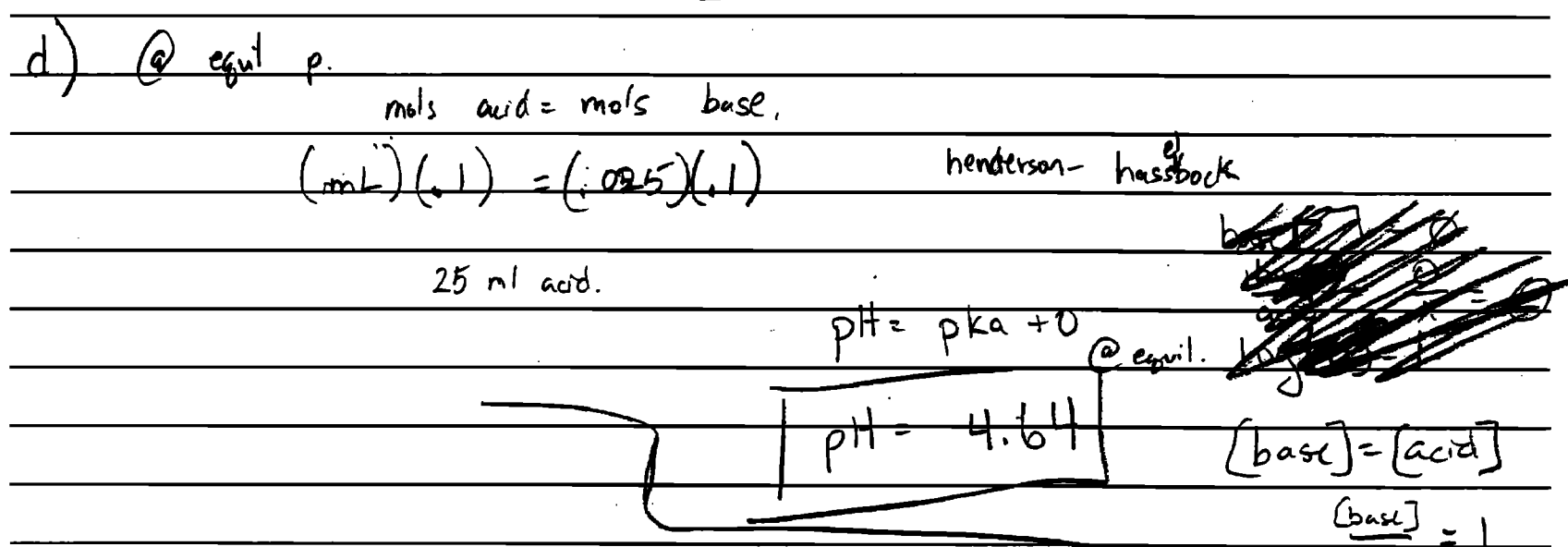
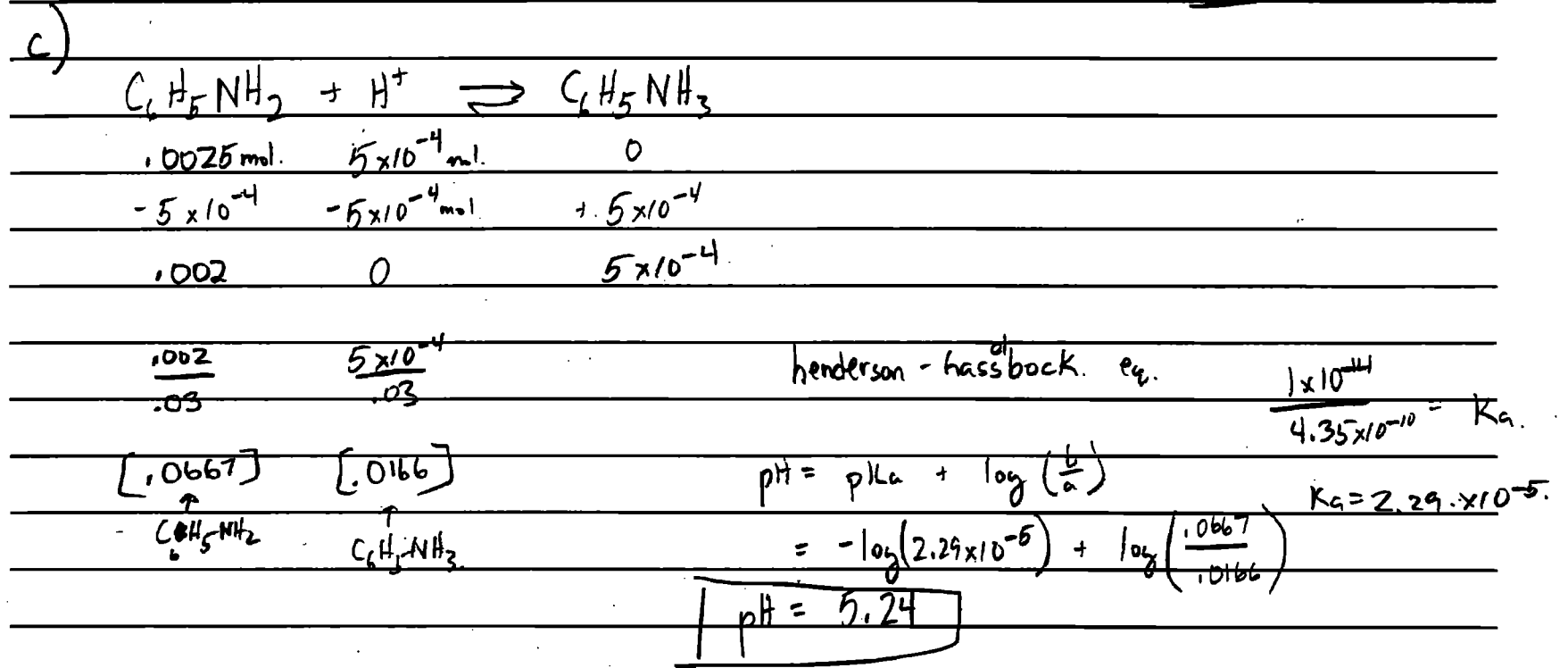
ADDITIONAL PAGE FOR ANSWERING QUESTION 1.

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

$pH = 8.82$ $pOH = 5.18$

$K_b = \frac{[6.60 \times 10^{-6}]^2}{[.1]}$

$[OH^-] = 6.60 \times 10^{-6}$ $K_b = 4.35 \times 10^{-10}$



e) The erythrosine indicator is the best because it is closest to the pH of 4.64, the pH of the solution's equil. point.

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CHEMISTRY
Section II
(Total time—90 minutes)

Part A

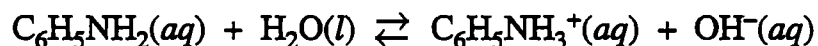
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Answer Question 1 below. The Section II score weighting for this question is 20 percent.



1. Aniline, a weak base, reacts with water according to the reaction represented above.
 - (a) Write the equilibrium constant expression, K_b , for the reaction represented above. ✓
 - (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) 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. ✓
 - (d) Calculate the pH at the equivalence point of the titration in part (c). ✓
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Indicator	$\text{p}K_a$
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a) $K_b = \frac{[\text{C}_6\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{NH}_2]}$

→

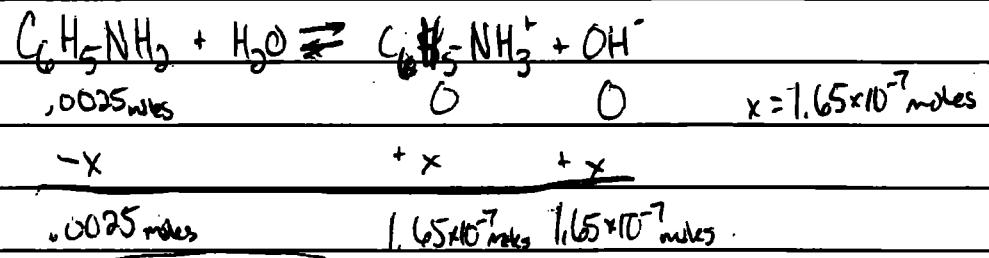
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b) $0.1 \text{ M/L} \times 0.025 \text{ L} = 0.0025 \text{ moles aniline}$

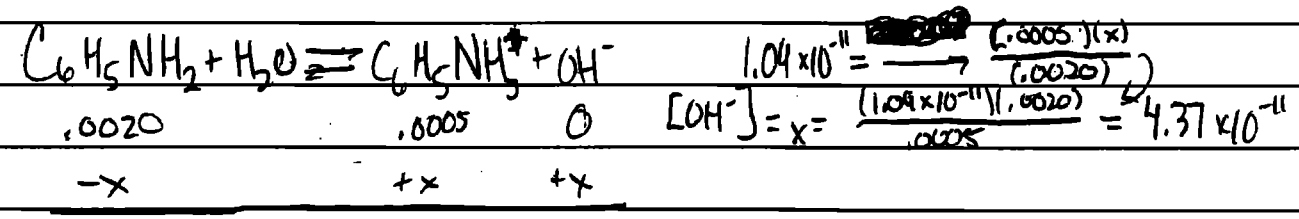
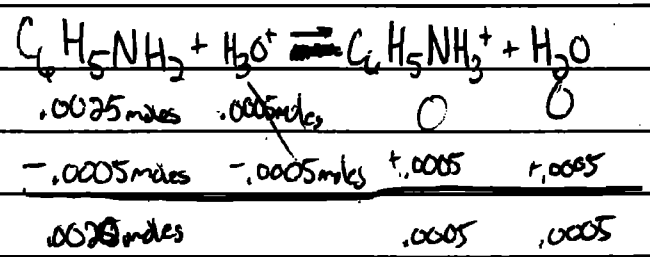
$\text{pH} = 8.82 \rightarrow [\text{H}_3\text{O}^+] = 10^{-8.82} = 1.51 \times 10^{-9} \text{ M/L H}_3\text{O}^+$
 $\text{pOH} = 5.18 \rightarrow [\text{OH}^-] = 10^{-5.18} = 6.61 \times 10^{-6} \text{ moles/L OH}^-$

$6.61 \times 10^{-6} \text{ M} \times 0.025 \text{ L} = 1.65 \times 10^{-7} \text{ moles}$



$K_b = \frac{(1.65 \times 10^{-7})^2}{.0025} = 1.09 \times 10^{-11}$

c) $0.10 \text{ moles/L} \times 0.005 \text{ L} = 0.0005 \text{ moles HCl}$



$\text{pOH} = -\log(4.37 \times 10^{-11}) = 10.36$ $14 - 10.36 = \text{pH} = 3.64$

d) $\text{pH} = \text{p}K_b = -\log(1.09 \times 10^{-11}) = 10.96$ $\text{pH} = 14 - 10.96 = 3.04$

e) Erythrosine would be the most appropriate indicator since the pH's are all coming out in the lower end of the pH scale near 3.

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