



AP Chemistry 2000 Student Samples

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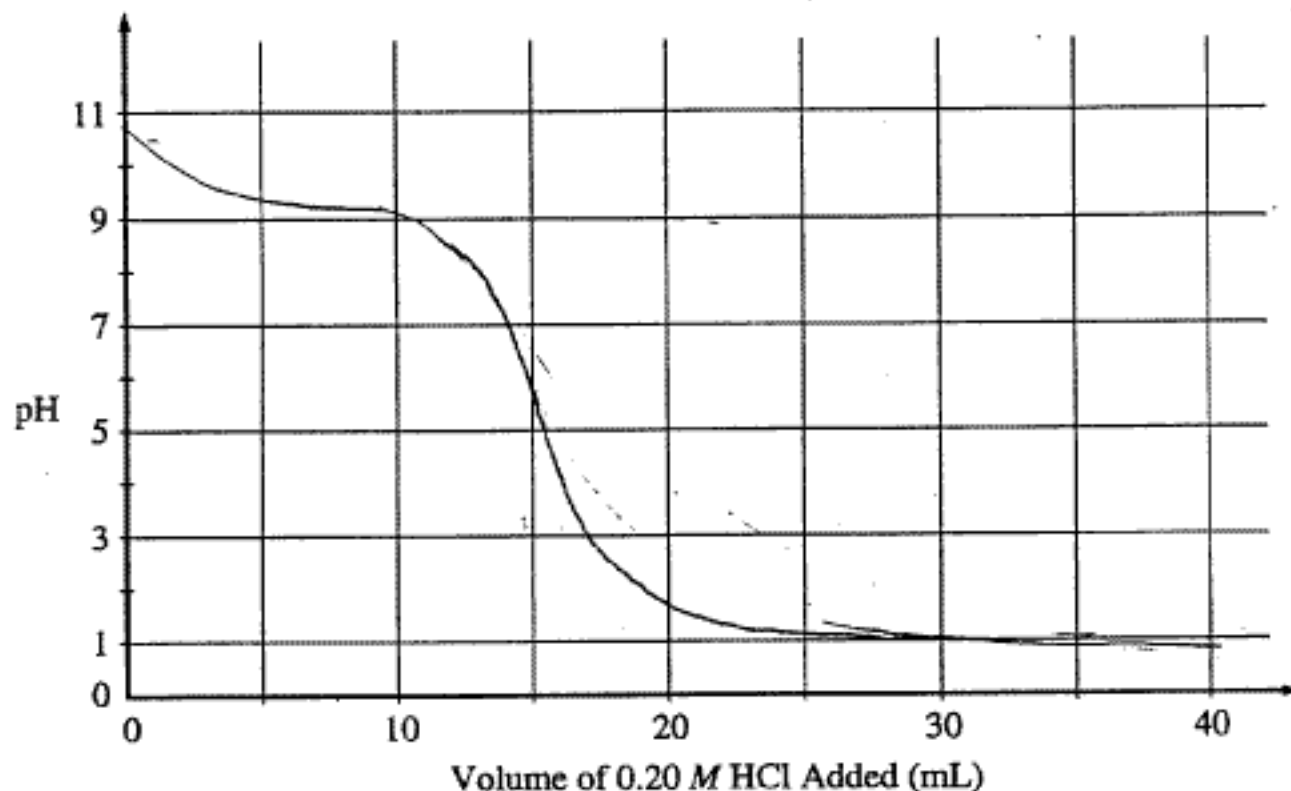
8. A volume of 30.0 mL of 0.10 M $\text{NH}_3(\text{aq})$ is titrated with 0.20 M $\text{HCl}(\text{aq})$. The value of the base-dissociation constant, K_b , for NH_3 in water is 1.8×10^{-5} at 25°C.

$$.2 \sqrt{\frac{.0015}{.003}} = \frac{.2}{10}$$

(a) Write the net-ionic equation for the reaction of $\text{NH}_3(\text{aq})$ with $\text{HCl}(\text{aq})$.

(b) Using the axes provided below, sketch the titration curve that results when a total of 40.0 mL of 0.20 M $\text{HCl}(\text{aq})$ is added dropwise to the 30.0 mL volume of 0.10 M $\text{NH}_3(\text{aq})$.

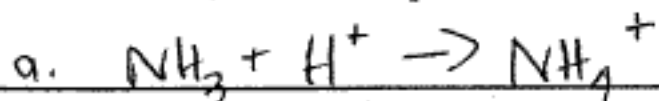
$$\frac{.03}{.003} = .01 \text{ mol NH}_3$$



(c) From the table below, select the most appropriate indicator for the titration. Justify your choice.

| Indicator | $\text{p}K_a$ |
|------------------|---------------|
| Methyl Red | 5.5 |
| Bromothymol Blue | 7.1 |
| Phenolphthalein | 8.7 |

(d) If equal volumes of 0.10 M $\text{NH}_3(\text{aq})$ and 0.10 M $\text{NH}_4\text{Cl}(\text{aq})$ are mixed, is the resulting solution acidic, neutral, or basic? Explain.



c. Methyl red, because at the equivalence point (what is being measured), the pH of the solution is less than 7 because the pH at the equivalence point

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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

is determined by the equilibrium for NH_4^+ acting as an acid:

$$\frac{[\text{NH}_3][\text{H}^+]}{[\text{NH}_4^+]} = K_a = \frac{10^{-14}}{K_b}$$

Once all of the NH_3 has been converted to NH_4^+ (this occurs at the equivalence point) the NH_4^+ begins making NH_3 and H^+ , an acidic solution with $\text{pH} < 7$. The only indicator with pH

d. Basic, because NH_3 more readily gains a proton from water (forming OH^- and NH_4^+) than NH_4^+ loses a proton (forming NH_3 and H^+)

$$K_b \text{ for } \text{NH}_3 > K_a \text{ for } \text{NH}_4^+$$

$$1.8 \times 10^{-5}$$

$$5.6 \times 10^{-8}$$

$$\frac{9.6}{4.5} = 2.13$$

END OF EXAMINATION

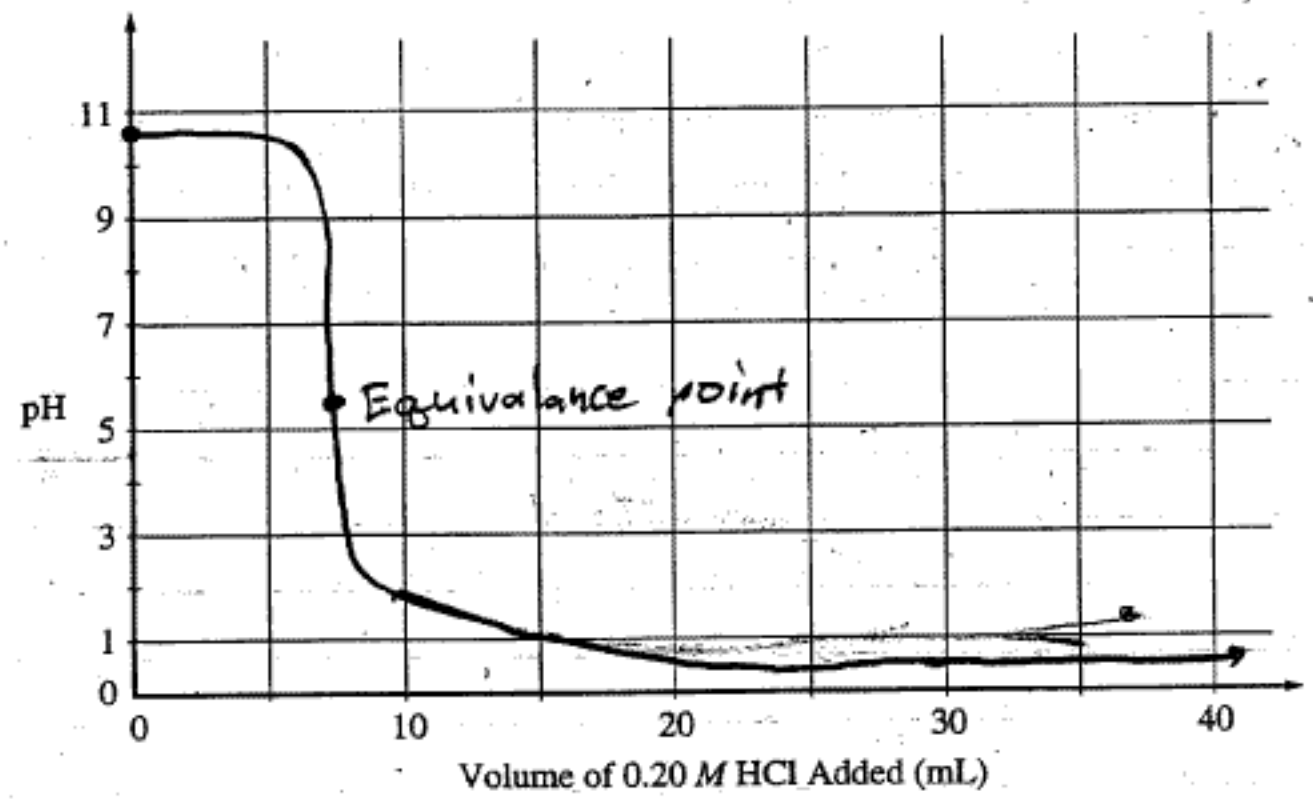
THE FOLLOWING INSTRUCTIONS APPLY TO THE BACK COVER OF THE SECTION II BOOKLET.

- CIRCLE THE NUMBERS OF THE FREE-RESPONSE QUESTIONS YOU ANSWERED AS REQUESTED ON THE BOTTOM OF THE BACK PAGE.
- MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE BACK OF THE SECTION II BOOKLET.
- CHECK TO SEE THAT YOUR AP NUMBER APPEARS IN THE BOX(ES) ON THE BACK COVER.
- MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMINATIONS YOU HAVE TAKEN THIS YEAR.

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8. A volume of 30.0 mL of 0.10 M NH₃(aq) is titrated with 0.20 M HCl(aq). The value of the base-dissociation constant, K_b, for NH₃ in water is 1.8 × 10⁻⁵ at 25°C.

- (a) Write the net-ionic equation for the reaction of NH₃(aq) with HCl(aq).
- (b) Using the axes provided below, sketch the titration curve that results when a total of 40.0 mL of 0.20 M HCl(aq) is added dropwise to the 30.0 mL volume of 0.10 M NH₃(aq).



(c) From the table below, select the most appropriate indicator for the titration. Justify your choice.

| Indicator | pK _a |
|------------------|-----------------|
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| Bromothymol Blue | 7.1 |
| Phenolphthalein | 8.7 |

(d) If equal volumes of 0.10 M NH₃(aq) and 0.10 M NH₄Cl(aq) are mixed, is the resulting solution acidic, neutral, or basic? Explain:

a. $NH_3 + H^+ \rightleftharpoons NH_4^+ + Cl^-$

b. Methyl red. Because HCl is a strong acid and NH₃ a weak

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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

base, the pH of the equivalence point will be lower than 7 because of the acidity of the solution. Therefore, we must choose an indicator with an endpoint of change lower than 7.

D. It will be neutral. Equal amounts of the conjugate acid/base pair NH_3 and NH_4^+ will be added, creating a buffer. Buffer solutions are

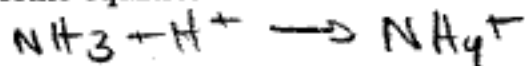
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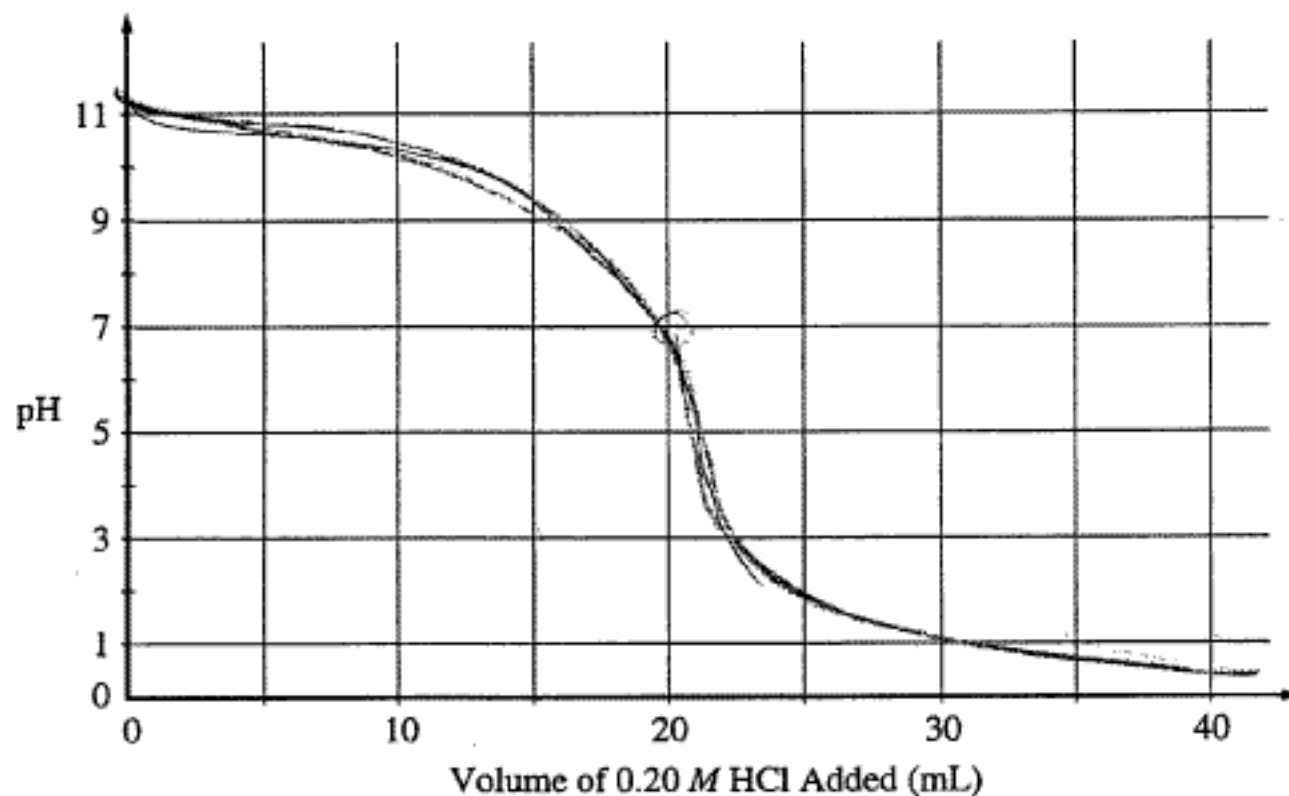
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(a) Write the net-ionic equation for the reaction of $\text{NH}_3(\text{aq})$ with $\text{HCl}(\text{aq})$.



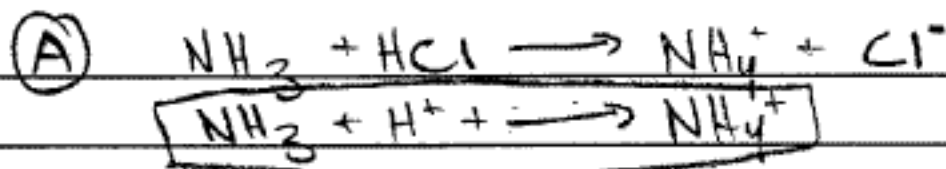
(b) Using the axes provided below, sketch the titration curve that results when a total of 40.0 mL of 0.20 M $\text{HCl}(\text{aq})$ is added dropwise to the 30.0 mL volume of 0.10 M $\text{NH}_3(\text{aq})$.



(c) From the table below, select the most appropriate indicator for the titration. Justify your choice.

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(d) If equal volumes of 0.10 M $\text{NH}_3(\text{aq})$ and 0.10 M $\text{NH}_4\text{Cl}(\text{aq})$ are mixed, is the resulting solution acidic, neutral, or basic? Explain.



(B) $M = \frac{m}{L}$
 $0.10 = \frac{x}{20}$
 $x = 2.0$
 $0.10 = \frac{y}{30}$
 $y = 3.0$

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

③ THE INDICATOR THAT SHOULD BE USED IS Bromothymol Blue BECAUSE THE PURPOSE OF THE TITRATION IS TO NEUTRALIZE THE NH_3 , WHICH IS DONE WHEN THE pH IS 7. SINCE THIS INDICATOR ~~INDICATES~~ INDICATES WHEN THE SOLUTION IS AT 7.1 pH, ONCE THE SOLUTION IS 7.1 YOU CAN ADD JUST ENOUGH HCl TO CHANGE THE COLOR AGAIN, REACHING A pH OF 7.

④ THE RESULTING SOLUTION IS NEUTRAL BECAUSE IN ORDER TO NEUTRALIZE NH_3 , THE EXACT SAME NUMBER OF MOLES OF HCl MUST BE ADDED. SINCE, IN THE CASE, NH_3 AND HCl HAVE THE SAME MOLARITY, THEY WOULD HAVE THE SAME NUMBER OF MOLES AT ANY GIVEN VOLUMES, WHICH MEANS IT IS NEUTRAL.

END OF EXAMINATION

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