Y

AP Chem - Unit - Super Problem - Buffers + Titration

$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$  $K_b = 1.80 \times 10^{-5}$

A) Equilibrium constant expression

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

B) pH = ?  .150 M $NH_3$

| | $NH_3$ | → $NH_4^+$ | + $OH^-$ |
|---|---|---|---|
| I | .150 | 0 | 0 |
| C | -x | x | x |
| Assume <5% | .150 - x | | |
| E | .150 | x | x |

$K_b = \frac{(x)(x)}{.150}$

$(.150)(1.80 \times 10^{-5}) = x^2$

$[OH^-] = x = 1.64 \times 10^{-3}$

$pOH = -\log[OH^-]$

$pOH = 2.784$  $pH = 14 - pOH$

**$pH = 11.216$**

C) 20 ml 0.150M $NH_3$ is <u>titrated</u> w/ 0.100 M HCl

$NH_3 + HCl \rightleftharpoons NH_4Cl$  Basic Salt in Beaker

Titrated means the equivalence pt was Reached

∴ How much volume of HCl required to Reach the equivalence pt

$NH_3$ 20 ml (0.150 M) = 3.00 mmol

HCl  X ml (0.100 M) = 3.00 mmol

X ml = 30 ml need

AP Chem - Unit 10 - SP: Buffers & Titrations

d) pH = ? after + 15 mL 0.100 M HCl

$HCl + NH_3 \rightleftharpoons NH_4Cl$

HCl: (15 mL)(0.100 M) = 1.5 mmol

| | | $HCl$ | $NH_3$ | $NH_4Cl$ |
|---|---|---|---|---|
| | I | 1.5 mmol | 3.00 mmol | 0 |
| x = 1.5 | C | −x | −x | x |
| | | −1.5 | −1.5 | 1.5 |
| | E | 0 | 1.5 mmol | 1.5 |

Beaker: Weak Base & Basic Salt

$[OH^-] = K_b \frac{[NH_4Cl]}{[NH_3]}$

$[OH^-] = 1.80 \times 10^{-5} \left(\frac{1.5}{1.5}\right)$

$pOH = -\log[OH^-]$

$pOH = 4.74$

$pH = 14 - pOH$

**pH = 9.26**

e) pH = ? @ equivalence pt of titration

$HCl + NH_3 \rightleftharpoons NH_4Cl$

| | | $HCl$ | $NH_3$ | $NH_4Cl$ |
|---|---|---|---|---|
| | I | 3.00 mmol | 3.00 mmol | 0 |
| x = 3.00 | C | −x | −x | x |
| | | 3.00 | 3.00 | 3.00 |
| | E | 0 | 0 | 3.00 mmol |

In Beaker Acidic SAlt

Strong Acid HCl, Weak Base $NH_3$ → $NH_4Cl$

Strong wins ⇌ $H^+$

Strong spectator $NH_4$~~Cl~~

New Total Volume

HCl 30 mL + $NH_3$ 20 mL = 50 mL

$NH_4^+ \rightleftharpoons H^+ + NH_3$

| | $NH_4^+$ | $H^+$ | $NH_3$ |
|---|---|---|---|
| I | 3.00 mmol | 0 | 0 |
| C | 3.00 − x (Assume 5%) | x | x |
| | 3.00 mmol | x | x |

But New Volume

$\frac{3.00 \text{ mmol}}{50 \text{ mL}} = .0600\text{ M}$

e) cont

$$Ka = \frac{[H^+][NH_3]}{[NH_4^+]} = \frac{x^2}{[.0600]} \qquad Ka \cdot Kb = Kw \qquad Ka = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

$$[.0600](5.6 \times 10^{-10}) = x^2$$

$$[H^+] = x = 5.80 \times 10^{-6}$$

$$pH = -\log[H^+]$$

$$\boxed{pH = 5.24}$$

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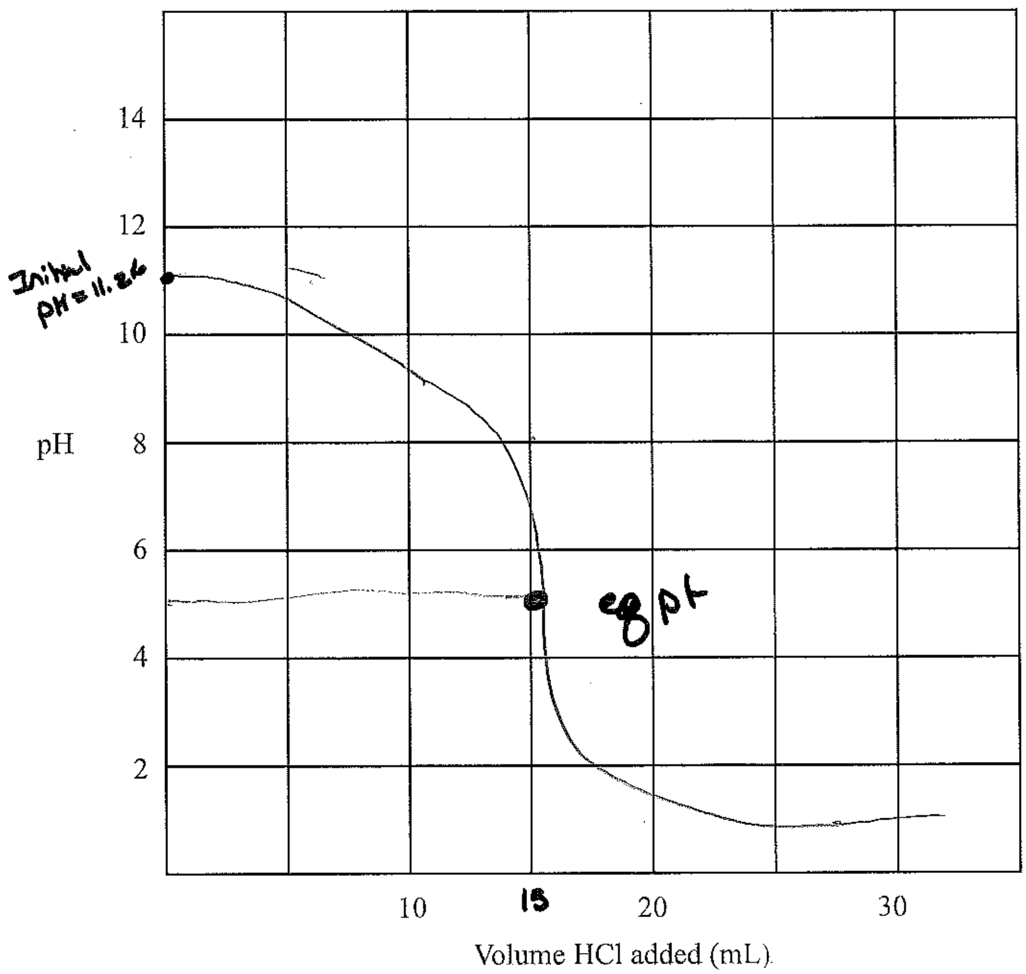
f. Using the axes provided below, sketch the titration curve that would result if the student had used 0.200 $M$ HCl instead of the 0.100 $M$ used above, to perform the titration. The equivalence point must be clearly marked.

(1 pt)




(1 pt) Looking Like Titration Curve

equivalence pt?

$NH_3$ 20 ml (.150M) = 3.00 mol

HCl x ml (.200M) = 3.00 mmol

x ml = 15 ml so vertical slope Here! (1 pt)

pH @ eq pt?

use info from part E

$\frac{3.00 \text{ mmol}}{35 \text{ ml}} = .0857 = x$

Total Volume = 20 ml + 15 ml = 35 ml

$x^2 = (.0857)(5.6 \times 10^{-10})$ (Ka)

$[H^+] = x = 6.93 \times 10^{-6}$

pH = 5.16

(1 pt)

(g) $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$   $K_b = 4.40 \times 10^{-4}$

150 ml

PH = ?   I   .150 M   0   0

C   -x   x   x

.150 - x   assume 5% Rule

.150   x   x

$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = \frac{x^2}{.150}$

$x^2 = (.150)(4.4 \times 10^{-4})$

$[OH^-] = x = 8.12 \times 10^{-3}$ M

pOH = -log [OH⁻]

pOH = 2.09

pH = 14 - pOH

**pH = 11.91**

H)

$[H^+] = K_a \frac{[Acid]}{[Base]}$

Acid: $CH_3NH_3^+Cl$   .120 mole

Base: $CH_3NH_2$   150 ml → .150 L

.150 M

$K_aK_b = K_w$

$K_a = \frac{1 \times 10^{-14}}{4.40 \times 10^{-4}} = 2.27 \times 10^{-11}$

$\left(\frac{.150 \text{ mole}}{1 L}\right)\left(\frac{.150 L}{1}\right) = .225$ mole

$[H^+] = 2.27 \times 10^{-11} \frac{(.120)}{(.225)}$

$= 1.21 \times 10^{-11}$

pH = -log [H⁺]

**pH = 10.917**