Chap 16
#73

Titration of a weak base with a strong acid

Chap 16

#73 25.0mL 0.175M CH_3NH_2 (weak base) $K_b = 4.4\times10^{-4}$

titrate w/ 0.150M HBr (strong acid)

(a) Initial pH

$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

	CH_3NH_2	$CH_3NH_3^+$	OH^-
I	0.175	0	0
C	$-x$	$+x$	$+x$
E	$0.175-x$	x	x

$$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = 4.4\times10^{-4} = \frac{[x][x]}{0.175}$$

$x = 0.0088\,M$

$pOH = -\log[0.0088]$

$= 2.06$

$\boxed{pH = 11.94}$

b) add 5mL of acid

Stoichiometry

Amt of CH_3NH_2 → $25.0mL\left(\frac{0.175mmol}{1mL}\right) = 4.375mmol\ CH_3NH_2$

Amt of HBr → $5.0mL\left(\frac{0.150mmol}{1mL}\right) = 0.75mmol\ HBr$

	CH_3NH_2	+ HBr	→ $CH_3NH_3^+$	+ Br^-
start	4.375	0.75	0	0
change	−0.75	−0.75	+0.75	+.75
End	3.625	0	+0.75	

$K_b = 4.4\times10^{-4}$

$K_w = K_a K_b$

$1\times10^{-14} = K_a(4.4\times10^{-4})$

$2.27\times10^{-11} = K_a$

$10.64 = pK_a$

Equil. for the Buffer

H-H

$$pH = pK_a + \log\frac{\left[\frac{3.625mmol}{30mL}\right]}{\left[\frac{0.75mmol}{30mL}\right]}$$

$pH = 10.64 + \log$

$pH = 11.33$

OR →

Equil.

$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

	CH_3NH_2 $\left(\frac{3.625\ mmol}{30\ mL}\right)$		$CH_3NH_3^+$ $\left(\frac{0.75\ mmol}{30\ mL}\right)$	OH^-
I	0.121 M		0.025 M	
C	$-x$		$+x$	$+x$
E	$0.121 - x$		$0.025 + x$	x

$$4.4\times10^{-4} = \frac{[x][0.025]}{[0.121]} \rightarrow x = 0.00213 = [OH^-]$$

$pOH = 2.67$

$\boxed{pH = 11.33}$

---

c) @ Equivalence pt — will produce

Stoich $4.375\ mmol\ CH_3NH_2 \rightarrow 4.375\ mmol\ HBr\left(\frac{1\ mL}{0.150\ mmol}\right) = 29.2\ mL\ HBr$

$CH_3NH_2 + HBr \rightarrow CH_3NH_3^+ + Br^-$

	CH_3NH_2	HBr	$CH_3NH_3^+$	Br^-
start	4.375 mmol	0		
add		+ 4.375 mmol		
rxn	−4.375	−4.375	+ 4.375	+ 4.375
End	0	0	+ 4.375 mmol	

in 25.0 mL — initial
+ 29.2 mL — HBr added
54.2 mL

Equilibrium

$CH_3NH_3^+ + H_2O \rightleftharpoons CH_3NH_2 + H_3O^+$

$K_b = 4.4\times10^{-4}$ for CH_3NH_2

$K_a = 2.27\times10^{-11}$ for $CH_3NH_3^+$

$1\times10^{-14} = 4.4\times10^{-4}\ K_a$

	$CH_3NH_3^+$ $\left[\frac{4.375\ mmol}{54.2\ mL}\right]$		CH_3NH_2	H_3O^+
I			+ x	+ x
C	$-x$			
E	$0.0807 - x$		+ x	+ x

$$K_a = \frac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]} = \frac{[x][x]}{[0.0807]} = 2.27\times10^{-11}$$

$x = 1.35\times10^{-6} = [H_3O^+]$

$\boxed{5.87 = pH}$ a bit acidic pH

d) Add 34.2mL HBr (5.0mL over) $34.2\text{mL}\left(\frac{0.150\text{mmol}}{1\text{mL}}\right) = 5.13\text{mmol}$

Chap 16 #73

Stoich

$CH_3NH_2 + HBr \rightarrow CH_3NH_3^+ + Br^-$

	CH_3NH_2	HBr	$CH_3NH_3^+$	Br^-	
start	4.375mmol				25.0mL
add		+5.13mmol			34.2mL
rxn	−4.375mmol	−4.375 →	+4.375		59.2mL total
end	0	0.755mmol	4.375mmol	4.375mmol	

Equilibrium

$CH_3NH_3^+ + H_2O \rightarrow H_3O^+ + CH_3NH_2$

I $\left[\frac{4.375\text{mmol}}{59.2\text{mL}}\right]$ $\left[\frac{0.755\text{mmol}}{59.2\text{mL}}\right]$

$K_a = 2.27\times10^{-11}$ for $CH_3NH_3^+$

C $-x$ $+x$ $+x$

E $(0.074-x)$ $(0.013+x)$ (x)

$$2.27\times10^{-11} = \frac{[0.013][x]}{[0.074]}$$

$1.3\times10^{-10} = x$ insignificant

$$pH = -\log[0.013] = 1.89$$