$M_aV_a = M_bV_b$

$(0.10)(100.0) = (0.200)V_b \Rightarrow V_b = 50.0\text{ mL}$ needed to reach eq. pt

2. Consider the titration of 100.0 mL of 0.10 0M H_2NNH_2 ($K_b = 3.0 \times 10^{-6}$) by 0.200 M HNO_3. Calculate the pH of the resulting solution after the following volumes of HNO_3 have been added.

a. 0.0 mL Only H_2NNH_2 ⇒ K_b problem

$$\underset{3.0E-6}{K_b} = \frac{[OH^-][H_2NNH_3^+]}{[H_2NNH_2]} = \frac{x^2}{\underbrace{0.10-x}_{x \text{ negligible, } K_b \ll 1}} \approx \frac{x^2}{0.10}$$

$x = \sqrt{(0.10)(3.0E-6)}$

$= 5.5E-4\text{ M} = [OH^-]$

$pOH = -\log(5.5E-4) = 3.26$

$pH = 14 - 3.26 = \boxed{10.74}$

b4 eq. pt = buffer! ★ calculate [HA], [A-] first

b. 20.0 mL $H_2NNH_2 = 100.0\text{ mL} \times 0.100\text{ M} = 10.0\text{ mmol}$

$H^+ = 20.0\text{ mL} \times 0.200\text{ M} = 4.00\text{ mmol}$

$$[H_2NNH_3^+] = \frac{4.00\text{ mmol}}{120.0\text{ mL}} = 0.0333\text{ M}$$

	$H_2NNH_{2(aq)}$ +	$H^+_{(aq)}$ →	$H_2NNH_3^+{}_{(aq)}$
B	10.0	4.00	∅
C	−4.00	−4.00	+4.00
A	6.0	∅	4.00

$[H_2NNH_2] = 6.0\text{ mmol}/120.0\text{ mL} = 0.050\text{ M}$

$$pH = pK_a + \log\frac{[H_2NNH_2]}{[H_2NNH_3^+]}$$

$$= -\log\left(\frac{1E-14}{3.0E-6}\right) + \log\left(\frac{0.050}{0.0333}\right) = 8.48 + 0.18 = \boxed{8.65}$$

c. 25.0 mL

↳ $\frac{1}{2}$ eq pt!!

$$pH = pK_a = -\log\left(\frac{K_w}{K_b}\right) = -\log\left(\frac{1E-14}{3.0E-6}\right) = \boxed{8.48}$$

@ eq. pt! only acidic salt (K_a problem) $K_a = \frac{1E-14}{3.0E-6} = 3.3E-9$

d. 50.0 mL

$$[H_2NNH_3^+] = \frac{(100.0\text{ mL})(0.100\text{ M})}{150.0\text{ mL}} = 0.0667\text{ M}$$

$$\underset{3.3E-9}{K_a} = \frac{x^2}{\underbrace{[H_2NNH_3^+]-x}_{x \text{ negligible, } K_a \ll 1}} \approx \frac{x^2}{0.0667}$$

$x = \sqrt{(0.0667)(3.3E-9)}$

$= 1.5E-5\text{ M } H^+$

$pH = -\log(1.5E-5) = \boxed{4.83}$

e. 100.0 mL

↳ past eq. pt = only strong acid! $H^+ = 100.0\text{ mL} \times 0.200\text{ M} = 20.0\text{ mmol}$

	$H_2NNH_{2(aq)}$ +	$H^+_{(aq)}$ →	$H_2NNH_3^+{}_{(aq)}$
B	10.0	20.0	~~∅~~
C	−10.0	−10.0	~~+10.0~~
A	∅	10.0	~~10.0~~

negligible weak acid contribution

$$[H^+] = \frac{10.0\text{ mmol}}{200.0\text{ mL}} = 0.0500\text{ M}$$

$pH = -\log(0.0500) = \boxed{1.301}$