

55) let Hlac : $\text{H}_2\text{C}_2\text{H}_3\text{O}_3$



$$K_a = \frac{[\text{H}^+][\text{Lac}^-]}{[\text{Hlac}]} = \frac{x^2}{0.100-x}$$

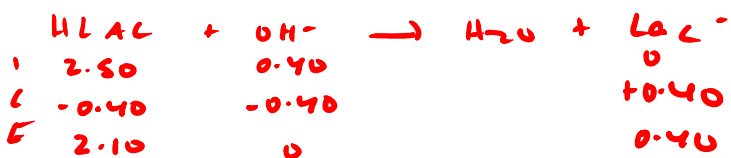
$$x = [\text{H}^+] = 3.7 \times 10^{-3}$$

$$\text{pH} = -\log(3.7 \times 10^{-3}) = 2.43$$

$$\% \text{ ion} = \frac{3.7 \times 10^{-3}}{0.100} \times 100 = 3.7\% \checkmark$$

$$\text{mmol Hlac} = (0.100 \text{ M})(25.0 \text{ mL}) = 2.50 \text{ mmol}$$

$$\text{mmol OH}^- = (0.100 \text{ M})(4.0 \text{ mL}) = 0.40 \text{ mmol}$$



$$\text{pH} = \text{p}K_a + \log \frac{A}{A} = 3.86 + \log \frac{0.40}{2.10} = 3.14$$

→ buffer region up to 24.0 mL

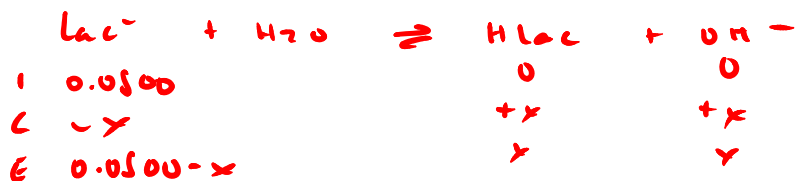
volume of titrant	pH
8.0 mL	3.53
12.5	3.86
20.0	4.46
24.0	5.24
24.5	5.60
24.9	6.30

@ 25.0 ml = stoichiometric equivalence pt

$$\text{mmol OH}^- = (0.100 \text{ M})(25.0 \text{ ml}) = 2.50 \text{ mmol}$$

$$\text{mmol OH}^- = \text{mmol Lac}^-$$

$$[\text{Lac}^-] = \frac{2.50 \text{ mmol}}{25.0 + 25.0 \text{ ml}} = 0.0500 \text{ M}$$



$$K_b = \frac{1 \times 10^{-14}}{1.4 \times 10^{-4}} = 7.1 \times 10^{-11} = \frac{x^2}{0.0500-x}$$

$$x = [\text{OH}^-] = 1.9 \times 10^{-6} \text{ M}$$

$$\text{pOH} = -\log(1.9 \times 10^{-6}) = 5.71$$

$$\text{pH} = 14 - 5.71 = 8.28$$

$$59.0 \frac{1.9 \times 10^{-6}}{0.0500} \times 100 \checkmark$$

past equivalence \rightarrow OH^- is in excess

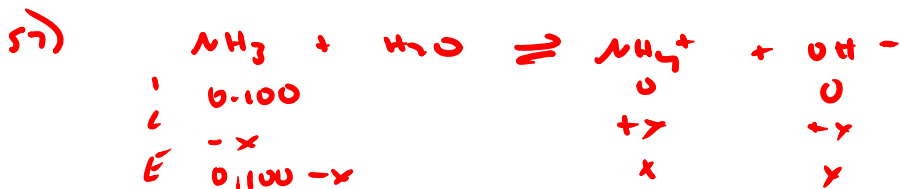
$$\text{mmol OH}^- = (0.100 \text{ M})(28.1 \text{ ml}) = 2.81 \text{ mmol}$$

$$\text{excess OH}^- = 2.81 - 2.50 = 0.01 \text{ mmol OH}^-$$

$$[\text{OH}^-] = \frac{0.010 \text{ mmol}}{25.0 + 28.1 \text{ ml}} = 2 \times 10^{-4} \text{ M}$$

$\text{pOH} = 3.7$
 $\text{pH} = 10.3$

titrant added	pH
26.0	11.30
28.0	11.75
30.0	11.96



$$K_b = 1.8 \times 10^{-5} = \frac{x^2}{(0.100 - x)}$$

$$x = [\text{OH}^-] = 1.3 \times 10^{-3} \text{ M}$$

$$\text{pOH} = -\log(1.3 \times 10^{-3}) = 2.89$$

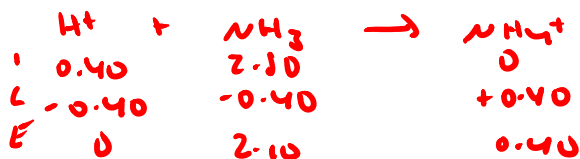
$$\text{pH} = 14 - 2.89 = 11.11$$

$$\% \text{OH}^- = \frac{1.3 \times 10^{-3}}{0.100} \times 100 = 1.3\%$$

buffer region (4.0-24.9 ml added)

$$\text{initial mmol NH}_3 = (0.100 \text{ M})(25.0 \text{ ml}) = 2.50 \text{ mmol}$$

$$\text{initial mmol H}^+ = (0.100 \text{ M})(4.0 \text{ ml}) = 0.40 \text{ mmol}$$



$$\text{pH} = \text{pKa} + \log \frac{B}{A} = 9.25 + \log \frac{0.40}{2.10} = 9.27$$

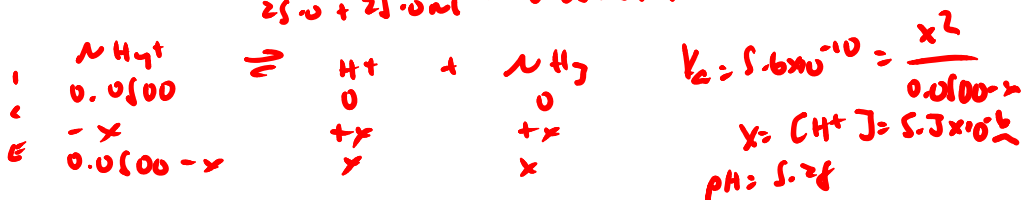
titrant added	pH
8.0 ml	9.58
12.5 ml	9.25
20.0 ml	8.65
24.0	7.87
24.5	7.60
24.9	6.90

25.0 ml H⁺ added = equivalence pt

$$\text{mmol H}^+ = \text{mmol NH}_4^+$$

$$\text{mmol H}^+ = (0.100 \text{ M})(25.0 \text{ ml}) = 2.50 \text{ mmol}$$

$$[\text{NH}_4^+] = \frac{2.50 \text{ mmol}}{25.0 + 25.0 \text{ ml}} = 0.0500 \text{ M}$$



$$K_a = 5.6 \times 10^{-10} = \frac{x^2}{0.0500 - x}$$

$$x = [\text{H}^+] = 5.3 \times 10^{-6}$$

$$\text{pH} = 5.28$$

past equivalence pt \rightarrow H^+ is in excess

$$H^+ \text{ added} = (0.100 M)(25.1 mL) = 2.51 \text{ mmol}$$

$$H^+ \text{ in excess} = 2.51 - 2.50 = 0.010 \text{ mmol}$$

$$[H^+] \text{ excess} = \frac{0.010 \text{ mmol}}{25.0 + 25.1 \text{ mL}} = 2.0 \times 10^{-4} M$$

$$pH = -\log(2.0 \times 10^{-4}) = 3.71$$

titrant added	pH
26.0 mL	2.71
28.0 mL	2.24
30.0 mL	2.04

(a) weak acid - strong base titration

$\frac{1}{2}$ equivalence pt

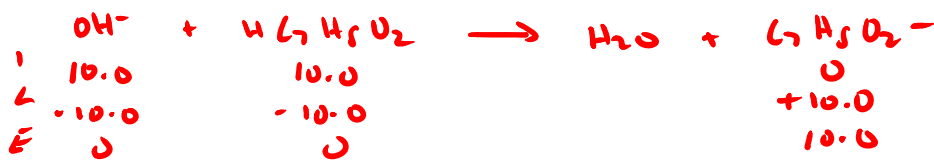
$$pH = pK_a$$

$$pH = -\log(6.4 \times 10^{-5}) = 4.19$$

* @ equivalence pt

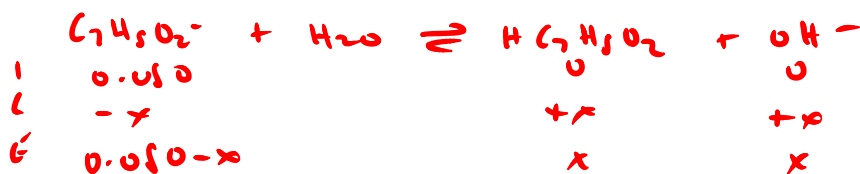
$$\text{mmol } H_2C_2O_4 = \text{mmol } OH^-$$

$$\text{mmol } H_2C_2O_4 = (0.10 M)(100.0 \text{ mL}) = 10.0 \text{ mmol}$$



$$\text{Volume of base added} = \frac{10.0 \text{ mmol}}{0.10 M} = 100.0 \text{ mL}$$

$$[C_2H_2O_4^-] = \frac{10.0 \text{ mmol}}{100.0 + 100.0 \text{ mL}} = 0.050 M$$



$$K_b = \frac{1.0 \times 10^{-14}}{6.4 \times 10^{-5}} = 1.6 \times 10^{-10} = \frac{x^2}{0.050 - x} \quad x = 2.83 \times 10^{-6}$$

$$pOH = -\log(2.83 \times 10^{-6}) = 5.54 \quad pH = 8.46$$

b) $\frac{1}{2}$ equivalence $pH = pK_a$

$$K_a = \frac{1 \times 10^{-4}}{5.6 \times 10^{-4}} = 1.8 \times 10^{-11}$$

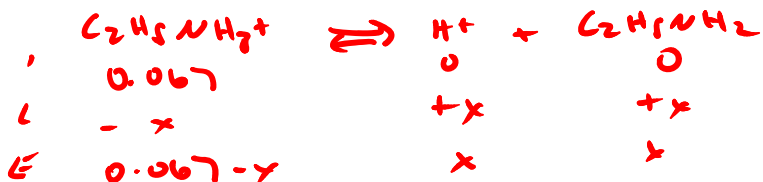
$$pH = -\log(1.8 \times 10^{-11}) = 10.74$$

* equivalence pH $mmol C_2H_5NH_2 = mmol H^+$

$$mmol C_2H_5NH_2 = (0.10M)(100.0ml) = 10.0mmol$$

$$\text{volume of } H^+ = \frac{10.0mmol}{0.20M} = 50.0ml$$

$$[C_2H_5NH_3^+] = \frac{10.0mmol}{100.0 + 50.0ml} = 0.067M$$



$$K_a = 1.8 \times 10^{-11} = \frac{x^2}{0.067-x}$$

$$x = [H^+] = 1.1 \times 10^{-6}M$$

$$pH = -\log(1.1 \times 10^{-6})$$

$$pH = 5.96$$

59. ✓

d) $\frac{1}{2}$ equivalence

$$mmol H^+ = (0.10M)(100.0ml) = 10.0mmol H^+$$

$\frac{1}{2}$ equivalence \rightarrow 25.0mmole H^+ remain

$$\text{volume } OH^- \text{ used} = \frac{25.0mmol}{0.25M} = 100.0ml$$

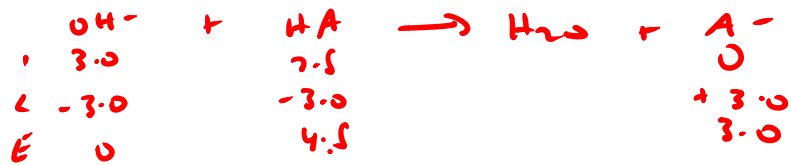
$$[H^+] = \frac{25.0mmol}{100.0 + 100.0ml} = 0.125M$$

$$pH = -\log(0.125) = 0.903$$



$$\text{mmol HA} = (0.10 \text{ M})(75.0 \text{ mL}) = 7.5 \text{ mmol HA}$$

$$\text{mmol OH}^- = (0.10 \text{ M})(30.0 \text{ mL}) = 3.0 \text{ mmol OH}^-$$



$$\text{pH} = \text{pK}_a + \log \frac{3}{4.5}$$

$$5.50 = \text{pK}_a + \log \frac{3.0}{4.5}$$

$$\text{pK}_a = 5.67$$

$$\text{K}_a = 10^{-5.67} = 2.14 \times 10^{-6}$$