

Acid-Base – Buffers/Titrations - Practice

Name: key

(Look up the K_a and K_b from data tables of your text book)

1) Which of the following solutions can be buffers?

KCl/HCl

$\text{KHSO}_4/\text{H}_2\text{SO}_4$

$\text{KNO}_2/\text{HNO}_2$

No

No

YES

2) Calculate the pH of the following buffers:

a) 0.15 M NH_3 /0.35 M NH_4Cl ($K_b = 1.8 \times 10^{-5}$) (ans: 8.89)

$$K_a = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.56 \times 10^{-10} \quad pK_a = 9.26$$

$$pH = 9.26 + \log \frac{0.15}{0.35} = \boxed{8.89}$$

b) 0.10 M Na_2HPO_4 /0.15M KH_2PO_4 ($K_a = 6.3 \times 10^{-8}$) (ans: 7.03)

as above

3) The pH of a sodium acetate/acetic acid buffer is 4.50. Calculate the ratio of $[\text{CH}_3\text{COO}^-]/[\text{CH}_3\text{COOH}]$ needed to make the buffer. ($K_a = 1.76 \times 10^{-5}$) (ans: 0.58)

$$pH = pK_a + \log \frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$4.5 = 4.75 + \log \frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$-0.24 = \log \frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]} \quad \therefore \text{antilog } -0.24 = \boxed{0.58}$$

4) In a titration experiment 12.5 mL of 0.500 M H_2SO_4 neutralizes 50.0 mL of NaOH. What is the concentration of the NaOH solution? (ans: 0.25M)

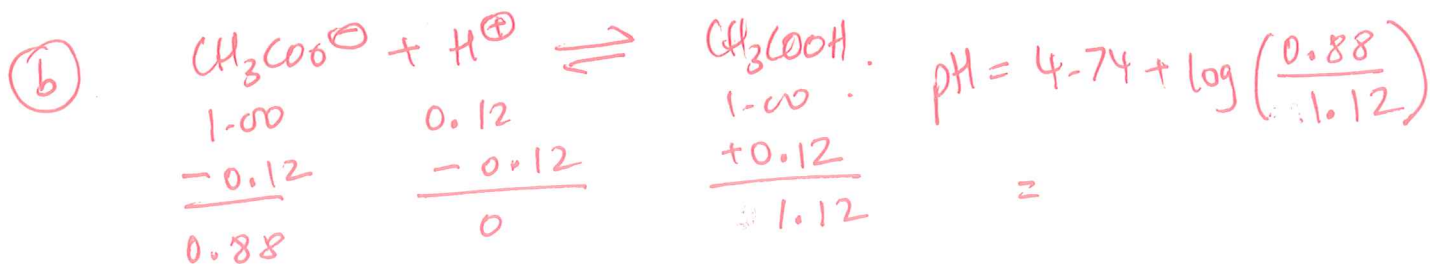
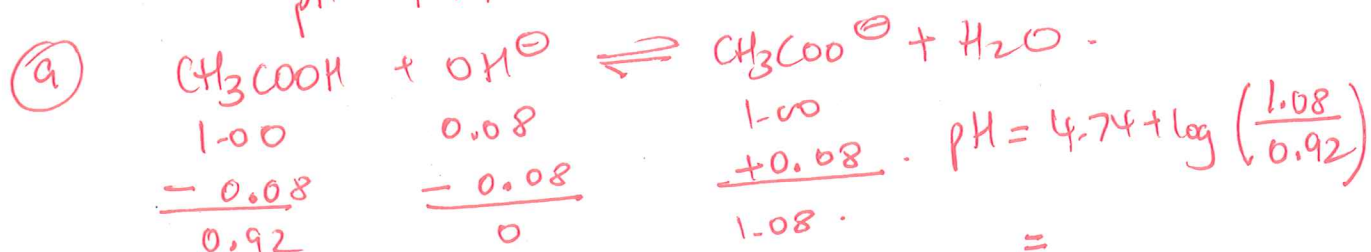


$$12.5 \text{ mL} \times \frac{0.5 \text{ mol}}{1000 \text{ mL}} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1}{50 \text{ mL}} = \boxed{0.25 \text{ M}}$$

- 5) Calculate the pH of a 1.00 L of a buffer 1.00 M CH_3COONa /1.00 M CH_3COOH before and after the addition of a) 0.080 mol NaOH and b) 0.12 mol HCl. (Assume there is no change in volume) ($K_a = 1.76 \times 10^{-5}$) (ans: 4.74; 4.82)

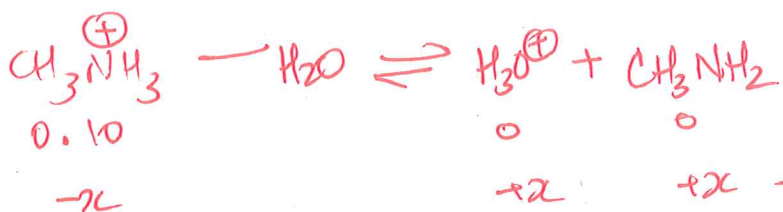
$$\text{pH} = 4.74 + \log\left(\frac{1.00}{1.00}\right)$$

$$\text{pH} = 4.74.$$



- 6) Calculate the pH at the equivalence point for the titration of 0.20 M HCl and 0.20 M (CH_3NH_2) . ($K_b = 4.4 \times 10^{-4}$) (ans: 5.82)

$$K_a = 1 \times 10^{-14} / (4.4 \times 10^{-4}) = 2.3 \times 10^{-11}$$



$$K_a = \frac{(x)(x)}{(0.10-x)}$$

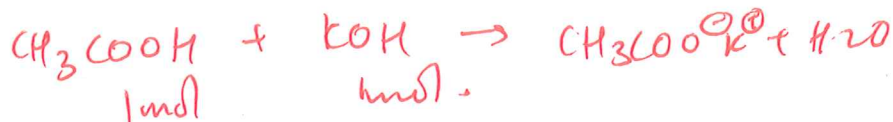
$$2.3 \times 10^{-11} = \frac{x^2}{0.1}$$

$$x = 1.5 \times 10^{-6} \text{ M} \quad \boxed{\text{pH} = 5.82}$$

→ same mol ratios
 → same conc.
 → ∴ at eq pt - vol is doubled
 → So conc. of $\text{CH}_3\text{NH}_3^\oplus$ at eq pt = $\frac{0.2\text{M}}{2} = 0.1\text{M}$

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

7) A 25.0 mL of 0.100 M CH₃COOH is titrated with 0.200 M KOH solution. Calculate the pH after the addition of a) 0.00 mL, b) 5.0 mL and c) 12.5 mL of the KOH. (ans: 2.87, 4.56, 8.78)



a) at 0 mL

$$0.1 \text{ mol} \quad \quad \quad 0 \quad \quad \quad 0$$

$$0.1 - x \quad \quad \quad +x \quad \quad \quad +x$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.1 - x}$$

$$x = \sqrt{0.1 \times 1.8 \times 10^{-5}}$$

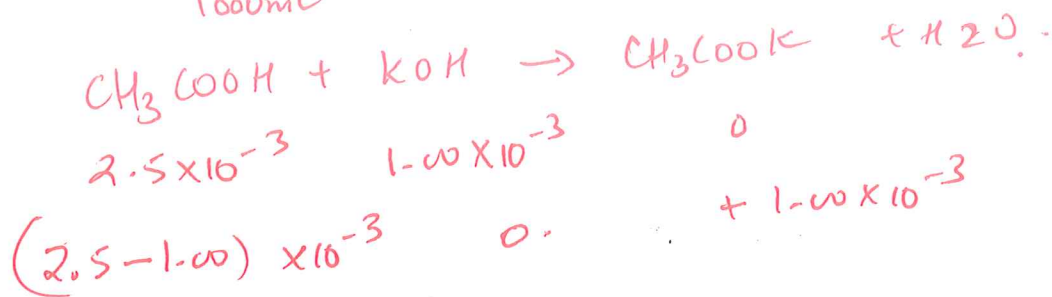
$$= 1.34 \times 10^{-3}$$

$\text{pH} = 2.87$

b) $25 \text{ mL} \times \frac{0.1 \text{ mol}}{1000 \text{ mL}} = 2.5 \times 10^{-3} \text{ mol}$

$5 \text{ mL} \times \frac{0.2 \text{ mol}}{1000 \text{ mL}} = 1.00 \times 10^{-3} \text{ mol}$

* remember
molarity changes.
moles remain the same.



easy to use buffer eqn

$$\text{pH} = -\log(1.8 \times 10^{-5}) + \log \left(\frac{1.00 \times 10^{-3}}{1.5 \times 10^{-3}} \right)$$

4.56

c) as b)