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 KHSO₄/H₂SO₄ KNO₂/HNO₂

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 $[CH_3COO^-]$/ $[CH_3COOH]$ needed to make the buffer. ($K_a = 1.76 \times 10^{-5}$) (*ans: 0.58*)

$$pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$4.5 = 4.74 + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$-0.24 = \log \frac{[CH_3COO^-]}{[CH_3COOH]} \quad \therefore \text{antilog} -0.24 = \boxed{0.58}$$

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*)

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

$$12.5\ mL \times \frac{0.5\ mol}{1000\ mL} \times \frac{2\ mol\ NaOH}{1\ mol\ H_2SO_4} \times \frac{1}{50\ mL} = \boxed{0.25M}$$

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*)

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

$$pH = 4.74.$$

(a) $CH_3COOH + OH^- \rightleftharpoons CH_3COO^- + H_2O$.

CH_3COOH	OH^-	CH_3COO^-
1.00	0.08	1.00
− 0.08	− 0.08	+0.08
0.92	0	1.08

$$pH = 4.74 + \log\left(\frac{1.08}{0.92}\right) =$$

(b) $CH_3COO^- + H^+ \rightleftharpoons CH_3COOH$.

CH_3COO^-	H^+	CH_3COOH
1.00	0.12	1.00
− 0.12	− 0.12	+0.12
0.88	0	1.12

$$pH = 4.74 + \log\left(\frac{0.88}{1.12}\right) =$$

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*)

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

→ same mol ratio
→ same conc.
→ ∴ at eq pt. vol is doubled
→ So conc. of $CH_3NH_3^+$ at eq pt $= \frac{0.2M}{2} = 0.1M$

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

$CH_3NH_3^+$	H_3O^+	CH_3NH_2
0.10	0	0
−x	+x	+x

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

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

$$x = 1.5 \times 10^{-6}\ M$$

pH = 5.82

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

7) A 25.0 mL of 0.100 M CH_3COOH 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*)

$$CH_3COOH + KOH \rightarrow CH_3COO^{\ominus}K^{\oplus} + H_2O$$

1 mol   1 mol.

(a) at 0 mL.

	CH_3COOH		
	0.1 mol.	0	0
		+x	+x.
	0.1 − x		

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

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

pH = 2.87

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

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

* remember molarity changes. mols remain the same.

$$CH_3COOH + KOH \rightarrow CH_3COOK + H_2O.$$

CH_3COOH	KOH	CH_3COOK
2.5×10^{-3}	1.00×10^{-3}	0
$(2.5 - 1.00) \times 10^{-3}$	0.	$+1.00 \times 10^{-3}$

easy to use buffer eqm

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

(4.56)

(c) as (b).