Acid-Base #2
(Titrations)

Part One: Multiple Choice - circle the best response

1. The stoichiometric point of a titration is reached when 35.50 mL 0.40 M HBr is added to a 25.00 mL sample of LiOH. The original [LiOH] is

A. 0.014 M B. 0.024 M C. 0.28 M (D.) 0.57 M

$HBr + LiOH \rightarrow LiBr + H_2O$

$0.40 \frac{mol\ HBr}{L} \times 0.03550\ L = 0.0142\ mol\ HBr$

$0.0142\ mol\ HBr \times \frac{1\ mol\ LiOH}{1\ mol\ HBr} = 0.0142\ mol\ LiOH$

$[LiOH] = \frac{0.0142\ mol}{0.02500\ L}$

2. A 25.0 mL sample of the weak acid H_2S is titrated with 31.8 mL of 0.30 M NaOH (a strong base). What is the concentration of the acid?

(A.) 0.19 M
B. 0.24 M
C. 0.38 M
D. 0.76 M

$H_2S + 2NaOH \rightarrow 2H_2O + Na_2S$

$0.30 \frac{mol\ NaOH}{L} \times 0.0318\ L = 0.00954\ mol\ NaOH$

$0.00954\ mol\ NaOH \times \frac{1\ mol\ H_2S}{2\ mol\ NaOH} = 0.00477\ mol\ H_2S$

$[H_2S] = \frac{0.00477\ mol}{0.0250\ L}$

3. Which of the following acid solutions would require the smallest volume to completely neutralize 10.00 mL of 0.100 M NaOH ? COMPLETE Neutralization

A. 0.100 M HCl $\rightarrow H^+ + Cl^-$
(B.) 0.100 M $H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$
C. 0.100 M $H_2C_2O_4 \rightarrow 2H^+ + C_2O_4^{2-}$
D. 0.100 M $CH_3COOH \rightarrow H^+ + CH_3COO^-$

~~0.100 mol~~ $0.100 \frac{mol}{L} NaOH \times 0.0100 L = 0.00010 mol NaOH$

$0.00010 \text{ mol NaOH} \times \frac{\text{mol } H^+}{\text{mol NaOH}} =$

A. $HCl + NaOH \rightarrow NaCl + H_2O$ $0.00010 \text{ mol NaOH} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = 0.00010 \text{ mol HCl}$

vs.

B. $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$ $0.00010 \text{ mol NaOH} \times \frac{1 \text{ mol } H_3PO_4}{3 \text{ mol NaOH}} = 3.3 \times 10^{-5} \text{ mol } H_3PO_4$

* it takes less H_3PO_4 to react with NaOH than HCl ~~[illegible]~~

4 The volume of 0.200 M $Sr(OH)_2$ needed to neutralize 50.0 mL of 0.200 M HI is

A. 10.0 mL
(B.) 25.0 mL
C. 50.0 mL
D. 100.0 mL

$Sr(OH)_2 + 2HI \rightarrow SrI_2 + 2H_2O$

$0.200 \frac{mol}{L} HI \times 0.050 L = 0.010 \text{ mol HI}$

$0.010 \text{ mol HI} \times \frac{1 \text{ mol } Sr(OH)_2}{2 \text{ mol HI}} = 0.0050 \text{ mol } Sr(OH)_2$

$0.0050 \text{ mol NaOH} \times \frac{1 \text{ L}}{0.200 \text{ mol}} = 0.025 L$

5 3. A 1.15 g sample of solid oxalic acid ($H_2C_2O_4$) is titrated with 28.0 mL of NaOH solution. How many grams of NaOH reacted?

A. 0.256 g
B. 0.456 g
C. 0.511 g
(D.) 1.02 g

$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

$1.15\ g\ H_2C_2O_4 \times \frac{1\ mol}{90\ g} = 0.012\bar{7}\ mol\ H_2C_2O_4$

$0.012\bar{7}\ mol\ H_2C_2O_4 \times \frac{2\ mol\ NaOH}{1\ mol\ H_2C_2O_4} = 0.0255\ mol\ NaOH$

$0.0255\ mol\ NaOH \times \frac{40\ g\ NaOH}{1\ mol\ NaOH}$

6. A 25.0 mL sample of a diprotic weak acid is titrated with 20.2 mL of 0.10 M NaOH. What is the concentration of the acid?

(A.) 0.040 M
B. 0.080 M
C. 0.16 M
D. 0.12 M

$H_2A + 2NaOH \rightarrow Na_2A + 2H_2O$

$0.10\ \frac{mol\ NaOH}{L} \times 0.0202\ L = 0.00202\ mol\ NaOH$

$0.00202\ mol\ NaOH \times \frac{1\ mol\ H_2A}{2\ mol\ NaOH} = 0.00101\ mol\ H_2A.$

$[H_2A] = \frac{0.00101\ mol}{0.025\ L}$

Part Two: Long Answer - write response in space provided. Remember sig figs & units

(3 marks)

1. In three separate trials, 10.00 mL samples of H_2SO_4 were titrated with 0.40 M NaOH and the results are tabulated below.

Trial	Volume of 0.40 M NaOH
1	~~18.20 mL~~
2	16.90 mL
3	17.10 mL

too far away from others (must be within 0.1 mL)

$$\text{Volume} = \frac{16.90 + 17.10\text{ mL}}{2} = 17.00\text{ mL}$$

Calculate the concentration of the H_2SO_4.

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

$$0.40\ \frac{\text{mol NaOH}}{\text{L}} \times 0.01700\text{ L} = 0.0068\text{ mol NaOH}$$

$$0.0068\text{ mol NaOH} \times \frac{1\text{ mol } H_2SO_4}{2\text{ mol NaOH}} = 0.0034\text{ mol } H_2SO_4$$

$$[H_2SO_4] = \frac{0.0034\text{ mol}}{0.0100\text{ L}} \qquad [H_2SO_4] = 0.34\text{ M}$$

2.

Consider the following reaction:

$$2HCl_{(aq)} + Ba(OH)_{2(s)} \rightarrow BaCl_{2(aq)} + 2H_2O_{(\ell)}$$

When 3.16 g samples of $Ba(OH)_2$ were titrated to the equivalence point with an HCl solution, the following data were recorded:

	Volume of HCl added
Trial 1	~~37.80 mL~~
Trial 2	35.49 mL
Trial 3	35.51 mL

$$\text{volume HCl} = \frac{35.49 + 35.51}{2} = 35.50\ \text{mL}$$

Using the data above, calculate the original [HCl]. **(4 marks)**

$$3.16\ \text{g}\ Ba(OH)_2 \times \frac{1\ \text{mol}\ Ba(OH)_2}{171.3\ \text{g}\ Ba(OH)_2} = 0.0184\ldots\ \text{mol}\ Ba(OH)_2$$

$$0.0184\ \text{mol}\ Ba(OH)_2 \times \frac{2\ \text{mol HCl}}{1\ \text{mol}\ Ba(OH)_2} = 0.0368\ldots\ \text{mol HCl}$$

$$[HCl] = \frac{0.0368\ldots\ \text{mol}}{0.03550\ \text{L}} = 1.04\ \text{M}$$