Exercise 15.4
Titration

Name: ________________________

Date:_________________ Per:________

Solving Titration Problems

A titration is a chemical process for finding the equivalence point (*the point where the moles of* H^+ *= moles of* OH^- *ions*) in a neutralization reaction.

The moles of H^+ may be calculated using the formula:	The moles of OH^- may be calculated using the formula:
moles $H^+ = M_{acid} \times V_{acid}$	*moles* $OH^- = M_{base} \times V_{base}$

Since the *moles of* H^+ = *moles* OH^- at the equivalence point,

$$M_{acid} \times V_{acid} = M_{base} \times V_{base}$$

- *While the volumes of acid and base should probably be converted to liters, as long as they are the same unit, the proportions will work out.*
- *When the acid or base produces multiple* H^+ *or* OH^- *respectively, the molarity of the solution must be multiplied by number of ions produced. For example, the* OH^- *molarity of a 0.600 M solution of* $Ca(OH)_2$ *is really 1.20 M because it dissociates to form 2x its molarity of* OH^- *ions.*

DIRECTIONS: Complete the following in the space provided.

1. If 26.4 mL of LiOH are required to neutralize 21.7 mL of 0.500 *M* HBr, what is the concentration of the LiOH?

2. If 75.0 mL of .823 *M* $HClO_4$ requires 95.5 mL of $Ba(OH)_2$ for neutralization, what is the concentration of the $Ba(OH)_2$?

3. What volume of 0.400 *M* NaOH would be required to titrate 100. ml of 0.250 *M* HCl?

4. A sample of H_2SO_4 it is titrated with 0.75 *M* KOH. If 370.6 mL of KOH are required to neutralize a 30.00 mL sample of sulfuric acid, what is the concentration of the sulfuric acid.

5. Lactic acid, a chemical responsible for muscle fatigue, is a monoprotic acid. When 0.578 g of lactic acid is titrated with 0.206 *M* NaOH, a volume of 31.11 mL of NaOH is used. What is the molar mass of lactic acid?

$$HA + NaOH \rightleftharpoons NaA + H_2O$$

6. If 40.0 ml of 0.100 *M* H_3PO_4 are required to titrate 150. ml of NaOH to the equivalence point, what is the molarity of the NaOH?

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7. Draw the titration curve of a generic weak acid, HA, with a strong base.
On the curve, indicate the point that correspond to the following:
    a. The stoichiometric (equivalence) point.
    b. The region with the maximum buffering.
    c. pH = pK_a
    d. pH depends only on $[HA]_0$
    e. pH depends only on $[A^-]$
    f. pH depends only on the amount of excess strong base added.

8. Sketch the titration curve for the titration of a generic weak base, B, with a strong acid.
The titration reaction is $B + H^+ \rightleftarrows BH^+$.
On this curve, indicate the points that correspond to the following:
    a. The stoichiometric (equivalence) point.
    b. The region with the maximum buffering.
    c. pH = pK_a
    d. pH depends only on $[B]_0$
    e. pH depends only on $[BH^+]$
    f. pH depends only on the amount of excess strong acid added.

9. A 25.0-mL sample of 0.100 *M* lactic acid ($HC_3H_5O_3$, pK_a = 3.86) is titrated with 0.100 *M* NaOH solution. Calculate the pH after the addition of
    a. 0.0 mL of the NaOH.

    b. 4.0 mL of the NaOH.

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c. 20.0 mL of the NaOH.

d. 30.0 mL of the NaOH.

10. Repeat the procedure in problem #9 but for the titration of 25.0 mL of 0.100 M propanoic acid ($HC_3H_5O_2$, $K_a = 1.3 \times 10^{-5}$) with 0.100 M KOH.

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11. Calculate the pH at the equivalence point for the titration of 50.0 mL of 0.205 *M* HBr is titrated with 0.356 *M* KOH.

12. Calculate the pH at the equivalence point for each of the following titrations:
    a. 0.104 g sodium acetate ($K_b = 5.6 \times 10^{-10}$) is dissolved in 25.0 mL of water and titrated with 0.0996 *M* HCl.

    b. 50.00 mL of 0.0426 *M* HOCl ($K_a = 3.5 \times 10^{-8}$) is titrated with 0.1028 *M* NaOH.