Exercise 15.2a

Titrations - Answers

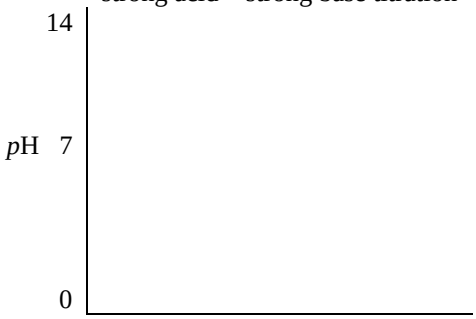
Name: _____

Date: _____ Per: _____

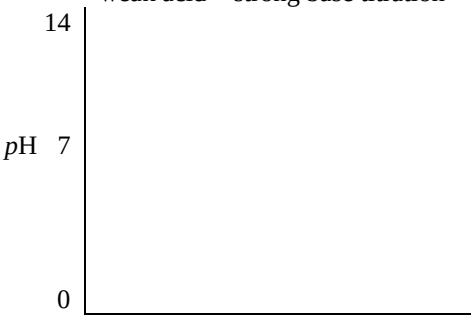
DIRECTIONS: Answer the following in the space provided.

1. Draw a titration curve for a strong acid – strong base titration, weak acid – strong base titration, strong acid – weak base titration, and strong base – strong acid titration. Label the equivalence point on each graph.

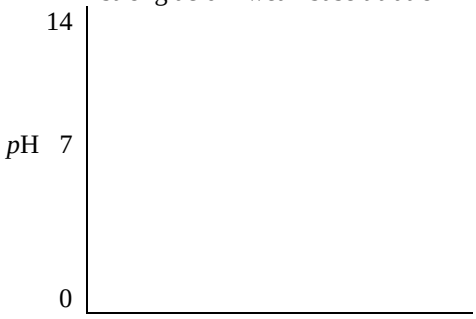
strong acid – strong base titration



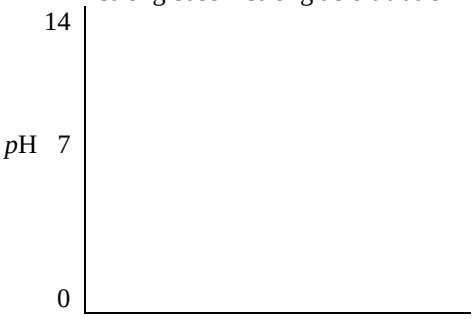
weak acid – strong base titration



strong acid – weak base titration



strong base – strong acid titration



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:
moles $H^+ = M_{acid} \times V_{acid}$

The moles of OH^- may be calculated using the formula:
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.*

2. 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?

Is it a 1:1 ratio? $1LiOH(aq) + 1HBr(aq) \rightarrow 1LiBr(aq) + 1H_2O(l)$: yes! ∴ $M_AV_A = M_BV_B$ will work.

$M_A = 0.500\ M$
$V_A = 21.7$ mL
$M_B = ?\ M$
$V_B = 26.4$ mL

$M_AV_A = M_BV_B$

$M_B = \frac{M_AV_A}{V_B} = \frac{(0.500\ M)(21.7\ \cancel{mL})}{(26.4\ \cancel{mL})} = 0.4109\ M = \boxed{0.411\ M}$

∴ *means "therefore"*

3. If 23.4 mL of 0.551 *M* NaOH is used to titrate 50.0 mL of HCl to endpoint, what is the concentration of the HCl?

Is it a 1:1 ratio? $1NaOH(aq) + 1HCl(aq) \rightarrow 1NaCl(aq) + 1H_2O(l)$: yes! ∴ $M_AV_A = M_BV_B$ will work.

$M_A = ?\ M$
$V_A = 50.0$ mL
$M_B = 0.551\ M$
$V_B = 23.4$ mL

$M_AV_A = M_BV_B$

$M_A = \frac{M_BV_B}{V_A} = \frac{(0.551\ M)(23.4\ \cancel{mL})}{(50.0\ \cancel{mL})} = 0.2578\ M = \boxed{0.258\ M}$

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Answers: 2) 0.411 *M* 3) 0.258 *M* 4) 0.275 *M* 5) 0.323 *M* 6) 0.125 *M* 7) 62.5mL 8) 49.3 mL 10) 30.0 mL 11) 0.080 *M* 12) 0.003 mol

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4. If 45.0 mL of 0.153 *M* LiOH is required to neutralize 25.0 mL of HBr, what is the concentration of the HBr?

Is it a 1:1 ratio? $1LiOH(aq) + 1HBr(aq) \rightarrow 1LiBr(aq) + 1H_2O(l)$: yes! ∴ $M_AV_A = M_BV_B$ will work.

M_A = ? *M*
V_A = 25.0 mL
M_B = 0.153 *M*
V_B = 45.0 mL

$M_AV_A = M_BV_B$

$M_A = \frac{M_BV_B}{V_A} = \frac{(0.153\ M)(45.0\ \cancel{mL})}{(25.0\ \cancel{mL})} = 0.2754\ M$ = **0.275 *M***

5. If 75.0 mL of 0.823*M* $HClO_4$ requires 95.5 mL of $Ba(OH)_2$ for neutralization, what is the concentration of the $Ba(OH)_2$?

Is it a 1:1 ratio? $2HClO_4(aq) + 1Ba(OH)_2(aq) \rightarrow 1Ba(ClO_4)_2(aq) + 2H_2O(l)$: **no!** ∴ $M_AV_A = M_BV_B$ will **not** work (unless adjusted).

M_A = 0.823 *M*
V_A = 75.0 mL (0.0750 L)
M_B = ? *M*
V_B = 95.5 mL (0.0955 L)

$mol_A = M_AV_A = (0.823\ mol/L)(0.0750\ L) = 0.06172\ mol\ HClO_4$

$0.06172\ \cancel{mol\ HClO_4} \left| \frac{1\ mol\ Ba(OH)_2}{2\ \cancel{mol\ HClO_4}} \right. = 0.03086\ mol\ Ba(OH)_2$

$M_B = \frac{mol_B}{V_B} = \frac{0.03086\ mol\ Ba(OH)_2}{0.0955\ L} = 0.3231\ M$

= 0.323 *M*

6. If 50.0 ml of 0.300 *M* KOH are required to titrate 60.0 ml of H_2SO_4, what is the molarity of the H_2SO_4?

Is it a 1:1 ratio? $2KOH(aq) + 1H_2SO_4(aq) \rightarrow 1K_2SO_4(aq) + 2H_2O(l)$: **no!** ∴ $M_AV_A = M_BV_B$ will **not** work (unless adjusted).

M_A = ? *M*
V_A = 60.0 mL (0.0600 L)
M_B = 0.300 *M*
V_B = 50.0 mL (0.0500 L)

$mol_B = M_BV_B = (0.300\ mol/L)(0.0500\ L) = 0.0150\ mol\ KOH$

$0.0150\ \cancel{mol\ KOH} \left| \frac{1\ mol\ H_2SO_4}{2\ \cancel{mol\ KOH}} \right. = 7.50 \times 10^{-3}\ mol\ H_2SO_4$

$M_A = \frac{mol_A}{V_A} = \frac{7.50 \times 10^{-3}\ mol\ Ba(OH)_2}{0.0600\ L} = 0.125\ M$

= 0.125 *M*

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

Is it a 1:1 ratio? $1NaOH(aq) + 1HCl(aq) \rightarrow 1NaCl(aq) + 1H_2O(l)$: yes! ∴ $M_AV_A = M_BV_B$ will work.

M_A = 0.250 *M*
V_A = 100. mL
M_B = 0.400 *M*
V_B = ? mL

$M_AV_A = M_BV_B$

$V_B = \frac{M_AV_A}{M_B} = \frac{(0.250\ \cancel{M})(100.\ mL)}{(0.400\ \cancel{M})} = 62.5\ mL$ = **62.5 mL**

8. If 55.0 ml of 1.20 *M* $HC_2H_3O_2$ are used to titrate a sample of 0.670 *M* $Ba(OH)_2$, what is volume of the $Ba(OH)_2$ used?

Is it a 1:1 ratio? $2HC_2H_3O_2(aq) + 1Ba(OH)_2(aq) \rightarrow 1Ba(C_2H_3O_2)_2(aq) + 2H_2O(l)$: **no!** ∴ $M_AV_A = M_BV_B$ will **not** work (unless adjusted).

M_A = 1.20 *M*
V_A = 55.0 mL (0.0550 L)
M_B = 0.670 *M*
V_B = ? mL

$mol_A = M_AV_A = (1.20\ mol/L)(0.0550\ L) = 0.0660\ mol\ \cancel{HC_2H_3O_2}$

$0.0660\ \cancel{mol\ HC_2H_3O_2} \left| \frac{1\ mol\ Ba(OH)_2}{2\ \cancel{mol\ HC_2H_3O_2}} \right. = 0.0330\ mol\ Ba(OH)_2$

$V_B = \frac{mol_B}{M_B} = \frac{0.0330\ mol\ Ba(OH)_2}{0.670\ mol/L} = 0.049253\ L$

= 49.3 mL

9. Would it take more 0.1 *M* HCl or 0.1 *M* H_2SO_4 to neutralize 30.0 ml of NaOH?

It will take twice as much 0.1 *M* HCl to neutralize the NaOH because it only provides ½ as many H^+ ions as H_2SO_4.

10. If 50.0 ml of 0.450 *M* $Sr(OH)_2$ are required to titrate a 0.750 *M* H_2SO_4 sample, what is the volume of the H_2SO_4?

$1Sr(OH)_2(aq) + 1H_2SO_4Br(aq) \rightarrow 1SrSO_4(aq) + 2H_2O(l)$: yes! ∴ $M_AV_A = M_BV_B$ will work.

M_A = 0.750 *M*
V_A = ? mL
M_B = 0.450 *M*
V_B = 50.0 mL

$M_AV_A = M_BV_B$

$V_A = \frac{M_BV_B}{M_A} = \frac{(0.450\ \cancel{M})(50.0\ mL)}{0.750\ \cancel{M}} = 30.0\ mL$ = **30.0 mL**

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

Is it a 1:1 ratio? $1H_3PO_4(aq) + 3NaOH(aq) \rightarrow 1Na_3PO_4(aq) + 3H_2O(l)$: **no!** ∴ $M_AV_A = M_BV_B$ will **not** work (unless adjusted).

M_A = 0.100 *M*
V_A = 40.0 mL (0.0400 L)
M_B = ? *M*
V_B = 150. mL (0.150 L)

$mol_A = M_AV_A = (0.100\ mol/L)(0.0400\ L) = 4.00 \times 10^{-3}\ mol\ H_3PO_4$

$4.00 \times 10^{-3}\ \cancel{mol\ H_3PO_4} \left| \frac{3\ mol\ NaOH}{1\ \cancel{mol\ H_3PO_4}} \right. = 0.0120\ mol\ NaOH$

$M_B = \frac{mol_B}{V_B} = \frac{0.0120\ mol\ NaOH}{0.150\ L} = 0.0800\ M$

= 0.0800 *M*

12. If 30.0 ml of 0.300 M NaOH are required to titrate H_3PO_4 to the equivalence point, how many moles of H_3PO_4 are needed to reach the equivalence point?

$1H_3PO_4(aq) + 3NaOH(aq) \rightarrow 1Na_3PO_4(aq) + 3H_2O(l)$

M_B = 0.300 *M*
V_B = 30.0 mL (0.0300 L)

$mol_B = M_BV_B = (0.300\ mol/L)(0.0300\ L) = 9.00 \times 10^{-3}\ mol\ NaOH$

$9.00 \times 10^{-3}\ \cancel{mol\ NaOH} \left| \frac{1\ mol\ H_3PO_4}{3\ \cancel{mol\ NaOH}} \right. = 3.00 \times 10^{-3}\ mol\ H_3PO_4$

3.00×10^{-3} mol H_3PO_4

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Answers: 2) 0.411 *M* 3) 0.258 *M* 4) 0.275 *M* 5) 0.323 *M* 6) 0.125 *M* 7) 62.5mL 8) 49.3 mL 10) 30.0 mL 11) 0.080 *M* 12) 0.003 mol