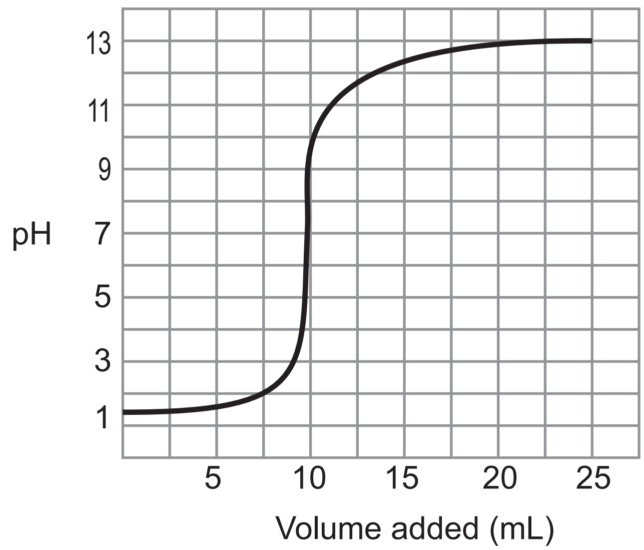
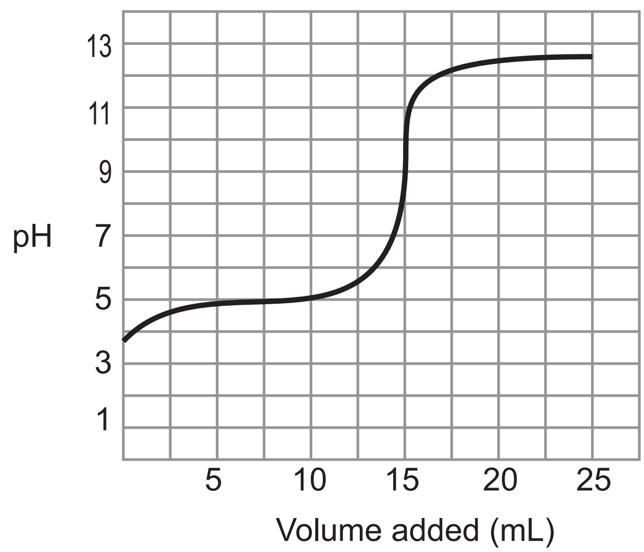
Titration Curve Practice Problems



1. From the graph at the right, determine
   a. if the acids/bases are strong or weak
   b. whether the acid or base was added from the buret
   c. the volume required to reach the equivalence point
   d. the pH at the equivalence point
   e. the concentration of base (BOH) used if this titration started with 50.0 mL of 0.050*M* acid, HA.



2. From the graph at the right, determine
   a. if the acids/bases are strong or weak
   b. whether the acid or base was added from the buret
   c. the volume required to reach the equivalence point
   d. the pH of the equivalence point
   e. the region where buffering occurs
   f. the volume and pH at the half equivalence point
   g. the K_a of the acid used
   h. the region where the [HA]:[A-] ratio has more [HA]

i. the region where the [HA]:[A-] ratio has more [A-]

j. the concentration of a base (BOH) if this represents reaction with 60.0 mL of 0.050*M* acid, HA.

k. the concentration of a base ($B(OH)_2$) if this represents reaction with 60.0 mL of 0.050*M* acid, HA.

3. From the graph at the right, determine
   a. if the acids/bases are strong or weak

   b. whether the acid or base was added from the buret

   c. the volume required to reach the equivalence point

   d. the pH of the equivalence point

   e. the region where buffering occurs

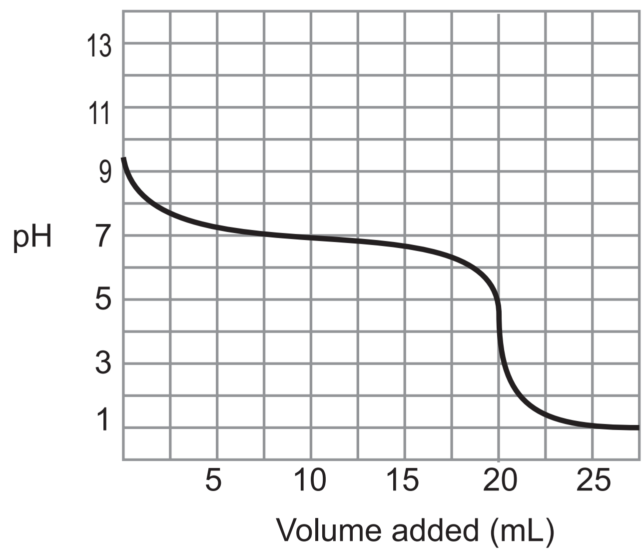
   f. the volume and pH at the half equivalence point

   g. the K_b of the base used

   h. the region where there is more base than conjugate acid ion.

   i. the region where the [base]:[conj. acid ion] ratio has more [conj. acid ion]

   j. the concentration of acid used if this represents the titration of 30 mL of 0.25*M* base.



4. 25 mL of 0.10*M* NaOH is titrated with 0.20*M* HCl. Determine,
   a. if the acids/bases are strong or weak

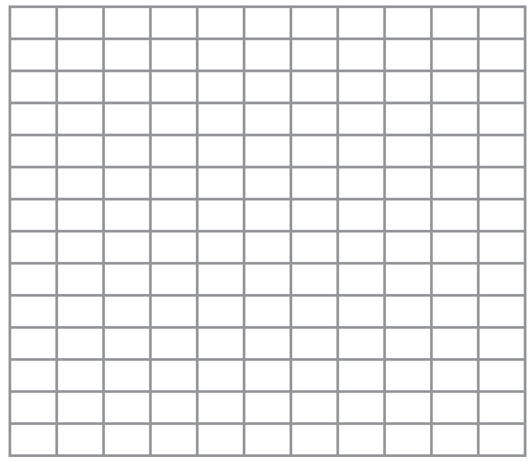
   b. if the acid:base is 1:1 or other

   c. the initial pH before the titration begins

   d. the volume required to reach the equivalence point

   e. the identity of the major species present at the equivalence point

   On the graph,
   f. label the axes
   g. sketch the curve
   h. mark the equivalence point with an X
   i. state the pH and volume at the equivalence point



5. 40.0 mL of 0.020*M* sorbic acid, $HC_6H_7O_2$, is titrated with 0.040*M* of sodium hydroxide to its equivalence point. (K_a of sorbic acid = 1.7×10^{-5})
   Determine
   a. if the acids/bases are strong or weak

   b. if the acid:base is 1:1 or other

   c. the initial pH before the titration begins

   d. the volume of sodium hydroxide required to reach the equivalence point

   e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7.

On the graph,

f. label the axes
g. sketch the curve
h. identify the portion of the curve where buffering occurs
   i. Identify the region of the buffer portion where the is more weak acid than conjugate base ion
   ii. Identify the region of the buffer portion where there is more conjugate base ion than weak acid
i. mark the half-equivalence point with an H and label the volume and pH
j. mark the equivalence point with an X and label the volume and approximate the pH

6. 20.0 mL of 0.030*M* nitric acid is titrated with 0.040 *M* potassium hydroxide. Determine,
   a. if the acids/bases are strong or weak

   b. if the acid:base is 1:1 or other

   c. the initial pH before the titration begins

   d. the volume of KOH required to reach the equivalence point

   e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

On the graph,

f. label the axes
g. sketch the curve
h. mark the equivalence point with an X
i. state the pH and volume at the equivalence point

7. 20.0 mL of 0.060*M* solution of ammonia, NH_3 is titrated with 0.060*M* perchloric acid, $HClO_4$. (K_b of ammonia is 1.8×10^{-5})
Determine
   a. if the acids/bases are strong or weak

   b. if the acid:base is 1:1 or other

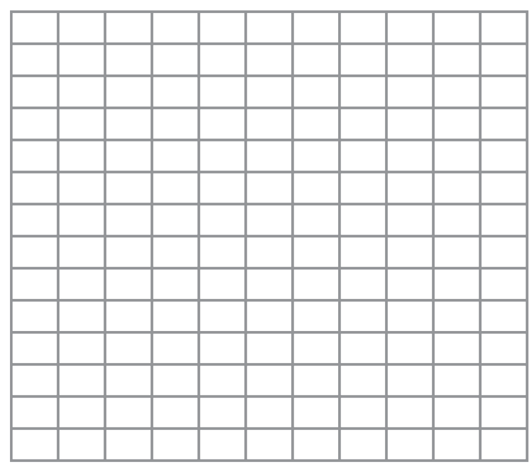
   c. the initial pH before the titration begins

   d. the volume of perchloric acid required to reach the equivalence point

   e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

On the graph,
   f. label the axes
   g. sketch the curve
   k. identify the portion of the curve where buffering occurs
      i. Identify the region of the buffer portion where the is more weak base than conjugate acid ion
      ii. Identify the region of the buffer portion where there is more conjugate acid ion than weak base
   h. mark the half-equivalence point with an H and label the volume and pH

   i. mark the equivalence point with an X and label the volume and approximate the pH

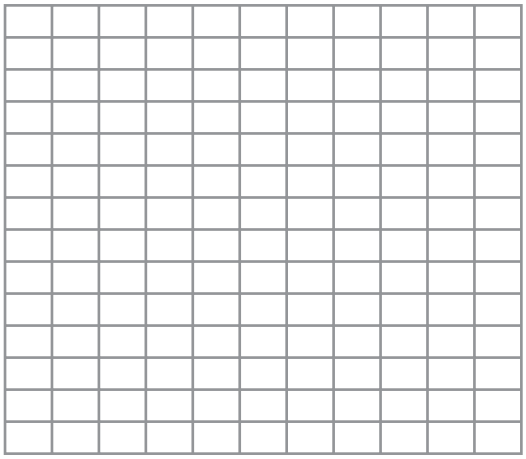


8. 50 mL of 0.020*M* magnesium hydroxide is titrated with 0.40*M* nitric acid. Determine
   a. if the acids/bases are strong or weak

   b. if the acid:base is 1:1 or other

   c. the initial pH before the titration begins

   d. the volume of nitric acid required to reach the equivalence point



e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

On the graph,

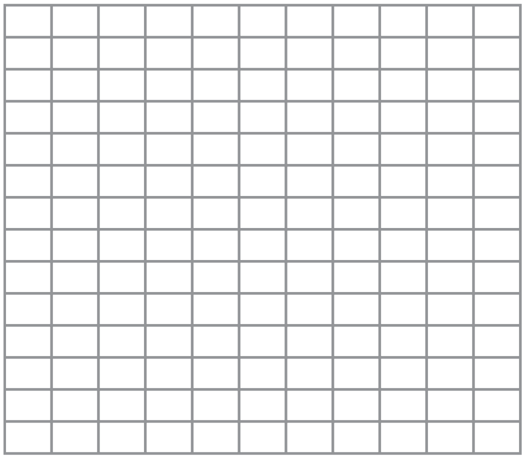
f. label the axes
g. sketch the curve
h. mark the equivalence point with an X
i. state the pH and volume at the equivalence point

9. 40.0 mL of 0.100*M* nitrous acid, HNO_2 is titrated with 0.200*M* potassium hydroxide, KOH. (K_a of nitrous acid = 5.6×10^{-4})

Determine

a. if the acids/bases are strong or weak

b. if the acid:base is 1:1 or other



c. the initial pH before the titration begins

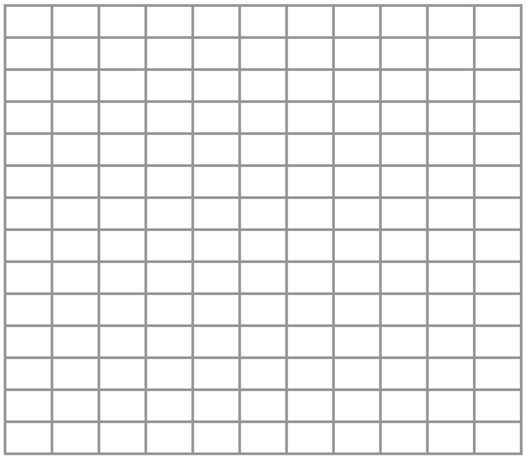
d. the volume required to reach the equivalence point

e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

On the graph,

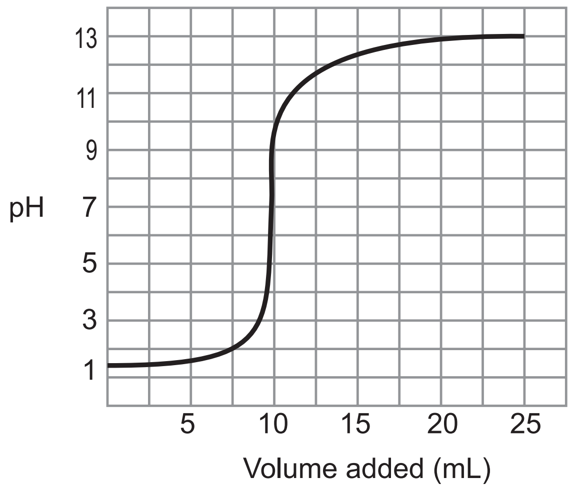
f. label the axes
g. sketch the curve
h. identify the portion of the curve where buffering occurs
   iii. Identify the region of the buffer portion where the is more weak acid than conjugate base ion
   iv. Identify the region of the buffer portion where there is more conjugate base ion than weak acid
i. mark the half-equivalence point with an H and label the volume and pH
j. mark the equivalence point with an X and label the volume and approximate the pH

10. 40.0 mL of 0.020*M* aniline, $C_6H_5NH_2$, is titrated with 0.040*M* of nitric acid to its equivalence point. (K_b of aniline = 4.3×10^{-10})
Determine
   a. if the acids/bases are strong or weak
   b. if the acid:base is 1:1 or other
   c. the initial pH before the titration begins
   d. the volume required to reach the equivalence point
   e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

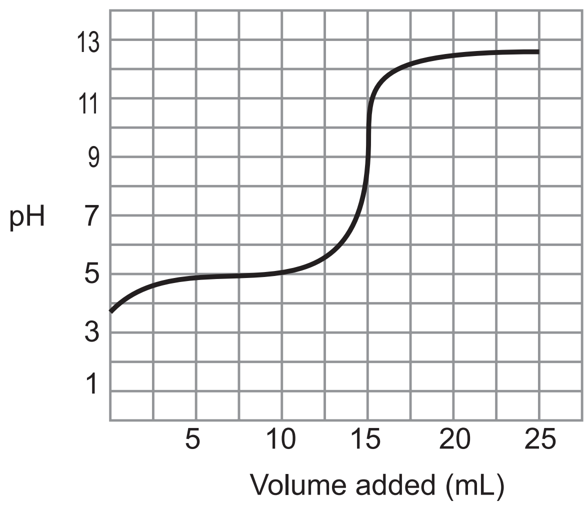


On the graph,
   f. label the axes
   g. sketch the curve
   h. identify the portion of the curve where buffering occurs
   i. mark the half-equivalence point with an H and label the volume and pH
   j. mark the equivalence point with an X and label the volume and approximate the pH

Titration Curve Practice Problems (KEY)



1. From the graph at the right, determine
   a. if the acids/bases are strong or weak
   Strong acid+strong base because there is a steep vertical region centered at pH 7.
   b. whether the acid or base was added from the buret
   The flask contained the acid, as evidenced by a pH 1.5 before anything else was added. As the solution is added from the buret the pH climbs and finishes in the basic pH region.
   c. the volume required to reach the equivalence point
   10 mL. The center of the vertical region occurs with 10 mL of base added.
   d. the pH at the equivalence point
   7. The center of the vertical region occurs at pH 7.
   e. the concentration of base (BOH) used if this titration started with 50.0 mL of 0.050*M* acid, HA.
   At the equivalence point moles acid = moles base.
   moles acid = moles base
   $(0.050M)(0.050L) = 0.0025$ mol acid = 0.0025 mol base
   $M_b = \frac{0.0025 \text{ mol base}}{0.010L} = 0.25M$



2. From the graph at the right, determine
   a. if the acids/bases are strong or weak
   Weak acid + strong base because there is a squatty equivalence region whose center is at about pH 9. Also, confirming this we see that the pH starts at 4ish (as opposed to 1ish) and ends near 13.
   b. whether the acid or base was added from the buret
   The base is added from the buret since we see the pH increasing with additional volume added.
   c. the volume required to reach the equivalence point
   15 mL. The vertical region is centered at 15 mL.
   d. the pH of the equivalence point
   9. The center of the vertical region has a y-coordinate of approximately 9.
   e. the region where buffering occurs
   From pH 4 to the equivalence point near pH 9. All points after the initial point and before the equivalence point have buffer characteristics.
   f. the volume and pH at the half equivalence point
   If the equivalence point occurs at 15 mL, then the half-equivalence point occurs at 7.5 mL. Notice the relatively flat slope of the curve around the half-equivalence point. At this point maximum buffering is occurring and pH changes are slight. At 7.5 mL the pH is about 5.
   g. the K_a of the acid used
   Always remember that pH=pKa at the half equivalence point. So, if the pH is 5 at the half equivalence point, the pKa = 5 and the Ka must be 1×10^{-5}.
   h. the region where the [HA]:[A-] ratio has more [HA]

Since this titration started with a weak acid HA, the A^- is being created as the strong base is added from the buret. Prior to the half-equivalence point there more HA than A^- in the solution. As the half-equivalence point approaches and the amount of A^- approaches equalizing with the amount of HA, that is where we see the best buffering solution and a flatter slope.

i. the region where the [HA]:[A-] ratio has more [A-]

After the half-equivalence point there more A- than HA in the solution. At the half-equivalence points HA and A^- are equal, and beyond that additional base added from the buret shifts the balance to an increase in A^- until the equivalence point is reached.

j. the concentration of a base (BOH) if this represents reaction with 60.0 mL of 0.050*M* acid, HA.

At the equivalence point moles acid = moles base.

moles acid = moles base

$(0.050M)(0.060L) = 0.0030 \text{ mol acid}$

$0.0030 \text{ mol acid} \times \frac{1 \text{ mol base}}{2 \text{ mol acid}} = 0.0015 \text{ mol base}$

$M_b = \frac{0.0015 \text{ mol base}}{0.015L} = 0.10M$

k. the concentration of a base ($B(OH)_2$) if this represents reaction with 60.0 mL of 0.050*M* acid, HA.

At the equivalence point moles acid = moles base, but beware since this base releases 2 OH^- ions/mol, you'll have to take that stoichiometry into consideration. Notice that with 2 OH^-/mol of base the concentration base required to neutralize the same amount of acid is exactly half of its value in (j).

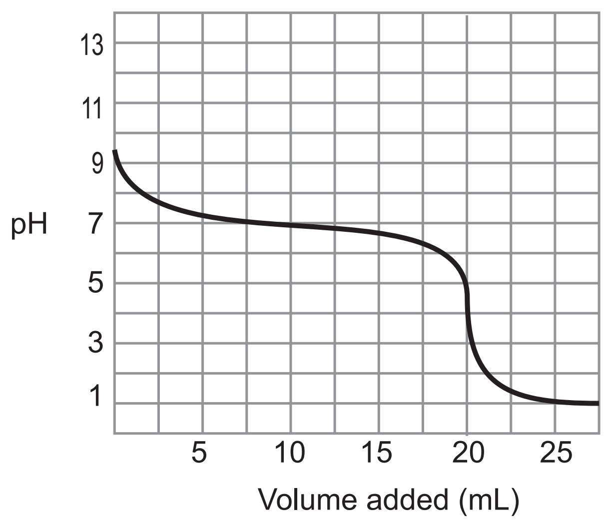
moles acid = moles base

$(0.050M)(0.060L) = 0.0030 \text{ mol acid}$

$0.0030 \text{ mol acid} \times \frac{1 \text{ mol base}}{2 \text{ mol acid}} = 0.0015 \text{ mol base}$

$M_b = \frac{0.0015 \text{ mol base}}{0.015L} = 0.10M$

3. From the graph at the right, determine



a. if the acids/bases are strong or weak

Weak base + strong acid because there is a squatty equivalence region whose center is at about pH 4. Also, confirming this we see that the pH starts at 9 and ends near 1.

b. whether the acid or base was added from the buret

The acid is added from the buret since we see the pH decreasing with additional volume added

c. the volume required to reach the equivalence point

20 mL. The vertical region is centered at 20 mL.

d. the pH of the equivalence point

4. The center of the vertical equivalence region has a y-coordinate of about 4.

e. the region where buffering occurs

From pH 9 to the equivalence point near pH 4. All points after the initial point and before the equivalence point have buffer characteristics.

f. the volume and pH at the half equivalence point

If the equivalence point occurs at 20 mL, then the half-equivalence point occurs at 10 mL. Notice the relatively flat slope of the curve around the half-equivalence point. At this point maximum buffering is occurring and pH changes are slight. At 10 mL the pH is about 7.

g. the K_b of the base used

Always remember that pH–pK_a at the half equivalence point. Since the pH is 7 at this half-equivalence point the pK_a is also 7 and the Ka is $1x10^{-7}$. But, ah, we need the Kb since that is what the question asked for. $K_w=K_axK_b$ so simply divide $1x10^{-14}$ by $1x10^{-7}$ to find the K_b. In this particular case, it happens to be equal to the K_a at $1x10^{-7}$. This will not usually be the case.

h. the region where there is more base than conjugate acid ion.

All points prior to the half-equivalence point will have a greater proportion of weak base than conjugate acid ion. With the weak base in the flask, the strong acid coming from the buret creates a conjugate acid ion with each drop that is added. Prior to the half-equivalence point there will be more weak base in the solution with increasing amounts of conjugate acid ion being created as the strong acid drips in. As the half equivalence point approaches, the pH curve flattens out as a more balanced buffer solution is created.

i. the region where the [base]:[conj. acid ion] ratio has more [conj. acid ion]

After the half-equivalence point and through the equivalence point there will be a greater proportion of conjugate acid ion than of weak base. At the half-equivalence point exactly half of the weak base will have been converted to conjugate ion. Beyond that point the balance shifts to a more conjugate acid ion than weak base in the solution. This occurs all the way up to the equivalence point where ALL of the weak base will have reacted and only the salt of the conjugate ion remains.

j. the concentration of acid used if this represents the titration of 30 mL of 0.25*M* base.

At the equivalence point moles acid = moles base

moles acid = moles base

$(0.25M)(0.030L) = 0.0075 \text{ mol base} = 0.0075 \text{ mol acid}$

$$M_a = \frac{0.0075 \text{ mol base}}{0.020L} = 0.375M$$

4. 25 mL of 0.10*M* NaOH is titrated with 0.20*M* HCl.
Determine,

a. if the acids/bases are strong or weak

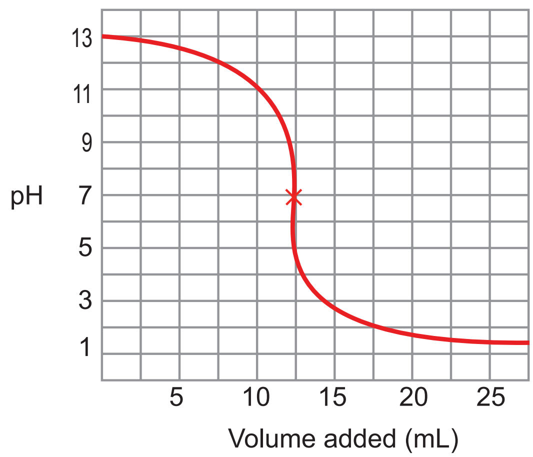
NaOH is a strong base and HCl is a strong acid

b. if the acid:base is 1:1 or other

HCl releases 1 H^+ and NaOH releases 1 OH^-

c. the initial pH before the titration begins

The pH of a strong base is 14-pOH. The pOH of 0.10M NaOH is –log[0.10]=1. So the pH = 14–1=13



d. the volume required to reach the equivalence point

At the equivalence point moles acid = moles base.

moles acid = moles base

$(0.10M)(0.025L) = 0.0025 \text{ mol base} = 0.0025 \text{ mol acid}$

$$M_a = \frac{\text{mol acid}}{V_a} \therefore V_a = \frac{\text{mol acid}}{M_a}$$

$$V_a = \frac{0.0025 \text{ mol acid}}{0.20M}$$

$V_a = 12.5 \text{ mL}$

e. the identity of the major species present at the equivalence point

At the equivalence point all of the NaOH and HCl have reacted leaving only NaCl and H_2O. NaCl is a neutral salt that does not undergo any hydrolysis.

On the graph,

f. label the axes

y-axis is pH, x-axis is volume of acid added

g. sketch the curve
see graph
h. mark the equivalence point with an X
see graph
i. state the pH and volume at the equivalence point
the equivalence point should be at pH 7 and 12.5 mL

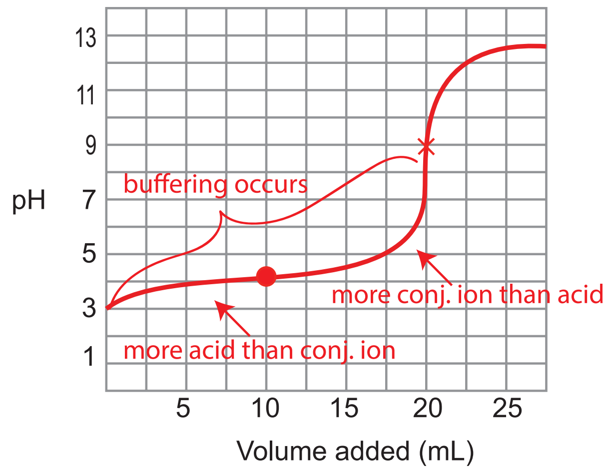
5. 40.0 mL of 0.020M sorbic acid, $HC_6H_7O_2$, is titrated with 0.040M of sodium hydroxide to its equivalence point. (K_a of sorbic acid = 1.7×10^{-5})
Determine
a. if the acids/bases are strong or weak
Sorbic acid is weak and sodium hydroxide is strong.
b. if the acid:base is 1:1 or other
Sorbic acid has one ionizable H^+ and NaOH has one OH^-.
c. the initial pH before the titration begins
The initial pH of a weak acid is determined from its equilibrium constant.

$$Ka = \frac{[x]^2}{[orig]}$$

$$1.7 \times 10^{-5} = \frac{[x]^2}{[0.020]}$$

$$x = 5.8 \times 10^{-4} = [H^+]$$

$$pH = -\log[5.8 \times 10^{-4}] = 3.23$$



d. the volume of sodium hydroxide required to reach the equivalence point
At the equivalence point moles acid = moles base. (Notice for this one that the base is exactly twice as concentrated as the acid, therefore it should take half as much volume to deliver an equivalent number of moles.)

moles acid = moles base

$(0.020M)(0.040L) = 0.00080$ mol acid $= 0.00080$ mol base

$$M_b = \frac{mol\ base}{V_b} \therefore V_b = \frac{mol\ base}{M_b}$$

$$V_b = \frac{0.00080\ mol\ base}{0.040M}$$

$$V_b = 20.0\ mL$$

e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7.
At the equivalence point all of the weak acid $HC_6H_7O_2$ will have reacted with NaOH creating an equivalent number of moles of the conjugate base salt, $NaC_6H_7O_2$. This is a basic salt and we expect the pH to be greater than 7.

On the graph,
f. label the axes
y-axis is pH; x-axis is volume of base added
g. sketch the curve
see graph
h. identify the portion of the curve where buffering occurs see graph
i. Identify the region of the buffer portion where the is more weak acid than conjugate base ion from the first drop through the half-equivalence point

ii. Identify the region of the buffer portion where there is more conjugate base ion than weak acid from the half-equivalence point to the equivalence point

i. mark the half-equivalence point with an H and label the volume and pH see graph

j. mark the equivalence point with an X and label the volume and approximate the pH
volume at equivalence point is 20.0 mL and pH should be greater than 7

6. 20.0 mL of 0.030*M* nitric acid is titrated with 0.040 *M* potassium hydroxide. Determine,

a. if the acids/bases are strong or weak
Nitric acid is a strong acid and potassium hydroxide is a strong base

b. if the acid:base is 1:1 or other
HNO_3 and KOH react in a 1:1 mole ratio

c. the initial pH before the titration begins
The pH of a strong acid is –log[H^+]. The pH of 0.03M is HNO_3 –log[0.030]=1.52.

d. the volume of KOH required to reach the equivalence point
At the equivalence point moles acid = moles base

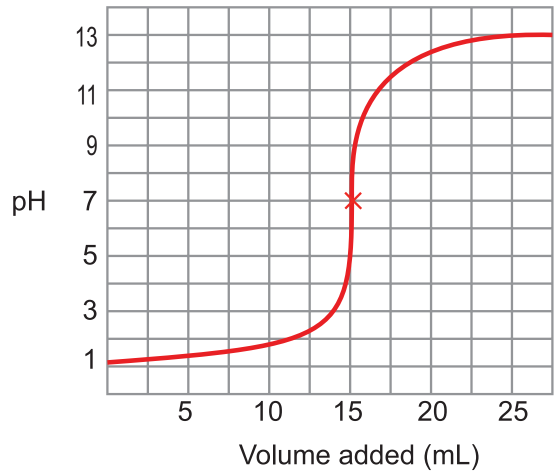
moles acid = moles base

(0.030*M*)(0.020*L*) = 0.00060 mol acid = 0.00060 mol base

$M_b = \frac{mol\ base}{V_b} \therefore V_b = \frac{mol\ base}{M_b}$

$V_b = \frac{0.00060\ mol\ base}{0.040M}$

V_b = 15 mL



e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7
At the equivalence point all of the nitric acid will have reacted with the potassium hydroxide leaving only the salt, KNO_3 and water. Since this salt is a neutral salt the pH should be 7.

On the graph,

f. label the axes
y-axis is pH; x-axis is volume of base added

g. sketch the curve see graph

h. mark the equivalence point with an X see graph

i. state the pH and volume at the equivalence point
The pH will be 7 and the volume is 15 mL at the equivalence point

7. 20.0 mL of 0.060*M* solution of ammonia, NH_3 is titrated with 0.060*M* perchloric acid, $HClO_4$. (K_b of ammonia is 1.8 x10^{-5})
Determine

a. if the acids/bases are strong or weak
Ammonia is a weak base and perchloric acid is a strong acid

b. if the acid:base is 1:1 or other
Ammonia and perchloric react in a 1:1 mole ratio

c. the initial pH before the titration begins
The initial pH of a weak base is determined from its equilibrium constant.

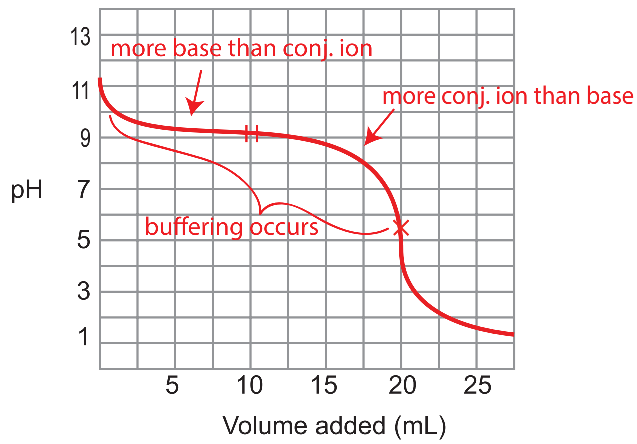
$$K_b = \frac{[x]^2}{[orig]}$$

$$1.8\times10^{-5} = \frac{[x]^2}{[0.060]}$$

$$x = 1.0\times10^{-3} = [OH^-]$$

$$pOH = -\log[1.0\times10^{-3}] = 3.0$$

$$pH = 14 - 3 = 11$$



d. the volume of perchloric acid required to reach the equivalence point
At the equivalence point moles acid = moles base. (Notice for this one that the acid and base concentrations are equal. Equal concentrations require equal volumes to reach the equivalence point.)

moles acid = moles base

$(0.060M)(0.020L) = 0.0012$ mol base = 0.0012 mol acid

$$M_a = \frac{mol\ acid}{V_a} \therefore V_a = \frac{mol\ acid}{M_a}$$

$$V_a = \frac{0.0012\ mol\ acid}{0.060M}$$

$$V_a = 20.0\ \text{mL}$$

e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7
At the equivalence point all of the weak base NH_3 will have reacted with $HClO_4$ creating an equivalent number of moles of the conjugate acid salt, NH_4ClO_4. This is an acidic salt and we expect the pH to be less than 7.

On the graph,

f. label the axes
y-axis is pH; x-axis is volume of base added

g. sketch the curve see graph

k. identify the portion of the curve where buffering occurs see graph

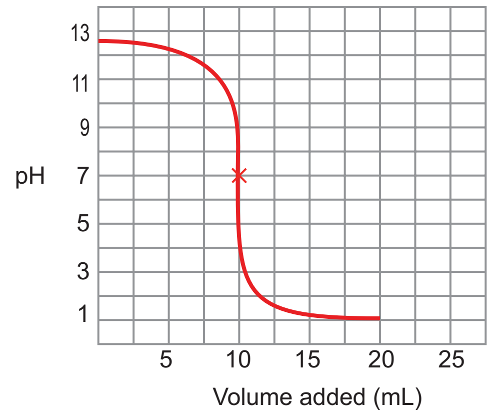
i. Identify the region of the buffer portion where the is more weak base than conjugate acid ion from the first drop through the half-equivalence point

ii. Identify the region of the buffer portion where there is more conjugate acid ion than weak base from the half-equivalence point to the equivalence point

h. mark the half-equivalence point with an H and label the volume and pH
the half equivalence point occurs at 10 mL and should have a pH = pK_a. Since this is a base whose K_b is 1.8 $\times10^{-5}$ its K_a is $1\times10^{-14}/1.8\times10^{-5}$, or 5.6×10^{-10}. The pKa = $-\log[5.6\times10^{-10}]$ =9.25.

i. mark the equivalence point with an X and label the volume and approximate the pH
At the equivalence point all of the weak base NH_3 will have reacted with $HClO_4$ creating an equivalent number of moles of the conjugate acid salt, NH_4ClO_4. This is an acidic salt and we expect the pH to be less than 7.

8. 50 mL of 0.020*M* magnesium hydroxide is titrated with 0.40*M* nitric acid. Determine



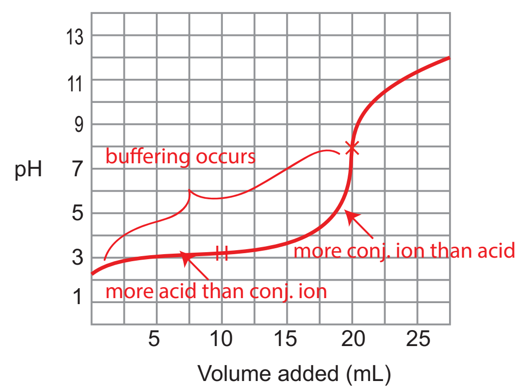
   a. if the acids/bases are strong or weak
      $Mg(OH)_2$ is a strong base and HNO_3 is a strong acid
   b. if the acid:base is 1:1 or other
      HNO_3 releases 1 H^+/mol but $Mg(OH)_2$ releases 2 OH^- /mol.
   c. the initial pH before the titration begins
      Be careful, this is a tricky one! Since $Mg(OH)_2$ is strong *and* it releases 2 OH-/mol, a 0.20M solution of $Mg(OH)_2$ would contain 0.040M OH-. So the pH would be 14-(-log(0.040)) = 12.6
   d. the volume of nitric acid required to reach the equivalence point
      At the equivalence point moles acid = moles base, but beware the reacting ratio is not 1:1. Since this base releases 2 OH- ions/mol, you'll have to take that stoichiometry into consideration.

$$\text{moles acid} = \text{moles base}$$
$$(0.040M)(0.050L) = 0.0020 \text{ mol base}$$
$$0.0020 \text{ mol base} \times \frac{2 \text{ mol acid}}{1 \text{ mol base}} = 0.0040 \text{ mol acid}$$
$$V_a = \frac{0.0040 \text{ mol acid}}{0.40M} = 0.010L$$
$$V_a = 10\,mL$$

   e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7
      At the equivalence point all of the $Mg(OH)_2$ base will have reacted with the HNO_3 to produce the neutral salt $Mg(NO_3)_2$. Since this is a neutral salt the pH will be 7.

On the graph,
   f. label the axes
      y-axis is pH; x-axis is volume of base added
   g. sketch the curve see graph
   h. mark the equivalence point with an X see graph
   i. state the pH and volume at the equivalence point
      The pH is 7 and the volume is 10 mL at the equivalence point

9. 40.0 mL of 0.100*M* nitrous acid, HNO_2 is titrated with 0.200*M* potassium hydroxide, KOH. (K_a of nitrous acid = 5.6×10^{-4})
Determine



   a. if the acids/bases are strong or weak
      nitrous acid is a weak acid and potassium hydroxide is a strong base.
   b. if the acid:base is 1:1 or other
      nitrous acid and potassium hydroxide react in a 1:1 stoichiometric ratio
   c. the initial pH before the titration begins
      The initial pH of a weak acid is determined from its equilibrium constant.

$$Ka = \frac{[x]^2}{[orig]}$$

$$5.6\times10^{-4} = \frac{[x]^2}{[0.100]}$$

$$x = 7.5\times10^{-3} = [H^+]$$

$$pH = -\log[7.5\times10^{-3}] = 2.13$$

d. the volume required to reach the equivalence point

At the equivalence point moles acid = moles base. (Notice for this one that the base concentration is twice that of the acid. Therefore, it should require only half as much volume to deliver an equivalent number of moles.)

moles acid = moles base

$$(0.100M)(0.040L) = 0.0040\ mol\ acid = 0.0040\ mol\ base$$

$$V_b = \frac{mol\ base}{M_b} = \frac{0.0040\ mol\ base}{0.200M} = 0.020L$$

$$V_b = 20\text{ mL}$$

e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7

At the equivalence point all of the HNO_2 acid will have reacted with the KOH base to produce the conjugate base salt KNO_2. Since this is a basic salt the pH will be greater than 7.

On the graph,

f. label the axes

y-axis is pH; x-axis is volume of base added

g. sketch the curve see graph

h. identify the portion of the curve where buffering occurs see graph

iii. Identify the region of the buffer portion where the is more weak acid than conjugate base ion from the first drop through the half-equivalence point

iv. Identify the region of the buffer portion where there is more conjugate base ion than weak acid from the half-equivalence point to the equivalence point

i. mark the half-equivalence point with an H and label the volume and pH see graph

j. mark the equivalence point with an X and label the volume and approximate the pH

The equivalence point occurs at 10 mL and should have a pH greater than 7.

10. 40.0 mL of 0.020*M* aniline, $C_6H_5NH_2$, is titrated with 0.040*M* of nitric acid to its equivalence point. (K_b of aniline = $4.3\text{x}10^{-10}$)

Determine

a. if the acids/bases are strong or weak

aniline is a weak base and nitric acid is a strong acid

b. if the acid:base is 1:1 or other

aniline and nitric acid react in a 1:1 stoiciometric ratio

c. the initial pH before the titration begins

The initial pH of a weak base is determined from its equilibrium constant.

$$Kb = \frac{[x]^2}{[orig]}$$

$$4.3\times10^{-10} = \frac{[x]^2}{[0.020]}$$

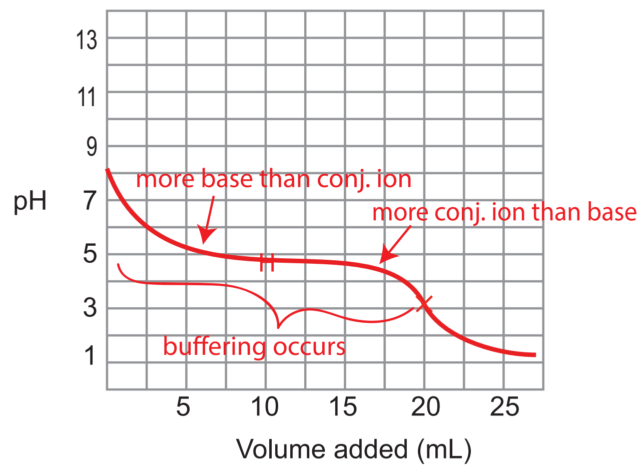
$$x = 2.9\times10^{-6} = [OH^-]$$

$$pOH = -\log[2.9\times10^{-6}] = 5.53$$

$$pH = 14 - 5.53 = 8.46$$

d. the volume required to reach the equivalence point
At the equivalence point moles acid = moles base. (Notice for this one that the acid concentration is twice that of the base. Therefore, it should require only half as much volume to deliver an equivalent number of moles.)
moles base = moles acid
$(0.020M)(0.040L) = 0.00080 \text{ mol base} = 0.00080 \text{ mol acid}$
$$V_a = \frac{\text{mol acid}}{M_a} = \frac{0.00080\,\textit{mol acid}}{0.040\,M} = 0.020\,L$$
$V_a = 20$ mL

e. the identity of the major species present at the equivalence point and whether the pH should be greater than, less than, or equal to 7
At the equivalence point all of the $C_6H_5NH_2$ will have reacted with the HNO_3 to produce the conjugate acid salt $C_6H_5NH_3NO_3$. Since this is acidic salt the pH will be greater than 7.



On the graph,

f. label the axes
y-axis is pH; x-axis is volume of base added

g. sketch the curve see graph

h. identify the portion of the curve where buffering occurs see graph

i. mark the half-equivalence point with an H and label the volume and pH see graph

j. mark the equivalence point with an X and label the volume and approximate the pH
The equivalence point occurs at 10 mL and should have a pH less than 7.