



Name: \_\_\_\_\_

Period: \_\_\_\_\_

Assigned on Monday, April 06, 2026

**13.1 Buffers and Buffering Action**

Due Tuesday, April 07, 2026

Name	Formula	K <sub>a1</sub>	K <sub>a2</sub>	K <sub>a3</sub>
acetic acid	HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	1.8x10 <sup>-5</sup>		
ammonium ion	NH <sub>4</sub> <sup>+</sup>	5.6x10 <sup>-10</sup>		
benzoic acid	HC <sub>7</sub> H <sub>5</sub> O <sub>2</sub>	6.5x10 <sup>-5</sup>		
carbonic acid	H <sub>2</sub> CO <sub>3</sub>	4.3x10 <sup>-7</sup>	5.6x10 <sup>-11</sup>	
chlorous acid	HClO <sub>2</sub>	1.1x10 <sup>-2</sup>		
citric acid	H <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub>	7.4x10 <sup>-4</sup>	1.7x10 <sup>-5</sup>	4.0x10 <sup>-7</sup>
formic acid	HCHO <sub>2</sub>	1.8x10 <sup>-4</sup>		
hydrocyanic acid	HCN	4.9x10 <sup>-10</sup>		
hydrofluoric acid	HF	6.8x10 <sup>-4</sup>		
hydrosulfuric acid	H <sub>2</sub> S	8.9x10 <sup>-8</sup>	1x10 <sup>-19</sup>	
hypochlorous acid	HClO	2.9x10 <sup>-8</sup>		
nitrous acid	HNO <sub>2</sub>	4.6x10 <sup>-4</sup>		
phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	7.5x10 <sup>-3</sup>	6.2x10 <sup>-8</sup>	4.2x10 <sup>-13</sup>
sulfurous acid	H <sub>2</sub> SO <sub>3</sub>	1.6x10 <sup>-2</sup>	6.4x10 <sup>-8</sup>	

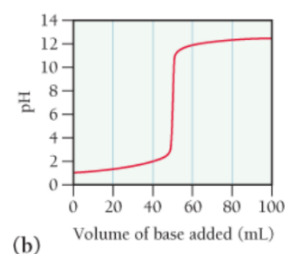
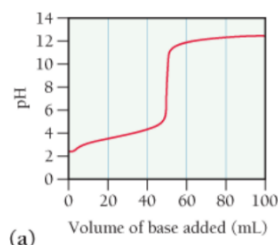
**Part 1**

- In which of these solutions will HNO<sub>2</sub> ionize less than it does in pure water? Why?  
a. 0.10 M NaCl    b. 0.10 M KNO<sub>3</sub>    c. 0.10 M NaOH    d. 0.10 M NaNO<sub>2</sub>
- Write the net ionic equilibrium equation for HF in water. Then calculate the pH of a 0.15 M HF solution. (The K<sub>a</sub> of HF is given above.)
  - Write the net ionic equilibrium equation for F<sup>-</sup> in water. Then calculate the pH of a 0.15 M NaF solution. (The K<sub>a</sub> of HF is given above, and from that you can determine the K<sub>b</sub> of F<sup>-</sup>.)
  - Calculate the pH of a solution that is 0.15M in HF and 0.15M in F<sup>-</sup>. (The K<sub>a</sub> of HF is given above. This is your first use of the Henderson-Hasselbalch Equation for a buffer solution!)
- A buffer contains significant amounts of acetic acid (HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>) and sodium acetate (NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>).
  - Identify the acid in this buffer solution.
  - Identify the base in this buffer solution.
  - If HCl is added to the solution, what substance will act to neutralize this added acid? Write the net ionic equation for this neutralization.
  - If NaOH is added to the solution, what substance will act to neutralize this added base? Write the net ionic equation for this neutralization.
- Use the Henderson-Hasselbalch equation to calculate the pH of each of the following solutions.
  - a solution that is 0.20 M in HCHO<sub>2</sub> and 0.15 M in NaCHO<sub>2</sub>
  - a solution that is 0.16 M in NH<sub>3</sub> and 0.22 M in NH<sub>4</sub>Cl
- Calculate the pH of the solution that results from each mixture. (Be careful...the volume changes when the two solutions are mixed so you need to calculate the initial concentrations after they are combined using M<sub>1</sub>V<sub>1</sub> = M<sub>2</sub>V<sub>2</sub>!)
  - 50.0 mL of 0.15 M HCHO<sub>2</sub> with 75.0 mL of 0.13 M NaCHO<sub>2</sub>
  - 125.0 mL of 0.10 M NH<sub>3</sub> with 250.0 mL of 0.10 M NH<sub>4</sub>Cl
- You want to make a buffer solution with a pH of 4.25. You have a 0.15M solution of benzoic acid (HC<sub>7</sub>H<sub>5</sub>O<sub>2</sub>). You also have some solid sodium benzoate (NaC<sub>7</sub>H<sub>5</sub>O<sub>2</sub>) that you can add to the solution in order to make the buffer. What does the concentration of the sodium benzoate need to be in order to create the buffer solution with a pH of 4.25?
  - What mass of sodium benzoate (NaC<sub>7</sub>H<sub>5</sub>O<sub>2</sub>) should you measure out to make 150.0 mL of the buffer solution?

## Part 2

7. a. What is the pH of a solution created by placing 0.010 mol of HCl in 500.0 mL of water?
- b. 0.010 mol of HCl is placed in 500.0 mL of a buffer solution that is 0.125 M in  $\text{HNO}_2$  and 0.115 M in  $\text{NaNO}_2$ .
- Identify the part of the buffer solution that is an acid.
  - Identify the part of the buffer solution that is a base.
  - Write the equation for the net ionic neutralization reaction that occurs when the added HCl is added to the buffer solution.
  - Calculate the new concentrations of the components of the buffer solution after the HCl is neutralized.
  - What is the new pH of the buffer solution after the HCl is neutralized?
- c. Following the same logic used in part b, calculate the pH after 0.010 mol of HCl is added to 500.0 mL of a buffer solution that is 0.155 M in  $\text{NH}_3$  and 0.145 M in  $\text{NH}_4\text{Cl}$ .
8. A 350.0-mL buffer solution is 0.150 M in HF and 0.150 M in NaF.
- What mass of NaOH can this buffer neutralize? (In other words, what is the solution's buffer capacity for neutralizing a base?)
  - If the same volume of the buffer were 0.350 M in HF and 0.350 M in NaF, what mass of NaOH could be neutralized by the buffer?
9. Blood is buffered by carbonic acid ( $\text{H}_2\text{CO}_3$ ) and the bicarbonate ion ( $\text{HCO}_3^-$ ). Normal blood plasma is 0.024 M in  $\text{HCO}_3^-$  and 0.0012 M  $\text{H}_2\text{CO}_3$  ( $\text{p}K_{\text{a}1}$  for  $\text{H}_2\text{CO}_3$  at body temperature is 6.35).
- What is the pH of blood plasma?
  - If 0.200 g of NaOH entered the blood stream, what would the new pH of the blood? (The average adult has a blood volume of 5.0 L.)
  - If 0.200 g of HCl entered the blood stream, what would the new pH of the blood? (The average adult has a blood volume of 5.0 L.)
10. Which buffer system is the best choice to create a buffer with  $\text{pH} = 7.2$ ? For the best system calculate the ratio of the molarities of the buffer components required to make the buffer.
- $\text{HC}_2\text{H}_3\text{O}_2/\text{KC}_2\text{H}_3\text{O}_2$
  - $\text{HClO}_2/\text{KClO}_2$
  - $\text{NH}_4\text{Cl}/\text{NH}_3$
  - $\text{HClO}/\text{KClO}$

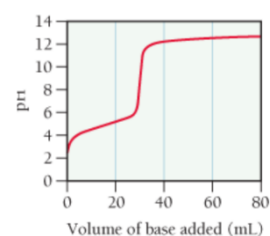
11. The graphs labeled (a) and (b) show the titration curves for two equal-volume samples of monoprotic acids, one weak and one strong. Both titrations were carried out with the same concentration of strong base.



- What is the approximate pH at the equivalence point of each curve?
  - Which graph corresponds to the titration of the strong acid and which one to the titration of the weak acid?
12. Two 20.0 mL samples, one 0.200 M KOH and the other 0.200 M  $\text{CH}_3\text{NH}_2$  ( $K_{\text{b}} = 4.4 \times 10^{-4}$ ), are titrated with 0.100 M HI.
- What is the volume of added acid at the equivalence point for each titration?
  - Is the pH at the equivalence point for each titration acidic, basic, or neutral?
  - Which titration curve has the lower initial pH?
  - Sketch each titration curve.

13. Consider the curve shown here for the titration of a weak monoprotic acid with a strong base and answer each question.

- What is the pH and what is the volume of added base at the equivalence point?
- At what volume of added base does  $\text{pH} = \text{p}K_{\text{a}}$ ?
- What is the  $K_{\text{a}}$  of the weak acid?

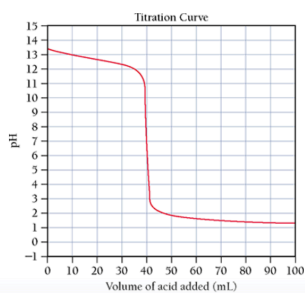




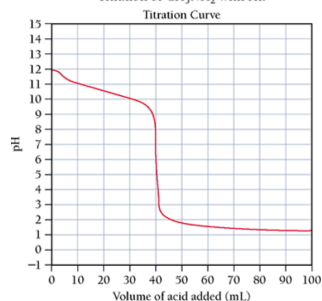
## Answers

- d
- a.  $\text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{F}^-$ ; 2.00  
b.  $\text{F}^- + \text{H}_2\text{O} \rightleftharpoons \text{HF} + \text{OH}^-$   
c. 3.17
- a.  $\text{HC}_2\text{H}_3\text{O}_2$   
b.  $\text{NaC}_2\text{H}_3\text{O}_2$  ( or  $\text{C}_2\text{H}_3\text{O}_2^-$  )  
c.  $\text{C}_2\text{H}_3\text{O}_2^- + \text{H}^+ \rightleftharpoons \text{HC}_2\text{H}_3\text{O}_2$   
d.  $\text{HC}_2\text{H}_3\text{O}_2 + \text{OH}^- \rightleftharpoons \text{C}_2\text{H}_3\text{O}_2^- + \text{H}_2\text{O}$
- a. 3.62  
b. 9.11
- a. 3.86  
b. 8.95
- a. 0.173 M  
b. 3.74 g
- a. 1.70  
bi.  $\text{HNO}_2$ ; ii.  $\text{NO}_2^-$ ; iii.  $\text{H}^+ + \text{NO}_2^- \rightleftharpoons \text{HNO}_2$ ; iv. 0.095 M  $\text{NO}_2^-$  and 0.145M  $\text{HNO}_2$ ; v. 3.15  
c. 9.16
- a. 2.1 g; b. 4.9 g
- a. 7.65 (at least for this problem); b. 8.44; c. 6.79
- $\text{HClO}/\text{KClO}$ ; 0.46 (about 1:2)
- ia. 8; ib. 7; ii. strong = b and weak = a
- a. 40.0 mL HI for both; b. KOH: neutral,  $\text{CH}_3\text{NH}_2$ : acidic; c.  $\text{CH}_3\text{NH}_2$ ;  
d.

Titration of KOH with HI:



Titration of  $\text{CH}_3\text{NH}_2$  with HI:



- a. pH = 9 and 30 mL of bas was added  
b. ~15 mL  
c. ~5